



## Expert forecast on emerging physical risks related to occupational safety and health





**EXPERT FORECAST ON EMERGING PHYSICAL RISKS  
RELATED TO OCCUPATIONAL SAFETY AND HEALTH**

Expert forecast on emerging physical risks related to occupational safety and health

Authors:

Eva Flaspöler & Dietmar Reinert, BGIA, Germany (Topic Centre Research)  
Emmanuelle Brun, BGIA, Germany (Topic Centre Research) & European Agency for  
Safety and Health at Work

In cooperation with:

Topic Centre Research members:

Manfred Hinker and Silvia Springer, AUVA, Austria  
Karen Peirens, Prevent, Belgium  
Kari Lindström and Krista Pahkin, FIOH, Finland  
Jean-Marie Mur, INRS, France  
Karl Kuhn and Ellen Zwink, BAuA, Germany  
Victor Hrymak, OSHII, Ireland  
Antonio Leva, ISPESL, Italy  
Pilar Hervás and Mercedes Tejedor, INSHT, Spain  
Richard Brown and Lee Kenny, HSL, UK  
Anneke Goudswaard, Irene Houtman, Elco Miedema and Martin van de Bovenkamp,  
TNO Work and Employment, Netherlands

European Agency for Safety and Health at Work: William Cockburn

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## FOREWORD

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The evolution of society and the changing world of work bring new risks and challenges for workers and employers. Indeed, working environments have changed considerably during the last 15 years and are continuing to evolve as a result of changes in the structure of the workforce related to the ageing workforce and increasing participation of women; of changes in the structure of the labour market due to globalisation and growth of the service sector; of new forms of employment and jobs; of the intensification of work; and of the introduction of new technologies and work processes.

In 2002, the Lisbon summit identified specific objectives to create quality jobs and increase workforce participation. Improving working conditions to keep people in work is a condition to achieve these objectives. In this context, the need to identify and anticipate emerging risks related to occupational safety and health (OSH) has been emphasised at the European political level so as to assist in better targeting of resources and to enable more timely and effective interventions.

The Community strategy on health and safety at work 2002–06 called on the European Agency for Health and Safety at Work to ‘set up a risk observatory’. One of the priorities identified in the strategy is the need to ‘anticipate new and emerging risks, whether they be linked to technical innovation or caused by social change’. This is to be done by ‘ongoing observation of the risks themselves, based on the systematic collection of information and scientific opinions’. Additionally, the strategy emphasised that ‘this kind of analysis is an integral part of a preventive approach’.

Responding to these needs, the Agency commissioned its Topic Centre Research on Work and Health (TCWH) with the identification of emerging OSH risks. A first forecasting exercise focused on physical risks has been carried out. This has then been repeated for risks related to human, social and organisational factors, chemical risks and biological risks so as to provide as comprehensive a picture as possible of the potential emerging risks in the world of work.

The report presents the results of the expert forecast on emerging physical OSH risks complemented by a literature review. These results should provide a basis for debate and reflection between policy-makers at various level for setting research and action priorities.

The Agency would like to thank Emmanuelle Brun, Eva Flaspöler and Dietmar Reinert from BGIA for their contributions to the drafting of this report, as well as Manfred Hinker and Silvia Springer from AUVA, Karen Peirens from Prevent, Kari Lindström and Krista Pahkin from FIOH, Jean-Marie Mur from INRS, Karl Kuhn and Ellen Zwink from BAuA, Victor Hrymak from OSHII, Antonio Leva from ISPESL, Pilar Hervás and Mercedes Tejedor from INSHT, Richard Brown and Lee Kenny from HSL, and Anneke Goudswaard, Irene Houtman, Elco Miedema and Martin van de Bovenkamp from TNO Work and Employment for their contributions to the project. The Agency would particularly like to thank the respondents to the survey, whose participation was essential for the accomplishment of the project. The Agency would also like to thank its Focal Points, Expert Group and Advisory Group for their valuable comments and suggestions.

European Agency for Safety and Health at Work  
October 2005





## EXECUTIVE SUMMARY

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### Context

The evolution of society and the changing world of work bring new risks and challenges for workers and employers. In this context, the Community strategy on health and safety at work 2002–06 called on the European Agency for Health and Safety at Work to ‘set up a risk observatory’. One of the priorities identified in the strategy is the need to ‘anticipate new and emerging risks, whether they be linked to technical innovation or caused by social change’. This is to be done by ‘ongoing observation of the risks themselves, based on the systematic collection of information and scientific opinions’. Additionally, the strategy emphasised that ‘this kind of analysis is an integral part of a preventive approach’.

This report presents the results of a forecast based on an expert survey and a literature review that aimed to identify emerging physical risks related to occupational safety and health (OSH). These activities are part of a larger project, the goal of which is the earlier identification of emerging trends and risks in order to assist in better targeting of resources and to enable more timely and effective interventions.

### Method

Within the scope of this project, an ‘emerging OSH risk’ has been defined as any occupational risk that is both new and increasing.

By new is meant that:

- the risk was previously unknown and is caused by new processes, new technologies, new types of workplace, or social or organisational change; or
- a long-standing issue is newly considered as a risk due to a change in social or public perceptions; or
- new scientific knowledge allows a long-standing issue to be identified as a risk.

The risk is increasing if:

- the number of hazards leading to the risk is growing; or
- the likelihood of exposure to the hazard leading to the risk is increasing (exposure level and/or the number of people exposed); or
- the effect of the hazard on workers’ health is getting worse (seriousness of health effects and/or the number of people affected).

For the formulation of the expert forecast on emerging OSH physical risks, a questionnaire-based survey was run in three consecutive rounds following the Delphi method. This method was chosen so as to reach a broad consensus and to obtain scientifically founded opinions. In total, 137 experts were invited to participate in the survey following their nomination by the Agency’s Focal Points and Topic Centre Research. Sixty-six valid questionnaires were returned from 53 organisations covering 14 European countries and the USA (response rate: 48 %). Participating experts were required to have at least five years’ experience in the field of OSH and physical risks. Respondents were mainly researchers (33 %) and heads of departments in organisations involved in OSH activities (33 %). Other respondents included labour inspectors, professors and lecturers, those in charge of policy or standards development, or of enforcement, consultants, or those involved in testing and certification.



## The 'top' emerging risks identified

The main risks identified in the forecast reflect a growing concern for multi-factorial issues. **Lack of physical activity**, which is the risk the experts agree on the most as being emerging, is to some extent the result of poor work organisation and harms the physical health of workers. The reasons mentioned for this lack of activity are the growing use of visual display units (VDU) and of automated systems resulting in prolonged sitting at the workplace, as well as the increasing time spent sitting during business travel. A literature review showed that occupations with very little physical activity and increased prevalence of musculoskeletal disorders (MSDs) usually involve prolonged sitting, but prolonged-standing workplaces are also a concern. The health outcomes identified in the literature are MSDs of the upper-limbs and of the back, varicose veins and deep-vein thrombosis, obesity, and certain types of cancers.

A further multi-factorial emerging risk related to MSDs and identified with a high degree of consensus is the **combined exposure to MSD risk factors and psychosocial risk factors**. According to the experts, 'job insecurity' and 'fear of the future' resulting from the unstable labour market both accentuate the effects of physical risk factors such as poor ergonomic design, thus contributing to an increase in the incidence of MSDs. Regarding this combined exposure, the literature mainly focuses on VDUs and call centre jobs and on the healthcare sector. The psychosocial factors identified are stress generated by poor ergonomic design of the work equipment; high job demand but also too low job demand; complex tasks leading to mental exhaustion; high time pressure; low job control and low decision level; poor support from colleagues and from the hierarchy; fear of downsizing, job insecurity and fear of unemployment; and harassment, violence and bullying at work. Combined exposure to MSD risk factors and psychosocial risk factors is shown to have a more serious effect on workers' health than exposure to one single risk factor.

The **complexity of technologies and work processes with complex human-system interfaces** is also a multifactorial risk strongly agreed on. A poor design of the interface may result in increased mental and emotional demands on the operator. Hence a potential increase in the incidence of stress, human errors and accidents. 'Intelligent' but complex human-machine interfaces are found in the air industry, in the healthcare sector (computer-aided surgery), in heavy trucks and earth-moving machinery (in-cab devices such as remote controls and joysticks) and in complex manufacturing or physically demanding manual handling activities (cobots).

A recurrent issue in the forecast is the **insufficient protection of high-risk groups against long-standing ergonomic risks**. Workers with a low employment status and poor working conditions, who paradoxically are the subject of fewer training and awareness-raising measures, are identified as being particularly at risk. Examples of such high-risk groups are illegal workers in the agriculture and construction sectors with poor knowledge of the thermal risks related to work performed in cold or hot environments.

In the field of thermal risks, the lack of prescriptions against **thermal discomfort at industrial workplaces**, where only the issue of thermal stress has been addressed so far, is also highlighted. According to the respondents, the role that thermal comfort plays on workers' overall stress and well-being at work has not been adequately assessed so far. Thermal discomfort may impede workers' performance and safety behaviour, hence increasing the probability of occupational accidents.



**Ultraviolet radiation** (UVR) is strongly agreed to be an emerging risk. The respondents do not only refer to occupational exposure but also consider the more general issue of increasing exposure during leisure time, linked to changing societal values and ways of living. As UVR exposure is cumulative, the more the workers are exposed, the more UVR-sensitive they are. Hence a potentially growing need for prevention measures at the workplace. The literature emphasises the need for advice limiting occupational UVR exposure both indoors and outdoors.

More generally, the experts especially emphasised **multi-factorial risks** in a generic item with a high degree of consensus. A lot of literature examines call centre workplaces, which are typical workplaces with multi-factorial exposure. The various risk factors call centre agents are exposed to are prolonged sitting, background noise and poor room acoustics, inadequate headsets, poor room atmosphere, inadequate lighting conditions, poor ergonomic design of the work equipment, inappropriate arrangement of the working premises, and factors of human and organisational nature such as low job control, high time pressure, poor work organisation, and high mental and emotional demands. Various health outcomes could be observed such as MSDs, varicose veins, nose and throat diseases, voice disorders, fatigue, stress and burnout.

A more 'traditional' risk identified in the survey is **vibration** both to the hand-arm and to the whole-body systems, which have gained more attention with Directive 2002/44/EC <sup>(1)</sup>. The experts particularly highlighted with a high degree of consensus the 'combined exposure to vibration' and to MSD risk factors such as 'awkward postures' and 'physically demanding work'.

## Perspectives

The expert forecast on OSH physical risks presented in this report is complemented with forecasts and literature reviews on human, social and organisational risks, and on chemical and biological risks so as to provide as comprehensive a picture as possible of the potential emerging risks in the world of work. All results will be linked to further activities of the Risk Observatory, which consists in the collection of data from European and national OSH monitoring systems and identification of research priorities in Europe. The overall aim of the Risk Observatory is to provide an overview of OSH in Europe, to highlight trends on OSH outcomes and risk factors, to provide early identification of newly emerging risks in the workplace and to identify areas and issues where more information is needed.

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(1) Directive 2002/44/EC of the European Parliament and of the Council of 25 June 2002 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (vibration). OJ L 177, 6.7.2002, pp. 13–19.





# 1.

## INTRODUCTION



*An 'emerging OSH risk' is any occupational risk that is both new and increasing.*

As society evolves under the influence of new technologies and of shifting economic and social conditions, workplaces, work practices and production processes are continuously changing. These new work situations bring new risks and challenges for workers and employers, which in turn demand political, administrative and technical approaches that ensure high levels of safety and health at work.

In this context, the need to identify and anticipate emerging risks related to occupational safety and health (OSH) has been emphasised on several occasions at the political and European level <sup>(2)</sup> <sup>(3)</sup> <sup>(4)</sup> <sup>(5)</sup>. More specifically, the Community strategy on health and safety at work 2002–06 mandated the European Agency for Safety and Health at Work (the Agency) to 'set up a risk observatory'. One of the priorities identified in the strategy is the need to 'anticipate new and emerging risks, whether they be linked to technical innovation or caused by social change'. This is to be done by 'ongoing observation of the risks themselves, based on the systematic collection of information and scientific opinions'. Additionally, the strategy emphasised that 'this kind of analysis is an integral part of a preventive approach'.

A key activity of the risk observatory developed by the Agency is the identification and dissemination of information on emerging OSH risks. In 2002, the Agency commissioned its Topic Centre Research on Work and Health (TCWH) with the identification of emerging OSH risks, which involved some of the principal OSH institutions in Europe. Two types of information on physical, chemical and biological risks, risks related to human, social and organisational factors, as well as combinations thereof, are collected: published information (from peer-reviewed journals and from the Internet) and expert forecasts.

### What are emerging risks?

An 'emerging OSH risk' has been defined as any occupational risk that is both **new** and **increasing**.

By **new** is meant that:

- the risk was previously unknown and is caused by new processes, new technologies, new types of workplace, or social or organisational change; or

<sup>(2)</sup> Commission of the European Communities: 'Adapting to change in work and society: a new Community strategy on health and safety at work, 2002–06'. COM (2002) 118 final, Brussels, 11.3.2002. <http://europe.osha.eu.int/systems/strategies/future/>

<sup>(3)</sup> Commission of the European Communities: 'Framework programme 2002–06 of the European community for research [...] towards the creation of the European research area', COM (2001) 94 final, Brussels, 21.2.2001. <http://europa.eu.int/comm/research/pdf/com-01-94-en.pdf>

<sup>(4)</sup> Diamantopoulou, A. (European Commissioner responsible for Employment and Social Affairs): 'Preventing accidents at work: a new European strategy for safety and health', Speech/01/571 held at the European Conference on Health and Safety, Brussels, 23.11.2001. <http://europa.eu.int/rapid/pressReleasesAction.do?reference=SPEECH/01/571&format=HTML&aged=0&language=EN&guiLanguage=en>

<sup>(5)</sup> European Agency for Safety and Health at Work: 'Quality of work — a future Community strategy for safety and health at work', Forum 1, 4.7.2001. <http://agency.osha.eu.int/publications/forum/1/en/index.htm>



- a long-standing issue is newly considered as a risk due to a change in social or public perceptions; or
- new scientific knowledge allows a long-standing issue to be identified as a risk.

The risk is **increasing** if:

- the number of hazards leading to the risk is growing; or
- the likelihood of exposure to the hazard leading to the risk is increasing (exposure level and/or the number of people exposed); or
- the effect of the hazard on workers' health is getting worse (seriousness of health effects and/or the number of people affected).

This publication presents the results of the expert forecast on emerging physical OSH risks based on a Delphi survey. The risks which were identified in the expert survey are related to musculoskeletal disorders (MSDs), noise, vibration, thermal risks, risks related to ionising and non-ionising radiation, to machinery, work processes and technologies, as well as various ergonomic risks. A literature review explores in more depth the context and the health outcomes of five of the main emerging risks singled out in the forecast: lack of physical activity in the workplace; combined exposure to musculoskeletal risk factors and psychosocial risk factors; multi-factorial risks; complexity of new technologies leading to increased mental and emotional strain; and increase of exposure to ultraviolet radiation (UV) at the workplace.





# 2.

## METHODOLOGY



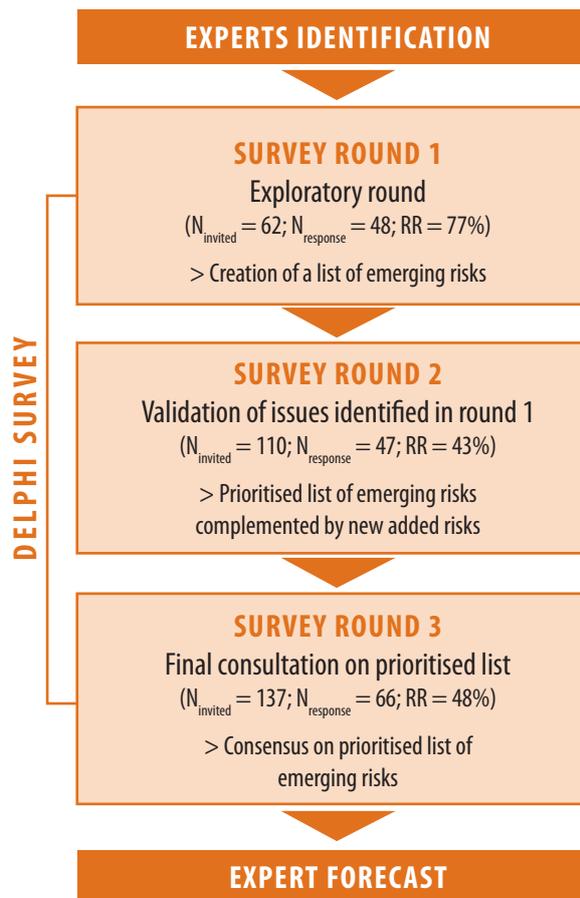
European experts were surveyed as to what are the emerging OSH physical risks. In this matter, the Delphi method was used in order to reach a broad consensus and to avoid non-scientifically founded opinions.

### Delphi method <sup>(6)</sup>

The Delphi method is a widely used methodology to create foresight information on topics for which only uncertain or incomplete knowledge is available. There are several variations of the Delphi method but all of them are based on an iteration process with at least two survey rounds in which the results of the previous rounds are fed back and submitted again to the experts for new evaluation. The feedback process ensures that the experts are aware of the views of other experts and gives them the possibility to revise their first evaluation accordingly. At the same time, it avoids group pressures, which could have the experts not dare giving their real opinion and would lead to distorted results.

The Delphi method adopted for formulating the expert forecast on emerging risks in this project consisted in three survey rounds (Figure 1).

**Figure 1: Delphi process implemented for the expert forecast on emerging OSH physical risks**



<sup>(6)</sup> Cuhls, K.: 'Technikvorausschau in Japan – Ein Rückblick auf 30 Jahre Delphi-Expertenbefragungen'. In: Technik, Wirtschaft und Politik, vol. 29. Schriftenreihe des Fraunhofer-Instituts für Systemtechnik und Innovationsforschung (ISI). Physica, Heidelberg, 1998.



## First survey round

A first exploratory survey round carried out in 2002 aimed at identifying the risks that the experts reckoned to be emerging. A questionnaire with open-ended questions was developed to help the experts in formulating their views as to what are the emerging OSH physical risks of the next 10 years. The experts were invited to either fill in the questionnaire together with a TCWH member under the scope of a questionnaire-based interview, or to fill in the questionnaire electronically by themselves. Based on all the issues identified in the questionnaires filled in and returned, a list was drawn up in which the risks were sorted into nine categories according to the field they were related to: risks of musculoskeletal disorders (MSDs), noise, vibration, thermal risks, non-ionising radiation, ionising radiation, risks related to machinery, work processes and technologies, mechanical risks and other general ergonomic risks.

*The forecast is the result of a three-round questionnaire-based survey run following the Delphi method.*

## Second survey round

A second questionnaire-based survey round was realised in 2003 and aimed at validating and complementing the results of the first step. The questionnaire presented the list drafted out of the first round with feedback on the frequency of nomination of each item. The experts had to indicate which of the issues listed they reckoned to actually be emerging risks (yes or no closed-question) and to rank the emerging ones by dividing 100 points. The ranking was internal to each nine categories of the list. At the end of each category, the experts had the possibility to add new risks to the list. Only the answers from experts who met the selection criteria for the category concerned were analysed (see 3.1). As a result of the second survey round, a prioritised list of risks was drawn up based on:

- the frequency of rating, which indicates the number of experts who considered a specific item to be an emerging risk;
- the mean value (MV) of the points attributed to an item, which indicates the weight the experts allocate to the risk. The standard deviation (SD) of the mean value was also calculated as an indication of the degree of consensus amongst the experts.

## Third survey round

As the last step towards reaching a consensus, a third consolidation round was carried out in 2004. Additional experts were invited to participate in the survey in order to have a larger — and better appropriate for statistical calculations — number of responses within each risk category.

As all the issues listed under the category 'mechanical risks' in the second round were actually related to personal protective equipment (PPE) matters, this category was removed from the third questionnaire and the issues were included into the category 'other ergonomic risks'.

Unlike the second round, the third questionnaire consisted of a non-comparative scaling process whereby the respondents were asked to rate each issue independently from the others on a five-point Likert scale. The scale ranged from 'disagree' to 'agree': The first box of the scale meant 'strongly disagree that the issue is an emerging risk', the third and middle box stand for 'undecided' and the fifth and last box for 'strongly agree that the issue is an emerging risk'. As in the second round, only answers from experts meeting the selection criteria for the risk category concerned were taken into consideration.



### Analysis of the results

For each risk, the mean values and the standard deviations were calculated. While the mean values help prioritising the risks within one risk category, the standard deviations reflect the level of consensus on one item among the respondents.

The following areas have been defined for the interpretation of the mean values, based on the definition of the five-point Likert scale used in the survey (see above), and in order to have a reasonable balance of items between the different areas:

- the risk is strongly agreed to be emerging if the mean value of the rating is above four ( $MV > 4$ );
- a mean value between 3.15 and 4 means that the item is considered to be an emerging risk ( $3.15 < MV \leq 4$ );
- as a mean value is unlikely to be exactly equal to 3, the 'undecided' area has been extended from 2.85 to 3.15, which means that the status of a risk is regarded as undecided if its mean value is within this interval ( $2.85 \leq MV \leq 3.15$ );
- there is agreement that the risk is not emerging if the mean value is between 2 and 2.85 ( $2 \leq MV < 2.85$ );
- there is strong agreement that the risk is not emerging if the mean value is below 2 ( $MV < 2$ ).

The prioritised lists of emerging risks established at the end of the third survey round form the expert forecast on emerging OSH physical risks.

For each item, the response data sets were checked for statistical anomalies (ratings deviating exceptionally low or high from the mean value). No specific respondent profile could be associated to the few exceptional ratings found. As the anomalies had no significant influence on the mean value, they were not removed from the data sets.

Kolmogorov-Smirnow-tests were also run in order to verify the standard distribution of the data.



# 3.

## EXPERT PARTICIPATION



# 3.1

## SELECTION CRITERIA FOR PARTICIPANTS

---

The expertise was collected and used in knowledge of the principles and guidelines of the European Commission (7).

*Participating experts were required to have at least five years' experience in the field concerned.*

The experts were proposed by the TCWH members and the Focal Points of the Agency. Selection criteria were defined so as to ensure a broad coverage of qualified expertise across Europe. For the first exploratory survey round, the experts had to meet following criteria:

- be a researcher involved in the areas related to OSH and physical risks;
- have at least five years of experience in the sub-field he replies to;
- have authored at least two publications in this sub-field.

In the further steps, the first and last criteria were loosened to also include experts with a less academic background but still very high-level expertise. Indeed, the expert group was extended to labour inspectors, policy-makers, safety practitioners and to people involved in following activities related to the field of physical OSH risks: research and management planning; testing and certification activities; development; law, policies and standards development, promotion and enforcement; training and teaching activities.

# 3.2

## RESPONSES

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For the first round, 62 experts were approached by the TCWH and invited to participate in the survey. Forty-eight experts returned the questionnaire filled in (response rate: 77 %).

In the second phase, the expert group was extended to 110 experts. Forty-seven questionnaires filled in were returned (response rate : 43 %). All answers fulfilled the criteria 'at least five years of experience' in the sub-field replied to.

*137 experts were approached. 66 questionnaires were returned. 14 European countries and the USA are covered.*

Some 137 experts were invited to take part in the last survey round. Sixty-six questionnaires — all of them valid — were returned (response rate: 48 %).

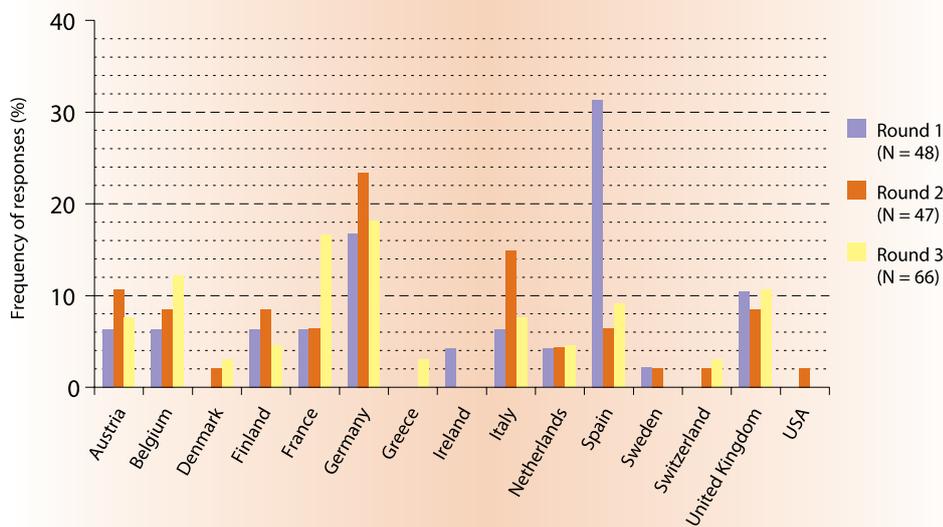
Over the three survey rounds, experts from 53 organisations (see Annex 1) from 14 European countries and from the USA participated in the formulation of the forecast on emerging OSH physical risks (Diagram 1).

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(7) European Commission: Collection and use of expertise by the Commission — principles and guidelines, Luxembourg, 2004. ISBN: 9289458216.  
[http://europa.eu.int/comm/research/science-society/pdf/guidelines\\_ss\\_en.pdf](http://europa.eu.int/comm/research/science-society/pdf/guidelines_ss_en.pdf)



Diagram 1: Country of origin of the respondents to the first, second and/or third rounds of the survey



## CHARACTERISTICS OF RESPONDENTS TO THE THIRD AND FINAL SURVEY ROUND

# 3.3

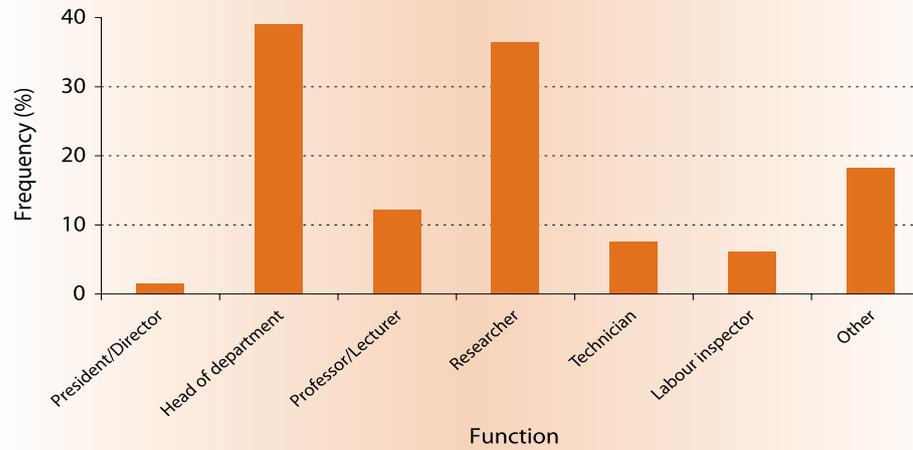
### Functions of the respondents

The majority of the respondents were heads of department or researchers (more than one third respectively). Among the four technicians who responded, one indicated to be also a labour inspector. Two further technicians were involved in professor/lecturer and another one a policy/standards development, consulting, testing/certification and training/teaching; one was involved in research, policy/standards development, law enforcement/promotion, work inspection, consulting, testing/certification and training/teaching.

Twelve experts ticked 'other'. Among them, four additionally ticked another function: one 'professor lecturer', one 'researcher' and two 'technician'. For eight of the 'other' cases, the following functions were specified: lead scientist; engineer; nuclear inspector; expert; emeritus since 2001; expert (ministerial counsellor, medical affairs). Two did not give any specification on their function but indicated to be involved in the following activities: research planning/management and policy/standards development (Diagram 2).



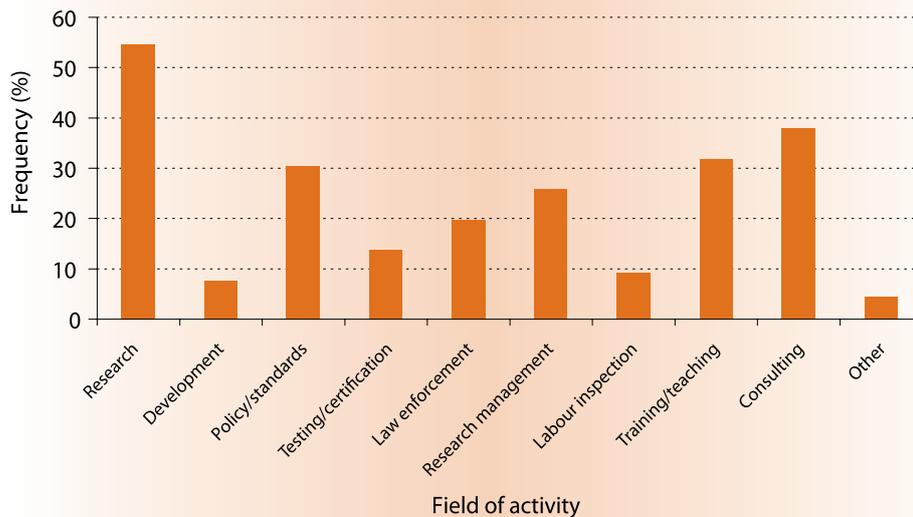
**Diagram 2: Respondents' functions (N=48)**



### Fields of activity of the respondents

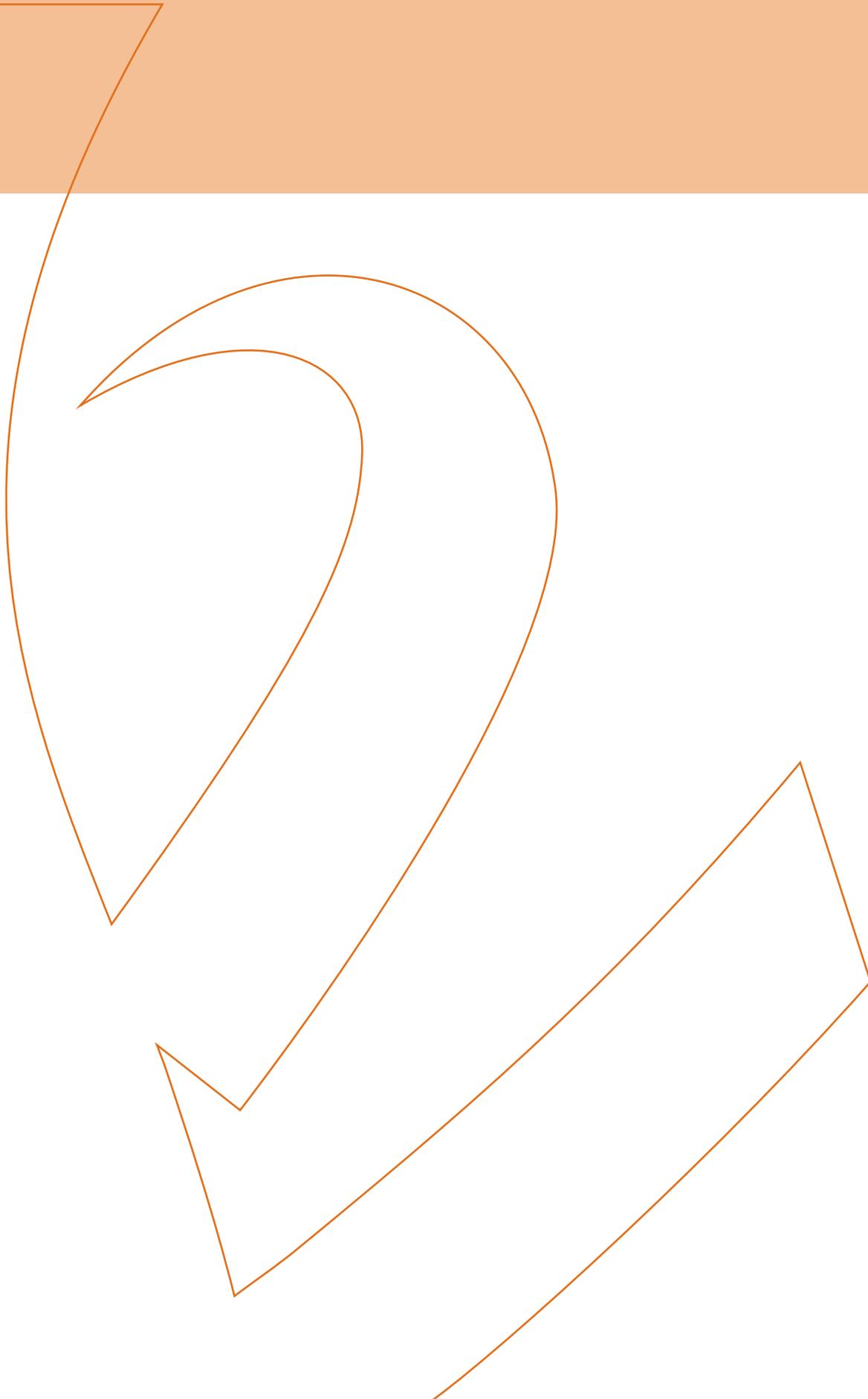
More than half of the experts whose answers were taken in account in the third survey round were involved in research. About one third of them were active in consulting activities, teaching/training activities and policies/standards development. Three experts ticked 'other'. One of them indicated to be involved in working condition assessment; one specified 'division head assistant'; and one wrote 'assistance' and ticked the following activities: consulting, development and training/teaching. All these activities were considered acceptable and all experts met the selection criteria defined (Diagram 3).

**Diagram 3: Main fields of activities of the respondents (N=48)**



# 4.

## RESULTS



# 4.1

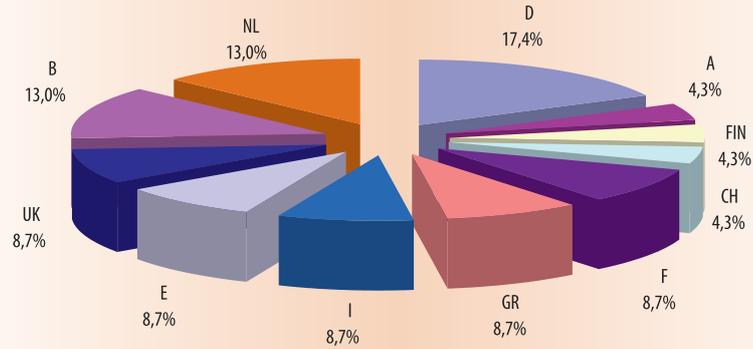
In the following sections, the exact descriptions of the risks rated by the experts are listed in tables together with the number of respondents to each item, the mean value of the ratings and the standard deviation. These figures are also compiled in diagrams. For some of the risks, references are made to literature, legislations and national historical data if relevant and, when available, experts' comments are added in order provide some context and to support the experts' evaluation.

## RISKS RELATED TO MUSCULOSKELETAL DISORDERS (MSDs)

### 4.1.1. Respondents

Twenty-three experts out of the 66 respondents to the survey had more than five years of experience in the field of 'risks related to MSDs' and answered this part of the questionnaire.

Diagram 4: Nationalities of experts who answered the questionnaire part related to risks of MSDs (N=23)



### 4.1.2. Results

Diagram 5: Risks related to MSDs identified in the survey (Y-axis: mean values on the one-to-five point Likert scale and standard deviations)



'Lack of physical activity' during working time is very much considered to be an emerging risk by the experts with a high degree of consensus. The suggested reasons are the growing use of visual display units (VDU) and of automated systems resulting in prolonged sitting at the workplace, as well as the increasing time spent sitting during business travel. (See also part 5.1. of the literature review).

Many of the risks agreed as emerging ( $M > 3.15$ ) are commonly considered as 'classical' ergonomic risks, such as 'static postures', 'repetitive movements', 'awkward postures'. Nevertheless, multi-factorial MSD risks are perceived as important issues to be tackled in the future, especially those that include human, social and organisational factors. Indeed, the emerging risk with the second highest rating is 'combined exposure to MSD risk factors and psychosocial risk factors', which achieved a high degree of consensus (see also part 5.2. of the literature review). Furthermore, the experts indicated that factors such as 'job insecurity' and 'fear of the future' resulting from the unstable labour market accentuate the effect of physical risk factors such as poor ergonomic design, thus contributing to an increase in the incidence of MSDs. 'Longer working hours', 'increased work-pace' and 'older working age' were also singled out as emerging risks that lead to MSDs.

*Multi-factorial MSD risks, especially those combined with human, social and organisational factors, are emerging.*



*Lift for the handling of persons in the healthcare sector  
Berufsgenossenschaftliche Unfallklinik Ludwigshafen 1996, © HVBG/Senn, Germany*

It should be noted that the consensus on the ratings among the experts is lower for the items 'repetitive movements', 'poor ergonomic design related to manual handling in the healthcare sector', 'poor ergonomic design of non-office VDU workplaces', 'longer working hours', 'increased work-pace' and 'VDU workplaces'.



**Table 1: Prioritised list of the risks related to MSDs identified in the survey (N=number of experts answering the specific item; mean value; standard deviation)**

MV>4: risk strongly agreed as emerging     
  2.85≤ MV≤ 3.15: status undecided  
 3.15<MV≤ 4: risk agreed as emerging     
  2≤ MV<2.85: risk agreed as non-emerging

NB: None of the risk was strongly agreed as non-emerging (MV<2)

Risks related to MSDs	N	Mean Value (MV)	Standard Deviation (SD)
Lack of physical activity (e.g. prolonged sitting at the workplace, during business trips, or due to the use of automated systems, etc.)	23	4,57	0,662
Combined exposure to MSD risk factors and psychosocial risk factors (e.g. fear of future, insecurity)	23	4,43	0,590
Static postures (including standing without possibility of resting, arm position above shoulder level, etc.)	23	3,96	1,065
Repetitive movements (e.g. Repetitive Strain Injury (RSI); repetitive movements at Visual Display Unit (VDU) workplaces)	23	3,96	1,331
Awkward postures (e.g. one-sided postures, forced body postures, e.g. due to new technologies, laptops, installation work in car industry)	23	3,91	0,996
Poor ergonomic design related to the manual handling of persons in the health care sector	23	3,87	1,290
Poor ergonomic design of non-office Visual Display Unit VDU workplaces (teleworking, in hospitals, etc.)	23	3,74	1,176
Longer working hours leading to longer exposure to MSD risk factors	23	3,70	1,295
Poor ergonomic design of human-machine interfaces (complexity of human-machine-interface; high forces required to operate machinery)	23	3,65	1,071
Older workers unable to cope with physical demands are especially likely to develop MSDs	23	3,61	0,941
Increased work-pace leading to an increasing number of MSDs	23	3,52	1,201
More physically demanding work in new industries (leisure industry, entertainment parks, pop concerts)	23	3,09	1,041
Gender-related home-working in addition to increased work-pace increasing the exposure to MSD risk factors	23	2,83	0,937
VDU workplaces lead to MSDs	23	2,78	1,278



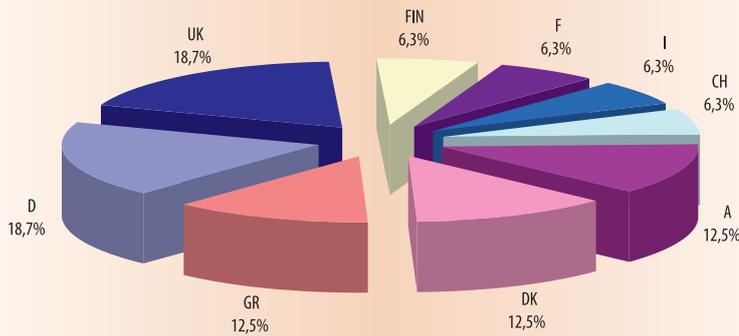
# 4.2

## RISKS RELATED TO NOISE

### 4.2.1. Respondents

Sixteen experts out of the 66 respondents to the survey had more than five years of experience in the field of risks related to noise and answered this part of the questionnaire.

Diagram 6: Nationalities of experts who answered the part related to noise (N=16)



### 4.2.2. Results

Diagram 7: Risks related to noise identified in the survey (Y-axis: mean values on the one-to-five point Likert scale and standard deviations)



'Acoustic shocks and excessive noise exposure due to new technologies and work organisation' was identified as an emerging risk mainly because of the increasing number of call centres where headphones are used <sup>(8)</sup>. Acoustic shocks are abnormal sound burst transmitted through the headset caused, for example, by electronic sounds from fax machines or accidental electronic impulses that can damage the hearing of the user <sup>(9)</sup>.

'Simultaneous exposure to noise and ototoxic substances', also considered by the experts as one of the 'top' emerging risks related to noise, is confirmed too by French national data <sup>(10)</sup>: those workers most exposed to noise are also those with the highest exposure to dangerous substances. Therefore, the current occupational exposure limit of 85 dB(A) concerning noise exposure over an eight-hour working sheet may need to be reconsidered with regards to combined exposure to ototoxic substances <sup>(11)</sup>.

The expert forecast also highlights 'noise exposure in classrooms'. Workers in education, health and social work in France, especially women, have increasingly reported noise exposure since 1984. In 1998, almost half a million French workers were exposed to occasional very loud or high sounds in these occupations <sup>(12)</sup>. Increases in the percentages of workers in the education and health sector who report noise exposure are also seen in Finland <sup>(13)</sup> (29 % reported to 'be exposed to noise and somewhat bothered' in 1997 as opposed to 34 % in 2003) and in the Netherlands <sup>(14)</sup> (13 % reported to 'regularly have to deal with noise at work' in 1998 and 19 % in 2002). Noise in schools is perceived as a disturbing factor impeding the transfer of knowledge, which is mainly based on verbal communication. Teachers try to compensate for the noisy background by raising their voice <sup>(15)</sup>. As a result, noise levels in the classroom become progressively higher and teachers not only suffer higher mental and emotional strain, but vocal chord disorders as well.

*Acoustic shocks, low-level noise, noise during pregnancy, or combined with vibration or ototoxic substances are emerging risks.*

Even though below the intensity considered to harm the hearing function, 'background noise' is seen as an emerging risk in that it makes it harder for workers to hear safety warnings and thus potentially leads to accidents. Nevertheless, one ex-

<sup>(8)</sup> Canada Safety Council: 'Shocking news about call centres' 2004. <http://www.safety-council.org/info/OSH/acoustic.html>

<sup>(9)</sup> TUC – Worksmart: 'What is "acoustic shock"?' <http://www.worksmart.org.uk/health/viewquestion.php?eny=194>

<sup>(10)</sup> Ministère de l'emploi et de la solidarité, DARES, 'Expositions aux contraintes et nuisances dans le travail — Sumer 1994', Les dossiers de la DARES, vol. 5–6, July 1999, ISSN 1263-1973.

<sup>(11)</sup> Institut National de Recherche et de Sécurité (INRS): Bruit at agents ototoxiques. In: Le point des connaissances sur ... ED 5028. 2005. [http://www.inrs.fr/inrs-pub/inrs01.nsf/IntranetObject-accesParReference/ED\\_5028/\\$File/ed5028.pdf](http://www.inrs.fr/inrs-pub/inrs01.nsf/IntranetObject-accesParReference/ED_5028/$File/ed5028.pdf)

<sup>(12)</sup> Ministère du travail, de l'emploi et de la cohésion sociale, 'DARES: enquête sur les conditions de travail — Efforts et risques au travail — Environnement de travail — Les nuisances sonores' [http://www.travail.gouv.fr/etudes/etudes\\_i.html](http://www.travail.gouv.fr/etudes/etudes_i.html)

<sup>(13)</sup> Finnish Institute of Occupational Health (FIOH): Finnish work and health survey. <http://www.ocupehealth.fi>

<sup>(14)</sup> Central Bureau of Statistics: Permanent Onderzoek Leefsituatie (POLS). <http://statline.cbs.nl>

<sup>(15)</sup> Schönwälder, H.-G.; Berndt, J.; Ströver, F.; Tiesler, G.: Lärm in Bildungsstätten — Ursachen und Minderung. In: Schriftenreihe der Bundesanstalt für Arbeitsschutz und Arbeitsmedizin. Fb 1030. 2004. [http://www.baua.de/fors/fb04/fb1030d\\_kurz.pdf](http://www.baua.de/fors/fb04/fb1030d_kurz.pdf)



pert commented that it is less the background sound than the 'communication sound that decreases the audibility of informative signals when wearing communication systems'.

The exposure to 'noise levels below the limit value' is also perceived as an emerging risk leading to 'fatigue and inefficiency', which may increase the occurrence of occupational accidents. Low-level noise in open-plan offices generated by equipment such as photocopiers, computers or ventilation systems, or by the ringing of a telephone impairs concentration and communication and increases the workers' mental and emotional strain<sup>(16)</sup>. Non-relevant conversations of colleagues also affect a worker's performance. Recent studies show that it is less the content of the conversation than the acoustic variation of the noise which plays a role<sup>(17)</sup>.

The combined exposure to 'noise and vibration' was identified as an emerging risk not only by the 16 experts who answered the 'noise' part of the questionnaire, but also by the 16 experts who answered the 'vibration' part (12 experts rated the item in both parts). The almost identical mean ratings (3.50 and 3.56 respectively) may be considered to validate the forecast.

'Noise during pregnancy' was also highlighted. Noise has been identified as an agent 'causing foetal lesion and/or likely to disrupt placental attachment' in Directive 92/85/EEC<sup>(18)</sup>.

The ratings of the items 'noise and ototoxic substances', 'background noise decreasing the audibility of informative signals' and 'noise exposure below limit values leading to fatigue and inefficiency' did not achieve a high consensus.

'Noise exposure leading to non-auditory whole-body effects' was not rated as an emerging risk. One expert specified that environmental noise like 'traffic sound (from cars, lorries, trains, aircraft) is the main problem but not noise at the workplace, as shown by the study 'NaRoMI' (noise and risk of myocardial infarction) published by the Umweltbundesamt'<sup>(19)</sup>.

<sup>(16)</sup> Canada Safety Council: 'Office health and safety — noise and acoustics'. <http://www.safety-council.org/info/OSH/noise.htm>

<sup>(17)</sup> AMI: Health effect of noise in the work environment (work-related noise). 2004. [http://www.ami.dk/Nyheder/Nyhedsarkiv/2004/Helbredseffekter af st %C3 %B8j i arbejdsmilj %C3 %B8et.aspx?lang=en](http://www.ami.dk/Nyheder/Nyhedsarkiv/2004/Helbredseffekter%20af%20st%C3%B8j%20i%20arbejdsmilj%C3%B8et.aspx?lang=en)

<sup>(18)</sup> Commission of the European Communities, Directive 92/85/EEC of 19 October 1992 on the introduction of measures to encourage improvements in the safety and health at work of pregnant workers and workers who have recently given birth or are breastfeeding, OJ L 348, 28.11.1992, pp. 1–8. [http://europa.eu.int/smartapi/cgi/sga\\_doc?smartapi!celexapi!prod!CELEXnumdoc&lg=en&numdoc=31992L0085&model=guichett](http://europa.eu.int/smartapi/cgi/sga_doc?smartapi!celexapi!prod!CELEXnumdoc&lg=en&numdoc=31992L0085&model=guichett)

<sup>(19)</sup> Babisch, W.: Die NaRoMI-Studie (noise and risk of myocardial infarction) — Auswertung, Bewertung und vertiefende Analysen zum Verkehrslärm. In: WaBoLu-Hefte 02/04. 11-159. Umweltbundesamt. 2004. <http://www.umweltbundesamt.org/fpdf-l/2621.pdf>



**Table 2: Prioritised list of the risks related to noise (N=number of experts answering the specific item; mean value; standard deviation)**

- $MV > 4$ : risk strongly agreed as emerging
- $2.85 \leq MV \leq 3.15$ : status undecided
- $3.15 < MV \leq 4$ : risk agreed as emerging
- $2 \leq MV < 2.85$ : risk agreed as non-emerging

NB: None of the risk was strongly agreed as non-emerging ( $MV < 2$ )

Risks related to noise	N	Mean Value (MV)	Standard Deviation (SD)
Acoustic shocks and excessive noise exposure due to new technologies and work organisation (e.g. headsets in call centres)	16	3,87	0,957
Combined exposure to noise and ototoxic substances	15	3,87	1,125
Noise exposure in classrooms due to poor acoustic properties of educational buildings located in loud urban areas	16	3,81	0,981
Background noise decreasing the audibility of informative signals when wearing communication systems (e.g. in the construction sector)	16	3,63	1,204
Noise exposure below limit values but which leads to fatigue and inefficiency (e.g. in call centres)	16	3,63	1,310
Combined exposure to noise and vibration	16	3,50	0,894
Noise during pregnancy	16	3,50	1,095
Daily life exposure to vibration increasing the sensitivity to occupational noise	16	2,94	1,237
Noise exposure leading to non-auditory whole-body effects (e.g. cardiovascular diseases)	15	2,80	1,082
Daily life exposure to high levels of environmental noise increasing the sensitivity to occupational noise	16	2,75	1,483

**Additional potential emerging risks proposed by the experts in the third questionnaire**

“Because of the new action levels set by the EU Directive 2003/10/EC, which is to be transposed into national law by 15 February 2006 at the latest, the number of employees exposed to noise levels above the (new) action levels will increase by about 40 % as compared to now”.



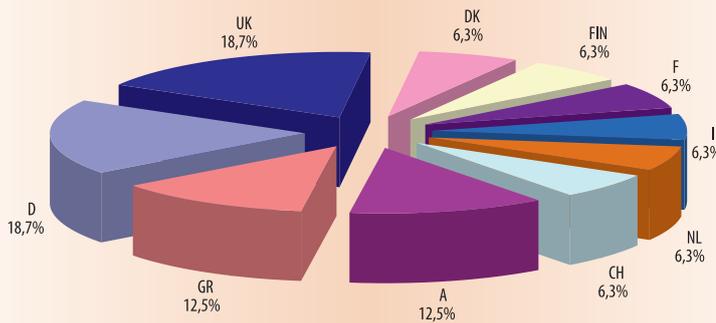
# 4.3

## RISKS RELATED TO VIBRATION

### 4.3.1. Respondents

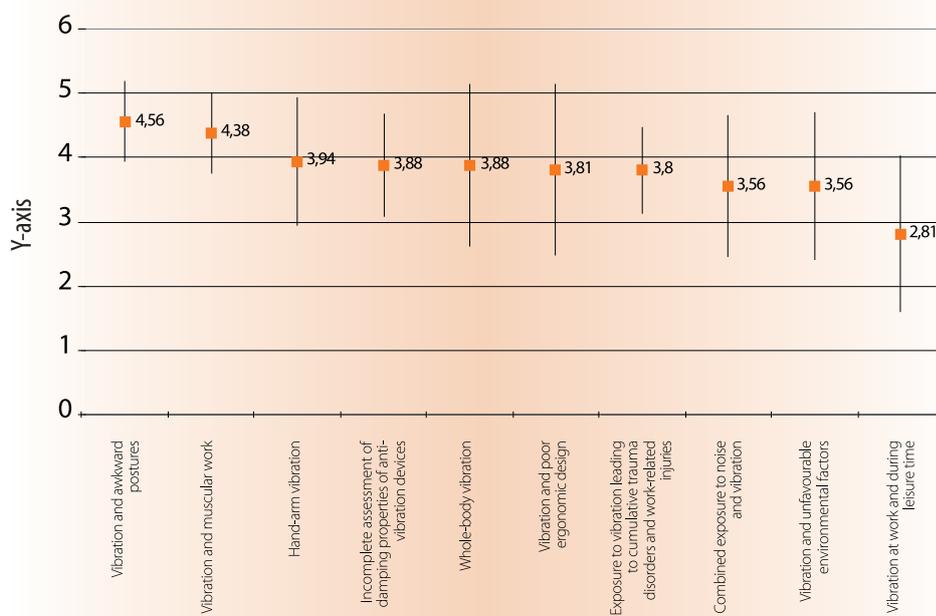
Sixteen out of the 66 respondents to the survey had more than five years of experience in the field of risks related to vibration and filled in this part of the questionnaire.

Diagram 8: Nationalities of experts who answered the questionnaire part related to vibration (N=16)



### 4.3.2. Results

Diagram 9: Risks related to vibration identified in the survey (Y-axis: mean values on the one-to-five point Likert scale and standard deviations)





Combined exposure to hand-arm vibration and noise  
Berufsgenossenschaftliches Institut für Arbeitsschutz, Germany

*The new European Directive 2002/44/EC has raised concern for vibration. The forecast highlights combined exposures to vibration and other physical factors.*

The risks of vibration both to the hand-arm and to the whole-body systems have gained more attention with the European Directive 2002/44/EC <sup>(20)</sup>. They are also perceived as emerging as the use of transportation systems and of industrial technologies grows and the working population exposed increases.

Globally, multi-factorial issues are an important concern as five of the nine risks related to vibration and identified as emerging ( $MV > 3,15$ ) are combined with other risk factors. Indeed, the two “top” emerging risks ( $MV > 4$ ) highlighted by the experts with a high degree of consensus are combined exposure to vibration and to MSD risk factors such as awkward postures and physically demanding work. Further multi-factorial emerging risks highlighted are the exposure to vibration combined with the poor ergonomic design of the workplace and of the work equipment, with the exposure to dangerous substances or to physical environmental factors such as cold temperatures. Previous work of the Agency recognised vibration and all these factors as MSD risk factors and particularly recommended to pay special attention at combinations thereof <sup>(21)</sup> <sup>(22)</sup>.

The risk resulting from combined exposure to vibration and noise identified as emerging in the expert forecast is mirrored in French statistical data: those workers most exposed to noise are also those with the highest exposure to other factors such as vibration <sup>(23)</sup>. In the forecast, it was identified as an emerging risk not only by the 16 experts who answered the vibration part of the questionnaire but also by the 16 experts who answered the noise part (12 experts answered both parts). The almost identical mean ratings (3,56 and 3,50 respectively) may be considered to validate the forecast. Symptoms of vibroacoustic diseases are generated by long-term exposure to low frequency noise and vary from gastrointestinal diseases, pharynx infections, bronchitis, urinary organs disorders and metal allergies, to bleedings in the nose and intestinal tract, varicose veins, ulcer, colitis, arthralgia and muscular disorders, and neurological disturbances after a ten-year exposure <sup>(24)</sup>.

<sup>(20)</sup> Directive 2002/44/EC of the European Parliament and of the Council of 25 June 2002 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (vibration), OJ L 177, 6.7.2002, pp. 13–19.

<sup>(21)</sup> European Agency for Safety and Health at Work: ‘Work-related musculoskeletal disorders in Europe’. Factsheet 3, 2000. [http://agency.osha.eu.int/publications/factsheets/3/en/facts3\\_en.pdf](http://agency.osha.eu.int/publications/factsheets/3/en/facts3_en.pdf)

<sup>(22)</sup> European Agency for Safety and Health at Work: ‘Preventing work-related musculoskeletal disorders’. Factsheet 4, 2000. [http://agency.osha.eu.int/publications/factsheets/4/en/facts4\\_en.pdf](http://agency.osha.eu.int/publications/factsheets/4/en/facts4_en.pdf)

<sup>(23)</sup> Ministère de l’emploi et de la solidarité, DARES: ‘Expositions aux contraintes et nuisances dans le travail — SUMER 1994’. Les dossiers de la DARES, vol. 5–6, July 1999, ISSN 1263-1973.

<sup>(24)</sup> AMI: ‘Health effect of noise in the work environment (work-related noise)’, 2004. <http://www.ami.dk/Nyheder/Nyhedsarkiv/2004/Helbredseffekter%20af%20st%C3%B8j%20i%20arbejdsmilj%C3%B8et.aspx?lang=en>



Even if the use of personal protective equipment (PPE) is only to be considered when removing the hazard at source is not possible and when collective measures do not reduce the exposure to an acceptable level, PPE made available to workers should be adapted to their needs, of high quality and properly tested. Otherwise workers may expose themselves to the hazard without being aware that they are not protected.

**Table 3: Prioritised list of the risks related to vibration (N=number of experts answering the specific item; mean value; standard deviation)**

<span style="display: inline-block; width: 15px; height: 10px; background-color: #f8d7da; border: 1px solid #c3e6cb;"></span> MV>4: risk strongly agreed as emerging	<span style="display: inline-block; width: 15px; height: 10px; background-color: #fff3cd; border: 1px solid #ffeeba;"></span> 2.85 ≤ MV ≤ 3.15: status undecided
<span style="display: inline-block; width: 15px; height: 10px; background-color: #fff3cd; border: 1px solid #ffeeba;"></span> 3.15 < MV ≤ 4: risk agreed as emerging	<span style="display: inline-block; width: 15px; height: 10px; background-color: #d1ecf1; border: 1px solid #bee5eb;"></span> 2 ≤ MV < 2.85: risk agreed as non-emerging

NB: None of the risk was strongly agreed as non-emerging (MV < 2)

Risks related to vibration	N	Mean Value (MV)	Standard Deviation (SD)
Combined exposure to vibration and awkward postures	16	4,56	0,629
Combined exposure to vibration and muscular work	16	4,38	0,619
Hand–arm vibration (HAV) as: <ul style="list-style-type: none"> <li>the new EU Directive 2002 sets a new low exposure limit value and raises awareness;</li> <li>the population of workers exposed is growing due to technological and industrial development in several European states</li> </ul>	16	3,94	0,998
Incomplete assessment of damping properties of widely–used anti–vibration devices (e.g. anti–vibration gloves) creating a false impression of being protected when exposed to vibration	16	3,88	0,806
Whole–body vibration (WBV) as: <ul style="list-style-type: none"> <li>the new EU Directive raises awareness;</li> <li>the population of workers exposed is growing due to the development of transportation systems in several European states</li> </ul>	16	3,88	1,258
Combined exposure to vibration and poor ergonomic design (e.g. poor seat support for the lumbar spine)	16	3,81	1,328
Exposure to vibration leading to cumulative trauma disorders (CTDs) and work–related injuries such as carpal tunnel syndrome	15	3,80	0,676
Combined exposure to noise and vibration leading to vibro–acoustic diseases	16	3,56	1,094
Combined exposure to vibration and unfavourable environmental factors (e.g. temperature, exhaust emissions)	16	3,56	1,153
Cumulative exposure to vibration at work and during leisure time increasing the sensitivity to occupational vibration	16	2,81	1,223



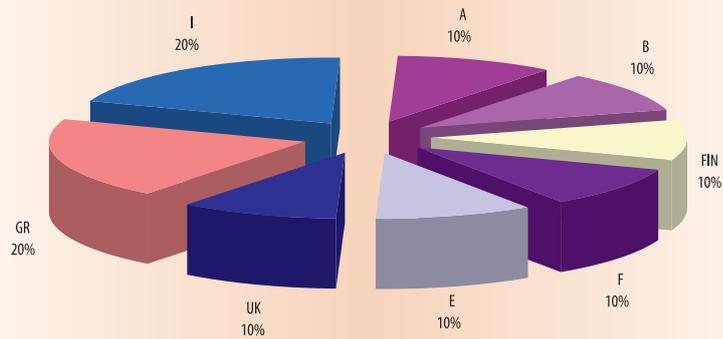
# 4.4

## THERMAL RISKS

### 4.4.1. Respondents

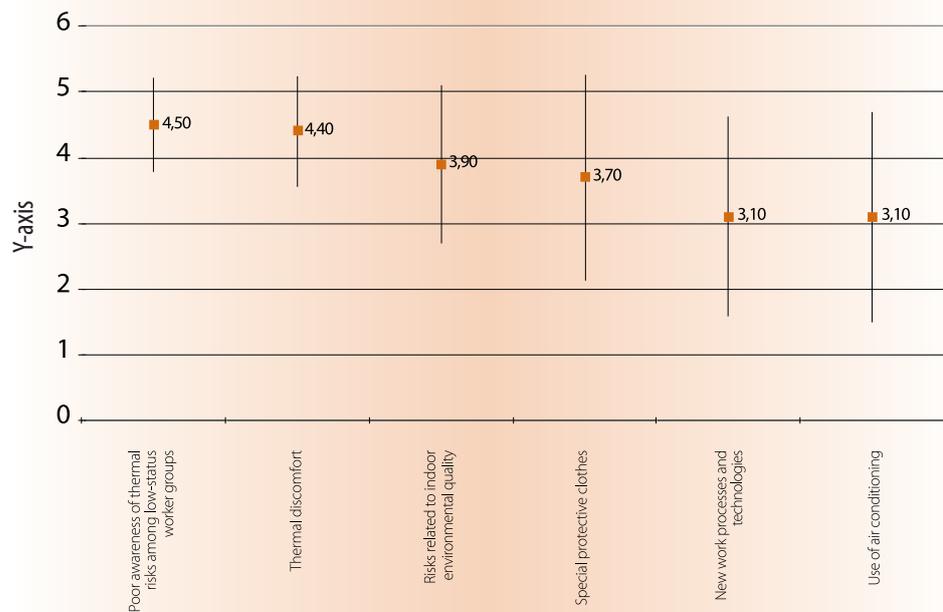
Ten out of the 66 respondents to the survey had more than five years of experience in the field of thermal risks and answered this part of the questionnaire.

Diagram 10: Nationalities of experts who answered the questionnaire part related to thermal risks (N=10)



### 4.4.2. Results

Diagram 11: Thermal risks identified in the survey (Y-axis: mean values on the one-to-five point Likert scale and standard deviations)



Two risks in the area of thermal risks were particularly perceived as emerging ( $MV > 4$ ). The risk with the highest rating is of a social and organisational nature. The experts point at the fact that workers with a low employment status and poor working conditions (for example, workers in sectors such as agriculture and construction) are the subject of fewer training and awareness-raising measures. Hence their poor knowledge of the risks related to work performed in cold or hot environments and the increased probability of being exposed.

*Low employment status workers benefit less awareness-raising measures and are the most exposed to thermal risks.*

Likewise, the lack of prescriptions against 'thermal discomfort at industrial workplaces', where only the issue of thermal stress has been addressed so far, is rated almost as high and with almost as much consensus. One expert commented that the role thermal comfort plays on the workers' overall stress, on his well-being and hence on his performance and safety behaviour, has not been adequately determined so far.

Concerning 'thermal stress' provoked by wearing 'special protective clothes', one expert pointed out that the issue is crucial for occupations such as first responders. Indeed, 'heat stress casualties amongst wearers of chemical biological radiological nuclear (CBRN) personal protective equipment (PPE) may severely hamper the abilities of emergency services to deal with the situation, to decontaminate victims, etc.' The same expert added that the issue of 'thermal comfort of PPE is not important as long as it does not interfere with the wearer's task, his cognitive performance or the way the PPE is worn. Thermal stress is far more important as it suggests a hazard for which the PPE was not intended.' In his opinion, 'thermal comfort and PPE is more a marketing issue than a real occupational safety and health problem.' Hence the need to 'focus on heat stress when wearing PPE'.

**Table 4: Prioritised list of the risks related to thermal risks (N=number of experts answering the item; mean value; standard deviation)**

<span style="display: inline-block; width: 15px; height: 10px; background-color: #f8d7da; border: 1px solid #f5c6cb; margin-right: 5px;"></span> $MV > 4$ : risk strongly agreed as emerging	<span style="display: inline-block; width: 15px; height: 10px; background-color: #fff3cd; border: 1px solid #ffeeba; margin-right: 5px;"></span> $2.85 \leq MV \leq 3.15$ : status undecided
<span style="display: inline-block; width: 15px; height: 10px; background-color: #fff3cd; border: 1px solid #ffeeba; margin-right: 5px;"></span> $3.15 < MV \leq 4$ : risk agreed as emerging	<span style="display: inline-block; width: 15px; height: 10px; background-color: #d1ecf1; border: 1px solid #bee5eb; margin-right: 5px;"></span> $2 \leq MV < 2.85$ : risk agreed as non-emerging

NB: None of the risk was strongly agreed as non-emerging ( $MV < 2$ )

Thermal risks	N	Mean Value (MV)	Standard Deviation (SD)
Poor awareness of thermal risks among low-status worker groups exposed to unfavourable thermal conditions (e.g. migrant workers in agriculture and construction area working overtime in hot/cold areas such as greenhouses/cold stores)	10	4,50	0,707
Thermal discomfort (There are prescriptions only against thermal stress, but not against thermal discomfort at industrial workplaces.)	10	4,40	0,843
Risks related to Indoor Environmental Quality (IEQ) (e.g. dysphonia in call centres due to dry air and high speech demand)	10	3,90	1,197
Special protective clothes causing thermal stress	10	3,70	1,567
New work processes and technologies leading to thermal stress	10	3,10	1,524
Use of air conditioning (e.g. in offices and vehicles) leading to thermal discomfort and increasing the chance of mishandling	10	3,10	1,595



### Other emerging risks added by the experts in the third round

'The exponential increase of cold and freezing work environments, especially in the food and transportation sectors, is not being followed by an equal increase in our knowledge of the possible long-term health effects of working in these environments. One issue of concern is risks during pregnancy. A further issue is inaccurate reporting procedures: when a worker in a food preparation cold store cuts his hand, this is recorded as manual handling injury and not as a cold-induced injury.'

'The impact of global warming and other potential climatic changes on outdoor work and the changing risks (both the nature of the risks and the severity of the consequences) need to be considered.'

'Many of the scientific methods described in thermal standards are of little value in many environments where workers are at risk of heat stress (for example, glass, steel, ceramics, bricks, firefighting, etc.). High thermal radiation, high humidity and new PPEs are often outside the scope of heat stress indices. We should therefore concentrate on developing our knowledge of physiological monitoring equipment which meets the practical needs of the user. Often the equipment that works in the laboratory does not work in the field (e.g. telemetry or electromagnetic field (EMF) interference, or workers' reluctance towards measuring methods such as rectal temperature measurements). We should therefore develop practical easy-to-use advice which tells the user what has an effect on equipment performance, etc.'

'User-centred standards which give details of physiological, biomechanical and clothing performance trials for the design and development of PPE are needed in order to move away from manufacturer-based standards which often inadequately address the thermoregulatory consequences and the thermal and other ergonomic design criteria of PPE. One classic area of concern is compatibility.'

'A possible risk cause is the lack of knowledge of actual clothing insulation and protection from radiant heat provided by garments. The risk assessment based on such quantities is subject to potentially dangerous uncertainties.'

## 4.5

### RISKS RELATED TO NON-IONISING RADIATION

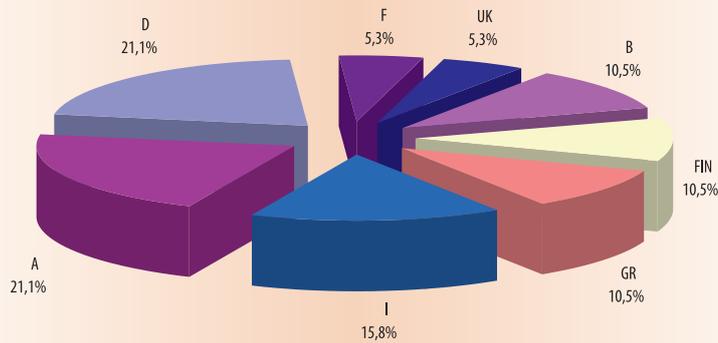
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#### 4.5.1. Respondents

Nineteen experts out of the 66 respondents to the survey had more than five years of experience in the field of risks related to non-ionising radiation and filled in this part of the questionnaire.



Diagram 12: Nationalities of experts who answered the questionnaire part related to non-ionising radiation (N=19)



### 4.5.2. Results

Diagram 13: Risks related to non-ionising radiation identified in the survey (Y-axis: mean values on the one-to-five point Likert scale and standard deviations)



The item related to ultraviolet radiation is rated as strongly agreed to be emerging, although the consensus amongst the respondents is relatively weak. According to the experts, it is not only a matter of occupational exposure but also a more general issue of increasing exposure during leisure time linked to changing societal values and ways of living. As the health effects of UV exposure have a cumulative nature, the more the workers are exposed, the more sensitive to UV radiation they become. Hence a potentially growing need for prevention measures at the workplace. (See part 5.5. of the literature review).





Emission of electromagnetic fields by a spot-welding gun  
 Berufsgenossenschaftliches Institut für Arbeitsschutz, Germany

One of the risks highlighted as emerging is actually linked to dangerous substances resulting from laser-based material treatment such as nanoparticles and dust. Ultrafine particles have also been identified as emerging risks in the expert survey on emerging chemical OSH risks <sup>(25)</sup>.

**Table 5: Prioritised list of the risks related to non-ionising radiation (N=number of experts answering the specific item; mean value; standard deviation)**

- $MV > 4$ : risk strongly agreed as emerging
- $2.85 \leq MV \leq 3.15$ : status undecided
- $3.15 < MV \leq 4$ : risk agreed as emerging
- $2 \leq MV < 2.85$ : risk agreed as non-emerging

NB: None of the risk was strongly agreed as non-emerging ( $MV < 2$ )

Risks related to non-ionising radiation	N	Mean Value (MV)	Standard Deviation (SD)
General increase of exposure to UV radiation (during leisure time; occupational outdoor activities; new UV technologies at the workplace) increasing the sensitivity to UV radiation at the workplace	18	4,17	1,098
Strong magnetic fields in magnetically levitated vehicles (e.g. trains) or in nuclear magnetic resonance (e.g. medical application) irradiating the staff	18	4,00	0,907
High frequency electromagnetic fields (EMF) (mobile telephony, radio-frequency, microwave, wireless applications at office workplaces)	18	4,00	0,970

<sup>(25)</sup> The results of the expert survey on emerging chemical OSH risks will be available from the Agency's website in the 'Risk Observatory' web feature in 2006. <http://riskobservatory.osha.eu.int>



EMFs affecting workers with active and passive implants (e.g. pacemakers), as the likelihood of being exposed is increasing	18	4,00	1,188
New laser technologies and light emitting diodes (LEDs) in communication engineering (optic rays for data transfer)	18	3,78	1,166
Laser applications creating chemical hazards (e.g. nanoparticles, dusts, vapours)	18	3,72	1,227
Welding with high current creating EMF emission (especially in the automobile industry)	18	3,61	1,243
Electronic article surveillance (EAS) and similar devices	18	3,56	1,338
New LED technologies becoming widely used in fields other than communication engineering (e.g. lighting)	18	3,50	1,465
“Old” laser technologies combined with unfavourable occupational safety conditions (use of price-code lasers in shops; use of poor quality laser pointers not meeting safety requirements)	18	3,44	1,247
Insufficient Electromagnetic Compatibility (EMC) impairing the function of machines and of electrical devices in airplanes, vehicles, etc.	18	3,17	0,924
EMFs from high voltage lines	18	2,78	1,353

### Other emerging risks added by the experts in the third round

‘Emerging use of hand operated laser processing devices (in material processing)’

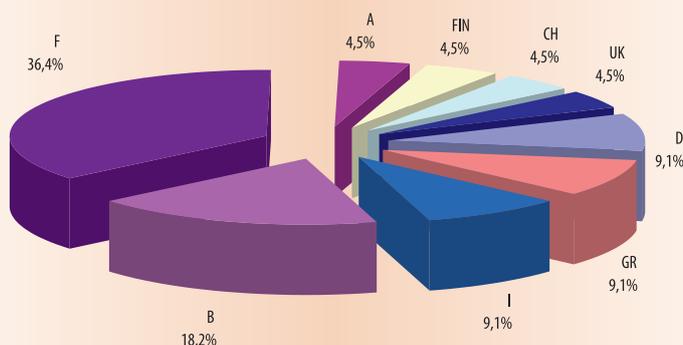
# 4.6

## RISKS RELATED TO IONISING RADIATION

### 4.6.1. Respondents

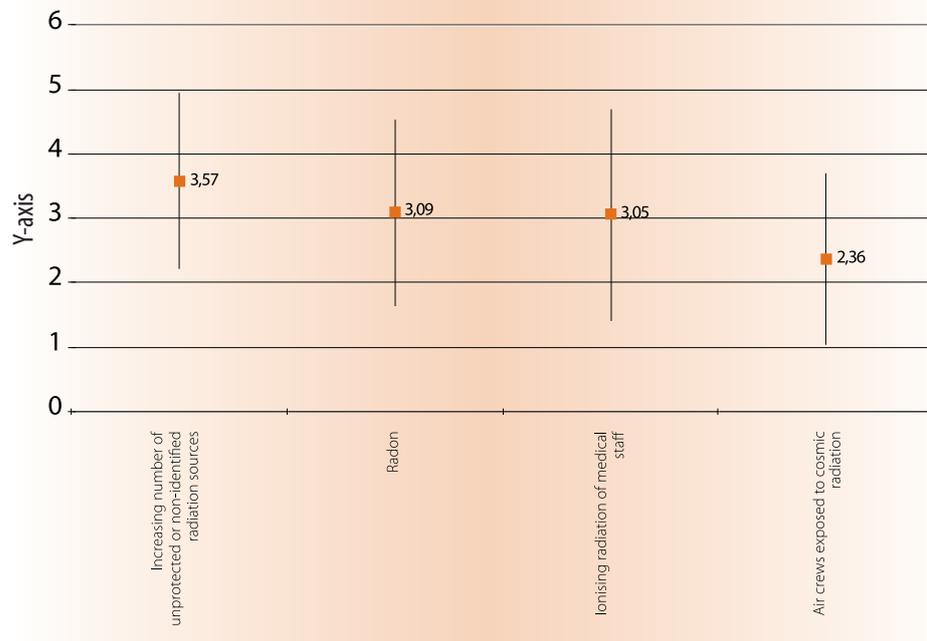
Twenty-two experts out of the 66 respondents to the survey had more than five years of experience in the field of risks related to ionising radiation and answered this part of the questionnaire.

Diagram 14: Nationalities of experts who answered the questionnaire part related to ionising radiation (N=22)



### 4.6.2. Results

**Diagram 15: Risks related to ionising radiation identified in the survey (Y-axis: mean values on the one-to-five point Likert scale and standard deviations)**



Only one item was identified as emerging risk in the field of ionising radiation with a relatively low level of consensus amongst the experts.

**Table 6: Prioritised list of the risks related to ionising radiation (N=number of experts answering the specific item; mean value; standard deviation)**

- $MV > 4$ : risk strongly agreed as emerging
- $2.85 \leq MV \leq 3.15$ : status undecided
- $3.15 < MV \leq 4$ : risk agreed as emerging
- $2 \leq MV < 2.85$ : risk agreed as non-emerging

NB: None of the risk was strongly agreed as non-emerging ( $MV < 2$ )

Risks related to ionising radiation	N	Mean Value (MV)	Standard Deviation (SD)
Increasing number of unprotected or non-identified radiation sources (e.g. international trade in treatment of scrap)	21	3,57	1,363
Radon (e.g. in contaminated spaces without air exchange: staff contamination in old mines used as health resort or in water works)	22	3,09	1,444
Ionising radiation of medical staff when examining or treating patients (Gamma rays, X-rays)	22	3,05	1,647
Air crews exposed to cosmic radiation	22	2,36	1,329

### Other emerging risks added by the experts in the third round

'Ionising radiation of medical staff when treating patients with beta emitters in unsealed sources'



### Comments on the risks proposed made by the experts in the third round

‘The items proposed in the field of ionising radiation are not really emerging. It is rather the interest in these risks which is increasing. For example, the exposure of air crew is not emerging (neither new, nor increasing), but the growing interest for this issue is linked to the decrease of annual exposure limits.’

‘The risks related to radon, radiation sources and cosmic radiation have not actually increased over the last years. But as there is more debate on these issues today, this gives the impression that the risks have increased. On the contrary, thanks to the increased amount of information available, the exposure to the risks is rather decreasing.’

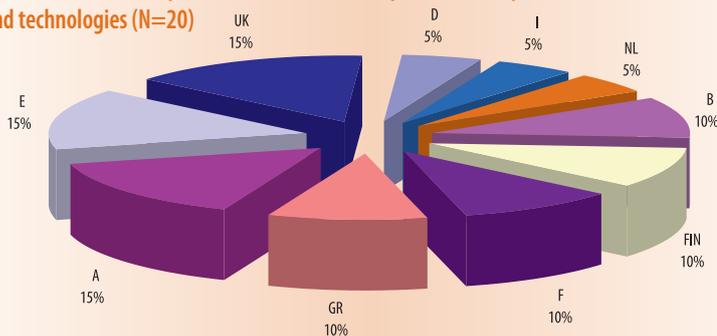
# 4.7

## RISKS RELATED TO MACHINERY, WORK PROCESSES AND TECHNOLOGIES

### 4.7.1. Respondents

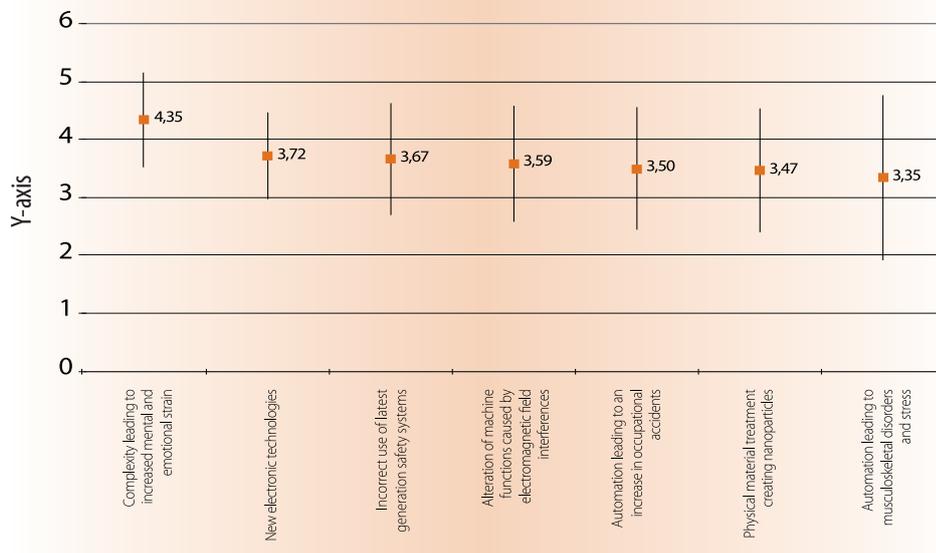
Twenty out of the 66 respondents to the survey had more than five years of experience in the field of risks related to machinery, work processes and technologies and answered this part of the questionnaire.

Diagram 16: Nationalities of experts who answered the questionnaire part related to machinery, work processes and technologies (N=20)



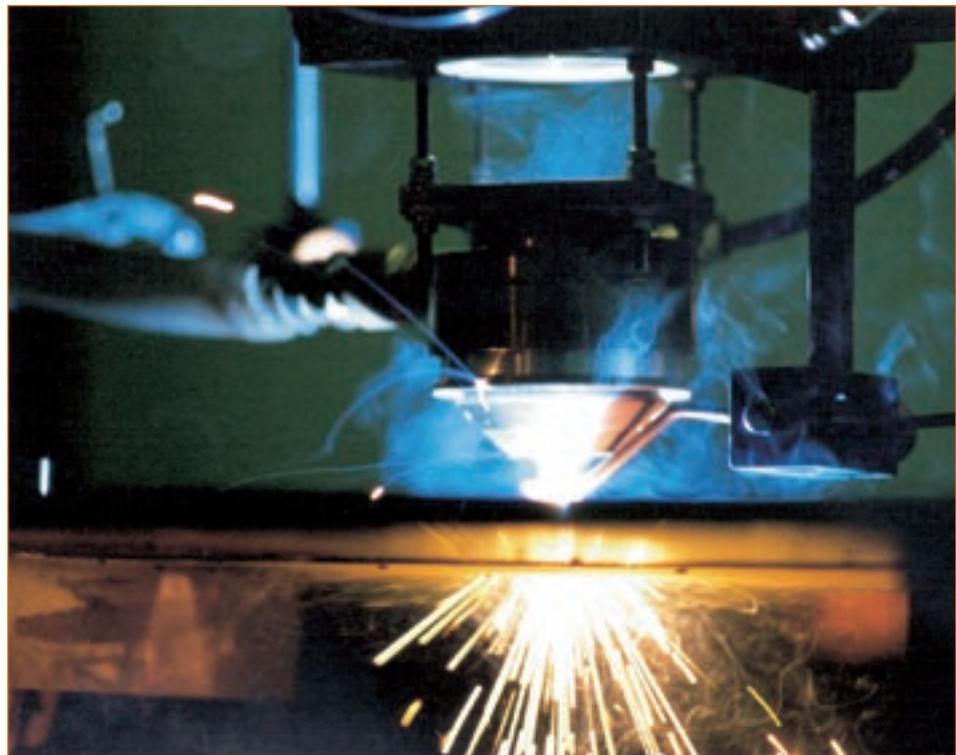
### 4.7.2. Results

Diagram 17: Risks related to machinery, work processes and technologies (Y-axis: mean values on the one-to-five point Likert scale and standard deviations)



The one item ‘complex technologies and work processes with complex human–system-interfaces’ which is strongly agreed to be emerging is a multi-factorial risk. Indeed, if the design of the interface does not take into consideration the cognitive processes involved when operating such a system, the mental and emotional demands on the operator is higher. Hence a potential increase in the incidence of stress, human errors and accidents. (See part 5.4. of the literature review).

The issue of ‘insufficient electromagnetic compatibility’, which was identified as an emerging risk by 18 experts (MV=3,17) in the part non-ionising radiation of the questionnaire, was also highlighted here by 17 experts as an emerging risk leading to the ‘alteration of machine functions’ and thus causing occupational accidents (MV=3,59) (six experts answered to both parts of the questionnaire). This may be considered to validate the forecast.



Material processing with laser beam  
Berufsgenossenschaftliches Institut für Arbeitsschutz, Germany

Dangerous substances resulting from physical processes, such as material treatment with laser applications creating nanoparticles, was agreed as emerging risk by 17 experts in this part, as well as in the part related to non-ionising radiation by 18 experts (six experts rated the items in both parts). Again, the almost identical mean ratings (3,47 and 3,72 respectively) may be considered to validate the forecast.



**Table 7: Prioritised list of the risks related to machinery, work processes and technologies identified in the survey (N=number of experts answering the specific item; mean value; standard deviation)**

- MV>4: risk strongly agreed as emerging
- 2.85≤ MV≤ 3.15: status undecided
- 3.15<MV≤ 4: risk agreed as emerging
- 2≤ MV<2.85: risk agreed as non-emerging

NB: None of the risk was strongly agreed as non-emerging (MV<2)

Risks related to machinery work processes and technologies	N	Mean Value (MV)	Standard Deviation (SD)
Complexity of new technologies, new work processes and human-machine-interfaces leading to increased mental and emotional strain	20	4,35	0,813
New electronic technologies (safe robots, residual movement control, numerical command, remote controlled vehicles, etc.) in process, production and machine control lead to new risks	18	3,72	0,752
Incorrect use of latest generation safety systems (immaterial barriers in detection zones, self-monitoring control systems such as safety software) leads to trips, falls, traps, crushes and other mechanical effects	18	3,67	0,970
Alteration of machine functions caused by electromagnetic field (EMFs) interfering with electronic control	17	3,59	1,004
Automation leading to an increase in occupational accidents in maintenance and production tasks	20	3,50	1,051
Physical material treatment (laser applications) creating nanoparticles	17	3,47	1,068
Automation leading to poor job content (repetitive and monotonous work) and consequently to MSDs and stress	20	3,35	1,424

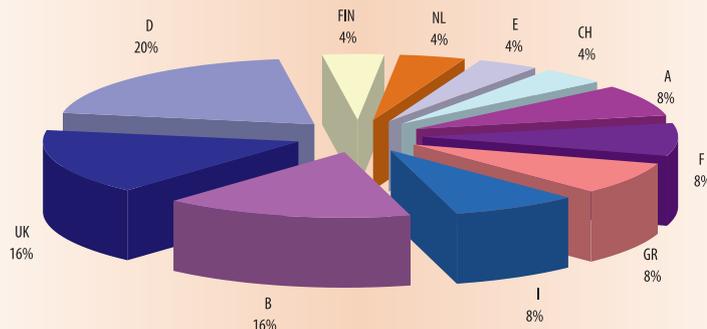
# 4.8

## OTHER ERGONOMIC RISKS

### 4.8.1. Respondents

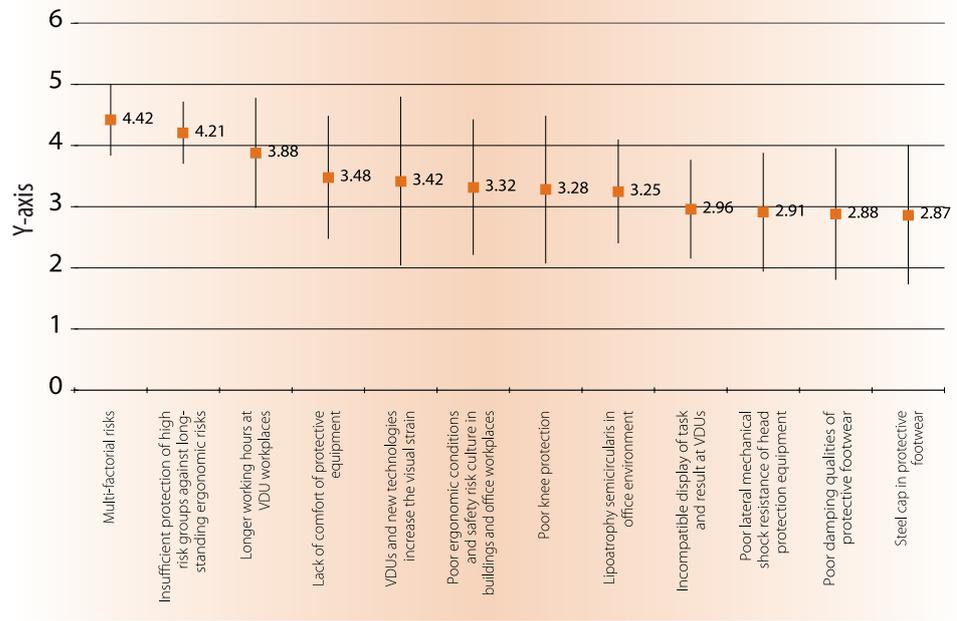
Twenty-five out of the 66 experts who participated in the survey had more than five years of experience in ergonomic risks and answered this part of the questionnaire.

**Diagram 18: Nationalities of experts who answered the questionnaire part 'other ergonomic risks' (N=25)**



### 4.8.2. Results

**Diagram 19: Other ergonomic risks identified in the survey (Y-axis: mean values on the one-to-five point Likert scale and standard deviations)**



Again, ‘multi-factorial risks’ are considered as issues of growing concern, as it is the item the most strongly agreed to be an emerging risk with a good consensus. (See part 5.3. of the literature review).

The issue ‘insufficient protection of high-risk groups against long-standing ergonomic risks’, as well strongly agreed to be emerging with a high consensus by 24 respondents, has also been pinpointed by 10 experts in the part ‘thermal risks’ of the questionnaire — though narrowed to the case of lower status workers exposed to unfavourable thermal conditions. Eight experts rated both items in both parts of the questionnaire. The almost equal mean values (4.21 respectively 4.50) may be considered to validate the forecast. The issue of lack of awareness of long-standing risks is recurrent as the experts also point out the poor safety culture and ergonomic conditions in office workplaces — although with a lower mean rating.

The issue of ‘lipoatrophy semicircularis in office environment’, highlighted here as emerging risk seems to be relatively new and its causes still the subject of controversy. Very little literature can be found on this topic and no older than from 2001 <sup>(26)</sup> <sup>(27)</sup>. Lipoatrophy semicircularis seems to be characterised by band-like horizontal depressions of the skin in the lower limbs, the distance between the floor and the horizontal indentations on the lower limbs being identical for all subjects independently of their height, weight and body mass index <sup>(26)</sup>.

<sup>(26)</sup> P. C. Gruber, L. C. Fuller, *Clinical and Experimental Dermatology*, vol. 26 (3), May 2001, pp. 269–271. [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Abstract&list\\_uids=21315459](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Abstract&list_uids=21315459)

<sup>(27)</sup> Annemarie Maes, Bart Curvers, Luc Verschaev, *Electromagnetic Biology and Medicine*, vol. 22 (2&3) (2003). ISSN: 1536-8378. pp. 183–193 <http://www.dekker.com/servlet/product/DOI/101081JBC120024627>



**Table 8: Prioritised list of the risks related to other ergonomic risks identified in the survey (N=number of experts answering the specific item; mean value; standard deviation)**

<span style="display:inline-block; width:15px; height:10px; background-color:#f8d7da; border:1px solid #c6c8ca;"></span> MV>4: risk strongly agreed as emerging	<span style="display:inline-block; width:15px; height:10px; background-color:#fff3cd; border:1px solid #ffeeba;"></span> 2.85≤ MV≤ 3.15: status undecided
<span style="display:inline-block; width:15px; height:10px; background-color:#fff3cd; border:1px solid #ffeeba;"></span> 3.15<MV≤ 4: risk agreed as emerging	<span style="display:inline-block; width:15px; height:10px; background-color:#d1ecf1; border:1px solid #bee5eb;"></span> 2≤ MV<2.85: risk agreed as non-emerging

NB: None of the risk was strongly agreed as non-emerging (MV<2)

Other ergonomic risks	N	Mean Value (MV)	Standard Deviation (SD)
Multi-factorial risks (e.g. call centres: combined effects of poor ergonomic design, poor work organisation, mental and emotional demands)	24	4,42	0,584
Insufficient protection of high risk groups (older workers, low status workers, foreign workforce, etc.) against long-standing ergonomic risks	24	4,21	0,509
Longer working hours at VDU workplaces leading to fatigue and exhaustion	24	3,88	0,900
Lack of comfort of protective equipment	25	3,48	1,005
Visual Display Units (VDUs) and new technologies increase the visual strain leading to deterioration of the visual capacity (e.g. miniaturisation effects of laptops)	24	3,42	1,381
Poor ergonomic conditions and safety risk culture in buildings and office workplaces	25	3,32	1,108
Poor knee protection (e.g. tile-setters or in the construction branch) leading to high load in the knee	25	3,28	1,208
New unexplained phenomena lipoatrophy semicircularis in office environment; possible causes have been formulated (body posture, static electricity of desk due to PC, electric cables and air humidity), but more research is still needed	24	3,25	0,847
Incompatible display of task and result at VDUs	24	2,96	0,806
Poor lateral mechanical shock resistance of head protection equipment	22	2,91	0,971
Poor damping qualities of protective footwear leading to injuries of the heel	24	2,88	1,076
Steel cap in protective footwear leading to toe squeezing when kneeling	23	2,87	1,140





# 5.

## LITERATURE REVIEW



A literature review explores in more depth the context and the health outcomes of five of the main emerging risks singled out in the forecast. 'Lack of physical activity', 'combined exposure to MSD risk factors and psychosocial risk factors', 'multi-factorial risks' and the 'complexity of human-machine interfaces leading to increased mental and emotional strain' were chosen for their multi-factorial aspects linked to the changing world of work <sup>(28)</sup>. Additionally, the 'general increase of exposure to UV radiation' was selected because of the societal dimension mentioned by the experts related to the growing UVR exposure during leisure time, which also increases workers' sensitivity to UVR at work.

The papers selected for this review all originate from scientific peer-reviewed journals, from reputable research or OSH organisations, or from proceedings of congress, the interventions of which are reviewed by a scientific committee. The papers had to be as recent as possible and not older than 1995. Nevertheless, out of the more than 110 references quoted, only nine papers published between 1990 and 1994 were referred to.

# 5.1

## LACK OF PHYSICAL ACTIVITY

*Occupations with little physical activity and increased MSD prevalence usually involve prolonged sitting or prolonged standing.*

The literature shows a clear link between work-related prolonged sitting and the higher incidence of musculoskeletal disorders (MSDs), such as neck and shoulder pain (Chandrasakaran, Chee, Rampal & Tan, 2003), neck, shoulder and upper back pain (Chee, Rampal & Chandrasakaran, 2004), low back pain (Burdorf, Naaktgeboren, de Groot, 1993), as well as diseases of the lumbar spine, which lead to permanent working incapacity in a large number of cases (Piazzini, Bollino & Mattioli, 1991). Static postures imply a diminution in the blood circulation through the muscles leading to the apparition of disorders and dysfunctions, hence increasing the incidence of MSDs (Cramer, J.; Ellegast, R.P.; von der Heyden, T.; Liedtke, M.; Pfeiffer, W.; Stamm, R, 2001). Examples of occupations with very little physical activity and increased prevalence of MSDs are crane operators and straddle-carrier drivers performing sustained sedentary work in non-neutral trunk posture (Burdorf, Naaktgeboren, de Groot, 1993; Herda, Ellegast, Ditchen, 2002), truck drivers (Piazzini, Bollino & Mattioli, 1991), bus drivers (Ellegast, Glitsch, Knipfer, 2002), workers in semiconductor factories (Chee, Rampal & Chandrasakaran, 2004), workers at video display unit (VDU) workplaces (Mitsuya, Ebine, Nozaki, Noro, 2003).

*Health outcomes are MSDs of the upper-limbs, back disorders, varicose veins, deep-vein thrombosis, obesity, and certain cancers*

A comparison between call centre agents and secretaries showed that the amount of time spent in sitting positions at work correlates positively with the amount of phone-call tasks performed (Herda, C.; Brun, E.; Ellegast, R.P.; Hauke, M., 2002). Indeed, more than 90 % of the working time was found to be spent in sitting positions — and an additional 5 % in static standing positions — at workplaces involving a high percentage of phone-calls. Due to the nature of their tasks, call centre workers are physically bound to their working equipment (phone or headset and computer) and thus to their workplace. It was furthermore observed that the longer the time spent in sitting positions, the worse the back posture evolves over the time. These observations correlate with the higher incidence of neck and back pains reported by the call centre agents in a questionnaire (Cramer, J.; Ellegast, R.P.; von der Heyden, T.; Liedtke, M.; Pfeiffer, W.; Stamm, R, 2001).

<sup>(28)</sup> European Agency for Safety and Health at Work: 'Research on the changing world of work'. <http://europe.osha.eu.int/research/rtopics/change/>



Conversely, physical activity at work helps prevent neck disorders among sedentary workers (Korhonen et al., 2003). Besides, ergonomic improvements of the workplace, changes in the work organisation and management practices, and awareness-raising measures were shown to reduce the incidence of low back pain, for instance among professional drivers (Lyons, 2002).

The literature does not only highlight the lack of physical activity related to prolonged sitting as an occupational health issue, but also related to prolonged standing, which causes fatigue and may lead to the apparition of oedema in the legs (Zander, King & Ezenwa, 2003).

In industrial countries, working conditions and especially the growing automation encourage the lack of physical activity in the workplace, which implies lower energy consumption. This results in an increase in workers' body weight and the prevalence of obesity rises, which is a risk factor for vascular, metabolic and neoplastic diseases. Beside the effect on the workers' health, the direct and indirect economic costs related to the emerging prevalence of obesity have grown (Colditz, 1999).

Prolonged sitting at work was also found to augment the risk of ovarian cancer (Zhang, Xie, Lee & Binns, 2004), breast cancer (Coogan et al., 1997; Kruk & Aboul-Enein, 2003) and renal cell cancer (Bergstrom et al., 1999) — although the last effect is only observed among male workers (Bergstrom et al., 1999). Conversely, physical activity in the workplace was shown to reduce the incidence of such diseases (Coogan et al., 1997; Kruk & Aboul-Enein, 2003; Bergstrom et al., 1999).

The lack of physical activity also has a hypertensive effect and causes a significant increase in gravitational stress on the cardiovascular system (Pekarski, 2004), which can result in thrombosis (Beasley et al., 2003). At VDU workplaces, the incidence of deep-vein thrombosis (DVT) could be linked to the long-term static postures (Mitsuya, Ebine, Nozaki, Noro, 2003). Further reports confirm the occurrence of DVT or pulmonary embolism (PE) following prolonged sitting in relation to work (Beasley, Heuser, Raymond, 2005). Indeed, whereas sitting jobs require less muscular effort, reports of varicose veins, stiff necks, and numbness in the legs are more common among seated workers than among those performing heavier tasks (Canadian Centre for Occupational Health and Safety, 1998).

In order to compensate the lack of physical activity in the workplace, the working equipment should support a dynamic alternation of working positions. For example, some chairs are designed so as to encourage dynamic sitting, that is, the regular alternation of bending forward or backward positions when sitting. Some working stations can be arranged so that it is possible to change between sitting and standing positions (Ellegast, Herda, Hoehne-Hückstädt, Lesser, Kraus, Schwan, 2004). Also, organisational measures should make possible to alternate tasks and to have a good repartition over the working time of breaks, during which workers should take different positions than at their workplace (Cramer, Ellegast, V. D. Heyden, Liedtke, Pfeiffer, Stamm, 2001). Some organisations propose on-site wellness programmes to their workers. Nevertheless, the degree of participation in these programmes is higher for the group of younger and better-educated workers. These recognise indeed more benefits in participating in these activities, such as increasing their performance at work, and are less reluctant to practise physical activities with colleagues in their working premises (Alexy, 1991).

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*Work equipment and organisation should enable to alternate body positions. On-site health programmes also help in preventing the risk.*

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# 5.2

## COMBINED EXPOSURE TO MSD RISK FACTORS AND PSYCHOSOCIAL RISK FACTORS

*VDUs and call centres jobs and the healthcare sector are exposed to both MSD and psychosocial risks.*

MSDs are the most common work-related diseases in Europe: in 2000, 33 % of workers in EU-15 reported back pain and 23 % reported neck and shoulder pain (European Foundation for the Improvement of Working and Living Conditions, 2000). As work-related MSDs lead to sick leaves, they have a negative impact on productivity (Buckle & Devereux, 2002) and generate socioeconomic costs in the European Union (European Agency for Safety and Health at Work, 2000).

Poor psychosocial factors at work can generate work-related MSDs (Bongers, de Winter, Kompier & Hildebrandt, 1993; Carayon, Smith & Haims, 1999; Devereux, 2004; Houtman et al., 1994; Leino & Hanninen, 1995; Malchaire, Roquelaure, Cock & Piette, 2001; Warren, 2001) and a lot of research is currently carried out in this field.

Different occupations and sectors exposed to the combination of MSD risk factors and psychosocial risk factors have been investigated. Complaints in the shoulder/neck region and low back area due to poor physical and psychosocial aspects of the working environment are often observed in workers of the healthcare sector, for instance nurses and dentists (Brulin et al., 1998; Gunnarsdottir, Rafnsdottir, Helgadottir & Tomasson, 2003; Ylipaa, Arnetz, Benko & Ryden, 1997). Moreover, VDU workers in general (Eklöw, 2004), but also more specific groups such as call centre agents (Halford & Cohen, 2003; Norman et al., 2004), are exposed to work-related psychosocial factors, which contribute to the incidence of mental and physical health problems (Smith, 1997). Shoulder disorders related to psychosocial work factors are also found among supermarket cashiers (Niedhammer et al., 1998).

At VDU workplaces in ordinary occupational settings, perceived muscular tension and emotional stress correlated with musculoskeletal pains and physical load in terms of muscle activity in the trapezius muscles (Joksimovic, Starke, v. d. Knesebeck & Siegrist, 2002; Nahit et al., 2003; Wahlström, 2003). More generally, stress and mental demand related to computer work increases the muscular activity and is positively associated with an increased prevalence of MSDs (Laursen et al., 2002; Smith, 1997; Smith, Conway & Karsh, 1999). Therefore, attention should be paid to the ergonomic design of the working equipment (Smith, 1997).

*Stress, too high or low job demand, complex tasks, time pressure, low decision level, poor support from colleagues, fear of unemployment and bullying increase the incidence of MSDs.*

High job demand is one of the risk factors contributing to MSDs mostly tackled in research papers (Bongers, de Winter, Kompier & Hildebrandt, 1993; Joksimovic, Starke, v. d. Knesebeck & Siegrist, 2002). Consequences of highly demanding work are neck and shoulder pain with possible pressure tenderness (Andersen, 2003) and low-back pain (Hoogendoorn et al., 2001). A mentally difficult job, mental exhaustion after a work shift, as well as intense time pressure, are all factors identified as psychosocial risk factors causing musculoskeletal symptoms (Gunnarsdottir, Rafnsdottir, Helgadottir & Tomasson, 2003). However, high job demand not only influences physical health negatively, but also the mental health of workers (Smith, 1997; Strazdins et al., 2004).

Conversely, a too-low job demand, for instance monotonous work, was also identified as a risk factor for new onset shoulder pain (Bongers, de Winter, Kompier & Hildebrandt, 1993; Harkness, 2003; Smith, 1997; Smith, Conway & Karsh, 1999).



Low job control is another of the most common factors associated with MSDs (Bongers, de Winter, Kompier & Hildebrandt, 1993; Norman et al., 2004; Smith, 1997; Smith, Conway & Karsh, 1999). More precisely, low decision level induces statistically significant increases in the incidence of sick leaves due to neck pain (Ariens et al., 2002). Furthermore, low influence at work generates hand-wrist affections and, predominantly in women, neck symptoms (Jensen, 2003).

Poor support from colleagues (Bongers, de Winter, Kompier & Hildebrandt, 1993; Nahit et al., 2003) and lack of solidarity (Gunnarsdottir, Rafnsdottir, Helgadottir & Tomasson, 2003) also contribute to musculoskeletal problems. Human aspects such as poor relationships with colleagues at work (Yip, 2004) or poor relations with supervisors (Smith, 1997) should be improved in order to reduce work-related health outcomes, especially low back pain (Hoogendoorn et al., 2001; Yip, 2004). Call centre agents who report poor support from their supervisors are more likely to develop musculoskeletal symptoms (Norman et al., 2004). More generally, work-related dissatisfaction with the hierarchy contributes to musculoskeletal problems (Gunnarsdottir, Rafnsdottir, Helgadottir & 1997). Evidence of the relationship between lower levels of support at work and severe numbness in the hands and arms was put forward (Faucett & Rempel 1994).



Artist: Piotr Garlicki  
 Courtesy of the Occupational Safety Poster Competition  
 organised by the Central Institute for Labour Protection — National Research Institute, Poland Piotr Garlicki

Workers who experience downsizing and job insecurity are more at risk of MSD (Kivimaki et al., 2001; Mohren et al., 2003; Smith, 1997; Strazdins et al., 2004). However, fear of unemployment was shown to affect the health of more highly educated employees more than less educated ones (Domenighetti, D'Avanzo & Bisig, 2001). Nevertheless, low job security does not increase significantly sickness absence due to neck pain (Ariens et al., 2002).

Harassment, violence and bullying at work are also psychosocial risk factors which predict the incidence of MSDs (Gunnarsdottir, Rafnsdottir, Helgadottir & Tomasson, 2003).

Workers highly exposed to the combination of occupational physical and psychosocial risk factors are more likely to report MSDs than workers highly exposed to the one or the other type of exposure; besides, the effects of exposure to psychosocial risk

*Combined exposure to MSD and psychosocial risks affect workers' health to a greater extent than single exposure.*



factors at work are more important when the simultaneous occupational exposure to physical risk factors is high (Devereux, Vlachonokolis & Buckle, 2002). Whereas physical and ergonomic variables play a more important role than psychological factors with regards to the development of upper extremity disorders and visual discomfort, psychological factors are the major contributors to back and lower extremity pain (Hsu & Wang, 2003). While occupational physical and psychological risk factors are associated with the occurrence of low-back pain and upper-extremity complaints, individual factors predominantly determine whether the persons affected will go on sick leave (Jzelenberg, Molenaar & Burdorf, 2004).

Change in the work organisation and better ergonomic planning of workplaces could reduce the prevalence of MSDs (Fracassi, 2001; Stubbs, 2000; Yu & Wong, 1996). Flexible organisation of the workplace helps reducing the incidence of work-related health disabilities, as the length of work disabilities related to MSDs in the neck and shoulders in traditionally organised workplaces is about two years higher (Shannon, Robson & Sale, 2001). In any case, the organisational context is an important factor for the success of ergonomic interventions (Westgaard, 2000). Last but not least, with a view to the central role psychosocial factors play in the incidence of work-related MSDs, psychology is seen as one of the emerging disciplines that should be systematically taken into consideration in the field of occupational health (Sauter et al., 1999).

## 5.3

### MULTI-FACTORIAL RISKS

*Call centres jobs are typical occupations with multi-factorial exposure.*

Most research and intervention papers dealing with multi-factorial risks are focused on call centres. One explanation might be that call centres are in expansion.

In spite of their younger age and shorter exposure to computer work, call centre operators suffer more from MSDs than VDU workers in other occupations, and especially from muscle tension and nerve affections in the neck and shoulder region (Toomingas et al., 2003). The use of VDUs in general generates musculoskeletal problems especially in the neck and shoulder regions (Yu & Wong, 1996). In computer–telephone interactive tasks, a low level of satisfaction with the physical arrangement of the workstation, but also psychosocial factors and job duration, predict the occurrence of MSDs in the neck, shoulders, hands and wrists, and of MSD-related absenteeism (Ferreira, Paulo & Saldiva, 2001). A further important MSD risk factor is work organisation (Fracassi, 2001; Malchaire, Roquelaure, Cock & Piette, 2001; Yu & Wong, 1996). For instance, lack of resting periods, tight work schedules and time pressure lead to upper extremity MSDs among workers involved in computer–telephone interactive tasks (Ferreira Junior, Conceicao & Saldiva, 1997; Halford & Cohen, 2003).

Call centre agents are found to work in sitting positions over longer periods than other VDU-related occupations such as secretaries (Herda, C.; Brun, E.; Ellegast, R.P.; Hauke, M., 2002). While sitting jobs require less muscular effort, reports of varicose veins, stiff necks, and numbness in the legs are more common among seated workers (Canadian Centre for Occupational Health and Safety, 1998). (See part 5.1. for more details on sitting workplaces).





*Increasing number of call centre jobs in Germany*

*Hauptverband der gewerblichen Berufsgenossenschaften, Germany — Pressebilder*

Poor working conditions specific to indoor workplaces, such as acoustics, room atmosphere, lighting conditions, arrangement of the working premises and ergonomics of the working equipment lead to increased workers' strains (FIRU, 2001). Call centres are particularly good examples of such indoor workplaces with multiple risk factors. Indeed, disturbing background noise generated by the high amount of work-related talks of colleagues on the phone or by the ringing of telephones hinders the workers' concentration and performance and leads to mental fatigue. Hence the need for good room acoustics and adequate headsets; poor lighting predict the occurrence of visual problems and headaches; poor room atmosphere caused by too high or too low temperatures, air drafts or dried air does not only impede the psychic and mental performance but also generates diseases of the airways and, in case of throat disorders, may affect the use of voice, which is a working instrument the agents mainly rely on (Cramer, Ellegast, V. d. Heyden, Liedtke, Pfeiffer, Stamm, 2001). Further factors predicting the increased occurrence of voice disorders are stress and background noise, which the agents try to compensate by raising their voice (Sportelli, Raestrup, 2001). Furthermore, the presence of chemical substances and biological agents in the workplace due to outdoor pollution infiltrating into the building or emitted indoors by humans (for example, carbon dioxide, smells), by working equipment such as printers, or by premises equipments (for example, furniture, wall paints, or air conditioning systems creating fungi and bacteria) can result in various health effects, from allergies to more general sick building syndrome (SBS) (Cramer, Ellegast, von der Heyden, Liedtke, Pfeiffer, Stamm, 2001).

Poor ergonomics of the software the agents use while dealing with clients' requests on the phone also increase the workers' mental demand (V. d. Heyden, 2001).

Last but not least, in call centre workplaces, higher stress levels related to interactions with clients, higher mental demand, lower job control and higher time pressure than in other occupations could be observed. These factors were found to correlate with higher incidence of job dissatisfaction, psychosomatic symptoms and burnout (Zapf, 2001).

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*Call centre agents suffer MSDs, varicose veins, nose and throat diseases, voice disorders, stress and burnout.*

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A further example of workplaces with multi-factorial risks is open-office workplaces where the exposure to low intensity background noise was shown to augment the level of urinary epinephrine, which is a risk factor for heart disease, and to lower the willingness to make postural adjustments of their computer workplace, which is a risk factor for MSDs (Evans, Johnson, 2000).

Besides, multi-factorial origin of shoulder disorders partly related to work organisation could be found among supermarket cashiers (Niedhammer et al., 1998). More generally, the combined exposure to individual factors (such as depressive symptoms), to organisational factors (such as low level of job control) and to biomechanical constraints (predominantly repetitive movements for men and, for women, the use of vibrating tools or work performed above shoulder level) was shown to increase the incidence of shoulder pain (Leclerc, Chastang, Niedhammer, Landre, Roquelaure, 2004).

More generally, low occupational status (Levenstein, Smith & Kaplan, 2001), worker's skills non-adapted to the task to be performed and — consequently — low performance (Smith, 1997) affect psychological distress and therefore increase the likelihood of developing hypertension. Sickness absence on the whole is associated with poor social support and low levels of job control (Vahtera, Kivimaki, Pentti & Theorell, 2000).

# 5.4

## COMPLEX HUMAN–MACHINE INTERACTION

*Poor design of human–machine interfaces increases the incidence of stress, human errors and accidents.*

In the industry, the use of complex automated systems increases and the inappropriate design of man–machine interfaces raise the chance of human errors (Norman, 1990), which have become a greater hazard than technical failures (Reason, 1995). In fields such as computer-aided neurosurgery, the high error rates are mostly the results of inadequate handling of the human–system interface (Spetzger et al., 2002; Visarius et al., 1997).

In the air industry area, operators not understanding the 'intelligent' but complex automated systems is also a frequent cause of errors, which can have severe consequences, for instance in the case of undersea systems, performance aircraft or an orbiting space station; However, human factors research is very active in this field and has established guidelines for the conception and use of automated systems supporting — rather than confounding — human performance and safety (Connors, 1998).

*A maximum number of functions that an operator can handle without his mental workload being increased was set.*

High-technology in-cab devices are more and more common in heavy trucks and aim at increasing the occupational safety on the road (Wierwille et al., 1992). In earth-moving machinery for instance, the use of joysticks is widespread. As the number of function groups available through buttons or switches on these devices augments, a maximum number of function units that an operator can handle without his mental workload — and thus the probability of accidents — being increased was determined (Zieschang, Müller-Gethmann 2004). Recommendations were also made as to the ergonomic design of the joystick, its compatibility with the machine response and the positioning of the functions on the device. Further research papers confirm the need for standardising the integration of joysticks into complex machines (Schmauder et al., 2004) and for the ergonomic arrangement of remote controls (Bömer, 2001).





*Multi-purpose control joysticks in earth-moving machinery  
Berufsgenossenschaftliches Institut Arbeit und Gesundheit, Germany*

Besides, the use of cobots in manual handling activities and in complex manufacturing and assembly processes is increasing. 'A cobot is a robot for direct physical interaction with a human operator, within a shared workspace' <sup>(29)</sup>. Vision-based protective devices able to automatically distinguish the worker from the cobot and from the products being manufactured are being developed in order to ensure a good teaming of the human-machine system and thus the operators' safety (Bömer, 2003; Bömer & Hauke, 2003).

Since a lot of incidents result from information-handling and motivational problems, managing these human risks will never be 100% effective (Reason, 1995). Nevertheless it has to be intervened. Human-machine interfaces should be designed and adapted to the workers. They should enable them to use their already acquired skills rather than forcing them to adapt to the technology and to learn new skills (Baber & Bauermann, 2002). A methodology for identifying errors in the design of human-machine interactions and for testing whether the interface provides the user with the feedback necessary to operate the system safely has been developed and can be automated (Degani, Heymann, 2002). Indeed, adequate feedback from the system and continual interaction with the operator reduce the risks of accidents related to complex human-machine interactions (Norman, 1990). Last but not least, the need for adequate and understandable information material such as operating instructions is addressed (Degani, Heymann, 2002; Brun, Reinert, 2004) and the role proper workers' training plays in reducing the risk of human errors related to the use of human-computer interfaces is emphasised (Smith, Conway & Karsh, 1999).

*Human-machine interfaces should be adapted to workers and provide adequate feedback.*

## ULTRAVIOLET RADIATION (UVR)

# 5.5

No literature was found on the increased sensitivity of workers to UV at work linked to changing societal values and behaviours, and more especially to a global increase in the UVR exposure during leisure time. Nevertheless, the need for advice limiting occupational UVR exposure both indoors and outdoors is emphasised (National Radiological Protection Board, 2002).

<sup>(29)</sup> <http://othello.mech.nwu.edu/~peshkin/cobot/>



*There is a need for advice limiting occupational UVR exposure, both indoors and outdoors.*

Some studies highlight the higher incidence of UV-generated health effects amongst outdoor workers exposed to sunlight (Guénel, Laforest & Lynge, 2002; NRPB, 2002). For instance in Germany, 2.5 to 3 million outdoor workers are exposed to UVR (Siekmann, 2001). The annual solar exposure dose of outdoor workers in mid-latitudes (40–60°N) has been estimated to be 250 times the ‘minimal erythema dose’ (MED) (IARC, 1997).

But indoor workers are also exposed to an annual exposure dose of solar UVR of about 40–160 times the MED, depending on the outdoor activities they perform during leisure time (IARC, 1997). Indeed, artificial UV radiation sources can contribute significantly to the personal total exposure dose (NRPB, 2002) and have important consequences in terms of health outcomes (Diepgen & Drexler, 2004). Few industrial lamps emit UVR: tungsten lamps, if they are unshielded, can emit UVR levels leading to erythema; high intensity discharge (HID) lamps may constitute a UVR hazard if they are used without secondary containment in an open situation (NRPB, 2002). Dentists, physiotherapists, lithographers, harbour masters, workers in lighthouses, tailors, tanners, fur dressers, patternmakers, cutters, electrical fitters, wiremen, telephone/telegraph installers/repairmen, glass/pottery/tile workers, rolling mill workers, chimney sweeps, aircraft pilots/navigation and flight engineers (Perez-Gomez et al., 2004), painters, construction workers and farmers (Nordstrom et al., 1997), workers in the food industry where UV is used to disinfect food packaging material, workers at machines involving UV to dry dyes and paints (in printing plants) and welders (Siekmann, 2003) are found to be at risk. More particularly arc welding processes emit UVR and, while overexposure leading to acute reactions is common among electric arc welders, even very short exposures may be hazardous to the eyes and skin (IARC, 1997; NRPB, 2002). In the healthcare sector, hospital staff working with unenclosed phototherapy equipment may be at risk of overexposure if no protective measure is implemented (IARC, 1997; NRPB, 2002). Besides, the growing use of UVR-based method for cleaning atmosphere in surgery rooms is controversial: on the one hand, it is an appreciated low-cost technique; on the other hand, it is criticised for putting medical staff and clinical patients at risk of UV exposure (Berg-Perier, Cederbald & Persson, 1992; Siekmann, 2003). Finally, in biological and chemical laboratories, UV exposure levels are also elevated (Cazzuli & Giroletti, 2002).



*Reconstructed case of occupational disease:  
medical staff irradiating a young child with a ultraviolet lamp  
Berufsgenossenschaftliches Institut für Arbeitsschutz, Germany*



UVR exposure predicts increased incidence of cataract (Müller-Breitenkamp, Hockwin, Siekmann, Dragomirescu, 1997), non-Hodgkin's lymphoma<sup>(30)</sup> (Nordstrom et al., 1997), myeloid<sup>(31)</sup> and lymphocytic<sup>(32)</sup> leukaemia, lip and stomach cancer and malignant melanoma (Hakansson et al., 2001). As for non-melanocytic skin cancer, the incidence and the mortality thereof is higher for outdoor workers. For example, in fishermen, the occurrence of squamous-cell carcinoma was found to correlate positively with estimations of individual annual and cumulative exposure to UVB, but not the occurrence of basal-cell carcinoma (IARC 1997). While the IARC report stipulated in 1997 that no study could adequately demonstrate any positive association between exposure to artificial sources of UVR and non-melanocytic skin cancer, in the case of squamous cell carcinoma, a more recent review of epidemiological studies concludes that exposure to both natural and artificial UVR increases the risk by at least twice (Diepgen and Drexler, 2004). A significantly increased risk of lip cancer could be associated with outdoor work (IARC 1997).

However, the European schedule of occupational diseases<sup>(33)</sup> exclusively includes 'conjunctival ailments following exposure to ultraviolet radiation' (No 502.02) — which is defined as an occupational disease in Finland<sup>(34)</sup> for instance — but no UV-generated cancer.

When neither the hazard can be eliminated at source through technical measures nor the exposure be reduced to an acceptable level through organisational measures, individual measures should be adopted. For example, researchers in biological and chemical laboratories in which the UV exposure levels are elevated are recommended to follow correct laboratory procedures and use personal protective equipment (Cazzuli & Giroletti, 2002). Welders have to wear ocular protection in addition to conventional welding helmets and all external skin areas should be protected (Tenkate & Collins, 1997; National Radiological Protection Board, 2002). Even simple protective measures, such as wearing a sun hat, can reduce the risk of non-melanoma skin cancers (Wong, Airey & Fleming, 1996). Nevertheless, it was shown especially that outdoor workers with an extremely high UVR exposure level, such as workers in the construction sector, make little use of appropriate personal UVR-protective equipment (Gies & Wright, 2003). Some practical recommendations for outdoor workers and their employers are available and aim at raising awareness and preventing health outcomes of occupational exposure to UVR (HSE, 2005).

<sup>(30)</sup> Medline Plus — Medical encyclopedia: 'Non-Hodgkin's lymphoma: cancers of lymphoid tissue (lymph nodes, spleen, and other organs of the immune system)'. <http://www.nlm.nih.gov/medlineplus/ency/article/000581.htm>

<sup>(31)</sup> National Center for Biotechnology Information (NCBI): 'Myeloid leukaemia: cancer of blood cells, characterised by replacement of the bone marrow with malignant, leukaemic cells'. <http://www.ncbi.nlm.nih.gov/disease/cml.html>

<sup>(32)</sup> CancerBACUP online: 'Lymphocytic leukaemia: cancer of the lymphocytes'. <http://www.cancerbacup.org.uk/Cancertype/Leukaemiachroniclymphocytic/General/WhatisCLL>

<sup>(33)</sup> Commission of the European Communities: Commission recommendation of 19 September 2003 concerning the European schedule of occupational diseases (2003/670/EC), OJ L 238/28 to L 238/34. 25.9.2003. [http://europa.eu.int/eur-lex/pri/en/oj/dat/2003/l\\_238/l\\_23820030925en00280034.pdf](http://europa.eu.int/eur-lex/pri/en/oj/dat/2003/l_238/l_23820030925en00280034.pdf)

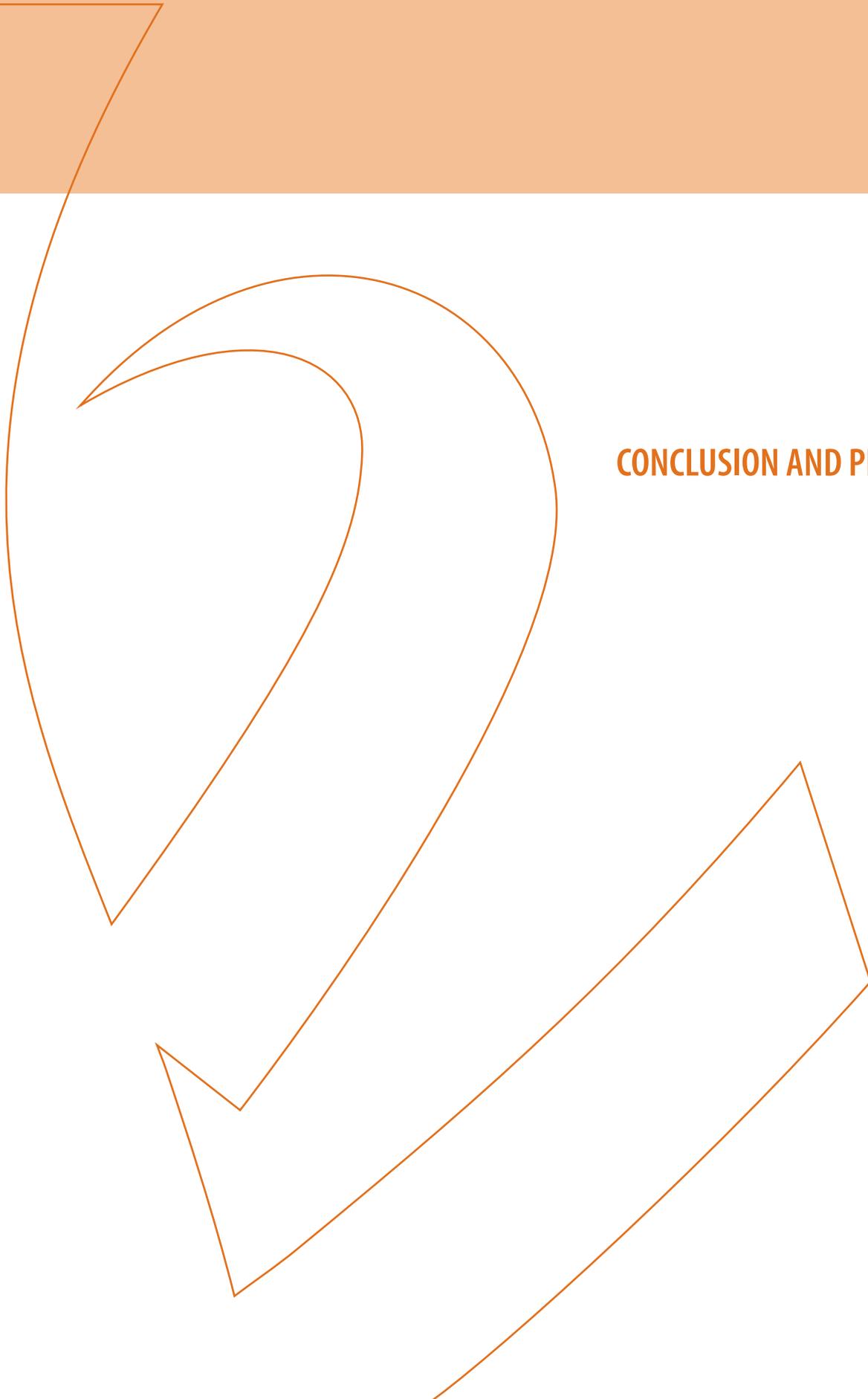
<sup>(34)</sup> Finnish Institute of Occupational Health (FIOH): Finnish Registry of Occupational Diseases — FROD. <http://www.ttl.fi/NR/rdonlyres/676F4FD9-BE35-4055-886F-2A699225A633/0/occu2002.pdf>





# 6.

## CONCLUSION AND PERSPECTIVES



The expert forecast highlights 10 risks strongly agreed as emerging by the experts. However, comparison of mean values across all parts of the questionnaire should be treated with caution as the respondents to one or other parts of the questionnaire may be different persons who possibly had different rating patterns.

The 'top' emerging risks highlighted in the expert forecast show that multi-factorial issues are a growing concern.

**Lack of physical activity**, which is the risk the experts agree on the most as being emerging, is to some extent the result of poor work organisation and harms the physical health of workers.

**High-risk worker groups**, such as workers with a low employment status, are the subject of **fewer awareness-raising measures** for physical risks and are more vulnerable, for instance to thermal risks.

*The 'top' emerging risks reflect a growing concern for multi-factorial issues.*

**Call centres** are multiplying and bring with them new types of workplaces with **multiple risk factors**: inadequate headsets not filtering acoustic shocks, poor ergonomic design of the workplace, poor work organisation and high mental and emotional demands.

**Unfavourable psychosocial aspects** of the working environment are perceived as emerging risks increasing the **incidence of MSDs**.

Conversely, the experts recognise that the **physical characteristics of workplaces**, such as poor ergonomic design of the human-machine interface, augment **workers' mental and emotional strain** and therefore the risk of accidents at work.

**Daily-life aspects** which enhance the effects of occupational exposure and affect workers' health are also emphasised, such as the increase in UV exposure during leisure time augmenting the sensitivity to occupational UV exposure.

But also, **combined exposure to longstanding physical factors** such as vibration, awkward postures and heavy physical work is put forward.

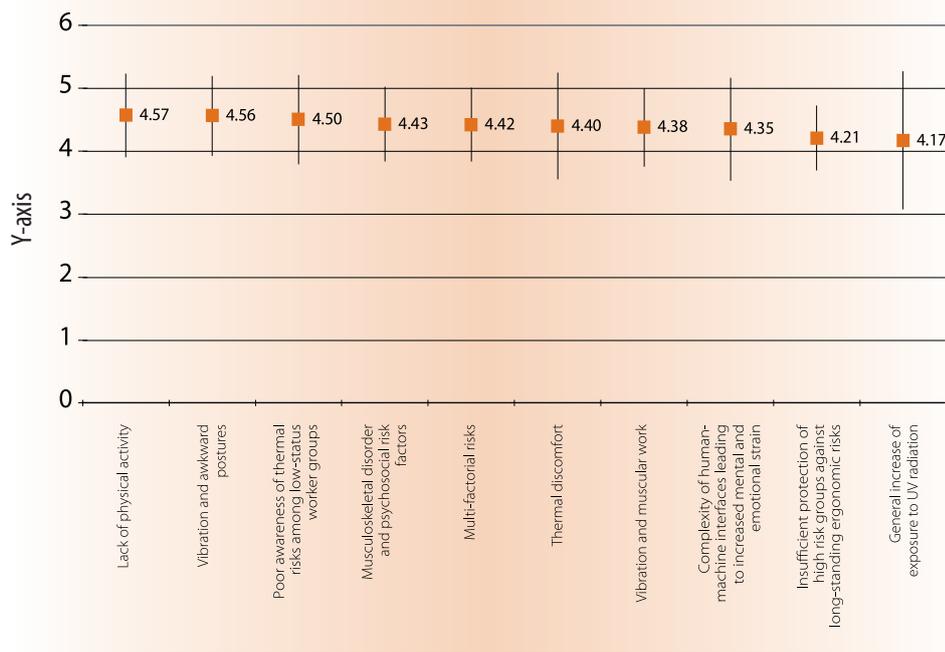
### The 'top' emerging risks as mentioned by the experts

- Lack of physical activity (e.g. prolonged sitting at the workplace, during business trips, or due to the use of automated systems, etc.);
- Combined exposure to vibration and awkward postures;
- Poor awareness of thermal risks among low-status worker groups exposed to unfavourable thermal conditions (e.g. workers in agriculture and construction area working overtime in hot/cold areas such as greenhouses/cold stores);
- Combined exposure to MSD risk factors and psychosocial risk factors (e.g. fear of future, insecurity);
- Multi-factorial risks (e.g. call centres: combined effects of poor ergonomic design, poor work organisation, mental and emotional demands);
- Combined exposure to vibration and muscular work;
- Thermal discomfort (there are prescriptions only against thermal stress, but not against thermal discomfort at industrial workplaces);
- Complexity of new technologies, new work processes and human-machine interfaces leading to increased mental and emotional strain;



- Insufficient protection of high-risk groups (older workers, low status workers, foreign workforce, etc.) against long-standing ergonomic risks;
- General increase of exposure to UV radiation (during leisure time; occupational outdoor activities; new UV technologies at the workplace) increasing the sensitivity to UV radiation at the workplace.

**Diagram 20: The 10 most important emerging physical risks identified in the survey**  
(Y-axis: mean values on the one-to-five point Likert scale and standard deviations)



A literature review enabled more in-depth description of five of the main emerging risks in terms of workplaces concerned, risk factors, health outcomes and solutions:

### Lack of physical activity at the workplace

Occupations with very little physical activity and increased prevalence of MSDs covered in the literature are mainly occupations involving prolonged sitting. Workers concerned are, for instance, crane operators, straddle-carrier drivers, truck and bus drivers, workers in semiconductor factories, workers operating automated systems and machines, workers at VDU workplaces and call centre agents. Published research also highlights occupations involving prolonged-standing.

The effects identified are MSDs of the upper-extremities and of the back, varicose veins, deep-vein thrombosis, obesity, ovarian cancer, breast cancer and renal cancer. Working equipment and work organisation supporting a dynamic alternation of body positions as well as on-site health programmes help preventing the risk.

### Combined exposure to MSD risk factors and psychosocial risk factors

Combined exposure to MSD risk factors and psychosocial risk factors dealt with in the literature is principally related to VDU and call centre jobs, but papers also focus on the healthcare sector and on supermarket cashiers.



The psychosocial factors identified are:

- stress generated by poor ergonomic design of the work equipment, for example of VDU stations;
- high job demand, complex tasks leading to mental exhaustion and high time pressure;
- too low job demand;
- low job control and low decision level;
- poor support from colleagues and from the hierarchy;
- fear of downsizing, job insecurity and fear of unemployment;
- harassment, violence and bullying at work.

Combined exposure to MSD risk factors and psychosocial risk was shown to affect workers' health to a greater extent than single exposure.

The subsequent health outcomes are low-back pains, shoulder and neck pains as well as hand–wrist affections.

Improvements of the workplace ergonomics and of the work organisation are identified as preventive measures identified.

### Multi-factorial risks

Call centre jobs are typical workplaces exposed to multi-factorial risks.

The different risk factors likely to affect call centre agents are prolonged sitting, background noise and poor room acoustics, inadequate headsets, poor room atmosphere, inadequate lighting conditions, poor ergonomic design of the work equipment and inappropriate arrangement of the working premises. There are also factors of a human and organisational nature such as low job control, high time pressure, poor work organisation and high mental and emotional demands.

Various health outcomes could be observed: MSDs, varicose veins, nose and throat diseases, voice disorders, fatigue, stress and burnouts.

### Complexity of human–machine interfaces

Increasingly 'intelligent' but complex human–machine interfaces are used in the air industry and healthcare sectors (e.g. computer-aided surgery). Complex in-cab devices such as remote controls and joysticks to operate heavy trucks and earth-moving machinery also become more common. Cobots, which are 'intelligent' robots teamed with an operator, are increasingly used in handling activities and in complex manufacturing processes.

A poor ergonomics design of such interfaces increases the operator's mental and emotional strain and thus the probability of human errors and of accidents at work.

Methodologies for testing design errors of human–machine are available and should help in reducing handling errors. The interface should be adapted to the workers and their skills instead of the workers having to adapt to the system. The interface should furthermore give proper feedback on the machine operations to the operator. Last but not least, adequate training and information about the system should be provided.



## Ultraviolet radiation

No literature could be found about the effects on workers' sensitivity to occupational UV exposure generated by UV exposure during leisure time. Nevertheless, the need for advice limiting occupational UVR exposure both indoors and outdoors is emphasised.

Beside outdoor workplaces where workers are exposed to sun radiation, occupational sources of UV radiation are found at workplaces where UV-based technologies are used, such as welding tools, dye and paint drying techniques (such as in printing workshops) or UV-based disinfecting applications in the food industry or in the healthcare sector.

Health outcomes of occupational UV exposure include cataracts and different types of cancers: non-Hodgkin's lymphoma, myeloid and lymphocytic leukaemia, lip and stomach cancer, and malignant melanoma or squamous cell carcinomas.

When the hazard cannot be eliminated at source or the exposure reduced to an acceptable level, individual protective measures such as personal protective equipment should be implemented.

## Perspectives

The expert forecast on OSH physical risks is complemented with further forecasts and literature reviews on human, social and organisational risks, and on chemical and biological risks so as to provide as comprehensive a picture as possible of the potential emerging risks in the world of work. The results will be linked to further activities of the Risk Observatory, which consist in the collection of data from European and national OSH monitoring systems and identification of research priorities in Europe. The overall aim of the Risk Observatory is to provide an overview of OSH in Europe, to highlight trends on OSH outcomes and risk factors, to provide early identification of newly emerging risks in the workplace and to identify areas and issues where more information is needed. Information on the activities carried out under the scope of the Risk Observatory are available online on the Risk Observatory web site <sup>(35)</sup> of the European Agency for Safety and Health at Work <sup>(36)</sup>.

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<sup>(35)</sup> <http://riskobservatory.osha.eu.int>

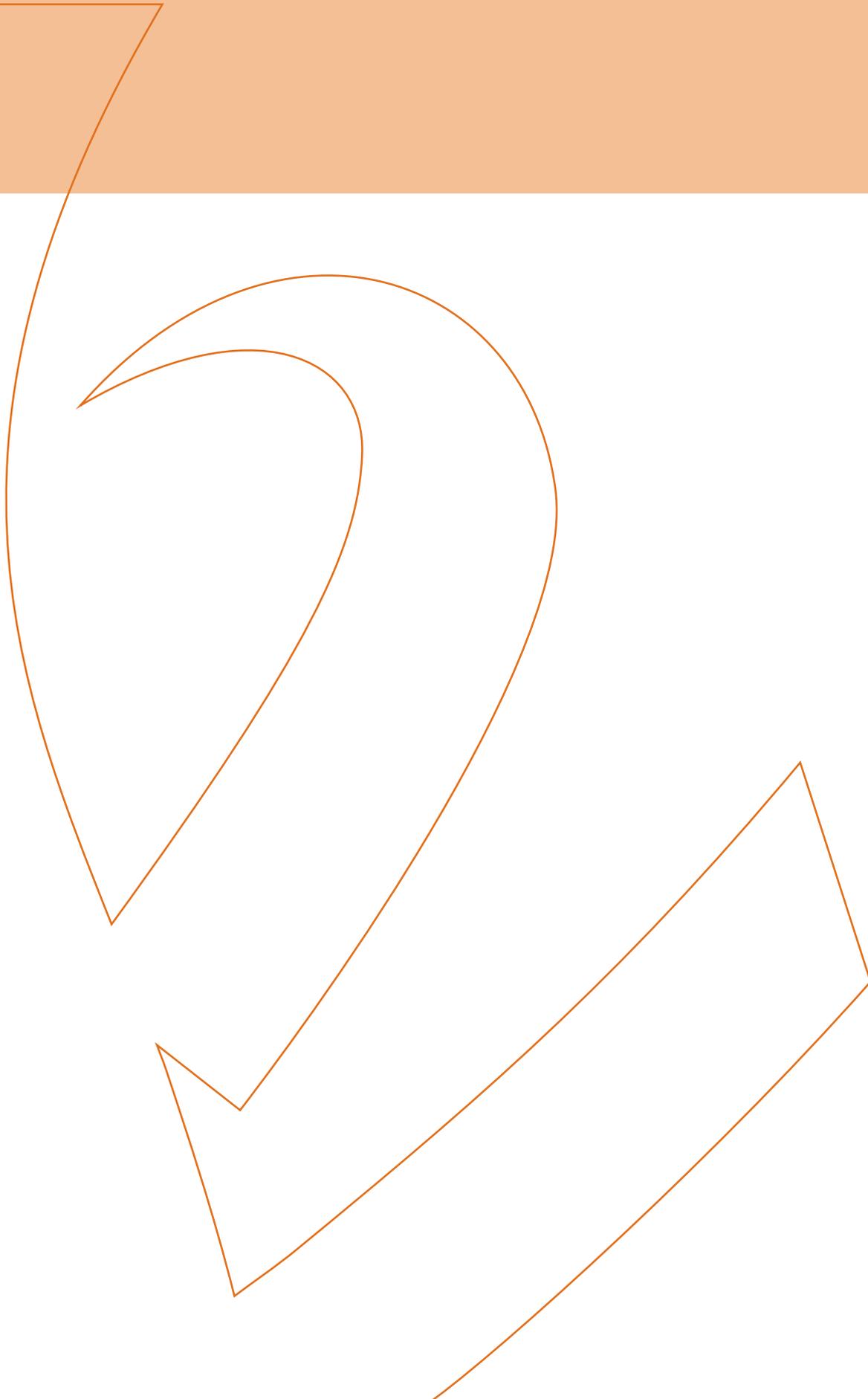
<sup>(36)</sup> <http://osha.eu.int>





# 7.

## ANNEXES



## 7.1

## ANNEX 1

## Organisations contacted for the survey on emerging OSH physical risks

Organisations in which experts:		
Country	were invited to participate	responded to at least one round
Austria	Vienna University of Technology	Yes
Austria	AUVA	No
Austria	Institut für Umwelthygiene	Yes
Austria	Austrian Research Centers – ARCS	Yes
Belgium	Université de Liège	Yes
Belgium	Prevent	Yes
Belgium	Université de Mons	No
Belgium	SCK-CEN Mol	No
Belgium	IKMO	No
Belgium	Association begle de radioprotection	Yes
Belgium	TUTB	No
Belgium	Université de Liège	Yes
Belgium	Université Catholique de Louvain UCL/SEHY	Yes
Belgium	CBMT	Yes
Belgium	Medische arbeidsinspectie (medical labour inspectorate)	No
Belgium	AFCN (agence federale de controle nucléaire)	No
Belgium	Universiteit Gent UGENT	No
Belgium	Université catholique de Louvain Hyperfréquences	Yes
Belgium	Controle Medische Toepassing FANC	Yes
Denmark	Arbejdstilsynet	Yes
Denmark	AMI (National Institute of Occupational Health)	Yes
Finland	Ministry of Social Affairs and Health	Yes
Finland	Finnish Institute of Occupational Health	Yes
Finland	University of Tampere	No
France	INRS	Yes
France	INERIS	No
France	IRSN	Yes



Germany	BGIA	Yes
Germany	Technische Universität München	No
Germany	Bundesanstalt für Arbeitsschutz und Arbeitsmedizin (BAuA)	Yes
Germany	Institut für Arbeitswissenschaft - TU Darmstadt	Yes
Germany	Bundesanstalt für Arbeitsschutz und Arbeitsmedizin (BAuA)	Yes
Greece	Hellenic Ministry of Labour and Social Affairs Centre of Occupational Health and Safety - KYAE	Yes
Ireland	University College Galway	No
Italy	Università di Milano	No
Italy	ISPESL	Yes
Italy	Hospital «Istituti Clinici di Perfezionamento»	Yes
Spain	National Institute for occupational Safety and Hygiene	Yes
Sweden	National Institute for Working Life (NIWL)	Yes
Sweden	Karolinska Institutet	Yes
Switzerland	IST - Institut universitaire romand de santé au travail	No
Switzerland	Federal Institute of Technology (EPFL)	No
Switzerland	SUVA	Yes
Switzerland	Institute for Hygiene and Work Physiology	No
Switzerland	Institut Universitaire de Radiophysique Appliquée	Yes
The Netherlands	TNO Work and Employment	No
The Netherlands	Vrije universiteit Amsterdam	Yes
The Netherlands	University Amsterdam	Yes
The Netherlands	TNO Work and Employment	Yes
United Kingdom	HSE	Yes
United Kingdom	HSL	Yes
USA	NIOSH	Yes
USA	Massachusetts Institute of Technology - MIT	No



# 7.2

## ANNEX 2

### References used in the literature review

Alexy, B. B.: 'Factors associated with participation or non-participation in a workplace wellness center', *Research in Nursing and Health*, vol. 14 (1), pp. 33–40, 1991.

Andersen, J. H.; Kaergaard, A.; Mikkelsen, S.; Jensen, U. F.; Frost, P.; Bonde, J. P.; Fallentin, N. and Thomsen, J. F.: 'Risk factors in the onset of neck/shoulder pain in a prospective study of workers in industrial and service companies', *Occupational and Environmental Medicine*, vol. 60, pp. 649–654, 2003.

Ariens, G. A. M.; Bongers, P. M.; Hoogendoorn, W. E.; van der Wal, G. and van Mechelen, W.: 'High physical and psychosocial load at work and sickness absence due to neck pain', *Scandinavian Journal of Work Environment and Health*, vol. 28, pp. 222–231, 2002.

Baber, C. and Baumann, K.: 'Embedded human computer interaction', *Applied Ergonomics*, vol. 33 (3), pp. 273–287, 2002.  
<http://www.sciencedirect.com/science/article/B6V1W-45CW101-1/2/ef8406e14c28b6a74d91a6756a85e74d>

Beasley, R.; Heuser, P.; Raymond, N.: 'SIT (seated immobility thromboembolism) syndrome: a 21st century lifestyle hazard', *Journal of the New Zealand Medical Association*, vol. 118 (1212), 2005.

Beasley, R.; Raymond, N.; Hill, S.; Nowitz, M. and Hughes, R.: 'Thrombosis: the 21st century variant of venous thromboembolism associated with immobility', *European Respiratory Journal*, vol. 21 (2), pp. 371–6. 2003.

Berg-Perier, M.; Cederblad, A. and Persson, U.: 'Ultraviolet radiation and ultra-clean air enclosures in operating rooms: UV-protection, economy, and comfort', *Journal of Arthroplasty*, vol. 7(4), pp. 457–63, 1992.

Bergstrom, A.; Moradi, T.; Lindblad, P.; Nyren, O.; Adami, H. O. and Wolk, A.: 'Occupational physical activity and renal cell cancer: a nationwide cohort study in Sweden', *International Journal of Cancer*, vol. 83 (2), pp. 186–91, 1999.

Bömer, T.: 'Safety-related radio remote controls for complex machinery' (Sicherheitsrelevante Funkfernsteuerungen für komplexe Maschinen). 2. Internationale Konferenz Sicherheit in der Industrieautomation, 13.-15.11.2001, Bonn - Vortrag. Berichtsband S. 373–382. Hauptverband der gewerblichen Berufsgenossenschaften - HVBG, Sankt Augustin. ISBN: 3-88383-604-4.

Bömer, T.: 'Vision-based protective devices (VBPD) — a vision becomes reality' (Schutzeinrichtungen mit Bildverarbeitung — Eine Vision wird Wirklichkeit). 3. Internationale Konferenz Sicherheit in der Industrieautomation, 13–15.10.2003, Nancy — Vortrag. Berichtsband und CD-ROM, Sitzung 7.1, S. 11-15, 1 Lit., 4 Abb. Hrsg.: Institut National de Recherche et de Sécurité — INRS, Vandoeuvre/Frankreich.



Bömer, T. and Hauke, M.: Anforderungen an sichere Kamerasysteme. 2. Workshop für OTS-Systeme in der Robotik — Mensch und Roboter ohne trennende Schutzsysteme, Fraunhofer IPA Workshop F 88. 24. Juni 2003, Stuttgart — Vortrag. Berichtsband. S. 103-117, 10 Lit., 17 Abb. Hrsg.: Schraft, R.-D.; Westkämper, E.; Sihm, W. Fraunhofer-Institut für Produktionstechnik und Automatisierung, Stuttgart, 2003.

Bongers, P. M.; de Winter, C. R.; Kompier, M. A. and Hildebrandt, V. H.: 'Psychosocial factors at work and musculoskeletal disease', *Scandinavian Journal of Work Environment and Health*, vol. 19 (5), pp. 297–312, 1993.

Brulín, C.; Gerdle, B.; Granlund, B.; Hoog, J.; Knutson, A. and Sundelin, G.: 'Physical and psychosocial work-related risk factors associated to musculoskeletal symptoms among home care personnel', *Scandinavian Journal of Caring Sciences*, vol. 12 (2), pp. 104–110. 1998.

Brun, E; Reinert, D.: Ergonomische Gestaltung von Betriebsanleitungen oder: Tod im Motorenwerk, BIA-Report 8/2004. Hauptverband der gewerblichen Berufsgenossenschaften (HVBG), Sankt Augustin, 2004. ISBN: 3-88383-679-6. <http://www.hvbg.de/d/bia/pub/rep/rep04/bia0804a/index.html>

Buckle, P. W. and Devereux, J. J.: 'The nature of work-related neck and upper limb musculoskeletal disorders'. <http://www1.elsevier.com/pub/14/12/show/top25.htm?issn=00036870>

Burdorf, A.; Naaktgeboren, B. and de Groot, H. C.: 'Occupational risk factors for low back pain among sedentary workers', *Journal of Occupational Medicine*, vol. 35 (12), 1993.

Carayon, P., Smith, M. J. and Haims, M. C.: 'Work organization, job stress, and work-related musculoskeletal disorders', *Human Factors*, vol. 41 (4), pp. 644–663, 1999.

Cazzuli, O. and Giroletti, E.: 'Risk of exposure to UV radiation at biochemical laboratories', *La Medicina del lavoro*, vol. 24 (1), pp. 56–65, 2002.

CCOHS (Canadian Centre for Occupational Health and Safety): 'Why is there so much fuss being made about "sitting"?' 1998. [http://www.ccohs.ca/oshanswers/ergonomics/sitting/sitting\\_overview.html](http://www.ccohs.ca/oshanswers/ergonomics/sitting/sitting_overview.html)

Chandrasakaran, A.; Chee, H. L.; Rampal, K. G. and Tan, G. L.: 'The prevalence of musculoskeletal problems and risk factors among women assembly workers in the semiconductor industry', *The Medical Journal of Malaysia*, vol. 58 (5), pp. 657–666, 2003.

Chee, H. L.; Rampal, K. G. and Chandrasakaran, A.: 'Ergonomic risk factors of work processes in the semiconductor industry in Peninsular Malaysia', *Industrial Health*, vol. 42 (3), pp. 272–281, 2004.

Colditz, G. A.: 'Economic costs of obesity and inactivity', *Medicine and Science in Sports and Exercise*, vol. 31 (11 Suppl), pp. 663–7, 1999.

Connors, M. M.: 'Teaming humans and automated systems in safely engineered environments', *Life Support and Biosphere Science: International Journal of Earth Space*, vol. 5(4), pp. 453–60, 1998.

Coogan, P. F.; Newcomb, P. A.; Clapp, R. W.; Trentham-Dietz, A.; Baron, J. A. and Longnecker, M. P.: 'Physical activity in usual occupation and risk of breast cancer (United States)', *Cancer Causes and Control*, vol. 8 (4), pp. 626–31, 1997.



Cramer, J.; Ellegast, R. P.; von der Heyden, T.; Liedtke, M.; Pfeiffer, W. and Stamm, R.: 'Arbeitsumgebung und Ergonomie', Ccall Report 4, Hrsg.: Verwaltungs-Berufsgenossenschaft, Hamburg, 2001.

[http://www.ccall.de/download\\_dat/ccall\\_report04.pdf](http://www.ccall.de/download_dat/ccall_report04.pdf)

Cuhls, K.: 'Technikvorausschau in Japan — Ein Rückblick auf 30 Jahre Delphi-Expertenbefragungen', Technik, Wirtschaft und Politik, vol. 29, Schriftenreihe des Fraunhofer-Instituts für Systemtechnik und Innovationsforschung (ISI), Physica, Heidelberg, 1998.

Degani, A.; Heymann, M.: 'Formal verification of human-automation interaction', Human Factors, vol. 44 (1), pp. 28–43, 2002.

Devereux, J. J.: 'The role of work stress and psychological factors in the development of musculoskeletal disorders', 2004. <http://www.eihms.surrey.ac.uk/robens/erg/stress.htm>

Devereux, J. J., Vlachonikolis, I. G. and Buckle, P. W.: 'Epidemiological study to investigate potential interaction between physical and psychosocial factors at work that may increase the risk of symptoms of musculoskeletal disorder of the neck and upper limb', Occupational and Environmental Medicine, vol. 59 (4), pp. 269–77, 2002.

Diepgen, T. L. and Drexler, H.: 'Skin cancer and occupational disease', Hautarzt, vol. 55 (1), 2004.

Domenighetti, G.; D'Avanzo, B. and Bisig, B.: 'Health effects of job insecurity among employees in the Swiss population', International Journal of Health Services, vol. 30 (3), pp. 477–90, 2000.

Eklöv, M.: 'Interventions for safe and healthy work', Arbete och Hälsa, vol. 12, 2004.

Ellegast, R. P.; Glitsch, U.; Knipfer, C.: Application of an electronic measurement system for assessment of the sitting posture of bus drivers — a field study (Anwendung eines elektronischen Messsystems zur Beurteilung der Sitzhaltung von Busfahrern — Eine Feldstudie). Congress Digitale Mensch-Modellierung, 18–22 Juni 2002, München — Presentation, VDI-Berichte, vol. 1675, pp. 367–375, VDI-Verlag, Düsseldorf, 2002, ISBN: 3-18-091675-3

Ellegast, R.P.; Herda, C.; Hoehne-Hückstädt, U.; Lesser, W.; Kraus, G.; Schwan, W.: Ergonomie an Näharbeitsplätzen. In: BIA-Report 7/2004. Hauptverband der gewerblichen Berufsgenossenschaften (HVBG), Sankt Augustin, 2004. ISBN: 3-88383-673-7. [http://www.hvbg.de/d/bia/pub/rep/rep04/pdf\\_datei/biar0704/bia0704.pdf](http://www.hvbg.de/d/bia/pub/rep/rep04/pdf_datei/biar0704/bia0704.pdf)

European Agency for Safety and Health at Work: Inventory of socio-economic information about work-related musculoskeletal disorders in the Member States of the European Union, Factsheet 9, 2000. [http://agency.osha.eu.int/publications/factsheets/9/en/facts9\\_en.pdf](http://agency.osha.eu.int/publications/factsheets/9/en/facts9_en.pdf)

European Foundation for the Improvement of Working and Living Conditions: 'European survey on working conditions', ESCW, Dublin, 2000. <http://www.eurofound.eu.int/working/surveys/index.htm>

Evans, W. and Johnson, D.: 'Stress and open-office noise', Journal of Applied Psychology, vol. 85 (5), pp. 779–783, 2000.



Faucett, J. and Rempel, D.: 'VDT-related musculoskeletal symptoms: interactions between posture and psychosocial work factors', *American Journal of Industrial Medicine*, vol. 26 (5), pp. 597–612, 1994.

Ferreira Junior, M.; Conceicao, G. M. and Saldiva, P. H.: 'Work organization is significantly associated with upper extremity musculoskeletal disorders among employees engaged in interactive computer-telephone tasks of an international bank subsidiary in Sao Paulo, Brazil', *American Journal of Industrial Medicine*, vol. 31 (4), pp. 468–73, 1997.

Ferreira Junior, M. and Saldiva, P. H. N.: 'Computer telephone interactive tasks: predictors of musculoskeletal disorders according to work analysis and workers' perception', *Applied Ergonomics*, vol. 33, pp. 147–153, 2002.

FIRU, Forschungsinstitut für integrative Raumluftqualität und Umwelttechnologie e.V.: *Leben in Räumen*. Neuötting, July 2001.

Fracassi, G.: 'Musculoskeletal disorders and the change in work organization', *La Medicina del lavoro*, vol. 23 (2), pp. 156–9, 2001.

Fritz, J. M.; George, S. Z. and Delitto, A.: 'The role of fear-avoidance beliefs in acute low back pain: relationships with current and future disability and work status', *Pain*, vol. 94 (1), pp. 7–15, 2001.

Gies, P. and Wright, J.: 'Measured solar ultraviolet radiation exposures of outdoor workers in Queensland in the building and construction industry', *Photochemistry and Photobiology (United States)*, vol. 78 (4), pp. 342–8, 2003.

Guénel, Pascal; Laforest, L. and Lynge, E.: 'Facteurs de risque professionnels, rayonnements ultraviolets et mélanome oculaire: une étude cas-témoin réalisée en France', *Cahiers de Notes Documentaires – Hygiène et Sécurité du Travail*, vol. 189, pp. 7–14, 2002.

Gunnarsdottir, H. K.; Rafnsdottir, G. L.; Helgadottir, B. and Tomasson, K.: 'Psychosocial risk factors for musculoskeletal symptoms among women working in geriatric care', *American Journal of Industrial Medicine*, vol. 44 (6), pp. 679–84, 2003.

Hakansson, N.; Floderus, B.; Gustavsson, P.; Freychting, M. and Halling, N.: 'Occupational sunlight exposure and cancer incidence among construction workers', *Epidemiology*, vol. 12 (5), pp. 552–7, 2001.

Halford, V. and Cohen, H. H.: 'Technology use and psychosocial factors in the self-reporting of musculoskeletal disorders symptoms in call center workers', *Journal of Safety Research*, vol. 34 (2), pp. 167–73, 2003.

Harkness, E. F.; Macfarlane, G. J.; Nahit, E. S.; Silman, A.J. and McBeth, J.: 'Mechanical and psychosocial factors predict new onset shoulder pain: a prospective cohort study of newly employed workers', *Occupational and Environmental Medicine*, vol. 60, pp. 850–857, 2003.

Health and Safety Executive (HSE): 'Skin at work: outdoor workers and sun exposure', 2005. <http://www.hse.gov.uk/skin/sunprotect.htm>

Herda, C.; Brun, E.; Ellegast, R.P. and Hauke, M.: *Muskel-Skelett-Belastungen an Call-center-Arbeitsplätzen*. Herbstkonferenz 2002 der Gesellschaft für Arbeitswissenschaft.



Technische Universität Illmenau. Ergonomie, moderne Bürokonzepte und Prävention, 26–27 October 2002, Illmenau. Vortrag. Tagungsband. S. 4. Hrsg.: Technische Universität Illmenau. 2002.

Herda, C.; Ellegast, R. P.; Ditchen, D.: 'Qualitative and quantitative assessment of musculoskeletal risk factors: a comparative ergonomic evaluation of crane operator workplaces' (Qualitative und quantitative Erfassung von muskuloskelettalen Risikofaktoren: Eine vergleichende ergonomische Untersuchung von Kranfahrerarbeitsplätzen). 2nd International Conference on Occupational Risk Prevention, 20–22 February 2002, Gran Canaria, 2002.

Hoogendoorn, W. E.; Bongers, P. M.; de Vet, H. C.; Houtman, I. L.; Ariens, G. A.; van Mechelen, W. and Bouter, L. M.: 'Psychosocial work characteristics and psychological strain in relation to low back-pain', *Scandinavian Journal of Work Environment and Health*, vol. 27 (4), pp. 258–6, 2001.

Houtman, I. L.; Bongers, P. M.; Smulders, P. G. and Kompier, M. A.: 'Psychosocial stressors at work and musculoskeletal problems', *Scandinavian Journal of Work Environment and Health*, vol. 20 (2), pp. 139–45, 1994.

Hsu, W.-H. and Wang, M.-J.: 'Physical discomfort among visual display terminal users in a semiconductor manufacturing company', *American Industrial Hygiene Association Journal*, vol. 64, pp. 276–282, 2003.

Huang, G. D. and Feuerstein, M.: 'Identifying work organization targets for a work-related musculoskeletal symptom prevention program', *Journal of Occupational Rehabilitation*, vol. 14 (1), pp. 13–30, 2004.

Huang, G. D.; Feuerstein, M.; Kop, W. J.; Schor, K. and Arroyo, F.: 'Individual and combined impacts of biomechanical and work organization factors in work-related musculoskeletal symptoms', *American Journal of Industrial Medicine*, vol. 43 (5), pp. 495–506, 2003.

International Agency for Research on Cancer (IARC): 'Solar and ultraviolet radiation — 5. Summary of data reported and evaluation', *IARC Monographs*, vol. 55, 1997. <http://www-cie.iarc.fr/htdocs/monographs/vol55/solar-and-uv-radiation.htm>

Ijzelenberg, W.; Molenaar, D. and Burdorf, A.: 'Different risk factors for musculoskeletal complaints and musculoskeletal sickness absence', *Scandinavian Journal of Work Environment and Health*, vol. 30 (1), pp. 56–63, 2004.

Jensen, C.: 'Development of neck and hand-wrist symptoms in relation to duration of computer use at work', *Scandinavian Journal of Work, Environment and Health*, vol. 29 (3), 197–205, 2003.

Joksimovic, L.; Starke, D.; v.d. Knesebeck, O. and Siegrist, J.: 'Perceived work stress, overcommitment and self-reported musculoskeletal pain: a cross-sectional investigation', *International Journal of Behavioral Medicine*, vol. 9 (2), pp. 122–38, 2002.

Kivimaki, M.; Vahtera, J.; Ferrie, J. E.; Hemingway, H. and Pentti, J.: 'Organisational downsizing and musculoskeletal problems in employees: a prospective study', *Occupational and Environmental Medicine*, vol. 58 (12), pp. 811–817, 2001.

Korhonen, T.; Ketola, R.; Toivonen, R.; Luukkonen, R.; Hakkanen, M.; Vii, Xy and Juntura,



E.: 'Work-related and individual predictors for incident neck pain among office employees working with video display units', *Occupational and Environmental Medicine*, vol. 60 (7), pp. 475–82, 2003.

Kruk, J. and Aboul-Enein, H. Y.: 'Occupational physical activity and the risk of breast cancer', *Cancer Detection and Prevention*, vol. 27 (3), pp. 187–92, 2003.

Laursen, B.; Jensen, B. R.; Garde, A. H. and Jorgensen, A. H.: 'Effect of mental and physical demands on muscular activity during the use of a computer mouse and a keyboard', *Scandinavian Journal of Work Environment and Health*, vol. 28, pp. 215–221, 2002.

Leclerc, A.; Chastang, J.-F.; Niedhammer, I.; Landre, M.-F.; Roquelaure, Y.: 'Study group on repetitive work', *Occupational and Environmental Medicine*, vol. 61, pp. 39–44, January 2004.

Leino, P. I. and Hanninen, V.: 'Psychosocial factors at work in relation to back and limb disorders', *Scandinavian Journal of Work and Environmental Health*, vol. 21 (2), pp. 134–42, 1995.

Levenstein, S.; Smith, M. W. and Kaplan, G. A.: 'Psychosocial predictors of hypertension in men and women', *Archives of Internal Medicine*, vol. 161 (19), pp. 1341–6, 2001.

Lund, T. and Csonka, A.: 'Risk factors in health, work environment, smoking status, and organizational context for work disability', *American Journal of Industrial Medicine*, vol. 44 (5), pp. 492–501, 2003.

Lyons, J.: 'Factors contributing to low back pain among professional drivers: a review of current literature and possible ergonomic controls', *Work*, vol. 19 (1), pp. 95–102, 2002.

Malchaire, J.; Roquelaure, Y.; Cock, N. and Piette, A.: 'Troubles musculosquelettiques des poignets: influence directe ou indirecte des facteurs psychologiques et organisationnels', *Cahiers de Notes Documentaires – Hygiène et Sécurité du Travail*, vol. 185, pp. 23–33, 2001.

Mitsuya, R.; Ebine, Y.; Nozaki, M.; Noro K.: 'Prevention of deep-vein thrombosis in VDU work', *International Journal of Occupational Safety and Ergonomics*, vol. 9 (4), pp. 393–403, 2003.  
<http://www.ciop.pl/757.html>

Mohren, D. C.; Swaen, G. M.; Van Amelsvoort, L. G.; Borm, P. J. and Galama, J. M.: 'Job insecurity as a risk factor for common infections and health complaints', *Journal of Occupational and Environmental Medicine*, vol. 45 (2), pp. 123–9, 2003.

Müller-Breitenkamp, U.; Hockwin, O.; Siekmann, H.; Dragomirescu, V.: 'Ultraviolet radiation as a cataract risk factor — a case report' (Grauer Star durch UV-Strahlung — eine Fallbeschreibung). *International Forum on Advanced Techniques in Lens and Cataract Research: Cataract Epidemiology*. 6–8. June 1995, Kanazawa — Vortrag, *Developments in Ophthalmology*, vol. 27, pp. 76–80. Verlag Karger, Basel, 1997.

Nahit, E. S.; Hunt, I. M.; Lunt, M.; Dunn, G.; Silman, A. J. and Macfarlane G. J.: 'Effects of psychosocial and individual psychological factors on the onset of musculoskeletal pain: common and site-specific effects', *Annals of the Rheumatic Diseases*, vol. 62 (8), pp. 755–60, 2003.



National Radiological Protection Board (NRPB): 'Health effects from ultraviolet radiation: report of an advisory group on non-ionising radiation', Documents of the NRPB, vol. 13(1), 2002.

[http://www.hpa.org.uk/radiation/publications/documents\\_of\\_nrp/b/pdfs/doc\\_13\\_1.pdf](http://www.hpa.org.uk/radiation/publications/documents_of_nrp/b/pdfs/doc_13_1.pdf)

Niedhammer, I.; Landre, M. F.; LeClerc, A.; Bourgeois, F.; Franchi, P.; Chastang, J. F.; Mari-gnac, G.; Mereau, P.; Quinton, D.; Du Noyer, C. R.; Schmaus, A. and Vallayer, C.: 'Shoulder disorders related to work organization and other occupational factors among super-market cashiers', International Journal of Occupational and Environmental Health, vol. 4 (3), pp. 168–78, 1998.

Nordstrom, M.; Hardell, L.; Magnuson, A.; Hagberg, H. and Rask-Andersen, A.: 'Occu-pation and occupational exposure to UV light as risk factors for hairy cell leukaemia evaluated in a case-control study', European Journal of Cancer Prevention, vol. 6 (5), pp. 467–472, 1997.

Norman, D. A.: 'The "problem" with automation: inappropriate feedback and interac-tion, not "over-automation"', Philosophical Transactions of the Royal Society of London. Series, B, Biological Sciences, vol. 327 (1241), pp. 585–93, 1990.

Norman, K.; Nilson, T.; Hagberg, M.; Tornqvist, E. W. and Toomingas, A.: 'Working condi-tions and health among female and male employees at a call center in Sweden', Ame-rican Journal of Industrial Medicine, vol. 46 (1), pp. 55–62, 2004.

Pekarski, S. E.: 'A gravitational hypothesis of essential hypertension as a natural adap-tation to increased gravitational stress caused by regular, prolonged sitting typical of modern life', Medical Science Monitor: International Medical Journal of Experimental and Clinical Research, vol. 10 (6), pp. 27–32, 2004.

Perez-Gomez, B.; Pollan, M.; Gustavsson, P.; Plato, N.; Aragones, N. and Lopez, X. Y.: 'Cu-taneous melanoma: hints from occupational risks by anatomic cite in Swedish men', Occupational Environmental Medicine, vol. 61 (2), pp. 117–26, 2004.

Piazzzi, A.; Bolino, G. and Mattioli, S.: 'Spinal pathology in self-employed truck drivers', La Medicina del lavoro, vol. 82 (2), pp. 122–30, 1991.

Reason, J.: 'Understanding adverse events: human factors', Quality of Healthcare, vol. 4 (2), pp. 80–9, 1995.

Sauter, S. L.; Hurrell, J. J. Jr.; Fox, H. R.; Tetrick, L. E. and Barling, J.: 'Occupational health psychology: an emerging discipline', Industrial Health, vol. 37 (2), pp. 199–211, 1999.

Schmauder, M.; Zieschang, H.; Prescher, W.; Paritschkow, S. and Müller-Gethmann, H.: 'Funktionelle Auslegung von Joystick-Steuerungen in Erdbaumaschinen — Gewähr-leistung der Arbeitssicherheit', Wissensportal baumaschine.de, vol. 1, 2004.

Shannon, H. S.; Robson, L. S. and Sale, J. E.: 'Creating safer and healthier workplaces: role of organizational factors and job characteristics', American Journal of Industrial Medicine, vol. 40 (3), pp. 319–34, 2001.

Shinnar, A.; Indelicate, J.; Altimari, M. and Shinnar, S.: 'Survey of ergonomic features of supermarket cash registers', International Journal of Industrial Ergonomics, vol. 34, pp. 535–541, 2004.



Siekmann, H.: UV-Strahlenexpositionen an Arbeitsplätzen - Grenzwerte, Meßverfahren, Schutzmaßnahmen – Grenzwerte, Messverfahren, Schutzmaßnahmen. Sicherheitstechnisches Informations- und Arbeitsblatt 220 235, 5. Lfg. II/87. In: BGIA-Handbuch Sicherheit und Gesundheitsschutz am Arbeitsplatz. Berufsgenossenschaftliches Institut für Arbeitsschutz - BGIA. 2. Auflage. Erich Schmidt Verlag, Berlin, 2003. ISBN: 3 503 07417 1

Siekmann, H.: 'Vorsicht Sonne!', BIA-Info 6/2001, Arbeit und Gesundheit spezial, vol. 52 (6). 2001. [http://www.hvbg.de/d/bia/pub/bai/pdf\\_datei/info0601.pdf](http://www.hvbg.de/d/bia/pub/bai/pdf_datei/info0601.pdf)

Smith, M. J.: 'Psychosocial aspects of working with video display terminals and employee physical and mental health', Ergonomics, vol. 40 (10), pp. 1002–15, 1997.

Smith, M. J.; Conway, F. T. and Karsh, B. T.: 'Occupational stress in human–computer interaction', Industrial Health, vol. 37 (2), pp. 157–73, 1990.

Spetzger, U.; Hubbe, U.; Struffert, T.; Reinges, M. H.; Krings, T.; Krombach, G. A.; Zentner, J.; Gilsbach, J. M. and Stiehl, H. S.: 'Error analysis in cranial neuronavigation', Minimally Invasive Neurosurgery, vol. 45 (1), pp. 6–10, 2002.

Sportelli, A.; Raestrup, B.: Call Center Agent als Sprechberuf – Belastungsfaktoren und Stimmerkrankungen. CCall Report 2. Verwaltungs-Berufsgenossenschaft. Hamburg, 2001.  
[http://www.ccall.de/download\\_dat/ccall\\_report02.pdf](http://www.ccall.de/download_dat/ccall_report02.pdf)

Strazdins, L.; D'Souza, R. M.; L-Y Lim, L.; Broom, D. H. and Rodgers, B.: 'Job strain, job insecurity, and health: rethinking the relation', Journal of Occupational Health and Psychology, vol. 9 (4), pp. 296–305, 2004.

Stubbs, D. A.: 'Ergonomics and occupational medicine: future challenges', Occupational Medicine, vol. 50 (4), pp. 277–282, 2000.

Tenkate, T. D. and Collins, M. J.: 'Personal ultraviolet radiation exposure of workers in a welding environment', American Industrial Hygiene Association Journal, vol. 58 (1), pp. 33–8.1997.

Toomingas, A.; Nilsson, T.; Hagberg, M.; Hagman, M. and Wigaeus Tornqvist, E.: 'Symptoms and clinical findings from the musculoskeletal system among operators at a call centre in Sweden — a 10-month follow-up study', International Journal of Occupational Safety and Ergonomics, vol. 9 (4), pp. 405–418, 2003.

Vahtera, J.; Kivimaki, M.; Pentti, J. and Theorell, T.: 'Effect of change in the psychosocial work environment on sickness absence: a seven-year follow up of initially healthy employees', Journal of Epidemiology and Community Health, vol. 54 (7), pp. 484–93, 2000.

Visarius, H.; Gong, J.; Scheer, C.; Haralamb, S. and Nolte, L. P.: 'Man–machine interfaces in computer assisted surgery', Computer Aided Surgery, vol. 2 (2), pp. 102–7, 1997.

Von der Heyden, T.: Softwareergonomie - Grundlegende Konzepte für Call Centre. Ccall – erfolgreich und gesund arbeiten im Call Centre. Verwaltungs-Berufsgenossenschaft. Hamburg, 2001.  
[http://www.ccall.de/download\\_dat/web\\_software.pdf](http://www.ccall.de/download_dat/web_software.pdf)



Wahlström, J.; Lindegard, A.; Ahlborg, G.; Ekman, A. and Hagberg, M.: 'Perceived muscular tension, emotional stress, psychological demands and physical load during VDU work', *International Archives of Occupational and Environmental Health*, vol. 76, pp. 584–590, 2003.

Warren, N.: 'Work stress and musculoskeletal disorder etiology: the relation of psychosocial and physical risk factors', *Work*, vol. 17 (3), pp. 221–234, 2001.

Westgaard, R. H.: 'Work-related musculoskeletal complaints: some ergonomics challenges upon the start of a new century', *Applied Ergonomics*, vol. 31 (6), pp. 569–580, 2000.

Wierwille, W.; Tijerina, L.; Kiger, S.; Rockwell, T.; Lauber, E. and Bittner, A.: 'Heavy vehicle driver workload assessment, Task 4: Review of workload and related research'. <http://www.nhsadot.gov>

Wong, J. C.; Aireay, D. K. and Fleming, R. A.: 'Annual reduction of solar UV exposure to the facial area of outdoor workers in southeast Queensland by wearing a hat', *Photodermatology, Photoimmunology and Photomedicine*, vol. 12 (3), 131–5, 1996.

Yip, V. Y.: 'New low back pain in nurses: work activities, work stress and sedentary lifestyle', *Journal of Advanced Nursing*, vol. 46 (4), pp. 430–40, 2004.

Ylipaa, V.; Arnetz, B. B.; Benko, S. S. and Ryden, H.: 'Physical and psychosocial work environments among Swedish hygienists: risk indicators for musculoskeletal complaints', *Swedish Dental Journal*, vol. 21 (3), pp. 111–. 1997.

Yu, I. T. and Wong, T. W.: 'Musculoskeletal problems among VDU workers in a Hong Kong bank', *Occupational Medicine (London)*, vol. 46 (4), pp. 275–80, 1996.

Zander, J. E.; King, P. M. and Ezenwa, B. N.: 'Influence of flooring conditions on lower leg volume following prolonged standing', *International Journal of Industrial Ergonomics*, vol. 34, pp. 279–288, 2004.

Zapf, D.: *Arbeits- und Organisationspsychologische Untersuchungen in Call Centern. CCall – Report 14. Verwaltungs-Berufsgenossenschaft, Hamburg, 2001.* [http://www.ccall.de/download\\_dat/ccall\\_report14.pdf](http://www.ccall.de/download_dat/ccall_report14.pdf)

Zhang, M.; Xie, X.; Lee, A. H. and Binns, C. W.: 'Sedentary behaviours and epithelial ovarian cancer risk', *Cancer Causes and Control: CCC*, vol. 15 (1), pp. 83–9, 2004.

Zieschang, H.; Müller-Gethmann, G.: *Ergonomische Anforderungen an Multifunktionsstellteile bei Erdbaumaschinen.* In: BGAG-Report 2/2004. Hauptverband der gewerblichen Berufsgenossenschaften (HVBG), Sankt Augustin, 2004. ISBN: 3-88383-665-6. [http://www.hvbg.de/d/bgag/publik/rep/bgag2\\_04.pdf](http://www.hvbg.de/d/bgag/publik/rep/bgag2_04.pdf)







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