Knowledge compilation 2016:8

Healthy workplaces for women and men of all ages

ARBETSMILJÖ VERKET

Healthy workplaces for women and men of all ages

Gunnar Aronsson, professor, Department of Psychology at Stockholm University
Kerstin Nilsson, doctor of medical science and PhD, occupational and environmental medicine at Lund University, and work science, economy and environmental psychology at the Swedish University of Agricultural Sciences (SLU)
Boo Johansson, professor, Department of Psychology at the University of Gothenburg
Maria Albin, MD, professor at Karolinska Institutet and Director of the Center for Occupational and Environmental Medicine, Stockholm County Council
Margareta Torgén, MD, senior physician at Akademiska University Hospital in Uppsala
Per Nylén, associate professor at the Royal Institute of Technology in Stockholm
Kerstin Persson Waye, professor, occupational and environmental medicine at the University of Gothenburg
Eva Vingård, MD, professor, occupational and environmental medicine at Uppsala University
Carin Håkansta, doctor of work science at Luleå University of Technology

ISBN: 1650-3171
Cover photo: Mikael Gustavsen and Mia Åkermark, Orasis
Printing: Elanders Sverige AB 2017z

Contents

Foreword

Every year, the Swedish Work Environment Authority publishes a number of knowledge compilations, in which renowned researchers summarise the state of knowledge in different areas. All knowledge compilations are made within the authority's framework of knowledge brokering, and are available free of charge on the Swedish Work Environment Authority website. There are also videos and presentations from the seminars we organize in conjunction with publication of the knowledge compilations.

This knowledge compilation has been produced on the occasion of the European Occupational Safety and Health Agency campaign 2016-2017: A healthy and safe work environment throughout working life.

A scientific review and coordination of knowledge compilation has been carried out by Professor Eva Vingård, occupational and environmental medicine at Uppsala University. The final design of the individual chapters, however, is the responsibility of the authors themselves.

Project manager for the knowledge compilation at the Swedish Work Environment Authority has been Dr Carin Håkansta. We also wish to thank other colleagues at the authority who have assisted in the work with the knowledge compilation.

The opinions expressed in this publication are those of the authors and do not necessarily reflect those of the Swedish Work Environment Authority.

Ann Ponton Klevestedt
Head of the Statistics and Analysis Unit
Swedish Work Environment Authority

Author introductions

Gunnar Aronsson is a professor of work and organizational psychology and works at the Department of Psychology, Stockholm University. He has published a large number of scientific articles on work, stress, recovery, health, sickness presenteeism and absenteeism. He is author of the book Work without boundaries - Psychological perspectives on the new working life (Wiley-Blackwell 2011).

Kerstin Nilsson has a PhD in public health, epidemiology, and a PhD in work science. She currently works as a university lecturer and researcher in the Division of Occupational and Environmental Medicine at Lund University and the Department of Work Science, Business Economy and Environmental Psychology at the Swedish University of Agricultural Sciences (SLU). She has, since 2003, conducted research and authored several publications on older people in the workplace and the factors that contribute to a sustainable and healthier working life.

Boo Johansson is a professor of psychology, particularly the psychology of ageing, at the Department of Psychology, University of Gothenburg. Since the 1970s, his research has focused on cognitive and mental health in late adulthood, and ageing. He is involved in several longitudinal population-based studies and is currently responsible for a study on health and well-being, in which one examines people before and after retirement.

Maria Albin is a MD, specialist in occupational and environmental medicine, professor of occupational and environmental Medicine at Karolinska Institutet and Director of the Center for Occupational and Environmental Medicine at Stockholm County Council. She leads research programs for the elderly in working life, working with evidence-based primary prevention methodology for occupational health services.

Margareta Torgén is MD and a specialist in occupational medicine and works as a senior physician in occupational and environmental medicine at Uppsala University Hospital. She has a PhD in the field of exercise physiology and is attached as a researcher to the Department of Medical Sciences at Uppsala University. She has long been active in projects related to the balance between work demands and the ability of the individual through epidemiological studies and method development in the area of occupational health.

Per Nylén is associate professor of industrial occupational science, employed at the Swedish Work Environment Authority and at the Royal Institute of Technology in Stockholm. He received his doctorate at the Karolinska Institute in 1994, with a dissertation on the synergistic effects on the retina from exposure to light and chemicals. He has supervised a number of PhD dissertations on ergonomics and lighting, and is the author of the book ”Vision and Lighting at Work” published in 2012.

Kerstin Persson Waye is a professor of environmental medicine, particularly noise research in occupational and environmental medicine, University of Gothenburg, and the research team leader for acoustic environment and health. She leads research into auditory effects in female-dominated professions, of noise impact on children and sleep impact of community noise. She has participated in several national and international knowledge compilations, and is involved in the development of the WHO’s guideline values for noise.

Eva Vingård is MD and specialist in occupational and environmental medicine. In 2005 she was appointed professor of occupational and environmental medicine at Uppsala University. Since 2014, she has emeritus status. Eva Vingård has conducted research in broad areas of occupational medicine, and, in recent years, has been in the Swedish Agency for Health Technology Assessment and Assessment of Social Services report ”The significance of work for cardiovascular disease,” and ”The significance of work for osteoarthritis.” She was also president of Forte’s research overview ”Mental health, work and sick leave.”

Carin Håkansta is a PhD in Work Sciences at Luleå University of Technology. She earned her PhD in 2014 with a dissertation on Swedish working life research and has worked with research and analysis of working life issues, both in Sweden and abroad. She is currently a senior analyst at the Swedish Work Environment Authority and secretary of an ongoing government public inquiry into a national centre for knowledge and evaluation of the work environment.

Summary

The aim of this knowledge compilation is to contribute with knowledge about the work environment in relation to the ever-older workforce. How do employee needs and possibilities change from a course of life perspective? What should the employer and other work environment actors think about in order for the workforce to be able to and want to work to a high age?

The Swedish Work Environment Authority wishes to give an overarching knowledge profile of different aspects of the work environment and the ageing workforce, and we therefore asked seven researchers to summarise the research-based knowledge within each of their areas, from a course of life and gender perspective. An eighth researcher acted as an editor for the anthology, and has also written the preface.

In summary, the report shows that we are becoming even healthier, living ever longer and working to an ever higher age. Older people in the workforce are positive for the economy because productivity increases, and the business sector can make use of competent and experienced staff for a longer time. But for the older labour force to be healthy and want to work at higher ages, one needs to take into consideration how ageing influences health and the capacity to work. With age, all people are affected to different degrees by reduced vision, hearing and physical capacity, as well as longer reaction times. Even their cognitive capacity changes. Certain cognitive abilities are strengthened with rising age, while others deteriorate. With an ageing workforce, more employees have chronic illnesses, which, however, seldom affect the actual working ability. Changes in working life also affect health and wellbeing, for example deregulated work and the technical development. Age and previous experiences impact upon our ability to adapt to these changes. One factor that promotes adaptation is partly resilience (that is to say, resistance and the ability to adapt to the new), partly compensation strategies when the mental and physical resources change. There are no great differences between gender when it comes to the consequences of ageing on health and wellbeing in the work. On the other hand, the public health trend shows increasing differences in health between the lower educated and the higher educated - a difference increasing more quickly among women than among men. The gender-segregated labour market also means that more women than men work in physical and mentally burdensome work. Attitudes at the workplace also affect wellbeing and the will to continue working at higher ages. Men tend to be more sensitive to age discrimination while women run the risk of double discrimination, that is to say based upon both gender and age. Work

environment and the attitude to an older workforce are central to the considerations that an employee makes in the choice between continuing to work and retiring. Other prerequisites that influence the decision are one's own health, private finances and self-fulfilling activities.

The employer can do a great deal to lengthen and improve their employees' working life. Systematic work environment management benefits everyone, and it can contribute to everyone keeping their working ability and to older people wanting to and being able to work for longer. Occupational health services of good quality also play an important role. Technical aids and adaptation of the working pace and working tasks are other measures that improve the work environment for the older workforce. The employer can also contribute to stimulating work arrangements and organisational support for the employees in order to strengthen their resilience and promote the development of compensation strategies.

Extended summary

This extended summary contains parts of all the researchers' contributions and thoughts, and relevant references can be found in the respective author's chapter. Within parentheses is stated to which chapter the text refers.

To be able to and be allowed to work and thereby support oneself should be a right for everyone. Not so many generations back, it was forbidden for married women to work outside the home or the farm. The ban on women holding higher positions within the state sector was removed as late as 1923 (with the exception of the military, the clergy and judges), and it was first in 1925 that female physicians were allowed to work at state hospitals. The Swedish labour market is now open to women in all professions but is, despite this, segregated. Women dominate in certain occupations, for example within healthcare and social care, while men dominate within the manufacturing industry. However, when exposed to similar factors in working life women and men react in the same way. That was shown in the latest systematic reviews from the Swedish Agency for Health Technology Assessment and Assessment of Social Services (SBU) about the significance of work exposures for depression and burnout, cardiovascular illnesses and osteoarthritis, as well as in Forte's systematic review of 'mental ill health, work and sick leave' (Forte, 2015)

WORK IS GOOD FOR HEALTH

Apart from the right and need to support oneself, is working good for health? From a Swedish perspective, the answer is generally yes. In a society where working is the norm, it has several negative consequences for a person to be outside the labour market, apart from purely economic effects. Social exclusion affects the social life, the feeling of context, and the person's social status. Unemployment researchers and others have defined the positive effects of work:

- Work structures the time.
- Work creates meaning.
- Work gives status and identity.
- Work encourages activity and creativity.

But unhealthy jobs and bad work environments exist and must be eliminated through state supervision, agreements between the partners on the labour market and individual initiatives at every workplace. Positive work environments must be strengthened in the same way. During working life, the individual faces different demands and opportunities in the interplay between work and private life. There are times of stress for young people who have limited experience of working life and at the same time should start a family, and there are challenges in being older and deal with the changes this entails.

EXTERNAL LIVING CONDITIONS AFFECT HEALTH

The difference in the expected remaining average life expectancy from the age of 30 increased during the period 2000 – 2015, in a comparison between groups with different education levels. This is shown by new data from Statistics Sweden. A comparison between groups with secondary and tertiary education levels respectively, the gap has increased from 4.1 to 5.4 years for women and from 4.6 to 5.8 years for men.

External living conditions affect the body and the brain during our entire life. There are many factors over the whole lifespan that influence people, and contribute to tangible differences in health and functional ability between individuals of the same age. A long life means that the person has been able to acquire much experience and new knowledge, but also an increased risk of him or her being exposed to factors that contribute to worsened health.

AGEING MEANS PHYSICAL AND COGNITIVE CHANGES

This knowledge compilation is firstly about the older workforce and its possibilities and limitations. There is not a definite boundary when someone is classified as older, because it is dependent of the actual situation. A dancer or a professional athlete becomes old early within their profession, while an artist or politician can carry on their work to a high age.

Research into ageing has been largely about the very old (80+) but to a lesser extent about persons in the group 60+ who are still in the labour force. With increasing age, most individuals have deteriorated muscle strength, physical endurance and mobility, vision and hearing. Age is associated with several non-communicable diseases but at the same time treatment is improving so that more people survive without lasting loss of function and do not need any special adaption. This means that more people can work to a higher age than previously, but also that more people in the active workforce have a chronic illness. The possibility of working increases further with a good work environment and with the support of qualified occupational health care services that can assess and give solutions in order to reduce risks in the work environment as well as assess possible adaptation needs for the individual (chapter 4-7).

Ageing also entails cognitive changes. These are both positive and negative, and do not seriously affects older employees in general before about the age of 70 (chapter 3).

AGE IS NOT JUST THE NUMBER OF YEARS

Age is often measured as chronological age, the number of years since birth. Within age research, one distinguishes between three different

types of age that do not unambiguously correspond with each other, or with a chronological measurement of age:

- Biological age comprises the individual's actual position on a lifeline with reference to their ability to survive or potential length of life.
- Psychological age is defined from the individual's ability to cope with changes in both the inner biological environment and the outer social environment. The cognitive ability has a central role in this.
- Social age refers to age-related roles and social habits in a certain socio-cultural context or in a society where age is valued differently and has significance for how one is treated. The view of the older labour force, pension age and gender roles are some factors which define social age.

A one-sided focus on chronological age risks hiding the fact that 50, 60, 70 or 80 year olds today often differ considerably from earlier generations and in all likelihood even from the coming generations. An ever-greater part of the populations has a generally better health situation and better living conditions and this has entailed an increased remaining average life expectancy even in higher ages. Younger generations have grown up and lived and are ageing now in a society with other prerequisites than those which characterised earlier generations. Increased average life expectancy also means higher expectations of cognitive health and retained cognitive function, both in the person themselves and in others. Earlier, those who were 60 – 65 were perceived as old and fragile, which also influenced their self-image. Today these 'younger older ages' are rather connected with good health and function, and the self-image often is in agreement with an middle age ideal rather than with an old person (chapter 3).

OLDER PEOPLE ARE 'SMARTER' TODAY

Those who are born during a certain time period belong to the same birth cohort. Later birth cohorts tend to perform better upon cognitive tests than earlier cohorts at the same chronological age, which is called the cohort effect or the Flynn effect. The reason is the combined effects of better health and intellectual stimulation in later birth cohorts, and that gives a greater cognitive reserve capacity. Generally seen, today's older people are 'smarter' than yesterday´s – and tomorrow's older people will probably be 'smarter' than todays (chapter 3).

PARTLY EASIER FOR THE OLDER WORKFORCE TODAY

The labour market and its demands are continually changing. If someone is able to continue working or not depends on the content and

prerequisites of the work, the individual's health and motivation, and society's way of treating their labour force of different ages and with different backgrounds

Hard physical labour is rarer and increased mental demands at work is more common today. This ongoing structural transformation of the labour market and the technical development should benefit the older labour force compared with earlier great changes. Many of the abilities that were used within manual work like agriculture and industrial mass production deteriorate with age, such as physical strength, endurance and speed. Furthermore, the worker reached the ceiling of the benefit of their earlier professional experience more quickly. This has probably contributed to a negative attitude towards the older workforce with, among other things, generalized judgements about older people being passive and too influenced by their working history. The image of passivation does not agree with newer research. Instead, researches find the older workforce actively involved in changing their working situation in order to deal with the loss of ability that can be due to age (chapter 1).

DIFFERENT WAYS OF COMPENSATING FOR DETERIORATED ABILITIES

People compensate for lost abilities with other ways of working, or technical aids. This is not new, but rather something that has probably occurred during the entire history of humanity. One example is glasses, which have existed for a long time. There are many innovations which make people to be able to react and perform in a satisfactory way far up in age, both at and outside work.

It is, however, only during recent years that the research carried out has entered the issues around compensation and its prerequisites in a systematic way. One theory, which has had a breakthrough, is called Selective Optimization with Compensation (SOC) (Chapter 1). The theory has mainly been developed within life course research, where one has, in large studies, followed individuals and their abilities throughout life. The representatives for the life course perspective assume that people can gain and lose competence throughout their entire life. They investigate compensation as a form or resource, which makes it possible for an individual´s capacity to be preserved and developed.

The SOC model builds upon the assumption that the individual must choose how and where to use their resources when it comes to mental and physical capacity and access to support. A further assumption is that all human development processes combine three adaptive behaviours or strategies, namely selection, optimisation and compensation:

- Selection governs individual behaviour on the way to the

individual's goals and priorities. The selection can either be based upon personal goals and preferences (so called elective selection), or refer to experienced loss of internal and external resources (loss-based selection). The focus upon fewer and more meaningful goals means a more effective use of accessible resources than when the energy is aimed towards many goals.

- Optimisation means that the individual continually and constantly acquires and improves their means and working methods to reach the chosen goals.
- Compensation is about how people maintain the desired function level when resources and means are reduced or lost. Compensation thus means that the individual acquires and uses alternative external methods in order to achieve the desired function level. The compensation strategy refers in the same way as the optimisation strategy to means and method but in this case to means that replace lost resources.

How aware people are of their own use of these strategies varies. Research shows that the different strategies vary in significance over the lifecycle. Individuals who apply the action strategies cope with their working life better than others. Younger people focus more often on optimisation, that is, to develop resources to achieve goals, while older have a stronger focus on compensatory goals and aspects to prevent further losses. Individuals who apply the strategies use their accessible resources more effectively. They can thereby also better deal with difficult situations and limited resources. The SOC strategies give positive results within a range of different areas with great relevance for the development and quality of work- places like health and wellbeing, the ability to deal with bad health, working ability, competence, performance, involvement in the work, job satisfaction, the ability to maintain professionalism in the work and faith in future possibilities in the work. The application of SOC strategies in the work has also led to a better balance between work and family.

SEVERAL FACTORS INFLUENCE THE WILL TO CONTINUE WORKING

In a situation of choice between continuing to work or retire, ad- van- tages and disadvantages of continued working life are assessed. Factors that influence the decision are work environment and working life in relation to one's own health, the individual's financial situation, how well the social support and interaction between people at the workplace works and how stimulating and developing the working tasks are (chapter 2).

DISPOSITION OF THE CONTENT OF THIS KNOWLEDGE COMPILATION

This text is an anthology, where seven leading Swedish researchers highlight the sustainable working life with a focus on the older workforce:

- Chapter 1, Work without boundaries, resilience and compensation, deals with the changing working life and the individual's opportunities for adaptation and compensation at all ages.
- Chapter 2, The ability and desire to extend working life, deals with factors governing the choice between retiring or continuing to work.
- Chapter 3, Cognitive ageing, deals with cognitive ageing during the course of life.
- Chapter 4 and 5 deal with age-related changes in health in relation to chronic illnesses, physical capacity and occupational performance.
- Chapter 6 and 7 deal with sensory ageing and with ergonomics and lighting and with hearing and occupational noise.

1. Work without boundaries, resilience and compensation

Gunnar Aronsson

THE CHANGEABILITY OF WORKING LIFE

The ongoing structural transformation and technical development should be of benefit to the older workforce compared with the earlier great transformations. Within agriculture and industrial mass production, abilities that deteriorate with age are used to a great deal, for example physical strength, endurance and speed. Physically heavy work is detrimental to older workers, as are simple repetitive movements at a high tempo. When it comes to these types of work, the worker quickly reaches the ceiling for the use of their earlier occupational experiences. These conditions lead to a strong negative connection between age and work performance. It has, in all likelihood also contributed to a negative attitude to the older workforce, with, among others, generalised judgements about older people as passive and all too shaped by their working history. Repetitive work with few opportunities for new learning over many years increases the risk of the employee losing self-confidence when it comes to taking new working tasks. Newer research shows, however, that even the older worker engages in so called job-crafting, which means that they are actively involved in changing their working situation so that it responds to eventual age-related loss of abilities (Kooij, Tims & Kanfer, 2015).

The automation of manual task and the gradual elimination of heavy and repetitive movements increases the possibility of reaching the goal of a working life for everyone at all ages. People are freed from cognitively simpler tasks in order to engage in mental and cognitively more complex tasks instead. The development is mirrored, among other things, in the lengthening of working life, and in the rising actual pension age, particularly for the ever-larger and growing group that has not had a physically demanding job or working life. The change is also reflected in the number of those sick listed for musculoskeletal disorders being lower now than the number sick listed for mental diagnoses.

The description above gives the general trend, but reality is naturally more differentiated, with differences between sectors, workplaces and occupations. The benefit of previous education and experiences can thus quickly be reduced when people receive changed working tasks and if there are large structural changes in working life. This firstly affects the people who, through the years, have obtained deep knowledge and experiences, which, however, can quickly become out-dated through technical development or changes in countries and companies' relative competitiveness. Experience has, in many cases, a strong connection with age, and this means that such changes primarily affect the older workers. Different sectors are also differently affected by technology and transformation. Within the IT area and

other technology-intensive activities, several years' absence means that the returning person is met by new work tools and different problems and issues. Within certain sectors and activities, the employees have a very narrow and workplace-specific competence that is not so easy to transfer to other companies. The competence can then be completely irrelevant resulting in radically worsened possibilities of finding new and equivalent work.

The trends described do not need to lead to exclusion or more difficult career adjustment problems, but special efforts can be necessary to facilitate the transition to another employer or to another profession. High age does not in, itself, necessarily reduce the ability or motivation to cope with technical transformation, but persons with long occupational experience can have a much greater benefit from another type of pedagogy that clearly links to practical experience and perceived benefit compared with school desk and textbook learning. The best pedagogy means individualisation and active participation in the learning, and that applies to younger as well as older, and to women as well as men.

In a number of activities, the individual, rather than the IT system, is the carrier of knowledge, and the work objects are not so changeable. In those cases, the risk of knowledge becoming out-dated is smaller. For example, most previous working experience for a clinical psychologist is relevant because the knowledge cannot be externally digitalised. Instead it is accumulated in an individual during the course of a working life.

DEREGULATED OR BOUNDARYLESS WORK

The strongest transformation pressure today comes from the fast development of information technology, in particular the fact that communication has together with become so much cheaper than previously. Wireless telephony and light personal computer equipment are integrated, which means that many types of work and working tasks no longer have to be carried out at a certain place or during the usual daytime working hours, that is, 8 – 17, and not within a certain organisation or within the framework of a normal employment. This means a dismantling of certain conditions that have given the work a common and relatively stable form (Allvin, Aronsson, Hagström et al. 2011). This development means that all the more people have the technical possibilities to work at home, while traveling, at clients or just about anywhere, and that the boundary between work and free time has been loosened up.

This dissolution of boundaries has been defined in four dimensions. It is about time, and more specifically the scope and scheduling of working hours over the day, week, year and entire life. It is about space, that is to say that work tasks are not fixed to a certain work-

place. It is also about organisation, that is the work task in relation to goals for the work and the individual's organisational association. Fourth, it is about the employment conditions and more specifically about rights and obligations in work commitment (Allvin et al. 2011).

Boundarylessness and the dissolution of boundaries is, however, something of a chimera. In the long run, activities without boundaries in time and authority, and without agreements about work commitments do not function. The development can rather be described as that responsibility is shifted and new boundaries are drawn up; the individual receives the responsibility of constructing and maintaining boundaries, for example the boundary between work and life in general, and thereby even the balance between these spheres. How he or she will succeed is a question of great societal relevance and could also be decisive for individual working life careers.

In the regulation of boundaries between work and free time, the permeability of the boundaries plays an important role. Borders can be constructed a long a scale from thin to strong. They can also be asymmetrical, so that the permeability is different depending on direction, for example an individual can allow high permeability from the job sphere to the private sphere but not in the other direction. Agreements that entail thin boundaries can mean that the individual is accessible and reachable for work almost anytime and anywhere. The individuals approach to their work also has greater significance when boundaries become more permeable and flexible. If the individual fails in the regulation of boundaries, work and free time begin to flow together in an undesirable way.

This development means that the individuals must be able to plan their work and their working tasks so that they fit into an overarching context, which can be complex and involve many people and different demands and relationships. In this lies not just carrying out the work in an acceptable way but also dealing with the resources and time so that he or she can cope with the workload. An important competence is therefore the ability to assess the time that different working tasks take and may take, and one's own available resources as well as other resources that can be mobilised. The dismantling of external timeframes and time management means that the time plays less of a role, rather that the individual must be more time aware as a part of the responsibility for coordination and the handling of resources.

Informal workplace learning is also waning in strength in that work, to a greater extent, is carried out and can be carried out in other places than that of the employer. To be at a workplace means the possibility of, purely concretely, learning how the work is done, which tools are necessary, who one can ask for advice and so on. The psychological and social environment at the workplace develops the individuals self-regulation and internalization of the company's system of norms and goals is conveyed via colleagues and supervisors. Both

these aspects mean that the individual can be independent, which entails taking responsibility for their own competence development and developing the relationships that are necessary for carrying out the work.

The shift from external regulation towards a more individual and internal regulation of one's own work can also affect the balance between work demands and workload and the individual's possibility to control these. This balance is significant for the emergence of stress reactions (Karasek & Theorell, 1990).

To have a good work-life it is important that the workplace demands are in agreements with the individual needs in the private sphere. The research based knowledge about this is limited so far, but the optimum is thought to be when an individual with varying and changing needs in their private life is at a workplace that allows such flexibility and an integration of private life and working life in both spatial and time aspects. This is thought to be particularly advantageous for women (Mellner, Aronsson & Kecklund, 2014).

Whether the transition to individual internal regulation of the boundaries between work and private life has positive or negative results depends, in summary, upon how the individual is able to shape and use strategies that balance and minimise the friction between different life areas (Kreiner, Hollensbe & Sheep 2009; Mellner, Aronsson & Kecklund, 2014).

The competence for setting of boundaries and the ability to create sustainable boundary agreements are new occupational skills, necessary for being able to carry out the working tasks in a rational way. They are also connected to stress and health.

Risk groups and risk behaviour

The ability to arrive at boundary agreements that balance demands and control is an important competence in order to be able to draw advantages from the freedom of deregulated work. Many seem to be able to cope with this and it is, without a doubt, possible to develop competence for the handling of boundaries and agreements. Are there individual factors or background factors that can reduce the ability to be able to handle boundarylessness and floating working conditions? Research is limited but there are indications of such risk factors.

One risk factor seems to be a strong link between performance and self-esteem – one becomes something and develops an identity by performing. Such a link can sometimes mean that people do not say no to working tasks, despite the fact that they know they actually do not have time (Hallsten, Josephson & Torgén, 2005). If the boundary from work to private life is thin, the individual can always have within reach the possibility of working, even during trips and leave. The risk of high ambitions and performance-related self-esteem is further strengthened in working tasks, which can always be done

better than well and when there are shortcomings in feedback around what an acceptable quantitative performance and around when sufficiently good quality has been reached.

Those who are professionally inexperienced can feel unsure about where the bar lies for an acceptable effort, both when it comes to quantity and quality in the work. If the work is always accessible, he or she can acquire a margin in the performance level by working extra outside of normal working hours. It can therefore be less suitable for beginners and the newly employed to work from home and thereby lose out on the informal learning and presence regulation at the workplace. Many need solid practical experience from the workplace and good integration in the organisational culture in order to assess what is good quality and do a good job.

Increased knowledge with relevance for the older

The recent decade's research has tangibly increased the practical useable knowledge about people's ability during the course of life and not least the knowledge about how people act or can act in order to compensate for falling capacity. Knowledge about the system's or the individual's ability to resist stress and recover their functional ability after stress – so called resilience – is under strong development.

These two knowledge areas – resilience and compensation for reduced ability – go together in that they are both related to stress and health, and to the individual's possibility to keep their working capacity and stay working for a living. In the growing knowledge within these areas is also new knowledge about how workplaces should be designed in order to develop resilience and support individual compensation for reduced capacity. This is the main theme in the following sections.

RESILIENCE

In the broad discussion about sustainability, the concept of resilience is used more often. Resilience is usually defined as the ability of a biological or a social system to cope with disturbances without losing basic functions and structures. It is also about the ability of the system to develop further.

Development is not seen as something linear and predictable, but rather during great change, a system can quickly grow from a linear continual change to breakdowns of different types. If it takes time for the system to lose its equilibrium one can say that it has good resilience – there is a buffer capacity in the system. Resilience is a key concept in the discussion about the environment's resistance and ability to recover after different types of environmental degradation or pollution. The concept has its origin in natural science but is also used, as mentioned, to study social systems and the recovery and development ability of social systems and organisations (see for ex-

ample Richtnér & Södergren, 2008). Diversity is one side of resilience, because diversity means a spreading of risks and therefore greater possibility of reorganisation after a disturbance.

Individual resilience

In individual research, resilience has up until now mainly been discussed in developmental psychology and then especially in studies of development in children who survive and manage in destructive environments – so called dandelion children. But resilience has also become a concept within behavioural sciences and within stress research, which focuses upon degrading and strengthening forces. High resilience means good resistance and the ability to also, after heavy setbacks, be able to recover strength and in some cases, become stronger than earlier. Within research one is now looking for strategies that can increase resilience and thereby reduce vulnerability and strengthen resistance to ill health. Some of the individual qualities that create resilience have been identified (Tugade & Fredrickson, 2007). One component is optimism – a general expectation that even threatening events will have a positive outcome, which benefits the ability for active adaptation and the mastering of changes in the world around us. People with an optimistic attitude have trust in their own capacity, and believe that they can act in a way that gives predictability and control over relationships that affect their lives. Belief in one's own competence can be self-fulfilling in a positive direction. Further in individual resistance lies being able to regard failures as a form of valuable feedback for the future. A further aspect is about the individual's ability to regulate feelings such as anger, anxiety and confusion, and maintain one's self-esteem even in difficult situations.

Resilience is a system concept that links the individual and the social surroundings. Individual qualities cannot and must not be seen in isolation. An individual's resilience is, in other words, dependent upon the quality of the connection with the surroundings, for example in the different forms of support an individual has or is able to mobilise.

Loss of resilience

The individual's resilience can be reduced due to age-dependent changes, injuries, or a large organisational change where supportive structures are broken (for an overview see Parent, 2011). The worst case scenario – level one – is when an individual loses so much of their functional ability in relation to their working task or that he or she cannot recover or function in their tasks or working life at all. Level two of lost resilience is when an individual recovers enough in order to stay in the organisation but not come back to their previous functional level. On the third level, the individual recovers and comes back to their earlier functional level. The fourth entails, finally, that the individual in addition is strengthened and can function at a hig-

her level than previously.

Research has primarily dealt with the three lowest levels, but now knowledge is also coming about the mechanisms that mean a loss can be turned into a gain, and development for the individual. The fourth pattern means a type of hardening. Research has now begun to identify how load and demands can lead to an increased resistance rather than degradation and weakening (Maddi, 2006). Some such factors are thought to be the feeling of being able to govern and control one's life oneself, positive feelings and the experience of challenges and possibilities.

What functional ability the individual can reclaim depends also upon individual qualities in combination with different social and organisational factors and their way of supporting the individual's reception of the change. There are several related perspectives and concepts, also of system character, that is they connect the individual to her/his surroundings. One such view is resource preservation, which means that an individual has the ability to conserve her/his resources under pressure and not accumulate stress (Hobfoll, 2002). Another concept is 'sense of coherence' which means that the individual sees the world and its challenges as manageable. This strengthens the individual's resources in order to deal with changes and readjustments – and thereby to preserve the health even under great pressure (Antonovsky, 1987).

Organisational support for resilience

The resilience perspective in research entails a stronger focus on the link between the individual and their surroundings than is usually the case when working conditions, health, and the organisation of the workplace is analysed. In their research, Richtner & Södergren (2008, pp 269), have identified different types of organizational resilience resources at the workplace. They point out four different research bases, the content of which can be said to have good evidence from many different studies. This approach is a good example of a system perspective, where the individual and other types of resources are brought together.

The resource bases apply to:

1) structural resources, such as clear organisational structures, which facilitate activity, visions, access to adequate financial resources, clear mandates and enough formal powers to act from.
2) cognitive resources, adequate skills, knowledge and competence, either in the team, or easy access to the skills of others.
3) relational resources, which means that there are networks and teams that can be mobilised (colleagues in other organisations, external partners and significant others such as subcontractors, consultants, customers or politicians).

4) emotional resources, that in the system there is a feeling of good will, support, trust, friendship, collegiality, respect and confidence and positive regard', i.e., a mutual assumption that other people have good intentions, and will try their best to contribute and help, rather than harm or destroy.

The view is relatively easy to convert into practical recommendations, because individuals are seen in a network of resources and relationships that can be strengthened and developed in different ways. A method of strengthening the relational resources in the work environment is to recruit managers and persons who have a good ability to build relationships, and a driving force to help others to develop (Richtnér & Södergren, 2008). Individualisation in the work can lead to weaker relational resources, but with a resilience-based way of thinking, it is possible to observe and counteract such a development.

There are also misgivings and warning signals around concepts such as resilience and 'resource preservation under pressure'. There is a critic that the traditional work environment and work organisation perspective risks being driven back to the benefit of a too-narrow individual perspective with the aim of strengthening the individual to cope with increasing pressure. The result of such an approach can also be that recruitment will be more focused on selection of stress-tolerant individuals.

COMPENSATION FOR REDUCED OR LOST ABILITIES

A person's resilience is also strengthened through compensation for lost or reduced abilities. It is nothing new that people compensate for lost abilities by means of other ways of working or with technical aids, rather it has been observed during the entire history of mankind. Even before the birth of Christ, a globe filled with water was used to enlarge text and letters. Eyeglasses were presumed to have been invented in Venice in the 13th century and through the printing press a few centuries later, the demand for this means of compensation increased dramatically. Many innovations with the aim of compensation contribute to people acting and performing in a satisfactory way far up in age both at and outside work.

It is, however, first during recent years that research in a systematic way has taken up the questions about compensation and its prerequisites. One theory, which has had a breakthrough, is called Selective Optimization with Compensation (SOC). The theory has mainly been developed within life course research where individuals have been followed throughout their life (Baltes, 1987). A basic assumption in the life course perspective is that people can gain and lose competence throughout their entire life. Compensation is investigated as a resource, which can contribute to development or preservation of human capacities. Another basic assumption is that people have

limited mental and physical capacity and limited access to support, which means that the individual must choose how and where he or she should use their resources.
A further supposition is that all human development processes combine three adaptive behaviours or strategies, namely selection, optimisation and compensation:

- Selection governs individual behaviour on the way to the individual's goals and priorities. The selection can either be based upon personal goals and preferences (so called elective selection), or refer to experienced loss of internal and external resources (loss-based selection). The focus upon fewer and more meaning ful goals means a more effective use of accessible resources than when the energy is aimed towards many goals.
- Optimisation means that the individual continually and constantly acquires and improves their means and working methods to reach the chosen goals.
- Compensation is about how people maintain the desired function level when resources and means reduce or are lost. Compensation thus means that the individual acquires and uses alternative external methods in order to achieve the desired function level. The compensation strategy refers in the same way as the optimisation strategy to means and method but in this case to means.

After 25 years of research using the SOC model, there is now a great number of studies that give support to the SOC strategies' scientific and practical value (see for example Kooij, Tims & Kanfer 2015; Müller, Heiden, Herbig et.al. 2015;. Riedel, Müller & Ebener 2015; Unson & Richardson 2012; Zacher & Frese 2011; Wiese, Freund & Baltes 2000; Yeung & Fung, 2009). Furthermore, research shows that the individual's possibility of control in their work affects the connection between age and SOC strategies when it comes to working ability. In particular, older workers, with control of their work, can use SOC strategies to preserve their working ability (Weigl, Müller, Hornung m. fl. (2013). The research thus shows that the various strategies vary in importance over the life cycle. Individuals applying SOC-strategies use their limited resources more efficiently; they handle difficult situations better and will thus manage their working life better.

Younger put more focus on optimization, i.e. to develop resources to achieve goals, while older people have a stronger focus on compensatory objectives and aspects to prevent further losses. Furthermore, research shows that individual's ability to control their work affects the relationship between age and SOC strategies when it comes to work. In particular, older people can control at work using SOC strategies to preserve their ability to work (Weigl, Müller, Hornung

m. Al. (2013).

The use of SOC strategies show positive results within a range of different areas that are important for the development and quality of the workplace. This applies to health and the ability to handle bad health, working ability, competence, performance, job involvement, job satisfaction, the ability to maintain professionalism in the work and trust in future opportunities at work. The strategies can be used to achieve a better balance between work and family life.

CONCLUDING SUMMARY

Research about deregulated work, resilience and compensation strategies gives knowledge about what is applicable at different ages, and for men as well as women. Generally, knowledge points towards the individual more easily being able to control their work and life situation if the outer regulation of the work diminishes. The individual thus gains greater possibilities of choosing themselves when and where they have to work. If the shift towards increased individual boundary regulation has a positive or negative result depends, however, upon how the individual is able to use strategies that balance and reduce the friction between different areas of life. Less rigid demarcations around the working tasks should benefit variation and individual choices and development opportunities. These advantages should apply independent of age, gender and other background conditions, but are, perhaps, particularly significant at ages where the individual has great demands upon coordination with others, for example in an very family-intensive phase of their life. The possibility of deciding oneself about the scheduling of working hours in time and space would probably be particularly valuable when the ability to perform varies or fails. At the same time, there is a risk of the individual having a more difficult time making use of the resources that exist in the workplace relationships and the network of common experiences. From a resilience perspective, individual resistance is seen as strongly contiguous with different types of resources in the work and in the private life. Managers at a workplace can strengthen the resilience of the workplace and the individual through consciously building relationships and resources that can compensate for the instability of a modern workplace. These are efforts that will benefit everyone at the workplace, irrespective of age. The individual can, through increased awareness about the different SOC strategies, ward off and prevent problems when abilities and resources diminish. On an overarching level it is about workplaces, work and relationships being organised in a way that allows and rewards compensation for losses through the building up of new resources.

REFERENCES

Allvin, M., Aronsson, G., Hagström, T., Johansson, G., & Lundberg, U.(2011). *Work without boundaries: psychological perspectives on the new working life.* John Wiley & Sons.

Antonovsky, A. (1987). *Unraveling the mystery of health: How people manage stress and stay well.* San Francisco, Jossey-Bass.

Baltes, P. B. (1987). *Theoretical propositions of life-span developmental psychology: On the dynamics between growth and decline.* Developmental psychology, 23(5), 611.

Hallsten, L., Josephson, M. & Torgén, M. (2005). *Performance-based self-esteem: a driving force in burnout processes and its assessment.* Stockholm: Swedish Institute of Working Life.

Hobfoll, S. E. (2002). *Social and psychological resources and adaptation.* Review of general psychology, 6(4), 307-324.

Karasek, R.A & Theorell, T. (1990). *Healthy work: Stress, productivity and the reconstructions of working life.* New York: Basic Books.

Kooij, D. T., Tims, M., & Kanfer, R. (2015). *Successful aging at work: The role of job crafting.* In P.M. Bal et al. (eds.), *Aging workers and the employee-employer relationship* (pp. 145-161). *Springer International Publishing.* DOI 10.1007/978-3-319-08007-9_9

Kreiner, G. E., Hollensbe, E. C., & Sheep, M. L. (2009). *Balancing borders and bridges: Negotiating the work-home interface via boundary work tactics.* Academy of management journal, 52(4), 704-730.

Maddi, S. (2006). *Hardiness: The courage to grow from stresses,* The Journal of Positive Psychology, 1:3, 160-168, DOI: 10.1080/17439760600619609

Mellner, C., Aronsson, G., & Kecklund, G. (2014). *Boundary Management Preferences, Boundary Control, and Work-Life Balance among Full-Time Employed* Professionals in Knowledge-Intensive, Flexible Work. Nordic Journal of Working Life Studies, 4(4), 7.

Müller, A., Heiden, B., Herbig, B., Poppe, F., & Angerer, P. (2015) *Improving Well-Being at Work: A Randomized Controlled Intervention Based on Selection, Optimization, and Compensation.* Journal of Occupational Health Psychology. Advance online publication. http://dx.doi.org/10.1037/a0039676

Parent, J. (2010). *Individual adaption to the changing workplace. A model of causes, consequences and outcomes.* I: J. Houdmont & S. Leka (red.): *Contemporary occupational health psychology – Global perspectives on research and practice,* 1, 188-207. Oxford: Wiley Blackwell.

Richtnér, A., Södergren B. (2008). *Innovation projects need resilience.* International journal of Technology and planning, 4, 257-275.

Riedel, N., Müller, A., & Ebener, M. (2015). *Applying Strategies of Selection, Optimization, and Compensation to Maintain Work Ability – A Psychosocial Resource Complementing the Job Demand–Control Model? Results From the Representative lidA Cohort Study on Work, Age, and Health in Germany.* Journal of Occupational and Environmental Medicine, 57(5), 552-56

Tugade, M. M., & Fredrickson, B. L. (2007). *Regulation of positive emotions: Emotion regulation strategies that promote resilience.* Journal of Happiness Studies, 8(3), 311-333.

Unson, C., & Richardson, M. (2012). *Insights into the experiences of older workers and change: Through the lens of selection, optimization, and compensation.* The Gerontologist, 53(3), 484-494.

Weigl, M., Müller, A., Hornung, S., Zacher, H., & Angerer, P. (2013). *The moderating effects of job control and selection, optimization, and compensation strategies on the age–work ability relationship.* Journal of Organizational Behavior, 34(5), 607-628.

Wiese, B.S, Freund A.M & Baltes P.B- (2000). *Selection, optimization, and compensation: An action-related approach to work and partnership,* Journal of Vocational Behavior, 57, 273.

Yeung, D. Y & Fung H.H. (2009). *Aging and work: How do SOC strategies contribute to job performance across adulthood?* Psychology and Aging, 24, 927-940.

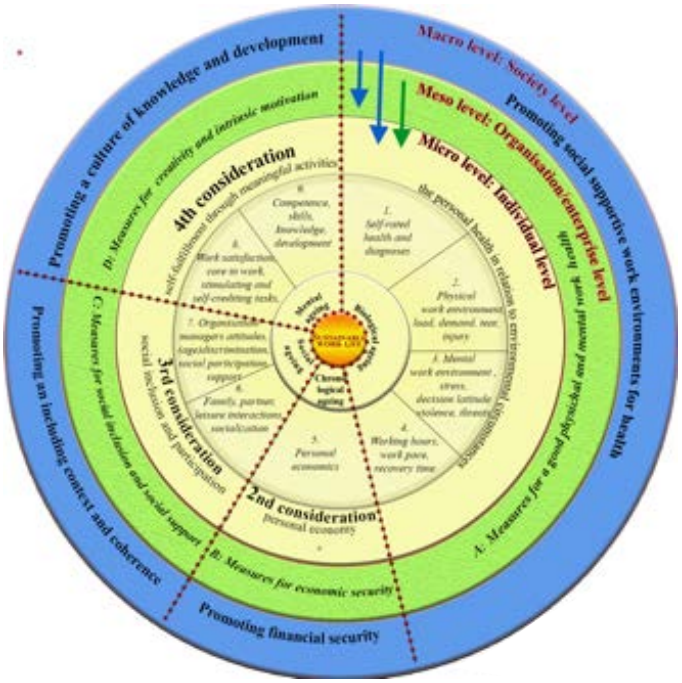
Zacher, H & Frese, M. (2011). *Maintaining a focus on opportunities at work: The interplay between age, job complexity, and the use of selection, optimization, and compensation strategies,* Journal of Organizational Behavior, 32, 291-318.

2. The ability and desire to extend working life

Kerstin Nilsson

Continuing to work at an older age is a complex and multidimensional issue that involves many factors (Nilsson 2003; Nilsson 2013; Nilsson 2016a). The complexity of a sustainable working life for all ages demonstrates in the theoretical model, the swAge TM -model (Figure 1).
The ability to work is affected at various levels (Rechel et al. 2013; UNFPA 2012) and is not solely the choice of the individual; more importantly, decisions and measures taken by managers, organisations and companies establish the conditions for older employees in the workplace and the work environment. These may include working hours, access to skills development, climate, organisational culture and attitudes towards age. The external framework for the opportunity to continue working to an older age or to retire is created at the societal level through decisions concerning laws, regulations, retirement age, and the pension and social insurance system. Laws and regulations imposed by society also govern the potential for companies and organisations to offer solutions to employees. However, we will not go into greater detail in the swage-model and measure propos in this chapter.

Figure 1.
Theoretical model illustrating the complexity and levels of influence for a healthier working life at all ages. Source: Kerstin Nilsson swAgeTM-model http://www.swage.org/



There are many factors that impact the ability of individuals to work, as shown in Figure 1 (Nilsson 2003; Nilsson 2005; Nilsson et al. 2011; Nilsson 2013; Nilsson 2016a). These factors could be included in nine areas:

1) diagnosed and self-rated health
2) physical work environment
3) psychological work environment
4) working hours and pace
5) financial incentive
6) partner/family, leisure activities and social environment
7) attitudes of managers, companies and organisations towards older employees
8) work satisfaction, the nature of the job, stimulation and meaningful duties.
9) knowledge, abilities and opportunity for skills development

FOUR CONSIDERATIONS REGARDING THE ABILITY TO WORK OR NOT TO WORK

To leave working life for retirement is a life-changing decision that entails leaving the workforce and entering into a new phase of life as a pensioner. Research has shown that individuals base their decision to leave working life or to continue working on four considerations (Nilsson 2012; Nilsson 2013; Nilsson 2016 (a)), which include the nine areas above. Below we describe and provide examples of these four considerations, followed by a discussion of which of the nine areas that are includes into the consideration and entire decision.

FIRST CONSIDERATION – WORK ENVIRONMENT AND WORKING LIFE IN RELATION TO PERSONAL HEALTH

The first consideration addresses issues relating to how individuals perceive the potential for good health in relation to their working life and the work environment, versus how they envisage their health and health development as pensioners:

- Favours remain in working life if: My self-rated health and diagnoses is good/good enough with respect to the physical work environment, the mental work environment, working hours, work pace and the opportunity for recovery in and between work sessions. My health remains good because my job keeps me physically and mentally active.
- Favours to leave the work life and retire if: My health is not good enough to keep working in my current work situation. My health may improve if I cut back on the physical and

mental strain caused by my work situation and the work environment if I retire. I will probably have better opportunities for rest and recovery if I retire.

The four areas that enter into this first consideration when deciding to go on and work or not are presented below.

1. Diagnosed and self-rated health

Health is an important factor for the ability to participate in working life (Schuring et al. 2011; Nilsson et al. 2011). Disease and ill health and a desire for better health may be arguments that not only favour early retirement, but also keeping working (Park 2010; Westerlund et al. 2009). Ill health provides both the individual and the organisation with an accepted exit from the job, and may offer an opportunity for rest and recovery. Variations in health among individuals are always high in an age group. However, vision, hearing and reaction time generally decline with age, while the risk of chronic disease and pain increases (Holliday 2010). Health is not a common cause for early retirement in countries with an average pension age of less than 60 years (Börsch - Supa et al. 2009), probably because these people have shorter exposure to the stressful demands posed by work and the environment.

Self-rated health and wellbeing are a better measure of the potential to extend working life than diagnoses and diseases (Nilsson, 2012; Nilsson, 2013). People who are satisfied with their work situation and work tasks minimise their health issues and will continue to work despite their illness, while those who dislike their tasks and the situation at work exaggerate their health problems and take early retirement (Dwyer & Mitchell, 1999). High levels of job satisfaction and quality of life also result in better self-rated health among older individuals; a good work environment can improve health and delay biological ageing. Moreover, a healthy lifestyle with physical, mental and social activities may delay health problems and extend work capacity among older employees, which is especially true for people with chronic diseases (Forma et al. 2005).

2. Physical work environment

A demanding physical work environment with high load and demanding or poorly thought-out working conditions causes burnout, accidents and work-related injuries, all of which increase the risk of individuals withdrawing prematurely from working life (Hult et al. 2010; Westerlund, 2010; Ahola et al., 2012; von Bonsdorff et al. 2011). Moreover, older employees generally require longer recovery times following illness or injury (Mitchell et al. 2002; Nilsson et al. 2010). Older employees are also at higher risk of occupational injuries compared with their younger counterparts, which may result

from factors such as deterioration of hearing and/or vision, chronic diseases, muscle stiffness and longer reaction times, along with their preference for using older technology and equipment (Myers et al. 2009; McLaughlin et al. 2011). Surveys have shown that work capacity in general increases up to age 50–55 years, after which it slowly declines (Göbel et al. 2010). Declining work capacity due to advancing age applies especially to people in physically demanding work environments, with little control over their jobs (Pohjonen 2001; Silver, 2008). Working at a greater age is not inherently problematical provided that the circumstances are good, for which reason improving physical working conditions may considerably facilitate and extend working life for older employees (Karlsson et al. 2008).

The foundation for today's gender segregation in the labour market was laid over one hundred years ago (Greiff, 2006), and remains a significant factor in why women are at greater risk of sustaining repetitive strain injuries (Swedish Work Environment Authority 2015). Men and women in the same occupation often have different duties and are therefore subjected to different kinds of physical challenges. Women are more likely to work with monotonous and repetitive tasks or movements. When men and women have the same duties in the same workplace they nevertheless face different physical challenges because tools, protective equipment and workstations are usually designed for men, not women (Karlqvist, Bildt, Dahl, 2004). While physical stress has been reduced in recent years, this mainly pertains to male-dominated occupations (Gonäs et al. 2005). However, sickness absence is higher among women in male-dominated occupations, which may in part be because they work under conditions adapted for men, using tools and protective equipment that are designed for men. In general, women have only 40–80 per cent of the muscle capacity of men (Savinainen, 2004), and strength declines even further with age. Women also experience to a higher degree than men that physical job requirements become more demanding with advancing age (Barbini, Squadroni, Andreani 2005). In addition, women generally assume responsibility for a greater share of unpaid housework, which also adversely affects their health (Gonäs et al. 2005).

3. Psychological work environment

Characteristics of a good sustainable working life include dialogue, communication, participation, a sense of context, clarity, trust and control over work (Ilmarinen, 2006). Job and occupational satisfaction, as well as being appreciated at work, are crucial for a sense of well-being and long-term health (Siegrist et al. 2007). A good psychological work environment and improved control over their lives also help people to feel younger (Kunze & Rea, 2015), and older people who work in a healthy psychological environment often demonstrate better mental and physical health than their retired counterparts of

the same age (Beehr et al.2000). Moreover, a poor mental working environment with negative stress, unclear objectives, lack of information, lack of integration in a workgroup, bullying and "scapegoating" is harmful and increases the risk of early retirement (Munnel et al, 2006; Nilsson, 2006). Women work more often than men in occupations that include encounters and contact with other people, which often increases mental stress. Moreover, women are especially likely to point to the psychological work environment as an obstacle to extending their working life (Nilsson, 2015). Those who work in human service occupations are at increased risk of early retirement because of this type of stress, and a Swedish study reports that nearly half of such workers perceived their jobs as too psychologically demanding to continue coping with work until they reach pension age (Johnston et al. 2009). Research also shows better self-rated health after retirement among people who worked in a deficient psychological work environment with high demands, low satisfaction and inadequate opportunities to achieve high quality in their duties (Sjösten et al. 2010).

4. Working hours and pace

Reduced working hours and a slower pace at work have been suggested as one option to encourage people to extend their working lives (Nilsson 2007; Nilsson et al, 2011). One study showed that the duration and scheduling of working hours were of greater importance to women than to men when deciding whether to leave the workplace, since women were more family-oriented and difficult working hours have a negative impact on family life (Nilsson, 2015). In one intervention programme employees were permitted to reduce their working hours by 20 per cent beginning at age 58, which allowed more rest time between shifts (Mykletun & Furunes, 2011). This reduced sickness absence, which ultimately results in increased productivity and profitability for the business. It also appears to be preferable to gradually reduce working hours prior to retirement rather than to abruptly halt working life, since this enables people to gradually adapt their lifestyle and embrace new routines and activities (De Vaus et al., 2007). Control over the timing and manner of retirement makes it easier to plan for these changes, and has a beneficial impact on psychological and social wellbeing that persists after retirement (Nordenmark & Stattin, 2009). However, studies have shown that older workers with chronic health problems do not necessarily need to reduce their working hours if they are given control over their work pace and schedule (Marcum et al, 2011).

In general, older employees need more time to rest and a balanced work pace to maintain good health. Lack of sleep and sleep disorders can also impair memory, cognition and concentration, and increase the risk of accidents (Carter et al. 2003; Åkerstedt et al., 2007). For

example, many work-related injuries and motor vehicle accidents occur because of fatigue and sleep disorders. Shift work also increases health problems and work-related accidents among older employees (Gander & Signal, 2008). In contrast, rest has a beneficial effect on memory and cognitive function (Hornung et al. 2005). Studies have found that mental fatigue and sleep disorders decrease after retirement (Laaksonen et al. 2012), mainly due to a reduction in work-related stress (Vahtera et al. 2009).

THE SECOND CONSIDERATION – PERSONAL FINANCES

The second consideration addresses issues relating to personal finances when remaining part of the labour force, compared with being retired:

- Favours remain in working life if: I can't afford early retirement. I feel that my salary from work will improve my personal finances, and provide me with better opportunities for a higher standard of living than being retired.
- Favours to leave the work life and retire if: My private finances are adequate to maintain my standard of living if I retire now. I would rather adjust to a lower standard of living and financial situation than continue working.

The individual's second consideration for continuing to work at a higher age concerns finances:

5. Financial incentive

Society often uses financial security and pension benefits to regulate the length of working life (Cobb-Clark et al. 2009; Tucker Seeley et al. 2009). Financial incentive also plays a major role in pension decisions and can be used either to retain employees in the workforce through the threat of poverty, or to make it possible to retire with a good lifestyle and standard of living (Diamond 2008; Coppola & Benita Wilke, 2010). Financial difficulties also affect mortality among older people (Brenes Comacho, 2011). Studies of Sweden's total population aged 55–65 years show that women with a low level of education in particular, but also their male counterparts, in occupations with high physical and mental stress, are especially vulnerable to changes in the social safety net (Nilsson et al., 2016). Restricting access to sickness and disability benefits appears to increase the proportion of workers who choose early retirement, leading to a shift from one economic safety net system to another. Personal finances and income have a particularly high impact on the retirement decision among low-income women who live alone and have not worked full-time (Fochsen et al., 2005). However, this does not apply to married or cohabiting women; they are less likely to mention finances as being important when deciding to retire. Men are still often viewed as the principal

income earners, and finances are therefore generally more important to men than to women when deciding to retire (Nilsson, 2015). Good personal finances increase self-rated health and the opportunity to enjoy retirement for both men and women (Hank 2011). It is also much better for the health of older workers if they continue to work because they want to, rather than because they cannot afford to leave working life (Wang 2010; Hult & Stattin, 2009). Many decide to receive their pensions while continuing to work in order to improve their economic standard.

The proportion taking early retirement has increased in recent years, especially among men and women with a low level of education, although it is still most common among well-educated men (Nilsson et al. 2016). In Sweden, 28 per cent of male operational and business managers took early retirement (from age 61) in both 2004 and 2011. This can be compared with women who work as packers and on factory lines, 3 per cent of whom took early retirement in 2004 and 11 percent in 2011.

THE SECOND CONSIDERATION – PERSONAL FINANCES

The second consideration addresses issues relating to personal finances when remaining part of the labour force, compared with being retired:

- Favours remain in working life if: I can't afford early retirement. I feel that my salary from work will improve my personal finances, and provide me with better opportunities for a higher standard of living than being retired.
- Favours to leave the work life and retire if: My private finances are adequate to maintain my standard of living if I retire now. I would rather adjust to a lower standard of living and financial situation than continue working.

The individual's second consideration for continuing to work at a higher age concerns finances:

5. Financial incentive

Society often uses financial security and pension benefits to regulate the length of working life (Cobb-Clark et al. 2009; Tucker Seeley et al. 2009). Financial incentive also plays a major role in pension decisions and can be used either to retain employees in the workforce through the threat of poverty, or to make it possible to retire with a good lifestyle and standard of living (Diamond 2008; Coppola & Benita Wilke, 2010). Financial difficulties also affect mortality among older people (Brenes Comacho, 2011). Studies of Sweden's total population aged 55–65 years show that women with a low level of education in particular, but also their male counterparts, in occupations with high physical and mental stress, are especially vulnerable to changes in the

social safety net (Nilsson et al., 2016). Restricting access to sickness and disability benefits appears to increase the proportion of workers who choose early retirement, leading to a shift from one economic safety net system to another. Personal finances and income have a particularly high impact on the retirement decision among low-income women who live alone and have not worked full-time (Fochsen et al., 2005). However, this does not apply to married or cohabiting women; they are less likely to mention finances as being important when deciding to retire. Men are still often viewed as the principal income earners, and finances are therefore generally more important to men than to women when deciding to retire (Nilsson, 2015). Good personal finances increase self-rated health and the opportunity to enjoy retirement for both men and women (Hank 2011). It is also much better for the health of older workers if they continue to work because they want to, rather than because they cannot afford to leave working life (Wang 2010; Hult & Stattin, 2009). Many decide to receive their pensions while continuing to work in order to improve their economic standard.

The proportion taking early retirement has increased in recent years, especially among men and women with a low level of education, although it is still most common among well-educated men (Nilsson et al. 2016). In Sweden, 28 per cent of male operational and business managers took early retirement (from age 61) in both 2004 and 2011. This can be compared with women who work as packers and on factory lines, 3 per cent of whom took early retirement in 2004 and 11 percent in 2011.

THE THIRD CONSIDERATION – SOCIAL INCLUSION AND PARTICIPATION

The third consideration addresses issues related to how the individual perceives the opportunities for social participation and inclusion in social groups in the workplace or as pensioners:

- Favours remain in working life if: My job involves a social group that is important to me, including coworkers, customers, clients, patients and managers, which I do not wish to give up. I feel such appreciation as an active participant in my job that I wish to continue working.
- Favours to leave the work life and retire if: I have a greater sense of appreciation and belonging through my participation in groups outside of work, such as family, friends and social organisations. I would like to spend more time on my social life outside my work and workplace.

Two areas are included in the third consideration that individuals face when deciding whether to extend their working lives.

6. Partner/family, leisure activities and social environment

Retirement is described as an important turning point in life, since work occupies a large portion of people's waking hours and impacts their family life and recreational activities (Kulik 2001; Friis et al., 2007). Partners, family considerations, social interaction, volunteer work and recreational activities greatly influence the retirement decision, especially when work and leisure activities are difficult to reconcile or collide with each other (Cobb-Clark & Stillman, 2009; Diamond, 2008). Both men and women who wish to work to a greater age have a positive attitude towards work (Soidre, 2005; Nilsson, 2015), particularly if they are more socially engaged at work than during their leisure time (Nilsson, 2012). Men who enjoy their social lives at work prefer to continue working to age 65 or longer, while a common reason for men who wish to retire is that they feel unwanted in the workplace (Soidre, 2005). Another important influencing factor is the age at which friends and people in the social environment retire (Hanson Frieze et al., 2011).

Many couples plan their retirement together, and individuals are less inclined to continue working if their partners have already retired (Kubiecek et al. 2010; Nilsson 2015; Nilsson 2012; Nordenmark & Stattin, 2009). Women in relationships are generally two to three years younger than their male partners and both partners often retire at the same time, which is of great importance because women leave the workplace earlier than men. A happy relationship has a strong positive influence on the decision to retire, provided the couple looks forward to spending more time together (Dosman et al. 2006; Smith & Moen, 2011). In order to feel good about retirement, however, it is important that individuals do not feel forced by their partners to leave the workplace (Vendramin & Valenduc, 2012). If the partner has a job, it is also more likely that the individual will re-enter the labour market after retirement (Pettersson, 2014). Men and women who live alone are more inclined to delay retirement than those who live with others (Nilsson 2015).

The need to take care of children, grandchildren, elderly parents or a sick partner also affects retirement planning, particularly for women (Nilsson et al. 2011; Nilsson 2015). However, a study conducted on 28,780 people from 27 European countries showed that employees aged 50 and older found it easier to balance work with their family and social commitments than their younger counterparts, which was true for all 18 occupational groups examined (Hao, 2008). This was due to a variety of factors; for example, older workers have older children who can manage on their own, so parents no longer need to stay home to care for sick children, a change which also provides financial stability.

7. Attitudes of managers, companies and organisations towards older employees

Employer support is a major factor influencing whether older workers have an opportunity to extend their working life (Jensen & Juul Møberg 2012; Molinié 2005; Nilsson 2011; Vercruyssen 2003). One study of municipal managers showed that almost 41 per cent of them felt it was important to keep their employees until they reached age 65, while only 14 per cent stated they wanted to keep their employees to age 66 or older (Nilsson, 2007). Some organisations and companies might essentially be considered "neophiles," which is to say they strive for youth and renewal in the workplace (Rhodes & Pullen 2010). Ageing in such organisations may therefore be particularly complicated. Employers who have positive attitudes and value the experience and knowledge of older workers encourage them to continue working (Nilsson 2011; Munnell et al. 2006). Few organisations and companies have taken concrete measures to increase opportunities to extend working life, even though everyone agrees that the growing number of older people creates significant challenges for society (Jensen & Juul Møberg 2012). It would appear that the personal retirement plans of managers, the budget and productivity requirements are especially influential regarding attitudes towards measures for older workers (Mykletun et al., 2012). Attitudes also vary depending on the occupation of the older employee; those with a special expertise are more likely to be offered measures to facilitate remaining in the job (Mykletun et al. 2012; Nilsson, 2012). Negative notions concerning older employees suggest that they are generally less open to change, unaware of the latest knowledge and technology, and slower compared to younger employees (Thorsen et al. 2012; Nilsson 2011).

Age discrimination against employees and preconceived notions about the importance of age (ageism) have a significant association with early retirement, especially among men (Thorsen et al., 2012). For example, older employees may have fewer opportunities for skills training and are less often selected for new projects and initiatives (Nilsson 2006; Nilsson 2012; Stattin 2005). Women in the workplace are "lower on the ladder" than men within all of the various hierarchical positions in the organisation (Gellerstedt 2005). In a way, women also stand on a lower rung of the ladder in relation to men from the class below them. Some employers also seem to regard women as older employees earlier than they do men. In one British study, managers were asked to state when they felt that their employees were "older." The results showed that women were considered to be older employees at age 48, while men were considered to be older at age 51 (McGoldrick & Arrowsmith, 2001). However, there seems to be no evidence to suggest that the ageing process is different for men

and women; instead, this merely reflects an attitude in society. Age and ageing are sometimes viewed as the last legitimate reason for not hiring someone or for getting rid of employees. Women also face age discrimination for two reasons (Bernard et al. 1995): first it can be difficult to get a job when they are of childbearing age, and once they pass this phase they are considered to be old. In one study of employees aged 55 and older, 8 per cent of women and 3 per cent of men said that they had experienced age discrimination at work (Nilsson, 2015). Older women from ethnic minorities face yet another cause of discrimination. In addition, individuals exposed to age discrimination who are forced to retire against their wishes are at risk of psychological problems (Vaillant et al. 2006; Jokela et al. 2010).

THE FOURTH CONSIDERATION – POTENTIAL FOR MEANINGFUL AND SELF-FULFILLING ACTIVITIES

The fourth consideration addresses issues related to how the individual perceives opportunities for meaningful and self-fulfilling activities in the workplace or as pensioners:

- Favours remain in working life if: I feel that my duties at work are meaningful and provide stimulation and the opportunity for both creativity and personal growth. I feel that my identity is primarily linked with my occupation and work, and that's where I have the opportunity for self-fulfilling activities.
- Favours to leave the work life and retire if: I feel that my duties at work no longer interest me or have never been interesting. My job is mostly routine. The activities, travel, volunteer work and/or hobbies, etc. that I pursue outside work feel far more stimulating, meaningful, attractive and ap pealing than my job. I would like to have more time and opportunity for personal growth and to pursue these activities by retiring.

Two areas are included in the fourth consideration that individuals face when deciding whether to extend their working lives.

8. Knowledge, abilities and opportunity for skills development

The ability to learn new skills at a greater age depends on whether older employees are offered the opportunity for skills development regardless of age (Nilsson 2006). Unfortunately, however, older employees are given fewer opportunities for skills development and inclusion in new projects at work as they age. Negative attitudes also persist and result in adages such as "you can't teach an old dog new tricks" (Bengtsson & Nilsson, 2004). However, it is precisely these negative attitudes, as well as the lack of confidence among older employees in their ability to achieve personal growth and learn something new, that pose the greatest obstacle for doing so (Mather

2010). It is important to use learning methods that connect new skills with those accumulated through life and experience so that older employees can link the new skills with those that are already ingrained. In addition, when new information is presented in a new way, it takes longer for older people to react cognitively – to structure and organise it in their minds (Mather 2010; Salthouse 2000). Time pressures also play an important role regarding the ability of older employees to learn new things.

Level of education, expertise and the opportunity to develop and use new skills are important to maintain employability and to extend working life (Järnfelt 2010; Doyle 2012; Mirowsky et al. 2008). Highly educated men are more likely to continue working even past age 70 (Ozawa & Lum 2005). However, more interventions need to be evaluated to expand knowledge and develop better ideas on how a change in career, from the perspective of expertise based on experience and skills development, can expand opportunities for a sustainable extension of working life (Nilsson 2015).

9. Job satisfaction, the nature of the job, stimulation and meaningful duties

People who value their jobs and see them as an important part of their personal identity and lives are more inclined to work beyond age 65 (Wang & Shultz 2010; Nilsson et al. 2011). Motivation and job satisfaction increase when people are given the opportunity for growth and meaningful duties at work, as well as when they can use their experience, knowledge and expertise at work (Börsch-Supan et al. 2009; Siegrist et al., 2007). Feelings of being needed and in demand also motivate older workers to extend their working life (Ilmarinen, 2006; Nilsson, 2005; Nilsson, 2012). Many who continue working do so because they have undertaken to complete a project, or because no one else possesses their unique skills and experience to do the job (Higgs et al. 2003). Individuals with high status in their professional lives often demonstrate a decline in mental health following retirement unless they can become involved in equally challenging tasks as pensioners; this is especially so for men (Vaillant et al. 2006; Jokela et al. 2010). This is probably because retirement reduces their opportunities for development, problem-solving and self-fulfilment, which contribute to their status and life satisfaction. Older individuals who continue working often feel they have better mental and physical health compared with their counterparts without any meaningful tasks to keep them occupied (Ozawa & Lum 2005; Oude Hengel et al. 2011). Meanwhile, some older individuals prefer to return to work after retiring because of the lack of meaningful and self-fulfilling activities as pensioners (Robinson et al. 2010; Nilsson 2012). Continued opportunities for personal growth and stimulation increase producti-

vity among older workers, for example, through participation in new projects regardless of age (Kunze & Reas, 2015). Such opportunities also contribute to ageing well (Vailliant et al. 2006). Conversely, early retirement is more common among individuals who are tired of their jobs and do not feel that their duties are stimulating or meaningful (Nilsson 2012; Bidewell et al. 2006). In this group the ageing process becomes healthier if they do not have to remain in working life.

ORGANISATIONAL PROPOSALS FOR ACTION

Measures are needed at every level in order for working life to become sustainable and health-promoting for employees of all ages, including older ones: at the societal, organisational and company levels, as well as at the individual level (Nilsson 2016). Measures at the organisational and company level are particularly important.

Below are some proposals at the organisational level for measures based on the information in this chapter. The measures are divided into three priority areas based on the nine areas of importance for the decision to be part of working life, for age-related aspects and for individual considerations concerning retirement, etc.

Measures to promote good physical and mental health at work:

- Provide a balanced physical and mental workload (duties and responsibilities).
- Rotate and vary duties to reduce monotonous workload and burnout.
- Create an organisational culture that promotes the use of technical and ergonomic assistive devices.
- Offer work schedules and shifts that meet the needs of the individual with respect to health and recovery time.
- Offer physical activity, "maintenance and organisation", wellness programmes to promote mental and physical well-being.
- Use occupational health services to promote good health at work.

Measures to promote feelings of security at work:

- Provide staff with information and encourage co-participation when changes are made (within reasonable limits).
- Fight discriminatory treatment, preconceived notions about age (ageism) and age discrimination.
- Offer work schedules and shifts that take into account the social needs of the individual regarding family, friends and leisure activities.

Measures to promote skills and motivation:

- Provide opportunities for skills development and inclusion in development and new projects, regardless of age.
- Create an organisational culture that takes advantage of the experience and knowledge of (older) employees as a production asset.
- Rotate and change duties to reduce boredom and increase motivation and job satisfaction, for example by encouraging staff to vary their duties and change workstation.

REFERENCES

Ahola K. Sirén I. Kivimäki M. et al. *Work-Related Exhaustion and Telomere Length: A Population-Based Study.* PLoS One 2012; 7 (7), Article e40186. *The Swedish Work Environment Authority Women's work environment 2011-2014.* Report 2015:6. Stockholm: the Swedish Work Environment Authority, 2015.

Barbini N. Squadroni R. Andreani M. *Gender difference regarding perceived difficulties at work with age.* I Costa G. Goedhard W. Ilmarinen J. (ed.) *Assessment and Promotion of Work Ability, Health and Well-being of Ageing Workers.* Amsterdam: Elsevier, 2005.

Beehr TA. Glazer S. Nielson NL. *Farmer SJ. Work and Non-work Predictors of Employees' Retirement Age.* Journal of Vocational Behavior 2000; 57:206–225.

Bernard M. Itzin C. Phillipson C. Skucha J. *Gendered Work, Gendered Retirement.* I Arber S. Ginn J. (ed.) Connecting Gender & Ageing. *A sociological approach.* Philadelphia: Open University Press, 1995.

Bidewell J. Griffin B. Hesketh B. *Timing of retirement: Including a delay discounting perspective in retirement models.* Journal of Vocational Behavior 2006; 68:368–387.

Bornefalk A. Yndeheim O. *Can we count on the elderly?* Appendix 5 to long-term inquiry 2003/2004. SOU 2004:44. Stockholm: Swedish Government Official Reports, 2004.

Brenes-Comacho G. *Favourable changes in economic wellbeing and self-rated health among the elderly.* Social Science & Medicine 2011; 72(8–10): 1228–1235.

Börsch-Supan A. Brugiavini A. Croda E. *The role of institutions and health in European patterns of work and retirement.* Journal of European Social Policy 2009; 19:341–358.

Carter N. Ulfberg J. Nyström B. Edling C. *Sleep debt, sleepiness and accidents among males in general population and male professional drivers.* Accident Analysis & Prevention 2003; 35:613–617.

Cobb-Clark DA. Stillman S. *The Retirement Expectations of Middle-aged Australians.* The Economic Record 2009; 85(269):146–163.

Coppola M. Benita Wilke C. *How sensitive are subjective retirement expectations to increases in the statutory retirement age?* The

German case. Mannheim: Mannheim Research Institute for the Economics of Ageing, 207, 2010.
De Vaus D. Wells Y. Kending H. Quine S. *Does gradual retirement have better outcomes than abrupt retirement?* Results from an Australian panel study. Ageing & Society 2007; 27:667–682.
Diamond P. *Behavioural economics.* Journal of Public Economics 2008; 92:1858–1862.
Doerpinghaus HI. Feldman DC. *Early Retirement Penalties in Defined Benefit Pension Plans.* Journal of Managerial Issues 2001; 13(3):273–288.
Dosman D. Fast J. Chapman SA. Keating N. *Retirement and Productive Activity in Later Life.* Journal of Family and Economic Issues 2006; 27:401–419.
Doyle YG. McKee M. Sherriff M. *A model of successful ageing in British populations.* European Journal of Public Health 2012; 22(1):77–76.
Dwyer DS. Mitchell OS. *Health problems as determinants of retirement: Are self-rated measures endogenous?* Journal of Health Economics 1999; 18:173–193.
Fochsen G. Sjögren K. Josephson M. Lagerström M. *Factors contributing to the decision to leave nursing care: a study among Swedish nursing personnel.* Journal of Nursing Management 2005; 13:338–344.
Forma P. Tuominen E. Väänänen-Tomppo I. *Who wants to continue at work? Finnish pension reform and the future plans of older workers.* European Journal of Social Security 2005; 7:227–250.
Friis K. Ekholm O. Hundrup YA. et al. *Influence of health, lifestyle, working conditions, and sociodemography on early retirement among nurses: The Danish Nurse Cohort Study.* Scandinavian Journal of Public Health 2007; 35:23–30.
Gander P. Signal L. *Who is too old for shift work? Developing better criteria.* Chronobiology International 2008; 25(23):199–213.
Gellerstedt S. *Work Environment: Class and Gender Stockholm*: LO in Sweden (LO), 2005.
Gonäs L. *On the verge of a breakthrough.* On the gender-segregated working life Stockholm: Agora, 2005.
Greiff M.? *Calling or profession? Professional cultures and the creation of male and female between the client and the buyers of work.* Peterson H. Leppänen V. Jönsson S. Tranquist J. (ed) *Conditions in work with people.* Working life in change 2006:4. Stockholm: Swedish Institute of Working Life, 2006.
Göbel C. Zwick T. *Which Personnel Measures are Effective in Increasing Productivity of Older Workers?* Centre for European Economic Research. 2010: No. 10-069.
Hank K. *How "Successful" Do Older Europeans Age?* Findings from SHARE. Journal of Gerontology: Social Science, 2011; 66B (2):230–236.

Hanson Frieze I. Olson JE. Murrell AJ. *Working Beyond 65: Predictors of Late Retirement for Women and Men MBAs.* Journal of Women & Aging 2011; 23:40–57.
Hao Y. *Productive Activities and Psychological Well-Being Among Older Adults.* Journal of Gerontology 2008; 63B (2):64–72.
Higgs P. Mein G. Ferrie J. et al. *Pathways to early retirement: structure and agency in decision-making among British civil servants.* Ageing & Society 2003; 23:761–778.
Holliday R. *Ageing and the decline in health.* Health 2010; 2(6):615–619.
Hornung OP. Danker-Hopfe H. Heuser I. *Age-related change in sleep and memory: Commonalities and interrelationships.* Experimental Gerontology 2005; 40:279–285.
Hult C. Stattin M. *Age, Policy Changes and Work Orientation: Comparing Changes in Commitment to Paid Work in Four European Countries.* Population Ageing 2009; 2:101–120.
Hult C. Stattin M. Janlert U. Järvholm B. *Timing of retirement and mortality – A cohort study of Swedish construction workers.* Social Science & Medicine 2010; 70:1480–1486.
Ilmarinen J. T*oward a longer working life: Aging and quality of workinglife in the European Union.* Helsinki: Finnish Institute of Occupational Health, 2006.
Jensen PH. Juul Møberg R. *Age Management in Danish Companies: What, How and How Much?* Nordic Journal of Working Life Studies 2012; 2(3):49–65.
Johnston DW. Wang-Sheng L. *Retiring to the good life? The short-term effects of retirement on health.* Economic Letters 2009; 103:8–11.
Jokela M. Ferrie JE. Gimeno D. et al. *From Midlife to early Old Age.* Health trajectories Associated With Retirement. Epidemiology 2010; 21(3):284–290.
Järnfelt N. *Education and Longer Working Lives: A longitudinal study on education differences in late exit from working life among older employees in Finland.* Helsinki: Finnish Centre for Pension Studies, 2010.
Karlsson NE. Carstens JM. Gjesdal S. Alexandersson KAE. *Work and Health. Risk factors for disability pension in a population-based cohort of men and women on long-term sick leave in Sweden.* European Journal of Public Health 2008; 18(3):224–231.
Karlqvist L. Bildt C. Dahlberg R. *Gender, Work and health - a regional research and development project in Östra Götaland* Working life report 2004:14. Stockholm: Swedish Institute of Working Life 2004.
Kubicek B. Korunka C. Hoonakker P. Raymo JM. *Work and Family Characteristics as Predictors of Early Retirement in Married Men and Women.* Research on Aging 2010; 32(4):467–498.

Kulik L. *Marital relations in later adulthood, throughout the retirement process.* Ageing & Society 2001; 21:447–469.
Kunze F. Reas AML. *It Matter How Old You Feel: Antecedents and Performance Consequences of Average Relative Subjective Age in Organizations.* J. of Applied Psychology 2015;100 (5):1511-1526.
Laaksonen M. Metsä-Simola N. Martikainen P. et al. *Trajectories of mental health before and after old age and disability retirement: a register-based study on purchases of psychotropic drugs.* Scandinavian Journal of Work, Environment & Health 2012; 38(5):409–417.
Marcum JL. Browning SR. Reed DB. Charing RJ. *Determinants of Work Hours Among a Cohort of Male and Female Farmers 50 years and Older in Kentucky and South Carolina* (2002–2005) Journal of Agromedicine 2011; 16:163–173.
Mather M. *Aging and cognition.* Cognitive Science 2010; 1:346–362.
Mirowsky J. Ross CE. *Cumulative Advantage and its Rising Importance.* Research on Aging 2008; 30(1):93–122.
Molinié A-F. *Feeling capable of remaining in the same job until retirement?* International Congress Series 2005; 1280:112–117.
McLaughlin AC. Sprufera JF. *Aging Farmers Are at Risk for Injuries and Fatalities: How Human-Factors Research and Application Can Help.* North Carolina Medical Journal 2011; 72(6):481–483.
Mitchell L. Hawranik P. Strain L. *Age-related Physiological Changes: Considerations for Older Farmers' Performance of Agricultural Tasks.* Canada Winnipeg: Centre of Aging, University of Manitoba, 2002.
Munnell AH. Sass SA. Soto M. *Employer attitudes towards older workers: survey results. Work Opportunities for Older Americans. An Issue in brief: Series 3.* Boston: Center for Retirement Research at Boston College, 2006.
Myers JR. Layne LA. Marsh SM. *Injuries and Fatalities to U.S. Farmers and Farm Workers 55 Years and Older.* American Journal of Industrial Medicine 2009; 52:185–194
Mykletun R. Furunes T. Solem PE. *Managers' Belief about Measures to Retain Senior Workforce.* Nordic Journal of Working Life Studies 2012; 2(3):109–127.
Mykletun R. Furunes T. *The Ageing Workforce Management Programme in Vattenfall AB Nordic, Sweden.* In Ennals R. Salomon RH. (eds.) *Older Workers in a Sustainable Society. Labor, Education & Society:* Frankfurt: Peter Lang Verlag, 2011: 93–106.
Nilsson K. *Extended working life - a literature study of factors with significance for extended working life as an alternative to early retirement.* Malmö: Swedish Institute of Working Life, 2003.
Nilsson K.? *Who can or will work until 65 years of age or longer? A study of employees within healthcare.* Work and Health 2005:14.

Stockholm: Swedish Institute of Working Life, 2005.
Nilsson K. *Older employees' attitudes to a long working life. Differences between occupational groups in healthcare.* Working life in transition 2006: Stockholm: Swedish Institute for Working Life 2006:10.
Nilsson K. *Attitudes of managers and older employees to each other and the effects on the decision to extended working life.* In Ennals R. Salomon RH. (eds.) *Older Workers in a Sustainable Society.* Labor, Education & Society. Frankfurt: Peter Lang Verlag, 2011: 147–156.
Nilsson K. *Why work beyond 65? Discourse on the decision to continue working or retire early.* Nordic Journal of Working Life Studies 2012; 2(3):7-28.
Nilsson K. *To work or not to work in an extended working life? Factors in working and retirement decision.* Doctoral Dissertation Series 2013:4. Lund University: Faculty of Medicine, 2013.
Nilsson K. *Gender and old age pension - a cross sectional study of the differences between men and women to be able and willing to work to 65 years or longer.* Rapport nr 4/2015. Lund: Work and environmental medicine, 2015.
Nilsson K. *Interventions to reduce injuries among older workers in agriculture: A review of evaluated intervention projects.* WORK: A Journal of Prevention, Assessment, and Rehabilitation 2015, Online First (Accepted 20151202)
Nilsson K. *Conceptualization of ageing in relation to factors of importance for extending working life – a review.* Scandinavian Journal of Public Health 2016; 44: 490–505 (a).
Nilsson K. *Best before date on the workforce? - the importance of various age concepts for older people in the workplace.* I Krekula C. Johansson, B. (eds.) *Age, power and organization - theoretical and empirical.* Malmö Gleerup Publishers 2016 (B).
Nilsson K. Pinzke S. Lundqvist P. *Occupational Injuries to Senior Farmers in Sweden: Journal of Agricultural Safety and Health* 2010; 16(1):19–29.
Nilsson K. Rignell-Hydbom A. Rylander L. *Factors influencing the decision to extend working life or to retire.* Scandinavian Journal of Work, Environment and Health 2011; 37(6):473–480.
Nilsson K. Östergren P-O. Kadefors R. Albin M. *Has the participation of older employees in the workforce increased?* Study of the total Swedish population regarding exit from working life. Scandinavian Journal of Public Health, 2016; 44: 506–516.
Nordenmark M. Stattin M. *Psychosocial wellbeing and reasons for retirement in Sweden.* Ageing & Society 2009; 29:413–430.
Oude Hengel K. Blatter BM. Geuskens GA. et al. *Factors associated with the ability and willingness to continue working until the age of 65 in construction workers.* International Archives of Occupational & Environmental Health 2011; 85(7):783–90.
Ozawa M. Lum TY. *Men Who Work at Age 70 or Older.* Journal of

Gerontological Social Work 2005; 45(4):41–63.
Park J. *Health factors and early retirement among older workers.* Statistics Canada 2010; 75–001:5–13.
Pohjonen T. *Perceived work ability of home care workers in relation to individual and work-related factors in different age groups.* Occupational Medicine 2001; 51(3):209–217.
Rechel B. Grundy E. Robine J-M. et al. *Ageing in the European Union.* Lancet 2013;181:1312–1322.
Rhodes C. Pullen A. *Editorial: Neophilia and organization.* Culture and Organization 2010;6(1);1-6.
Robinson O. Demetre JD. Corney R. *Personality and retirement: Exploring the links between the Big Five personality traits, reasons for retirement and the experience of being retired.* Personality & Individual Differences 2010; 48:792–797.
Salthouse T. *Aging and measures of processing speed.* Biological Psychology, 2000; 54: 35-54.
Savinainen M. *Physical Capacity and Workload among Ageing Workers.* Helsinki: Finnish Institute of Occupational Health, 2004.
Schuring M. Mackenbach J. Voorham T. Burdorf A. *The effect of re-employment on perceived health.* Journal of Epidemiology & Community Health 2011; 65:639–644.
Siegrist J. Wahrendorf M. Von dem Knesebeck O. et al. *Quality of work, well-being and intended early retirement of older employees – baseline results from the SHARE Study.* European Journal of Public Health 2007; 17(1):62–68.
Silverstein M. *Meeting the Challenges of an Aging Workforce.* American Journal of Industrial Medicine 2008; 51:269–280.
Sjösten N. Nabi H. Westerlund H. et al. *Influence of retirement and work stress on headache prevalence: A longitudinal modelling study from GAZEL Cohort Study.* Cephalagia 2010; 31(6):696–705.
Smith DB. Moen P. *Retirement Satisfaction for Retirees and Their Spouses. Do Gender and the Retirement Decision-making Process Matter?* Journal of Family Issues 2011; 25(2):262–285.
Stattin M. *Retirement on grounds of ill health.* Occupational & Environmental Medicine 2005; 62:134–139.
Thorsen S. Rugulie R. Løngaard K. et al. *The association between psycho social work environment, attitudes towards older workers (ageism) and planned retirement.* International Archives of Occupational & Environmental Health 2012; 85(4):437–45.
Tucker-Seeley RD. Li Y. Subramanian SV. Sorensen G. *Financial Hardship and Mortality among Older Adults Using the 1996–2004 Health and Retirement Study.* Annals of Epidemiology 2009; 19(12):850–857.
UNFPA & HelpAge International. *Ageing in the Twenty-First Century: A Celebration and A Challenge.* New York: United Nations Population Fund (UNFPA) & London: HelpAge International, 2012.

Vahtera J. Westerlund H. Hall M. et al. *Effect of Retirement on Sleep Disturbances: the GAZEL Prospective Cohort Study.* Sleep 2009; 32(11):1459–1466.
Vaillant GE. DiRago AC. Mukamal K. *Natural History of Male Psychological Health, XV: Retirement Satisfaction.* American Journal of Psychiatry 2006; 163(4):682–688.
Vendramin P. Valenduc G. *Occupation and ageing at work. An analysis of the findings of the Fifth European Working Conditions Survey.* Working paper 2012.9. European Trade Union Institution, 2012.
Vercruyssen M. *Lifespan Functional Fitness: Encouraging Human Struggle (Physical Activity) and Warning About the Cost of Technology.* In Kumashiro M, (ed.) Aging and Work. London: Taylor & Francis, 2003: 62–71.
von Bonsdorff ME. Kokko K, Seitsamo J. et al. *Work strain in midlife and 28-year work ability trajectories.* Scandinavian Journal of Work, Environment & Health 2011; 6:455–463.
Wang M. Shultz KS. *Employee Retirement: A Review and Recommendations for Future Investigation.* Journal of Management 2010; 36(1):172–206.
Weaver DA. *The work and retirement decision of older women: A literature review.* Social Security Bulletin 1994; 57(1):1–40.
Westerlund H. Kivimäki K. Sing-Manoux A. et al. *Self-rated health before and after retirement in France (GAZEL): a cohort study.* Lancet 2009; 374:1889–1896.
Westerlund H. Vahtera J. Ferrie JE. et al. *Effect of retirement on major chronic conditions and fatigue:* French GAZEL occupational cohort study British Medical Journal 2010; 341:c6149.
Åkerstedt T. Kecklund G. Gillberg M. *Sleep and sleepiness in relation to stress and displaced work hours.* Physiology & Behavior 2007; 92:250–255.

3. Cognitive ageing

Boo Johansson

This chapter provides a brief overview of cognitive ageing and the prerequisites of mastering the many cognitive challenges that accompany increasing age.

Cognition is a collective term for the brain's most complex functions. These psychological functions are localised to the cerebral cortex, and are often involuntary. This means that we can acquire experience and establish memories that help us to consciously navigate and master our complex daily life. Cognitive function requires coordination and integration of processes such as attention, perception, concentration, working memory and episodic memory, decision-making, executive processes, problem solving, language, spatial and motor skills. Cognitive performance or cognitive health means an assessment of individual cognitive abilities and how these operate when we face various cognitive challenges at work, during leisure time or in particular test settings. The individual's assessment of own cognitive abilities is also important for how one perceives health and functional ability. A person's cognitive ability has decisive significance for how we can adapt to demands in the external environment, but also for how we can change these conditions. With age, the internal biological environment changes, and we need to master age-related changes in the brain and nervous system as well as an increasing risk of ill health and illness.

The early ageing research often assumed that cognitive abilities would deteriorate with age in the same manner as physical abilities and external attributes. Later research has shown that cognition has its own ageing processes and that more tangible effects are primarily seen in very late life, and then it often depends upon illness and overall declining vital functions. An overview of cognitive ageing can be found in the background report S2011:05 to the Government Commission for Longer Working Life and Retirement age (Johansson, 2011), and in overviews such as Hofer & Alwin (2008). In the Swedish Work Environment report 'The brain-friendly workplace – cognition, cognitive impairment and work environment´ (Karlsson et.al, 2014), an even more detailed description is provided of the significance and occurrence of different cognitive impairments in the working population (18–65 years of age. Here it is calculated that a significant proportion (extrapolated at 55 per cent) may have temporary or permanent cognitive problems due to impaired health. With age, the risks also increase. To which extent such problems affect daily functions and work capacities depends, however, to a large extent upon the demands placed upon cognitive function, but also on the compensatory possibilities and support systems that are available in the external environment, for example in the form of general technical aids or cognitive ergonomics in working life.

COGNITIVE AGEING – TYPE OF AGEING AND COGNITIVE ABILITY

By ageing is meant the last period in an individual's adult life, without an actual reference to chronological age or the number of years that have passed since we were born. Notably, chronological age is in fact becoming an ever-worsening indicator of function with increasing age, which becomes clear with comparisons within a group of younger and older individuals. In gerontology – the science of ageing – one often distinguishes between three different types of age which do not unambiguously correspond with each other or with a chronological age measurement:

- Biological age refers to the individual's actual position on a lifeline with reference to the ability of survival or potential life span.
- Psychological age is defined from the individual's ability to cope with changes in both the inner biological environment and the outer social environment. Our cognitive abilities have a central role in this mastering.
- Social age refers to age-related roles and social habits in a certain socio-cultural context or in a society where age is valued differently and has significance for how one is treated. The view of the older labour force, pension age and gender roles are some factors which define social age.

The associations between biological, psychological and social age can change, among other things as a result of population ageing. The calculated remaining lifespan for a 65 year old today is about 19 years for men and about 22 years for women, according to Statistics Sweden. The corresponding number 50 years ago (1966) was about 14 years for men and about 16 years for women. According to the forecast for 2066 (in 50 years), the remaining lifespan for 65-year-old women will be close to 26 years and for men just over 24 years. The prerequisites for a long life have increased significantly. At the same time, the prerequisites for a long life also depend upon the educational background and many other factors. The differences in survival are also reflected in the cognitive performance in older individuals.

As a rule there are two different 'yardsticks' to assess what happen with increasing age. We can either compare ourselves with people who are even older, as old or younger, or we start from changes in ourselves or others that we have previous knowledge about. The first benchmark provides cross-sectional comparisons, and age differences becomes a basis for conclusions about how one may change with increasing age. These comparisons, however, do not take into account

other factors that may contribute to the observed differences. In the second yardstick the individuals are their own controls or "self-checks" which gives information about whether a particular feature or function is stable or has changed. This longitudinal method avoids comparisons that could more likely be the result of changes in living conditions (generation and which cohort one belongs to) and other facts of life that become apparent later in life (Bosworth & Hertzog, 2009; Hofer & Alwin, 2008). It is important to distinguish age differences from age changes. It is enough to refer to how health conditions, education, and occupational life has changed, to understand the significance of changed life circumstances.

The external conditions of life also affect the brain and our inner biological environment. Ageing is now seen to a larger extent as a reflection of past influence, and a life course perspective has replaced an earlier view of ageing as a distinct period of life. This also gives a better understanding that there are myriad factors throughout life that affect how people function in old age and that manifests itself in the major differences in health and functional capacity between individuals of the same chronological age. Those who have lived a long life have been able to acquire much experience and knowledge, but at the same time being exposed to risk conditions that could impair their cognition.

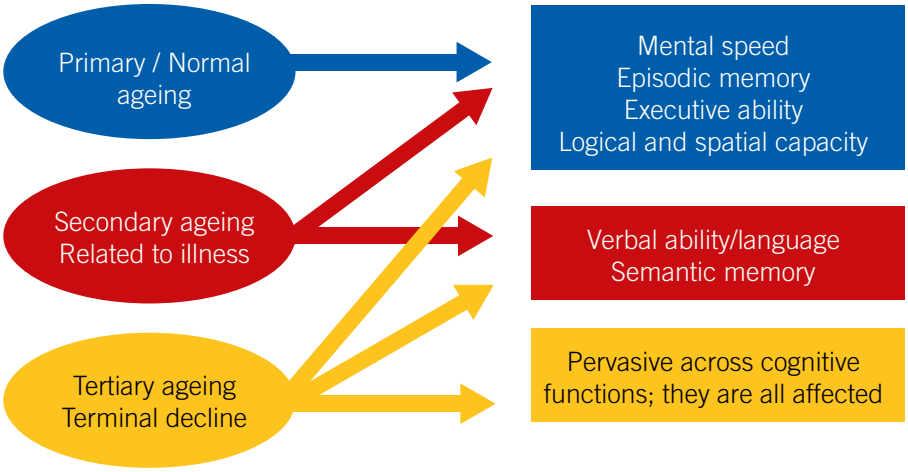
TYPE OF COGNITIVE AGEING

With increasing age, chronological age becomes a less informative marker of cognitive function and health. Cognition is certainly affected by the primary ageing changes in the brain and nervous system, but there is a considerable plasticity even in old age. The brain is shaped and reshaped throughout life by experience and other influences, which enables a better adaptation to cognitive demands (see, for example, Greenwood, 2007). At the same time, this also contributes to large differences between people of the same chronological age.

Throughout adulthood there is a loss of nerve cells, though not as large in all parts of the brain. The single nerve cell has numerous contacts, which is required for communication within the brain and nervous system. A reduced number of interfaces or synapses may be a neurobiological explanation for the slower perception and reaction time. It takes longer for older people to perceive visual and auditory stimuli that must be processed before one reacts. The ability to quickly assimilate information and to perform tasks under time pressure declines. Our body movements are also largely dependent on brain function. Impaired mobility, coordination and balance can produce difficulties in situational changes, something that is also seen in otherwise vital older people.

The slower reaction time is a reflection of the fact that it takes longer to activate the cognitive processes required for our perception, and then to send a signal to the musculature to perform a certain motor activity. Many cognitive tests are designed with a time limit, which means that performance is also evaluated based upon how quickly one is able to carry out a task. This can also apply to tests of linguistic abilities, logical ability, spatial ability, and decision making or certain memory functions. That we tend to slow down with age is, however, noticeable especially when we face new and more complex tasks where it is not possible to utilize previously established strategies and ingrained thought patterns. When one examines the brain capacity during in older adults, it is rarely just the primary normal biological ageing that contributes to the observed changes. It is largely related to the increased risk of ill health and diseases that can affect our cognition. The clinical picture is often more complex. In addition, the treatment of disease often involves medication that may also affect memory and other cognitive abilities. Chronological age or ”age in itself ” naturally does not cause cognitive change. The explanation must be sought in neurobiological ageing processes and in the age-related changes (disease and ill health) that becomes increasingly more common with advancing age.
So, we need to identify various types of age-related cognitive loss. The changes that affect everyone with increasing age are usually referred to as primary ageing. The changes that occur in the context of age-related disease and ill health are called secondary ageing. Changes that indicate impending death is called tertiary ageing (Birren & Cunningham, 1985). With increasing age, primary ageing tends to become increasingly overshadowed by the effects of illness and disease which also affect survival. Tertiary ageing refers to an overall l de-vitalization of life functions, including cognition that often decline before a person dies. The tertiary ageing effects are mainly seen in advanced ages because of the increased population survival.

Figure 2. Cascade model for cognitive ageing.



Source: Modified by author

The cascade model (Figure 2) shows that primary ageing affects mental speed, episodic memory, and what is called fluid intelligence, such as executive, logic and spatial skills. These skills play a central role in our information processing, and they are particularly susceptible to neurobiological changes.

Secondary ageing is characterized by disease loads with cognitive effects. Here, even more robust cognitive abilities are affected, such as language, general knowledge or semantic memory. In addition, we can see a further deterioration of cognitive functions that are already affected by primary ageing. Many diseases can produce cognitive impairment. Diseases diagnosed later in life often have an onset between the ages of 55-65 years, and estimates show that about 70 per cent in this age range may already have some sort of illness or impaired function (Pierce et.al, 2012). The eventual cognitive effects of these illnesses may become manifest later in life, if it is not about, for example, a stroke.

MEMORY

Memory is a complex cognitive function often associated with ageing. It is however, not affected similarly, which is reflected in the differences between the various memory systems such as working memory, episodic memory and semantic memory.
Working memory is the active partial function in the short-term memory that is mobilized when we temporally have to keep the information current, at the same time as we need to process this

information. Primary ageing effects are well documented for working memory, which thus deteriorates.
Studies of semantic memory or factual memory now show that it is relatively unaffected by primary ageing. This memory system can also develop positively with age, and older people often perform better than younger in tests that measure more general knowledge or vocabulary. Older persons, however, perform worse in tests where they have to quickly reproduce facts or find words.
The episodic memory system stores the memories of what we ourselves have experienced. This is the memory that we often relate to in order to assess our own or other's memory ability. This memory system also deteriorates during primary ageing. To what extent it hampers everyday life depends on the ability to compensate by various means.

FLUID COGNITIVE ABILITIES

Executive and logic functions provide the means to plan, evaluate, organize and initiate logical solutions to new and unfamiliar cognitive challenges. Some solutions require experiential (inductive) inference or the ability to see general patterns in single units. Others require a deductive approach where more general solution principles or rules provide guidance to solve a task.
Cognitive flexibility is one aspect of problem solving where one, with no instruction, must find a strategy to solve a problem, but also be prepared to abandon this strategy in favour of another if necessary. Even during primary ageing, people are more likely to keep to the solutions that we already know work. To simultaneously manage many different tasks, so-called "multi-tasking", becomes increasingly difficult for those who do not already have procedures and strategies for dealing with complex cognitive challenges and situations that require both mental speed and simultaneous problem solving.
Creativity is an aspect that requires the ability to create or formulate new ideas or products. This can be examined in the data where it is important to identify possible solutions to a problem. Non-cognitive factors such as motivation and institutional factors can make it difficult to assess the degree of age-related change in the creative ability. Creative people in real life may in fact the risk of becoming victims of their own success and perhaps receive executive tasks that hinder them to continue own creative work. Reduced expectations of older people's ability are also important in this context. Within mathematics, history shows that new ideas are often formulated by young people, while in the arts and humanities they can relate to things in the opposite way. Most indications are that creative ability is fairly robust during primary ageing, although the forms of expression change. It's not just younger who can think in new ways.
Spatial ability refers to the ability to perceive and orient oneself in the

spatial three-dimensional (3-D) context. It shows, among other things in the way we can orient ourselves in different environments and understand or draw a map or a pattern. In tests this is typically investigated by being instructed to draw patterns, perform construction tasks, or determine if rotated figures are the same shape. Age effects are, as in other cognitive tests, dependent on the difficulty of the task. For more complex tasks there is a more pronounced deterioration and older persons generally require more time to solve the task. Simpler spatial construction tasks show no actual ageing effects apart from those due to sensory and motor problems.

CRYSTALLIZED COGNITIVE ABILITIES

Unlike the fluid abilities, the so-called crystallized abilities are relatively stable during primary ageing. They are established through experience and maintained by the new cognitive challenges we face over an increasingly longer life. This applies particularly to factual memory or semantic memory, in which deterioration is primarily produced by dementia, stroke or other brain damage.

Verbal abilities such as word comprehension, vocabulary, grammar and syntax, can often differ between age groups. It is also shown in the ability to find synonyms, a test task where there is a strong association with education and general knowledge. Test of word fluency shows deterioration, as do tests that measure how fast you can find a certain terminology. This is related to our mental speed and is seen mainly in older age.

One aspect of our crystallized ability is the pragmatic intelligence that we acquire over the entire life and which helps us make decisions and cope with everyday problems. This form of intelligence or acquired expertise can in many situations compensates for shortcomings or failures in other cognitive abilities. The prerequisite is, however, that the person can use previous experience and does not face new cognitive challenges that require new ways of thinking and acting. The pragmatic intelligence therefore reflects the skills and habits that the individual has acquired during life. Many of these experiences have been at work, but are also tied to gender roles.

CHANGE AND STABILITY IN COGNITIVE ABILITY DURING LIFE

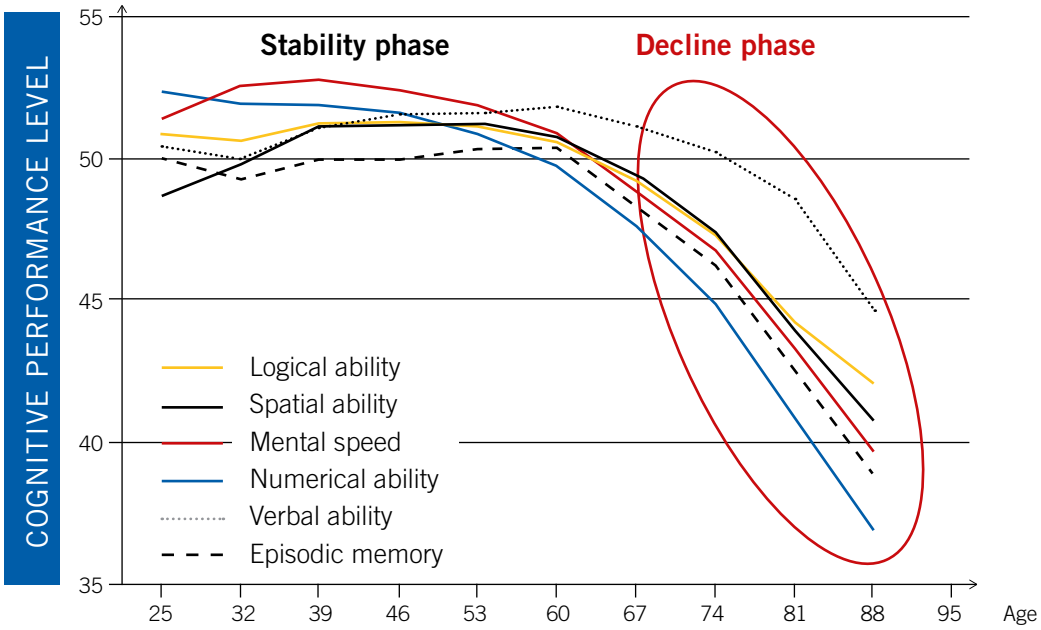
Studies based on cognitive tests have shown that our fluid abilities are at their best in early adulthood, while more crystallized abilities may become better in the later phases. In an extensive study, Hartshorne and Gerimine (2015) tried to answer as to when people perform best. A large group of volunteers in the age range 10-70 years received various cognitive tests (working memory, perceptual and mental speed, as well as vocabulary) over the Internet. As expected, the outcomes depended on specific cognitive ability. The performance

peak for working memory was in the 30s, which is slightly later than the best age for mental speed. On the other hand, vocabulary appeared to be peak in the 50-60s.
Today's 50, 60, 70 or 80 year-olds are significantly different from the past, and likely from future generations even when it comes to cognition. The population generally has a better overall health status and living conditions, and this has meant an increase in remaining life expectancy even in older age groups of later born people. They have grown up, lived and aged in a society with different conditions than what was found in previous generations. This increased life expectancy also means expectations about cognitive health and preserved cognitive function, both at the individual level and among others.
A person aged 60-65 years was earlier perceived perhaps as old and fragile, which also lowered self-esteem. Today these "young seniors" are rather characterized by continued good health and function, and their self-image is often more in line with a middle aged ideal than with old age.

Later birth cohorts tend to perform better on cognitive tests than previous cohorts at the same chronological age. These cohort differences, called the Flynn effect, are due to the combined effects of better health and intellectual stimulation in later birth cohorts, which also has increased their cognitive reserve capacity. One exception is numerical ability, where later born cohorts did not receive the same training in mental arithmetics because they had electronic calculators, mobile phones and computers. The Flynn effect was also confirmed in the study of Hartshorne and Gerimine (2015). It was also found that the average "peak performance" in later cohorts tended to occur at a higher age than in earlier cohorts. This has also been shown in several longitudinal studies (such Schaie, 2005; Rönnlund & Nilsson, 2009), where later born cohorts perform better than earlier cohorts.

Longitudinal studies show that cognitive performance in most tests is fairly stable until 60-70 years of age, with the exception of tests where speed is crucial. A more marked decline in the population is thus first seen in higher ages. In ageing research, focus has therefore increasingly shifted from the ratio of younger-older to the later phases of life, where the risks are greater for an actual deterioration.

Figure 3. Longitudinal results for various cognitive tests calculated on a 7-year interval.



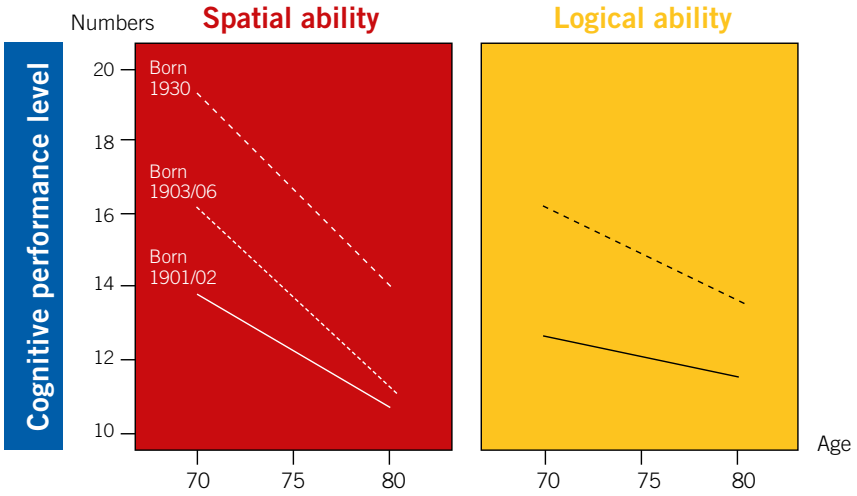
Source: Schaie, 2005.

The differences between various cognitive abilities may be large. Some functions are more sensitive to both primary and secondary ageing changes. In studies of people in advanced ages, changes will be more noticeable as the effects of secondary and also tertiary ageing increase. Sometimes it has been assumed that women have better cognitive health than men at the same chronological age, because women on average live longer. Most studies show that gender differences are relatively small even when taking into account differences in survival. The differences established earlier in life tend to persist, for example, that women perform better on episodic memory tests, while men perform slightly better on spatial tasks.

There are longitudinal studies that report cognitive decline already in earlier in adult life. In a study by Singh-Manoux et al (2012) it is shown, for example, that 45-70-year-olds have poorer episodic memory, logical ability and verbal speed over a 10-year period, while word

comprehension improved. Against the background of the tangible cohort effects, even longitudinal results are not seen as static. The validity is limited to the investigated age cohorts and the environment in which they lived. There is also support for cohort differences regarding change. In a comparison between different birth cohorts it is shown that the performance level was higher in the later cohorts while their longitudinal decline was more substantial (Karlsson, et al, 2015).

Figure 4. Cognitive change between 70 and 79 years of age in three birth cohorts.



Source: Karlsson et al, 2015.

Regardless of the actual extent of cognitive ageing, the ultimate question is about the factors that contribute to changes in the latter part of adult life. With increasing age, the cascade model indicates that all types of ageing have ever-greater effects. We risk being affected by fewer and fewer only primary or normal ageing effects and more and more secondary (disease-related changes) and tertiary (general devitalisation preceding death) ageing effects. This mixture tend to produce great differences between individuals, even among those with the same chronological age. The mean values underpinning for example, Figures 3 and 4 also hide that some in fact may show stable cognition. By calculating the proportion that are stable, showing deterioration or improvement between the different surveys, one receives a more informative picture of the risk of deterioration and the conditions for preserved cognitive health in older age.

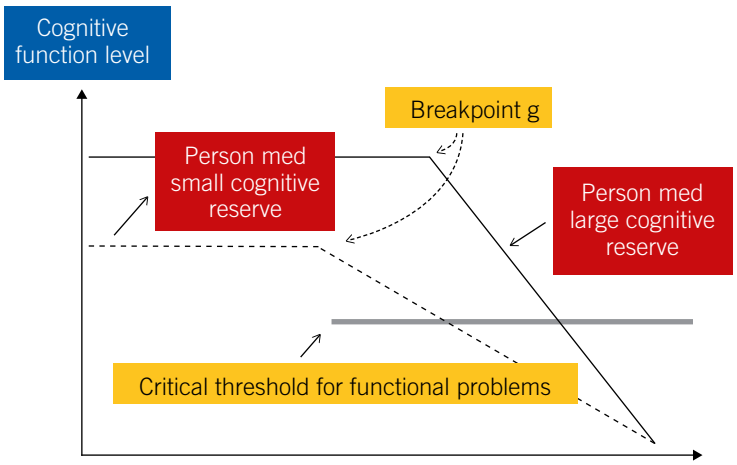
COGNITIVE HEALTH - CHALLENGES IN EVERYDAY LIFE AND WORKING LIFE

An exclusive focus on cognitive test performance means that we miss the significance of many non-cognitive factors for function and change. Mental well-being, motivation, cognitive engagement, networks and other social factors are also important for cognitive health. In real life, it is the functional capability that is absolutely critical, that is, whether and how our cognitive abilities are able to master the work and the numerous challenges and demands of everyday life, compromised cognition producing functional problems in people younger than 70-75 years are more likely an effect of pathological changes than the effects of primary or normal cognitive ageing.

Work is an essential part of our adult life. It helps shape many other conditions of our lives, and also provides diverse prerequisites for our ageing. In line with the increase in prosperity, reduced working hours and even retirement is seen as a laudable way of benefitting health and well-being. At the same time, the positive effects of working life are receiving increasing attention. To leave the world of work gives no guarantees of good health, and preserved cognition without working life can indeed be an important source of cognitive stimulation for the individual. Today's discussion of retirement age in many welfare societies is usually based only upon our increased longevity. It should also include a detailed analysis of working life's, positive impact on our cognitive reserves and health (see Staudinger et al., 2016).

A number of studies have investigated the association between job content and cognitive function. One example is a study in Scotland by Smart and colleagues (2014), where they had the opportunity to analyse these relationships in a large age cohort. For everyone, there was also cognitive test data (IQ, mental speed, and memory) from 11 years of age, which made it possible to check for the differences that existed already in the early years, as well as for education and other later living conditions. The study shows that working with more complex cognitive challenges, both socially and for work, was positive for cognitive function in later life. Similar results are also available from twin studies that controlled for the importance of genetic effects before and after retirement (Finkel, et al., 2009). There are also studies showing a greater decline in people leaving cognitively challenging work and that retirement is also likely to contribute to a "cognitive retirement" (Rohwedder & Willis, 2009). A working life that contributes towards cognitive engagement and stimulus therefore seems to be favourable for health promotion and cognitive ageing.

Figure 5. Cognitive change with increased morbid load of the brain in people with lower and higher cognitive reserves.



Source: Modified from Stern, 2009.

Differences in cognitive reserve may be a partial explanation for some showing greater cognitive decline than others (Stern, 2009), because the cognitive reserve is important for the individual's ability to master neuropathological changes. One assumes that differences in cognitive reserve is due to the neural networks that have been established over the years and which thus provide different prerequisites to compensate for primary ageing but mainly for secondary ageing effects.

A greater cognitive reserve thus provides greater opportunity for preserved cognition. But, when a critical threshold is exceeded, we can observe a more rapid decline in people who previously had a greater cognitive reserve. This can e.g. seen when people suffer from dementia, and is also confirmed in the results presented in Figure 4.

The research on cognitive ageing has been dominated by studies in which cognitive test performances have been key outcome measures. These tests examine the individual maximum performance for a more limited function. Even if this can prove a general deterioration, there are large differences between individuals of the same chronological age. Also, test-related impairments does not necessarily become evident in everyday situations where one has the opportunity to use technical aids for remembering or solving cognitive tasks. We typically activate several cognitive abilities to support our coping with a

certain task. The SOC model describes how people, through selection, optimization and compensation master cognitive demands in their daily lives (see the section by Gunnar Aronsson for more details of the SOC model). Thus, the prerequisites for dealing with the challenges of daily life and working life depend not only upon the cognitive reserve, but also on the coping strategies and the pragmatic intelligence that we have acquired. To quickly remember a single name can paradoxically be more difficult than many other seemingly more complex cognitive activities.

Finally, diseases and non-cognitive factors such as motivation and one's own and others' expectations may have greater impact on the actual ability to cope with complex cognitive demands at work and in everyday life than the primary ageing effects (see Nilsson, 2016; Henning et.al, 2016). Chronological age does not provide any real guidance.

REFERENCES

Baltes, P.B. (1993): *The aging mind: Potential and limits.* The Gerontologist, 33, 580-594.

Birren, J.E. & Cunningham, W.R. *Research on the psychology of aging: Principles, concepts and theory.* I J.E. Birren & K.W. Schaie (eds.). *Handbook of the psychology of aging.* 2nd ed. Van Nostrand, 1985.

Bosworth H.B. & Hertzog, C. (2009). *Aging and cognition. Research methodologies and empirical advances*. American Psychological Association, Washington, DC.

Finkel D, Andel R, Gatz M, Pedersen NL. *The role of occupational complexity in trajectories of cognitive aging before and after retirement.* Psychology and Aging, 2009, 24(3):563-73.

Greenwood, P. M. *Functional plasticity in cognitive aging: Review and hypothesis.* Neuropsychology, 2007, 21, 657–673.

Henning, G., Lindwall, M., & Johansson, B. (2016). *Continuity in well-being in the transition to retirement.* GeroPsych: The Journal of Gerontopsychology and Geriatric Psychiatry, 2016, in press.

Hofer, S.M. & Alwin, D.F. (eds.). *Handbook of cognitive aging. Interdisciplinary perspectives.* Sage Publications, 2008.

Johansson, B. *Cognitive health and function during aging.* Background report to Government Commission for Longer *Working Life and Retirement Age.* S 2011:05 SOU 2012: 28 *A longer life, longer working life.* Prerequisites and barriers to older people work for longer. Interim report of the Government Commission for Longer Working Life and Retirement Age

Joshua K. Hartshorne. J.K. & Germine, L.T.: *When Does Cognitive Functioning Peak?*

Karlsson, P., Thorvaldsson, V., Skoog, I., Gudmundsson, P. & Johansson, B. *Birth cohort differences in fluid cognition in old age: comparisons of trends in levels and change trajectories over 30 years in three population-based samples.* Psychology and Aging, 2015 30(1):83-94.

Karlsson, T., Classon, E. & Rönnberg, J. *The brain-friendly workplace - cognition, cognitive impairments and work environment.* Knowledge compilation. Swedish Work Environment Authority, Report 2014: 2.

Nilsson, K. *Conceptualisation of ageing in relation to factors of importance for extending working life – a review.* Scandinavian Journal of Public Health, 2016, 1–16.

Pierce, M.B., Silverwood R.J., Nitsch D., Adams J.E., Stephen A.M., Nip, W., Macfarlane, P., Wong, A., Richards, M., Hardy, R., Kuh, D. & NSHD Scientific and Data Collection Teams. *Clinical disorders in a post war British cohort reaching retirement: evidence from the First National Birth Cohort study.* PLoS One. 2012:7(9).

Rohwedder , S.& Willis, R.J. *Mental retirement. Working Paper.* Rand Labor and Population, 2009.

Rönnlund, M & Nilsson, L-G. *Flynn effects on sub-factors of episodic and semantic memory: parallel gains over time and the same set of determining factors.* Neuropsychologia, 2009, 47(11): 2174-80.

Schaie, K.W. *What Can We Learn From Longitudinal Studies of Adult Development?* Research in Human Development, 2005; 2(3): 133–158.

Smart, E.L., Gow, A.J., & Deary, I.J. *Occupational complexity and lifetime cognitive abilities.* Neurology, 2014; 83:2285–2291.

Staudinger, U.M., Finkelstein, R, Calvo, E & Sivaramakrishnan, K. *A global view on the effects of work on health in later life.* The Gerontologist, 2016; 56, Suppl. Uinger. 2:S281-92.

Stern, Y. *Cognitive reserve.* Neuropsychologia, 47, (2009; 47, 2015–2028)

4. Physiological ageing – chronic illnesses

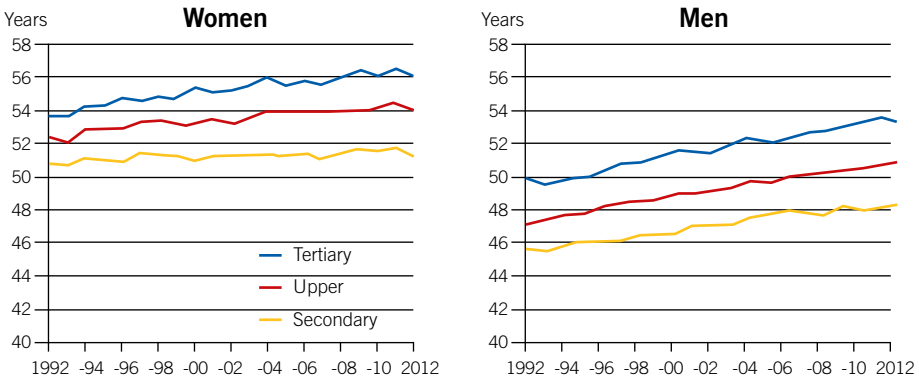
Maria Albin

Today sees a decreased risk of developing several major diseases, and treatment is improving, so that more survive without permanent loss of function. This means that more people can work up to a higher age than previously, but also that more people working have a chronic illness. Better treatment means it often does not require any special adaptation. The possibility to work further increases with a good working environment and with the support of qualified occupational health care services that can assess and address risks in the work environment, and assess the possible adaptation needs of the individual case.

THE DEVELOPMENT OF PUBLIC HEALTH

Life expectancy is increasing in the population, and so is the number of years of good health. This provides a huge potential for increased employment, especially in the group over 65 years (Johansson et al 2015). In recent decades, the mortality rate for, for example from cardiovascular disease has greatly reduced and more and more are now surviving a heart attack or stroke, but the risk of these diseases has also decreased. During the period 2010- 2013, the expected remaining life expectancy at 30 years was 54 years for women and nearly 51 years for men. Over the past 20 years, life expectancy has generally increased, and the gap between women and men has tended to decrease. On the other hand, an increase is seen in the difference between groups with different levels of education, where particularly women with, at most, secondary education have a much weaker performance than the other groups (Figure 6). The difference between the groups with tertiary and secondary education was 5 years for both women and men, 2012 (Public Health Agency of Sweden 2014).

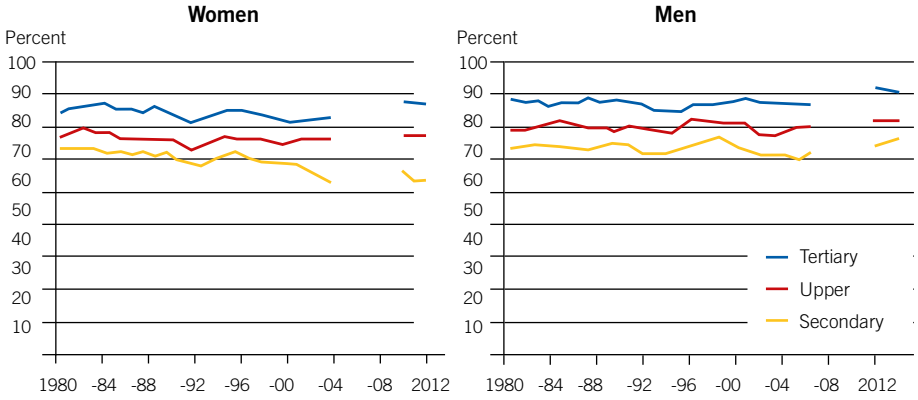
Figure 6. Development of the expected remaining life expectancy for women and men at age 30 in the period 1992-2012, broken down by highest education completed.



Source: Public Health Agency of Sweden 2014.

These differences are also reflected in the proportion that report that they have good health, where women with, at the most, secondary education report a negative trend (Figure 7). There has also been a difference between men and women since 1980, so that for every education level there are 2012 fewer women than men who report good health.

Figure 7. Percentage who report good general health. Development 1980-2012, for women and men 30-74 years, in different educational groups. Three-year moving averages.



Source: Public Health Agency of Sweden 2014.

MORE ARE WORKING WITH CHRONIC ILLNESS

The proportion that states they have chronic illness or disease increases with age. In the group 16-24 years, about 20 per cent reported this, among both women and men. At 45-54 years of age the proportion has risen to 32 per cent among men and 43 per cent among women. Thereafter, the increase continues, but the gender gap decreases, so that in the ages 65-74, 51 per cent of men and 53 per cent of women report that they have long-term disease or illness (Statistics Sweden: ULF survey 2014-15).

The risk of being affected by common diseases, such as cardiovascular disease and cancer, increases greatly with age. Improved treatment of e.g. heart attack, stroke and cancer, however, means that a growing proportion can return to work. There are also more people living with diabetes, which is believed to be due to improved survival rather than that more people develop diabetes.

CONSEQUENCES FOR THE WORKPLACE

Improvements in public health and medical treatment mean that health is becoming an increasingly smaller obstacle to a long or longer

working life. But because the improvement varies between different groups, this simultaneously increases the spread of the condition at a given age. More people work to an older age and it is therefore more common that an employee has a chronic illness or, for example, has been treated for cancer. Most need no adaptation of the work situation, but individual workplaces need to be prepared to adapt working conditions for the individual's health condition in order to respond to older workers and increasing spread in health conditions. One problem here is that only a few studies have directly examined how work and different working conditions affect the prognosis of chronic disease and the possibility to remain in employment. In the absence of such studies, the considerations are based upon more indirect data from studies of risk factors for disease and illness, and knowledge of the functional losses with which the disease is associated.

Most people who have a chronic disease work, however, and those who remain in the labour market are a healthier group than the population as a whole. Sick pay does not differ significantly between e.g. age groups 50-59 years and 60-64 years (15.7 and 16.5 days in April 2016, the Social Insurance Agency, Statistics Division). The risk of contracting common diseases increases significantly with age but it is still only about 1 in 100 in a year who are affected by e.g. stroke or heart attack, and two of 100 who develop cancer.

CARDIOVASCULAR DISEASES, MYOCARDIAL INFARCTION

The risk of myocardial infarction (heart attacks) is generally dropping in the population (Public health in Sweden, 2015). Improved treatment means not only that more people survive a heart attack but also that fewer have a permanent disability.

Problematic conditions in the workplace in terms of organizational and social factors can lead to long-term stress. During the stress the metabolic balance (including blood lipids and blood sugar) and blood pressure changes in a way that is appropriate to deal with an immediate risk, but which is harmful if it persists for a long time. Furthermore, it has been shown that poor psychosocial conditions contribute to deteriorating living habits (e.g. in terms of physical activity and smoking; SBU 2015). The combination of high mental demands and low control at work (so-called job strain) also increases the risk of heart attacks. Several high quality studies show this. Job strain occurs more often in female-dominated sectors than in other parts of the labour market, and although men and women have the same professions, women tend more often to have working conditions that entail such a load. With the same exposure, however, there does not appear to be a higher risk of becoming ill for women than for men. Other negative aspects of the psychosocial work environment appear

to increase the risk, but also job insecurity (such as concern that the workplace may close). There is also evidence that night work, long working weeks and noise at work is associated with an increased risk (SBU 2015).

Those who have previously had a heart attack have a higher risk than others of suffering a new heart attack. There are also some studies that examined the risk of renewed myocardial infarction in relation to working conditions. A comprehensive study of heart attack patients in Stockholm showed that the risk factors for a first heart attack also widely produced a greater risk of further myocardial infarction (diabetes, tense work, abdominal obesity, disturbed blood lipids, etc.) but also that the forecast was influenced by the severity of the heart attack (Leander et al 2007). A further follow-up showed that both the risk of relapse in myocardial infarction and the risk of dying of a heart attack were linked to job strain, even after adjusting for a large number of other risk factors (László et al 2010). The same findings were made in a Canadian study (Aboa Eboulé et al, 2007). The risk of relapse in these studies was approximately doubled. In the study by Aboa Eboulé and colleagues (2007) one found 6 relapses per 100 persons / year under observation, as against just under 3 per 100 persons / year in those who did not have a labour situation with job strain.

Heart attack patients in Stockholm have also been studied in terms of whether the risk of relapse increases with the fear of being dismissed from work (László et al 2013). The study suggests that there is such an increase in risk, which is reasonable given that unemployment increases the risk of cardiovascular disease. The risk increases even for those who are laid off and who risk dismissal. However, we need more studies in the area. Exposure to small particles from combustion (mainly road traffic) has, in the general environment, been shown to be associated with an increased risk of heart attack, both in relation to short and long-term exposure. There are far fewer studies of this in the work environment. When it comes to engine exhaust gases, there are, however, a few high quality studies that indicate a correlation (Ilar et al 2014). Diesel exhaust gases also have an effect on the regulation of the cardiovascular system so that one experimentally in healthy research subjects, sees a vasoconstriction; blood pressure increases and vasodilator medication has less effect. In people with coronary heart disease, exposure to diesel exhaust gas gives more stress signals in an ECG during a work test as compared to when the same test is performed without diesel exposure (Taxell and Santonen 2016). These effects occur at levels below the current occupational exposure limit for the work environment (2016). This suggests that exposure to diesel exhaust gases should be kept low. Also, exposure to welding fumes appears to increase the risk of heart disease (Moce-

vic et al 2015). Mechanistically there is thus support for an increased risk for relapse from occupational exposure to air pollution (small particles), but there is a lack of empirical studies.
Anyone who has a cardiovascular disease has poorer tolerance to heat stress, because of both the disease itself and the medication that is often used. Even working in cold conditions can be a problem. The load on the heart increases because of vasoconstriction to protect the body against cooling. People with cardiovascular disease are more affected by this (Mäkinen and Hasso 2009). Furthermore, heavy work is a problem for many people who have had a heart attack that gives a permanent disability.

CONCLUSION

There are only a few studies of risk factors for relapsing with a new heart attack when returning to work after a first-time illness. Existing studies suggest that the risk factors for the first onset are also risk factors for relapses. Moreover, the severity of the heart attack is important. There are also results suggesting that concerns about job loss increases the risk of relapse, and this is also supported by other knowledge about the threat of unemployment.
A pragmatic approach would be as follows:

- Those who return to work after a heart attack need to feel secure in their employment.
- Any exposure to factors that can cause a heart attack should be eliminated by agreement between the employee and the employer. This applies to both organizational and social factors, as well as chemical and physical issues.

Stroke

The risk of developing a stroke has generally declined in the population, but less in people of working age than at older ages. Despite this, there is a strong correlation between age and the risk of falling ill. There is also evidence of increased risk of stroke if the work includes: low control, shift work, exposure to noise, and exposure to ionizing radiation (Gustavsson and Jakobsson 2013; SBU 2015).

Hypertension

About a third of Europe's population has hypertension (blood pressure disorders), and the incidence increases with age. Several studies indicate that night work is a risk factor, as well as a work situation with job strain, and an imbalance between effort and reward (SBU 2015).

Lung diseases

Chronic obstructive pulmonary disease

Chronic obstructive pulmonary disease (COPD) is estimated to account for just over 3 per cent of lost disability adjusted life years (DALY) in Sweden. The disease primarily affects smokers, and the prevalence in the general population ranges from 1 per cent among those who never smoke daily and 5 per cent among daily smokers, with a slightly higher incidence among women in each category. Level of education also plays a role, with people with lower education having a greater risk of illness (Backhans et al 2015).

About 15 per cent of all COPD is estimated to be due to occupational exposure to dust, fumes and gases, but among non-smokers, as much as half of the cases could be caused by such exposure (Blanc 2012). For those who have developed COPD it is important to reduce or eliminate any aggravating factors as well as tobacco smoking as a possible contributory occupational exposure, because more serious forms of the disease greatly affects health, quality of life and survival. Progress can be monitored with pulmonary function testing through e.g. occupational health services.

Asthma

Asthma is a common disease in the population: 8-12 per cent report that they were diagnosed with asthma by a physician, with a slightly higher proportion of women than of men. Unlike the other diseases described here, the incidence does not increase with age, due to increasing incidence among children and young people (Backhans et al 2015). About 15 per cent of all asthma among adults is considered to be caused by exposure at the workplace. Relatively many asthmatics also feel that there are factors at work that exacerbate their illness, regardless of whether the asthma is primarily caused by work or not.

Approximately one in five adults with asthma experiences such deterioration. It is common that it is caused by non-specific respiratory irritants (dust and chemicals), but also by tobacco smoke, cold, heat, etc. If the asthma is caused by an allergenic substance in the workplace, even a relatively low exposure causes the person problems. Limits for air pollution are generally not low enough to protect the person who has asthma from work-related deterioration. The initial measure is to try to reduce exposure. Medication may also need to be revised (Henneberger et al 2011). For asthma that is primarily caused by the work, studies show that the forecast is best if you can completely avoid continued exposure to the factors that caused the asthma (Friedman-Jimenez et al 2015).

Diabetes

Diabetes is a common disease, and 85-90 per cent of all diabetes is type 2 diabetes. This debuts in middle age and older, and is due to reduced insulin sensitivity. The incidence of type 2 diabetes in the general population is about 3-4 per cent (more common among men than among women) with an increasing trend (Knutsson and Kempe, 2013). There is also a socio-economic link so that more than double the number with compulsory school education report that they have diabetes compared with those who also have tertiary education. Disease incidence increases with age; in the ages of 45-64 years, 8 per cent of men and 4 per cent of women said they been diagnosed with diabetes by a doctor, and in the group 65-84 years, the corresponding proportion is 15 per cent and 10 per cent (Backhans et al 2015). There are clear indications that shift work (especially night work) increases the risk of diabetes type 2. Night work is more common among women than among men. Furthermore, it has been known for a long time that shift work (especially night work) makes it harder to have good control of blood sugar. Good control of blood sugar is essential to reduce the risk of complications of the disease (e.g., cardiovascular disease). However, there are only a few formal studies of this. Both the shift time and the individual's clinical presentation has significant importance for whether is good to work shifts with diabetes. There may be cause to monitor the disease extra carefully if someone begins to work shifts or shift work is changing. In all likelihood, many are able to work shifts with good control of the disease, but others may need to switch to daytime work. Furthermore, irregular and prolonged strenuous tasks increase the risk of low blood sugar, which can lead to impaired consciousness with the risk of accidents and fainting or unconsciousness. Some may need work adaptation (Knutsson and Kempe, 2013). There is night work involving statutory requirements for medical checks, but in other cases it may also be appropriate to offer such an examination via occupational health services (The Swedish Work Environment Authority 2005) who can provide regular advice on, among other things diet, and assess how appropriate night work is for the individual.

Cancer

Because the rate of cardiovascular disease is dropping, cancer has become relatively more important as a cause of death. Up to the age of 78, cancer is now a more common cause of death than cardiovascular disease, and approximately every third person receives a diagnosis of cancer during their lifetime. Breast cancer is the most common cancer among women and prostate cancer is the most common among men.

Breast cancer

One in nine women in Sweden risk developing breast cancer before the age of 75, and the median age of those affected is just over 60 years. The disease is increasing, but deaths are decreasing due to improved treatment. Nine out of ten survive their disease for five years or more, and more than eight out of ten survive the disease for at least ten years (Swedish Public Health Agency 2015). The risk of developing cancer is strongly linked to hormonal factors, such as late childbearing and hormone therapy. Alcohol intake is also important. In recent years, more studies point to shift work that disturbs the biological clock increasing the risk of breast cancer, and therefore a group of Nordic occupational physicians have recommended that those being treated for breast cancer should not have such work (Farmer et al 2012).The decision must, of course, be based on the individual's overall situation.

Prostate cancer

Prostate cancer is rare before the age of 50, but the risk increases with age. One out of eight men risks developing prostate cancer before the age of 75 years (Swedish Public Health Agency 2015). Nine out of ten survive the disease for five years or more, and eight out of ten survive the disease for at least ten years (Swedish Public Health Agency 2015). The disease is linked to, among other things, genetic factors and smoking, but in terms of risk factors in the workplace, there are no clear results. However, there are studies that indicate a link to shift work and also to e.g. chromium exposure, but with a relatively modest increase in risk.

Adapting to individual abilities

For those who have a chronic illness, it is important to have both a generally good work environment and individual solutions. A good psychosocial work environment (especially high control and good support) can also reduce the risk of having sickness benefits, according to a study of chronic disease and withdrawal from the labour market (Leijten et al 2015). With age, the need for individual flexible solutions increases, but this need can be especially great for those who have a chronic illness. Occupational health services are the employer's expert resources to put primary preventive interventions into place and to adapt the work to the employee's ability with regard to their physical and mental health (ILO, 1985). The availability of occupational health services has declined, more among women and more among workers than among salaried employees. In the age group 50-64 years, 55 per cent of female workers and 61 per cent of male workers who are not skilled reported that they had access to occupational health services. The corresponding percentage for salaried

workers at middle level is 76 per cent and 80 per cent respectively, and high-level, 74 per cent for both sexes (Work Environment Survey 2013).
The increasing disparities regarding access to occupational health services are a significant problem, especially since the decline is most marked for the groups in greatest need. There is a gender aspect with a gender difference in the age of exit from the labour market is the largest in county council and municipal sector, followed by workers in the private sector, but is small among salaried employees in the private sector (Albin et al 2016). Furthermore, there is a socio-economic aspect.

The group of unskilled workers has, to a greater extent, for example, physically demanding work, shift work and work with exposure to air pollutants, and they have also a higher proportion of chronic disease at the end of their working life. Occupational health services should be an obvious expert resource with the knowledge of the workplace and the link between work and health and disease.

THANKS

Sincere thanks to the occupational physician, Kerstin Marinko, who provided valuable comments on the text. The author is, however, wholly responsible for the conclusions.

REFERENCES

Aboa-Eboulé C, Brisson C, Maunsell E, Mâsse B, Bourbonnais R, Vézina M, Milot A, Théroux P, Dagenais GR. *Job strain and risk of acute recurrent coronary heart disease events.* JAMA. 2007 Oct 10;298(14):1652-60.

Albin M, Toomingas A, Bodin T. Working environment in female-dominated sectors. *Swedish Research Council for health, working life, and welfare (Forte) 2016.* Swedish Work Environment Authority. *Medical checks at work and general guidelines on the application of the provisions.* AFS 2005:6.

Backhans M, Stjernschantz Forsberg J, Lager A (editors). *Public health report 2015.* Stockholm: Centre for Epidemiology and Community Medicine, Stockholm County Council; 2015.

Blanc PD. *Occupation and COPD: a brief review.* J Asthma 2012;49:2-4.

Bonde JP, Hansen J, Kolstad HA, Mikkelsen S, Olsen JH, Blask DE, Härmä M, Kjuus H, de Koning HJ, Olsen J, Møller M, Schernhammer ES, Stevens RG, Åkerstedt T. *Work at night and breast cancer report on evidence-based options for preventive actions.* Scand J Work Environ Health. 2012 Jul;38(4):380-90. *Public Health Agency of Sweden. Public Health in Sweden.* Annual Report 2014.

Friedman-Jimenez G, Harrison D, Luo H. *Occupational asthma and work-exacerbated asthma.* Semin Respir Crit Care Med. 2015 Jun;36(3):388-407.
Henneberger PK, Redlich CA, Callahan DB, Harber P, Lemière C, Martin J, Tarlo SM, Vandenplas O, Torén K; ATS Ad Hoc Committee on Work-Exacerbated Asthma. *An official American Thoracic Society statement: work-exacerbated asthma.* Am J Respir Crit Care Med. 2011 Aug 1;184(3):368-78
Ilar A, Lewné M, Plato N, Hallqvist J, Alderling M, Bigert C, Hogstedt C, Gustavsson P. *Myocardial infarction and occupational exposure to motor exhaust: a population-based case-control study in Sweden.* Eur J Epidemiol. 2014 Jul;29(7):517-25
ILO. The ILO Convention on Occupational Health Services No. 161, 1985 Jakobsson K, Gustavsson P. *Systematic knowledge overviews; 5. Work environment exposure and stroke - a critical scrutiny of the evidence for the connection between exposure in the work environment, and stroke.* Arbete och Hälsa 2013:47(4).
Johansson P, Laun L, Palme M. Can we work until we are 75? *What does the micro-data on the health and working capacity of older people in the workforce say?* The Institute for the Evaluation of Labour Market and Education Policy Report 2015:24.
Knutsson A, Kempe A. *Systematic knowledge overviews; 4. Diabetes and work.* Arbete och Hälsa 2013;47:3.
László KD, Ahnve S, Hallqvist J, Ahlbom A, Janszky I. *Job strain predicts recurrent events after a first acute myocardial infarction: the Stockholm Heart Epidemiology Program.* J Intern Med. 2010 Jun;267(6):599-611.
László KD, Engström K, Hallqvist J, Ahlbom A, Janszky I. *Job insecurity and prognosis after myocardial infarction: the SHEEP Study.* Int J Cardiol. 2013 Sep 10;167(6):2824-30.
Leander K(1), Wiman B, Hallqvist J, Andersson T, Ahlbom A, de Faire U. *Primary risk factors influence risk of recurrent myocardial infarction/ death from coronary heart disease: results from the Stockholm Heart Epidemiology Program (SHEEP).* Eur J Cardiovasc Prev Rehabil. 2007 Aug;14(4):532-7.
Leijten FR, de Wind A, van den Heuvel SG, Ybema JF, van der Beek AJ, Robroek SJ, Burdorf A. *The influence of chronic health problems and work-related factors on loss of paid employment among older workers.* J Epidemiol Community Health. 2015 Nov;69(11):1058-65
Mocevic E, Kristiansen P, Bonde JP. R*isk of ischemic heart disease following occupational exposure to welding fumes: a systematic review with meta-analysis.* Int Arch Occup Environ Health. 2015 Apr;88(3):259-72.

Mäkinen TM, Hassi J. *Health problems in cold work.* Ind Health. 2009 Jul;47(3):207-20

Roberts SD, Farber MO, Knox KS, Phillips GS, Bhatt NY, Mastronarde JG, Wood KL. FEV1/FVC ratio of 70 per cent misclassifies patients with obstruction at the extremes of age. Chest. 2006 Jul;130(1):200-6

SBU. *The significance of the work environment for cardiovascular disease. A systematic literature overview.* Swedish agency for health technology assessment and assessment of social services (SBU); 2015 SBU report No. 240

Taxell P, Santonen T. *The Nordic Expert Group for Criteria Documentation of Health Risks from Chemicals and the Dutch Expert Committee on Occupational Safety.* 149. Diesel engine exhaust. Arbete och Hälsa 2016;49(6):1–147.

5. Physiological ageing - physical capacity and occupational performance

Margareta Torgén

Signs of ageing can be detected in most bodily functions even before the 40s, and in all of them in the 60s. Many of these changes are so subtle that they are irrelevant to daily functioning, but if it comes to sports performance at elite level, it is another matter. We must not be led to believe that the physical workload is irrelevant because the demands for maximum performance are rarely relevant in today's working life. The risk of injury does not only arise if the requirements exceed the person's maximum performance, but also if the load is lower with limited possibility of variation and breaks (Mathiassen 2006). There is considerable scientific evidence around the development of muscle strength and aerobic capacity in relation to age, but less science around endurance and risks at lower load levels.

The combined effect of age-related changes and possible injuries and diseases varies widely between individuals, and with increasing age, there is a growing spread of physical performance. With the years, age will therefore become an increasingly uncertain indicator of what a person can accomplish.

It is the possibility of adapting the demands of the workplace to the individual's ability that determines whether one can continue working. What worked well in our 20s may not be as good 45 years later. In a study of physical performance in relation to the labour market, there are three main components: strength, endurance and quality of movement (Hogan 1991). The physical performance in terms of muscle strength and oxygen uptake (aerobic capacity) is important, especially in the perspective of gender and age, because there are significant interactions between biological factors and factors in the workplace. If a job is considered physically demanding, it is often the person's aerobic capacity that is assumed to decide whether he can manage it. Aerobic capacity therefore has a central role and is included, for example, in the NIOSH Guide for manual handling of loads, in order to avoid accumulated fatigue and the risk of back injury (Walters et al. 1993). Measurements of the load in physically demanding jobs show, however, that it is muscle strength that often limits the possibilities (Jackson 1994). Assessment of physical performance is useful when examining the balance between the demands of work and the individual's capacity. Low performance ability is often regarded as a lifestyle-based individual characteristic and a risk for future musculoskeletal disorders, while ongoing trouble is in many cases the cause of low performance. Individual tests of physical performance

have often been weak ability to predict musculoskeletal morbidity, for example test results for back muscle strength (Hamberg-van Reenen et al. 2007). The results were not particularly clear on the correlation between test results for the neck muscles and trouble, but this is because there are few published studies of high class. Physical performance also depends on other functions than muscle strength and aerobic capacity, and therefore it is important to also consider, for example balance and perception capacity.

OXYGEN UPTAKE

In a physically demanding job that involves most of the body, the ability to absorb oxygen is important, and can be what limits the working capacity. Oxygen uptake is determined mainly by ability of the heart and blood vessels to pump oxygenated blood into the tissues and remove breakdown products from the muscles. With increasing age, however, oxygen uptake decreases, mainly because the heart and arteries become more rigid (Betik and Hepple 2008), and from 30 to 60 years of age oxygen consumption decreases by an average of about 1 per cent per year.

Physical fitness is also an important occupational physiological concept and can be simply expressed as oxygen uptake related to body mass: if two people with different body weights have the same maximum oxygen uptake, the lighter person has better fitness than the heavier. The heavier person becomes e.g. more tired than the lighter one if both are walking up the same hill. If the work also requires management tools, the situation is somewhat different because the smaller person might not have sufficient muscle strength in the arms. Good condition is thus then not enough.

MUSCLE STRENGTH

Muscular strength, endurance, flexibility, agility and coordination are of great importance for how we manage to work for a living. The ability of all of these decreases with age and is determined by genetics, training rate and incidence of injuries and pathological changes.

The function that has been studied the most is muscle strength, often measured as maximum instantaneous power that can be provided, for example, hand grip strength. Here there are age grouped results from both the mixed population sample as well as from groups with different education, training and professional backgrounds. The muscle strength that is instantly deliverable is above the strength that can be maintained throughout the work shift. High muscular capacity means, however, that you can work at a lower level than you can handle at maximum, and thereby counteract fatigue and risk of injury.

Muscle strength of grip and arms is maintained fairly well with age, while the strength in the leg and trunk muscles drops relatively more

(Engstrom et al. 1993). This may possibly be an effect of exercise because there are a lot of moments in daily life that require strength - especially in the hands.
Good muscle strength is not solely dependent on the maximum power but also on muscular endurance - specifically the extent to which one can maintain a high power output for longer. Here, age does not have the same significance because it does not affect the endurance to the same extent as it impacts strength.

PHYSICAL CAPACITY AND AGE

Reduced muscle strength with age is mainly due to changes in muscle composition and decreased muscle mass due to reduced physical activity, less efficient neurogenic control, and loss of motor units (Miljkovic et al. 2015). In particular, it reduces muscular fast twitch muscle fibres (type II fibres), which have been associated with a decrease in the explosive strength and reduced balance control (Charlier et al., 2016; Izquierdo, et al. 1999). Reduced muscle strength with age is often more pronounced in the lower extremities and to a lesser extent of the grip (Engstrom et al. 1993), which is assumed to be a result of decreased physical activity. These studies are often focused on maximum muscle strength, while there is less research on the development of muscular endurance in relation to age. The age-related decline of muscular endurance seems to be much less than the decrease in maximal muscle strength (Bemben 1998; Laforest et al. 1990).

Much of the age-related changes described can theoretically be related to a decrease in physical activity with age, and it is therefore doubtful whether there is any primary age dependent process in the muscle that gives the decrease in muscle strength seen (Allman and Rice 2002).

The decline in aerobic capacity with age is mainly related to lower maximum heart rates and therefore the lower volume of blood the heart can pump (Åstrand et al. 1973). Increased percentage of body fat and reduced physical activity over the years may also contribute (Jackson et al. 1995; Jackson et al. 1996).

In today's working life, endurance with consistent performance over a full working day is as important as maximum physical performance and one can therefore imagine that age does not matter as much. The work, however, requires frequent interaction between physical performance and cognitive ability, and here age can be significant. An American research team has studied this and saw that simultaneous mental load worsening the muscular endurance in the work, more in the elderly than in younger (Van den Noven et al. 2014). This brings to mind the need for good ergonomic design of modern workplaces such as open plan offices and activity-based offices.

PHYSICAL PERFORMANCE AND GENDER

Gender aspects of physical performance are of great importance in light of the differences in body size, body composition and hormone regulation, resulting in differences in the effect of both internal (e.g., age) and external factors (e.g. workload).

Muscle strength in women is 50-65 per cent of that of men and the most obvious difference is seen for muscle strength in the upper extremities (Heyward, Joannes-Ellis, and Romer 1986; Laubach 1976). This difference is due to a smaller body mass, muscle fibre diameter, and a smaller proportion of fat tissue in the upper part of the body in women compared with men (Frontera et al., 1991; Miller et al. 1993). Endurance in submaximal static load shows a different pattern, and here women often have better performance than men, especially concerning arm exercise (Hunter 2009; Vine et al. 2010).

This difference in muscular fatigue between men and women seems to wane with the years, however, and under the influence of stress at work. In jobs where men and women seemingly perform the same tasks women often work at a significantly higher level of muscular load, because they fundamentally have a lower maximum capacity than men. This is likely to have significant impact on gender differences in the occurrence of musculoskeletal disorders, and is important to keep in mind (Dahlberg et al., 2004; North Anderson et al. 2008). The aerobic capacity of women is about 70 per cent of that of men, mainly related to differences in body size and thus in the cardiac stroke volume, the amount of haemoglobin and muscle mass (Ogawa et al. 1992). Fitness, i.e. the ability to move the body weight, shows less difference between the sexes (Engstrom et al. 1993; Nygard et al. 1994) and it is believed to be due largely to differences in exercise habits (Zwiren, Cureton, and Hutchinson, 1983).

EFFECTS OF PHYSICAL WORKLOAD

Physical strain at work has unfortunately seldom any training effect. Young people with physically heavy work have admittedly somewhat higher physical ability than people with light work, but older people with physically light work have higher physical performance than those with heavy work. This could suggest that young people with good physical strength increasingly seek out jobs that are physically demanding, compared to physically weaker peers, but that this ”head start” is later converted into a disadvantage for those who remain in the heavy duty jobs.

There are few reports in literature about physical performance in relation to previous physical workload, and the described results have

mostly been related to the current work situation. Effects of exercise can be achieved within weeks and months, while negative effects due to high loads and frequent overloading may take longer to develop. The health-related selection of individuals to and from physically demanding jobs is well known, which means that causation can point in different directions in different surveys. If healthier and stronger people are attracted to physically demanding jobs, the impact of physical load can be underestimated. At the same time, some studies have shown that elderly people with high physical workload have lower performance (Moller et al. 2013; Schibye et al. 2001). This underlines the need for longitudinal studies of the relationship between musculoskeletal capacity and physical work (De Zwart, Frings-Dresen, and Van Dijk, 1995).

A Swedish study shows that years of high physical loads at work, especially among women, is associated with low torso muscle strength, endurance during squatting (Torgen, et al., 1999). In contrast, arms and hands were strong, which was seen as a possible training effect among those who had physically heavy work for a long time. In a Finnish longitudinal study of older municipal workers, however, a significant reduction in exercise capacity during a four-year follow-up period was seen in both men and women, regardless of physical workload (Savinainen, Nygard, and Ilmarinen 2004).

The Swedish labour market is highly gender-segregated in the sense that women and men respectively predominate strongly in certain professions and positions, such as in industry, trade, and health and social care. Perhaps gender differences in physical abilities contribute to women gathering in jobs that require endurance and fine motor skills, such as assembly work, text processing and inspection, precisely because women are assumed to have talent for that kind of job? In that case it is a risky talent because it appears to decrease with increasing age and is also associated with the development of various disorders.

ADAPTATION WITH AN AGE PERSPECTIVE

Over the past 50 years, the physical demands of working life have changed. Heavy industrial jobs requiring high performance ability have declined, as have jobs in agriculture and forestry with high physical demands. The physical demands of the work must always be seen in relation to the employee's ability. It is not just the physical demands in themselves that are significant, but the percentage of the person's performance ability required by the job. A benchmark is not to exceed 30 per cent of a person's maximum oxygen uptake, measured over the entire working day (Åstrand and Åstrand 1978; Ilmarinen 1992). Today's work contains many jobs with moderate

physical demands, but low performance ability in workers still causes fatigue at the end of the working day and also accumulates during the workweek. The risks of the elderly not being able to remain working are great if they cannot choose the pace and take breaks for rest and recovery (Mohren, Jansen, and Kant 2010). This can be illustrated with a few examples of the need for oxygen consumption during operation (Table 1). For endurance over a whole day with these activities, approximately three times the specified value is demanded, to be on the safe side. Many people have a total oxygen absorption capacity of less than 2.5 litres / minute and may then end up with the risk of increased fatigue during work e.g. those working in health care, cleaning and workshops.

Table 1. Need for oxygen uptake per unit time (litres / minute) during different professional work and leisure activities.

Oxygen uptake	**Activity**
2,0–3,0	Smoke diving, manual heavy work and forestry work
1,5–2,0	Heavy industrial work, heavy gardening and agricultural work, manual loading and unloading
1,0–1,5	Deep cleaning, heavy engineering work, construction, fast walking or running 7 km / h
0,6–1,0	Alternating sitting and standing-walking, health care, cooking, light engineering work, work in home care, light housekeeping, walk 4-5 km / h
0,2–0,6	Seated light assembly work, driving, sitting office work, personal hygiene
0,2–0,4	Passive sitting

Ref. (Kilbom 1987)

In the construction, care and cleaning sectors as well as in catering, it is common that older workers reach the limit that is acceptable with respect to their capacity, and in these professions there are also many older workers (Sluiter 2006). Men often go from physically heavy work to physically lighter work, while many women remain in heavy work even with increasing age (Lannerheim 1993).

Static and monotonous operations also negatively affect the muscles, and to reduce fatigue in the muscles we need to be able to switch between different tasks with different movements and degree of force development. Heavy tasks requiring muscle strength can also be facilitated with technical aids. It is important that there is enough time, because stress causes one to tense the body and coordinates muscle in a worse way and you might skip the use of technical aids.

Even today, many jobs are felt to be heavy, as is shown in Statistics Sweden's work environment surveys. Here one has interviewed a representative sample of the working population in order to investigate the working conditions experienced. In the entire working population, about 20 per cent of men and 15 per cent of women experience their work as heavy, defined as that one breathes faster for at least a quarter of the working time. There are large differences between workers and salaried employees, where workers experience a higher workload, which also seems to accelerate from 1997 to 2013, especially among women (Table 2).

Table 2. Incidence of heavy work for more than a quarter of the working time, in 1997 and 2013. The incidence expressed as a percentage of different types of occupations and age groups.

Occupation year	Gender	16-29	30-49	50-64	All 1997	16-29	30-49	50-64	All 2013
Non-skilled worker	M F	32 21	28 19	30 18	30 19	.. ..	34 32	33 24	34 31
Skilled worker	M F	32 22	31 13	27 17	30 16	.. ..	51 27	33 27	44 30
Low-level salaried employee	M F	14 5	16 3	10 2	14 3	.. ..	.. 5	.. 5	15 7
Middle-level salaried employee	M F	10 7	5 6	4 5	6 6	.. ..	9 8	7 4	9 8
High level salaried employee	M F	.. ..	2 0	3 1	2 1	.. ..	.. 2	5 ..	2 3
Company owner	M F	.. ..	28 20	31	30 18	.. ..	.. ..	39 ..	42 ..

Source: SCB statistics from work environment surveys.

What can be done to better adjust the load for employees in physically demanding jobs? There are a number of measures, including:

- allowing employees to regulate the pace of work themselves
- designing workplaces so that one can work undisturbed
- providing opportunities for physical exercise, preferably during working hours
- adapting the demands

One of the most important measures is to create opportunities to regulate the pace of the work. In a job where you yourself can combat fatigue by means of breaks and pauses and through a variety of tasks, one has the opportunity for recovery and the risk of injury is avoided. There is always a fashion aspect in the design of workplaces. For example, solutions with activity-based premises and open plan offices should be reviewed from an age perspective, for example, given the disturbance factors that affect performance ability. Through physical exercise, preferably during working hours, good physical working capacity is maintained. Training need not be intense; regular fast walking and cycling is enough. Regular exercise counteracts degenerative cardiovascular diseases and, as a side effect, improves well-being (Åstrand and Rodahl 1986).
Finally, adaptation is required so that the demands of working life are not a drain on employee health, and the ability to work remains. This is part of systematic work environment management (SAM), and here occupational health services are a potentially valuable resource (Griffiths 2000).

REFERENCES

Allman, B. L., and C. L. Rice. 2002. *'Neuromuscular fatigue and aging: central and peripheral factors',* Muscle Nerve, 25: 785-96.

Avin, K. G., M. R. Naughton, B. W. Ford, H. E. Moore, M. N. Monitto Webber, A. M. Stark, A. J. Gentile, and L. A. Law. 2010. *'Sex differences in fatigue resistance are muscle group dependent',* Med Sci Sports Exerc, 42: 1943-50.

Bemben, MG. 1998. *'Age-related alterations in muscular endurance',* Sports Med, 25: 259-69.

Betik, A. C., and R. T. Hepple. 2008. *'Determinants of VO2 max decline with aging: an integrated perspective',* Appl Physiol Nutr Metab, 33: 130-40.

Charlier, R., S. Knaeps, E. Mertens, E. Van Roie, C. Delecluse, J. Lefevre, and M. Thomis. 2016. *'Age-related decline in muscle mass and muscle function in Flemish Caucasians: a 10-year follow-up',* Age (Dordr), 38: 36.

Dahlberg, R., L. Karlqvist, C. Bildt, and K. Nykvist. 2004. *'Do work technique and musculoskeletal symptoms differ between men and women performing the same type of work tasks?'*, Appl Ergon, 35: 521-9. De Zwart, B C H, M H W Frings-Dresen, and F J H Van Dijk. 1995. *'Physical workload and the aging worker: a review of the literature',* Int Arch Occup Environ Health, 68: 1-12.
Engström, LM, B Ekblom, A Forsberg, Mv Koch, and J Seger. 1993., *Lifestyle-Performance-Health*, LIV90. Report 1: Lifestyle-Performance-Health: Physical activity habits, fitness and health among Swedish women and men at the ages of 20-65 (Idrottens publishing: Farsta).
Frontera, W, V Hughes, K Lutz, and W Evans. 1991. *'A cross-sectional study of muscle strength and mass in 45- to 78-yr-old men and women',* J Appl Physiol, 71: 644-50.
Griffiths, A. 2000. *'Designing and managing healthy work for older workers',* Occup Med (Lond), 50: 473-7.
Hamberg-van Reenen, H. H., G. A. Ariens, B. M. Blatter, W. van Mechelen, and P. M. Bongers. 2007. *'A systematic review of the relation between physical capacity and future low back and neck/ shoulder pain',* Pain, 130: 93-107.
Heyward, V, SM Joannes-Ellis, and JF Romer. 1986. *'Gender differences in strength.',* Res Quart.ex.c Sport, 57: 154-59.
Hogan, J. 1991. *'Structure of physical performance in occupational tasks',* J Appl Psychol, 76: 495-507.
Hunter, S. K. 2009. *'Sex differences and mechanisms of task-specific muscle fatigue',* Exerc Sport Sci Rev, 37: 113-22.
Ilmarinen, J. 1992. *'Job design for the aged with regard to decline in their maximal aerobic capacity: Part 2- The scientific basis for the guide',* Int J Ind Erg, 10: 65-77.
Izquierdo, M, X Aguado, R Gonzalez, JL Lopez, and K Hakkinen. 1999. *'Maximal and explosive force production capacity and balance performance in men of different ages.'*, Eur J Appl Physiol, 79: 260-67. Jackson, AS. 1994. 'Chapter 3: pre-employment physical evaluation.', Exerc Sports Sci Rev: 53-90.
Jackson, AS, EF Beard, LT Wier, RM Ross, JE Stuteville, and SN Blair. 1995. *'Changes in aerobic power of men, aged 25-70 yr'*, Med Sci Sports Exerc, 27:113-20.
Jackson, AS, LT Wier, GW Ayers, EF Beard, JE Stuteville, and SN Blair. 1996. 'Changes in aerobic power of women, aged 20-64 yr', Med Sci Sports Exerc, 28: 884-91.
Kilbom, Å. 1987. *'Work Physiology.'* in N Lundgren, U Luthman and K Elgstrand (eds.), Man at work (Almqvist & Wiksell). Laforest, S, D St-Pierre, J Cyr, and D Gayton. 1990. *'Effects of age and regular exercise on muscle strength and endurance'*, Eur J Appl Physiol, 60: 104-11.

Lannerheim, L. 1993. *Winners and losers.* A study of middle-aged and older women's work. "In Final Report. Lund: Gerontological Centre.

Laubach, L. 1976. *'Comparative muscular strength of men and women: a review of the literature.'*, Aviat Space Environ Med, 47: 534-42. Mathiassen, S. E. 2006. *'Diversity and variation in biomechanical expo sure: what is it, and why would we like to know?',* Appl Ergon, 37: 419-27.

Miljkovic, N., J. Y. Lim, I. Miljkovic, and W. R. Frontera. 2015. *'Aging of skeletal muscle fibers'*, Ann Rehabil Med, 39: 155-62.

Miller, AE, JD MacDougall, MA Tarnopolsky, and DG Sale. 1993. *'Gender differences in strength and muscle fiber characteristics.',* Eur J Appl Physiol, 66: 254-62.

Mohren, D. C., N. W. Jansen, and I. Kant. 2010. *'Need for recovery from work in relation to age: a prospective cohort study'*, Int Arch Occup Environ Health, 83: 553-61.

Moller, A., S. Reventlow, A. M. Hansen, L. L. Andersen, V. Siersma, R. Lund, K. Avlund, J. H. Andersen, and O. S. Mortensen. 2013. *'Does a history of physical exposures at work affect hand-grip strength in midlife? A retrospective cohort study in Denmark'*, Scand J Work Environ Health, 39: 599-608.

Nordander, C., K. Ohlsson, I. Balogh, G. A. Hansson, A. Axmon, R. Persson, and S. Skerfving. 2008. *'Gender differences in workers with identical repetitive industrial tasks: exposure and musculoskeletal disorders',* Int Arch Occup Environ Health, 81: 939-47.

Nygård, CH, Å Kilbom, E Wigaeus Hjelm, J Winkel, and Stockholm MUSIC 1 Study Group. 1994. *'Life-time occupational exposure to heavy work and individual physical capacity',* Int J Ind Erg, 14: 365-72.

Ogawa, T, R Spina, W Martin III, W Kohrt, K Schechtman, J Holloszy, and et.al. 1992. *'Effects of aging, sex and physical training on cardiovas-cular responses to exercise.',* Circulation, 86: 494-503.

Savinainen, M., C. H. Nygard, and J. Ilmarinen. 2004. *'A 16-year follow-up study of physical capacity in relation to perceived workload among ageing employees',* Ergonomics, 47: 1087-102.

Schibye, B, A.F Hansen, K Sogaard, and H Christensen. 2001. *'Aerobic power and muscle strength among young and elderly workers with and without physically demanding work tasks',* Appl Ergonom, 32: 425-31.

Sluiter, J. K. 2006. *'High-demand jobs: age-related diversity in work ability?',* Appl Ergon, 37: 429-40.

Torgen, M., L. Punnett, L. Alfredsson, and A. Kilbom. 1999. *'Physical capacity in relation to present and past physical load at work: a study of 484 men and women aged 41 to 58 years',* Am J Ind Med, 36: 388-400.

Walters, T, V Putz-Anderson, A Garg, and L Fine. 1993. *'Revised NIOSH equation for the design and evaluation of manual lifting tasks.'*, Ergonomics, 36: 749-76.
Van den Noven, M. L., H. M. Pereira, T. Yoon, A. A. Stevens, K. A. Nielson, and S. K. Hunter. 2014. *'Motor Variability during Sustained Contractions Increases with Cognitive Demand in Older Adults'*, Front Aging Neurosci, 6: 97.
Zwiren, LD, KJ Cureton, and P Hutchinson. 1983. *'Comparison of circulatory responses to submaximal exercise in equally trained men and women.'*, Int J Sports Med, 4: 255-59.
Åstrand, I, P-O Åstrand, I Hallbäck, and Å Kilbom. 1973. *'Reduction in maximal oxygen uptake with age', J Appl Physiol, 35: 649-54. Åstrand, I, and P.O Åstrand. 1978. 'Aerobic work performance, a review'*, Environment stress: 149-62.
Åstrand, PO, and K Rodahl. 1986. *'Physical training.'* in PO Åstrand and K Rodahl (eds.), Textbook of work physiology - Physiological bases of exercise (McGraw-Hill Book Company: New York).

6. Sensory ageing – visual ergonomics and lighting

Per Nylén

Natural age-related changes in the eye affect our visual functions. For example, decreased refractive powers of the lens cause deteriorated near vision, decreased pupil size reduces the amount of light intake, and changes in the retina result in reduced visual acuity. Furthermore, the reduced visual field, decreased contrast sensitivity and decreased night vision as well as lens opacities impair vision and cause increased sensitivity to glare (Neitz et al., 2000; Grosvenor 2007). But old age in itself does not appear to significantly impair the ability to perform the work; on the contrary, increased work and life experience seems to compensate for physiological changes so that the work can still be carried out effectively.

Natural changes in the ageing eye

Changes in the eye associated with age, e.g. the lenses' natural ageing and degenerative processes in the retina, can have an effect on several visual functions. The most obvious age-related visual change is that the ability for sharp near vision gradually decreases. This is due to a reduced ability of the lens to change shape, which in turn makes it more difficult to focus at close distance (Coates 1955; Turner 1958; Duane 2006). This can be corrected easily by glass in the form of e.g. reading glasses.

With age the pupil becomes too small (senile miosis), which contributes to a need for higher lighting levels. In addition, pupillary contraction slows down, reducing the ability to quickly adapt to different lighting conditions (Feinberg 1965). The upper eyelids drop more for various reasons, and can partially cover the cornea, thereby disturbing vision purely optically, but these conditions can be corrected surgically.

VISION-RELATED PROBLEMS FOR OLDER WORKERS

Age-related eye diseases

Eye diseases become more common with increasing age and many of them cause vision related problems and inconvenience. Examples of such diseases include cataracts, glaucoma, AMD (age-related macular degeneration), and diabetic retinopathy.

Impaired near vision

The first symptoms of presbyopia often arise in the 40s when many find it difficult to focus at close range in low light (Grosvenor 2007). Initially one extends the reading distance, more or less unconsciously, by leaning backward or holding objects farther away than normal reading distance (about 30-40 cm). Strenuous working positions can thus be caused by insufficiently corrected presbyopia. If the individual is advised to start using reading glasses it is likely to reduce the

problem of strenuous working postures (North 2001; Hemphälä et al. 2012).

Increased light needs

At about 60 years of age the individual needs about three times more light than a 20 year-old, among others things because the crystalline lens of the eye transmits less of the incident light to the retina (Sadun et al. 1990). For 80-year-olds it is estimated that it takes about four times more light (Hagerstown Strom-Portnoy 1999). With cataracts, the transmission of a wavelength of 470 nm is greatly reduced, a wavelength that is essential for melatonin regulation and circadian rhythms (Sadun et al.1990). Reduced pupil diameter due to senile miosis and retinal degeneration also results in increased light requirements (O'Neill Biba et al. 2010).

Reduced contrast sensitivity

Most eye diseases such as cataracts, glaucoma and diabetic retinopathy, reduce contrast sensitivity. This can remain undetected in the individual visual acuity when normally tested on high contrast eye charts in strong lighting (Elliott et al. 1995).

Increased sensitivity to glare

Older people need more light to cope with visual tasks such as reading and distinguishing between colours. But increased exposure to light can also be annoying and cause glare (Figueiro et al. 2008; Barstow et al. 2011). Ceiling fixtures, windows, workplace lighting, and lighting of employee work areas are potential sources of glare (Garzia 1996). Glare prevent acute vision, but can also lead to stress symptoms, depending on how long the glare is ongoing. Intensive glare can be tolerated for short periods while a smaller degree of glare can be very troublesome if it continues for a long time.

Reduced visual acuity

Impaired vision can be caused by many factors such as reduced optical quality of the cornea, opacities or cataracts of the crystalline lens and vitreous body, macular degeneration, especially in the retina and optic nerve, and disorders of the brain's visual cortex (Tunnacliffe 1997). An age-related decrease of the best-corrected visual acuity that can be achieved begins at about 50 years old. Half the population over 70 years of age has a visual acuity of less than 1.0; in the group of 80-year-olds, the average visual acuity reduced by half (Slataper 1950; Waldrop 2003). However, about 15 per cent of the population aged 74-81 years do not suffer from reduced visual acuity (Slataper 1950).

Impaired colour vision

The presence of non-congenital defects in colour vision increases with age (Schneck et al. 2014) and is often due to filtering effects in the eye's optical media such as yellowing of the lens of the eye, diseases of the retina, for example, AMD, and damages from e.g. glaucoma on the optic nerve. Colour vision changes may also occur in systemic diseases such as multiple sclerosis, which affects the optic nerve, diabetes and the eye diseases such as glaucoma and optic neuropathy (Neitz et al., 2000; Barbur et al. 2012).

Visual acuity and reaction time (response time)

There is a strong correlation between reaction time and age, in the form of a slower reaction with increasing age (Vetter 2010). In the age group 60-72 years compared to the age group 40-59 years, however, the differences in reaction times dropped when the test object size increased.

Dry eyes

Problems with dry eyes are also related to reduced blinking frequency. During visually demanding tasks, and tasks that require great concentration, it is also common to blink less frequently. Working on computer monitors is often accompanied by a higher viewing angle and more opened eyelids than during normal reading, which usually aggravates the problem of dry eyes (Tsubota et al. 1995; Helland et al. 2008).

Visual aids for presbyopia, vision loss and eye disease

Progressive glasses and lenses provide increased ability to see at both long and short distances and are therefore often used by people who have visual impairment due to age. There are many different types of vision aids and tools for elderly people, which are used to overcome a deterioration of vision. Visual aids mean the person can use their remaining vision more effectively through magnification and optical corrections. Today, even cell phones and tablets work as a means to enhance contrast and adjust colours, font size and font style in a way that suits the individual.

Perceptual and cognitive systems

With increasing age, the ability to interpret the stimuli that our sensory system receives reduces, which also inhibits visual abilities, and impairs the individual's way of perceiving the visual environment (Boyce 2003). An important function is linked to the so-called functional visual field. The size of this field is defined by consciousness and perception of visual elements such as shape, movement and colour

(Ikeda et al., 1985; Itoh 2009). Aging can make it harder to see things that appear in the visual field. Beginning in the 60s, the number of perceptual changes decreases, and at 75 years old, the number has nearly halved in the most peripheral vision compared to the original capacity (Hägerström-Portnoy et al. 1999). Functionally impaired vision is relevant, for example, for the design and placement of traffic signs and warning signs in workplaces. It also becomes harder to see moving objects in the periphery, such as vehicles approaching from the side. This is believed to be a partial explanation for older drivers being involved in traffic accidents at particular junctions (Owsley et al. 2013).

Risk of accidents, injuries and disorders as well as preventive measures

It is not just in traffic that age-related visual impairment may increase the risk of accidents. Reduced visual acuity, impaired vision and glare causes impairments that can lead to trips, slips and falls due to uneven ground or that you miss a step or bump protruding parts of furnishings. The accident may also be due to low light, glare, poor contrast, the inability to see or read the warning texts, or impaired colour vision that makes it difficult to quickly find the red emergency stop button. To reduce the risk of accidents for older workers, one can adapt the lighting with fixtures that provide a higher intensity in combination with good screening and placement, and by marking out hazardous items in a way that provides good contrast.

Fall accidents

Falls among older people are very common, and every year about 30 per cent of those aged 70 and over, fall. Because such cases can lead to serious injuries and even death, the right visual correction can protect against injuries and even save lives. Progressive glasses and contact lenses, by contrast, are associated with an increased number of cases (Black et al. 2005). This may be due to the reading segment skewing the visual perception of the background, which can impair balance and make the elderly put their foot down in the wrong spot. Reduced cognitive ability is reinforced by optical changes in the eye (decreased retinal illumination and visual acuity), and loss of balance and motor movement, and a combination of these factors contributes greatly to the increased incidence of falls among the elderly (Figueiro et al. 2008). The increased risk of falling among workers over 65 years is a risk factor to consider when trying to create safer working environments for older people.

The elderly have, as mentioned above, poorer contrast perception. This leads to an increased risk of falling at e.g. steps, curbs and other objects, but also provides problems for the elderly, such as pouring hot liquids (Barstow et al. 2011). These risks of accidents decrease considerably if illumination and shielding is adapted to the individual vision needs.

The functional field of vision is of great significance for the risk of accidents. There is no effective medical ways to treat diminished functional vision. It is important to inform older people of this natural age change in order to raise awareness of the need to be more careful when e.g. driving in intersections.

Secondary musculoskeletal disorders

Age-related changes in vision may secondarily cause headaches if the person is forced to peer more. The changes may also lead to strained body postures as a result of the person, for example, leaning closer to or further away from the visual object, often unconsciously. In combination with a weaker constitution in older individuals, this gives a slightly increased risk of musculoskeletal injuries. See also the section on the differences between women and men below.

Circadian rhythm and alertness

The author has not found any research reports on how the elderly are affected by daylight in his work, but older people have reduced optical transmission at the wavelengths that affect the regulation of the sleep hormone melatonin. In addition, they often have less strength and mobility, which can contribute to less time outdoors and therefore less access to daylight. Overall, the reduced light exposure has a negative impact on older people's alertness during the day and their synchronization of the circadian rhythm (Figueiro, Balance et al. 2008). In the group 65+, a full 40-70 per cent suffer from sleep disorders (van Someren, 2000). Disturbed sleep also gives rise to secondary effects such as on the heart, blood vessels and endocrine systems, as well as providing a weakened immune system, balance disturbances and decreased daytime alertness (Van Cauter et al. 1998). Night sleep may become better by means of older people staying in good lighting conditions in the day, because light exposure increases the production of serotonin (Ganguly et al. 2002), a substance that, among other things, is converted into melatonin at night (Axelrod 1974).

Vision screening

The prevalence of visual problems and eye diseases is increasing in the age group of 65+, and regular eye exams with early diagnosis and treatment can reduce the risk of accidents, but also increase the working capacity and well-being. Older workers should be encouraged to explore their visual function regularly with an optician. These can, if necessary, refer the individual to the more comprehensive medical assessments and cooperation with ophthalmologists. Such interdisciplinary collaborations, including involvement with ergonomists, have proven to be effective in the visual rehabilitation and workplace interventions (Long 2011; Markowitz et al. 2011).

Differences in visual functions and conditions between women and men

Dry eyes in ages over 50 years is a more common problem among women than men; about 8 per cent and 4 per cent suffer respectively (Moss et al. 2004). The problems increase with age and can be caused by a variety of factors, e.g. hormonal changes, medications and eye diseases. The quality and quantity of tears decreases significantly after menopause (Altintas et al. 2004) and this may, but need not, reduce working capacity and well-being.

Women have a lower mean value than men for the eye's vertical position, both during sitting (6 cm) and standing (11 cm), (Hansson et al. 2009). This means an increased risk of glare in that the eye position is slightly further down and hence, more often than men, below the level where the light source in ceiling luminaire is shielded, e.g. for example by the luminaire housing or its shields.

Visual impairment is also more common among women than men, which can have both biological and socio-economic causes. The longer lifespan of women contributes, as well as the increased risk of cataracts and AMD (Zetterberg, 2016).

Furthermore, women can be slightly more affected by secondary musculoskeletal disorders due to visual impairment as described in the section of these ailments above, because they are more susceptible to this type of injury. The reasons for this may e.g. be that they have more monotonous, repetitive and stressful work and that tools, protective equipment and workstations are often designed for men.

Impact in general of age related visual deteriorations on work ability

It is a fact that the vision can affect working ability. Here are three examples from the manufacturing industry, transport and electricity sectors, which illustrate this.

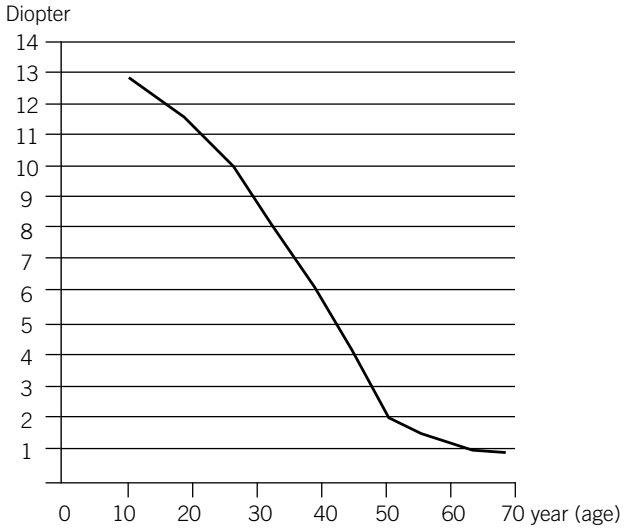
In heavy manufacturing, visual aids must sometimes be combined with goggles so that the eye is not damaged by e.g. dust, particles, welding sparks, or harmful levels of ultraviolet or infrared radiation. The ageing eye is more sensitive to the unwanted spread of light that occurs in goggles and visors, and even more if they are dirty.

Drivers, particularly those who drive frequently on roads without lighting, become, with age, more sensitive to glare from oncoming vehicles at night because of the increasing proportion of opacities primarily in the lens. These problems can be significant even though the vision is otherwise not perceived as impaired, and some cannot continue to work as drivers when waiting for surgical lens replacement.

Electricians work frequently with connecting colour coded cables. In poorly lit areas, age-related diminished colour vision deteriorates further, which means increased risk of misconnection. This in turn means increased risk of accidents for the individual and secondarily even for other employees. In addition, the individual is affected by

stress and annoyance at not being able to easily distinguish the colours of the cables.
For those who have reduced visual acuity, it is now easy to increase the text size on the screen and when printed. There are many forms of drugs, treatments and especially visual aids in the form of eyeglasses and lenses. The costs to the employer for, for example, terminal glasses for older workers is unlikely to be higher than for individuals in middle age. On the contrary, the cost of visual display glasses are likely higher for employees aged 45-55 years, because that is when eye's lens changes most rapidly. In this age range more frequent eye examinations and changing of glasses are required, while changes have almost stopped in the group 65+, see Figure 8.

Figure 8. The lens's decreasing ability to vary its refractive power (diopter) in relation to increasing age. The rate of change is highest between the ages of 40-50 years, about 0.4 diopters per year; to, in ages over 60 years, decrease to a few hundredths of a diopter per year.



Basic data from Duane (1912).

Recommendations in standards and formal requirements
The standard for lighting of indoor workplaces (SS-EN 12464-1) is based on parameters that do not take into account the ageing of the eye, or reduced vision. This is an obvious shortcoming that should be corrected in future updates of this and other related standards. These standards are important incentives for developing viable lighting design which, in the future, will lead to improved, universally designed policies that even the oldest proportion

of the labour force should have a good working environment. As a basis for updating the standards, more knowledge is needed about the vision and lighting adjustment of work and workplaces for older workers remaining in employment. It has even been interpreted as a violation of human rights to not reasonably adapt the workplace for workers with reduced vision (Robertson 2011).
In several of the Swedish Work Environment Authority provisions (see e.g. SWEA 2009) there are statutory requirements that lighting and visual conditions not only be assessed from the workplace as a whole but also from the specific individual tasks and visual prerequisites. Every individual is therefore entitled to lighting that is tailored just for them. These requirements include the availability of daylight, because it is also a form of lighting. Being in daylight during working hours can, as mentioned above, provide particularly significant health benefits for older workers.

References

Altintas, O., Y. Caglar, et al. (2004). *"The effects of menopause and hormone replacement therapy on quality and quantity of tear, intraocular pressure and ocular blood flow."* International journal of ophthalmology. 218(2): 120-129.

Axelrod, J. (1974). *"The pineal gland: a neurochemical transducer."* Science 184(4144): 1341-1348.

Barbur, J. L. and E. Konstantakopoulou (2012). *"Changes in color vision with decreasing light level: separating the effects of normal aging from disease.* Optics, image science, and vision 29(2): A27-35.

Barstow, B. A., D. K. Bennett, et al. (2011). *"Perspectives on home safety: do home safety assessments address the concerns of clients with vision loss?"* The American journal of occupational therapy 65(6): 635-642.

Black, A. and J. Wood (2005). *"Vision and falls."* Clinical & experimental optometry 88(4): 212-222.

Boyce, P. (2003). *Human Factors in Lighting.* 2nd edition, Taylor and Francis Group.

Coates, W. R. (1955). *"Amplitudes of accommodation in South Africa."* Br J Physiol Opt 12: 76–86.

Duane, A (1912). *Normal values of accommodation.* JAMA. 12:1010-1013.

Duane, A. (2006 (2nd ed)). *Studies in monocular and binocular accommodation with their clinical implication.* Am J Ophthalmol. 1922, 5, 865–877. Borish's Clinical Refraction. J. Benjamin. St. Louis, Missouri, Elsevier, Butterworth Heinemann: 128–129.

Elliott, D. B., K. C. Yang, et al. (1995). *"Visual acuity changes throughout adulthood in normal, healthy eyes: seeing beyond 6/6."* Optometry and vision science 72(3): 186-191.

Feinberg, R., Podolak E., (1965). *Latency of pupillary reflex to light stimulation and its relationship to aging.* Georgetown, Georgetown Clinical Research Institute.
Figueiro, M. G., E. Saldo, et al. (2008). *"Developing architectural lighting designs to improve sleep in older adults."* The Open Sleep Journal 12: 40-51.
Ganguly, S., S. L. Coon, et al. (2002). *"Control of melatonin synthesis in the mammalian pineal gland: the critical role of serotonin acetylation."* Cell and tissue res. 309(1): 127-137.
Garzia, R. P. (1996). *Vision and reading. Mosby-Year Book.* Missouri,USA, Inc., St. Louis: 102–103.
Giniger, S., Dispenzieri, A., Eisenberg, J. (1983). *"Age, experience and performance on speed and skill jobs in an applied setting."* Journal of Applied Psychology 68(3): 469–475.
Grosvenor, T. (2007). *Primary Care Optometry. Age-related vision problems.* Butterworth-Heinemann. St. Louis, Missouri, Elsevier Inc.
Hager Strom-Portnoy, G., Schneck, M.E., Brabyn, J.A. (1999). *"Seeing Into Old Age: Vision Function beyond Acuity."* Optom. Vis Sci76: 141–158.
Hanson L, Sperling L, Gard G, Ipsen S, Vergara CO, (2009). *Swedish anthropometrics for product and workplace design.* Applied Ergonomics, 40(4), 797-806.
Helland, M., G. Horgen, et al. (2008). *"Musculoskeletal, visual and psychosocial stress in VDU operators after moving to an ergonomically designed office landscape."* Applied ergonomics 39(3): 284-295.
Hemphälä, H. and J. Eklund (2012). *A visual ergonomics intervention in mail sorting facilities: effects on eyes, muscles and productivity."*Appl. ergonomics 43(1): 217-229.
Ikeda, F., M. Ikeda, et al. (1985). *"Functional visual field of patients with visual field loss."* Japanese journal of ophthalmology 29(2): 222-237.
Itoh, N., Sagawa, K., Fukunaga, Y. (2009). *"Useful visual field at a homogeneous back-ground for old and young subjects."* Gerontechnology 8(1): 42–51.
Long, J. (2011). *"Users of assistive technology also require assistance with ergonomics."* Work 39(1): 79-84.
Markowitz, M., R. E. Markowitz, et al. (2011). *"The multi-disciplinary nature of low vision rehabilitation--a case report."* Work 39(1): 63-66. Moss, S. E., R. Klein, et al. (2004). "Incidence of dry eye in an older population." Archives of ophthalmology 122(3): 369-373.
Neitz, M. and J. Neitz (2000). *"Molecular genetics of color vision and color vision defects."* Archives of ophthalmology 118(5): 691-700.
North, R. V. (2001). Work and the Eye. Second edition. Oxford, Butter worth-Heinemann.

O'Neill-Biba, M., S. Sivaprasad, et al. (2010). *"Loss of chromatic sensitivity in AMD and diabetes: a comparative study."* Ophthalmic & physiological optics 30(5): 705-716.
Owsley, C., G. McGwin, Jr., et al. (2013). *"A population-based examination of the visual and ophthalmological characteristics of licensed drivers aged 70 and older."* The journals of gerontology. Series A, Biological sciences and medical sciences 68(5): 567-573.
Robertson, D. (2011). *"Individualized functional work evaluation and vision: a case study in reasonable accommodation."* Work 39(1): 31-35.
Sadun, A. A. and T. Libondi (1990). *"Transmission of light through cataracts."* American journal of ophthalmology 110(6): 710-712.
Schneck M.E. Haegerstrom-Portnoy, G., Brabyn, J.A. (2014). *Comparison of panel D-15 tests in a large older population.* Optom Vis Sci. 2014 (3):284-90
Slataper, F. J. (1950). *"Age norms of refraction and vision."* Arch. Ophthal. 43(3): 466–481. SS-EN 12464-1 Light and lighting - Lighting of workplaces - Part 1: Indoor workplaces. (European standard).
SWEA (2009) *Workplace design* (AFS 2009:2Eng), provisions
Tsubota, K. and K. Nakamori (1995). *"Effects of ocular surface area and blink rate on tear dynamics."* Archives of ophthalmology 113(2): 155-158.
Tunnacliffe, A. H. (1997). *Introduction to Visual Optics. 4th ed. London,* The Association of British Dispensing Opticians.
Turner, M. J. (1958). *"Observations on the normal subjective amplitude of accommodation."* Br J Physiol Opt 15: 70–100.
Waldrop, J., Stern, S. M. (2003). Disability Status: 2000. D. o. Commerce. Washington, DC, U.S Census Bureau.
Van Cauter, E., L. Plat, et al. (1998). *"Alterations of circadian rhythmicity and sleep in aging: endocrine consequences."* Hormone research 49(3-4): 147-152.
Van Someren, E. J. (2000). *"Circadian rhythms and sleep in human aging."* Chronobiology international 17(3): 233-243.
Vetter, S., Jochems, N., Kausch, B., Mütze-Niewöhner, S. Schlick, C.M. (2010). *"Age-induced change in visual acuity and its impact on performance in a target detection task with electronic information displays."* Occupational Ergonomics 9: 99–110.
Zetterberg, M. (2016) *Age-related eye disease and gender.* Maturitas 83:19–26

7. Sensory ageing – hearing and occupational noise

Kerstin Persson Waye

Hearing damage may have several causes, but among adults the reasons are usually age-related (presbycusis) or due to excessive noise exposure. Noise is usually defined as unwanted sound and is therefore a subjective concept, but the term is often used synonymously with sound levels to describe noise exposure.

Hearing damage or hearing disorders usually manifests as hearing loss, tinnitus, hypersensitivity to various sounds (hyperacusis), distorted perception of speech and difficulty understanding speech.

Hearing damage, regardless of origin, can significantly affect communication and contact with other people, negatively impact fatigability, sleep and recovery, and may be a serious risk factor for injuries during activities where warning signals may be relevant.

Communication-intensive occupations involve close contact with other people, and include education, health care and social services, as well as service occupations and sales including retail, telemarketing and restaurant-related duties. In such occupations, communication can account for a large portion of the workday and its quality may be crucial for the outcome, for example, in health care, social services and education. Impaired ability to understand speech can result in misunderstandings and improper actions, which through various means may have a negative impact on work. In such work environments good hearing is crucial, and it may also be difficult to use hearing protection. Inability to understand speech also affects self-esteem, which may cause people to feel depressed and avoid social situations. People who must concentrate to understand what is being said fatigue easily, which may also limit their potential for social and physical activities and other recreational pursuits.

In acoustically hostile workplaces, where machinery and transports generate high noise levels and noise pollution, people with hearing damage may miss acoustic warning signals.[1] Research has found that workers with impaired hearing are more likely to suffer occupational injuries in noisy environments where hearing protection is required. A problem of particular concern for workers who wear personal hearing protectors or earplugs is the difficulty determining the direction from which sound is coming, especially sound that comes from in front or behind. Impaired directional hearing is also commonly found with presbycusis and this problem deserves particular attention in older occupational groups.

People with hearing damage are at increased risk for somatic and mental illness[2] and are twice as likely to take early retirement as their counterparts with normal hearing (SBU 164:2003). Individuals with hearing loss, especially women, are also at higher risk of adverse health effects from a stressful psychosocial work environment when compared with a reference population.[3]

IMPACT OF NOISE AND AGE ON HEARING

Change in hearing with advancing age

Change in hearing with advancing age, presbycusis, is thought to be a combination of a) pure presbycusis, which is linked to the biological aging process, b) sociocusis, which refers to the role played by collective noise exposure (work and leisure), and c) nosocusis, which refers to the importance of external factors other than noise exposure, all of which contribute to hearing damage. Examples of such external factors include medications that can damage the auditory nerve, solvents, vibrations, smoking and head injuries. Genetic factors also play a major role in age-related hearing change. The relative contribution of the various risk factors is difficult to evaluate, and the importance of each one remains unclear.[4]

To assess whether a particular occupational group is at risk of hearing loss due to occupational exposure, hearing threshold values must be related to age-standardised threshold values. The current standard was recently revised (ISO 1999:2014). Hearing impairment is often given as a pure-tone average in the better ear for the frequencies 0.5, 1, 2 and 4 kHz (M4). This method of denoting hearing impairment is also used in this document.

Prevalence of age-related hearing loss (presbycusis)

According to Swedish studies one of five 70-year-olds has presbycusis,[5] while studies from the US show that about one third of people aged 60–70 years have a hearing loss of 25 dB HL (decibel hearing level) or more.

Swedish data further show that hearing loss increases with advancing age. In a study of the general population, it was found that approximately 2 per cent of people aged 25–50 years suffered from hearing loss (M4 ≥ 25 dB HL and <35 dB HL), while a corresponding hearing loss was found in 11 per cent of people aged 50–60 years and 42 per cent of people aged 60–70 years.[6] All data relate to measurements of the better ear and the study population excludes people who are exposed to extremely high noise levels at work (so loud that people are forced to shout to hold a conversation at a distance of 1 metre). As reflected also by other studies, Johansson and Arlinger found a somewhat higher incidence of hearing loss among men. The proportional gender difference for mild hearing loss (25dB HL≤M4 <35 dB HL) was most pronounced in the 50–60-year age group, where over 14 per cent of men and 8 per cent of women experienced hearing loss. The 20–50-year and 70–80-year age groups showed hardly any gender difference. The proportion with more pronounced hearing loss (HL ≤ 25 M4 <70 dB HL) was similar between the sexes in the 20–50-year age group, while the proportion of men with pronounced hearing impairment was nearly twice as high between the ages of 50

and 60 years (23 per cent for men and 12 per cent for women). The gender difference declines again in the 60–70 year age group, where 66 per cent of men and 56 per cent of women had pronounced loss of hearing.

Studies among people with no history of noise exposure within our modern civilisation, however, do not display any gender difference.[7] This raises the question of whether there is a biological difference between men and women, or whether the differences seen in hearing threshold data also reflect factors related to culture, leisure activities and gender-related risk behaviours.

Noise-induced hearing damage

Noise is one of the most widespread environmental problems within and outside of our workplaces. One of the most serious effects is hearing damage, which can manifest as an organic injury, hearing loss, tinnitus, hyperacusis, various types of distortion in perception of sound and difficulty understanding speech in a noisy environment. In the context of the work environment, the traditional focus has been on hearing loss. Other hearing problems, such as hyperacusis, tinnitus and difficulty understanding speech, may also adversely affect health, well-being and the ability to hold a job or to remain at work in the same workplace. Such problems, however, cannot be measured and diagnosed through the usual hearing tests; instead, assessment must be based on the individual's perception of symptoms.

Loss of hearing is usually measured using a standardised test known as pure tone audiometry, where the listener's ability to detect subtle tones is plotted as a decibel hearing level (dB HL) for the frequencies 125–8000 Hertz. There are also objective tests to measure the function of the sensory cells in the cochlea (the outer hair cells). Other measurements, such as tests of speech intelligibility and electrophysiological tests, each reflects different hearing functions and measures different parts of the auditory system. In general, several different tests are needed to obtain a good understanding of an individual's hearing. Nevertheless, today's methods cannot adequately provide a comprehensive diagnostic picture of the symptoms or predict the problems that people exposed to noise report and demonstrate. For example, recent research shows that hearing damage among individuals exposed to noise may cause speech perception problems even when the results of the usual hearing diagnostic tests are normal.[8] Consequently, there is a great need for additional knowledge and better hearing diagnostics.

The nature of the injury in noise-induced hearing loss varies. Damage may occur immediately after acoustic trauma, or as a consequence of exposure to high noise levels over many years. Usually, injury first occurs to the outer hair cells, and most clearly in the basal portions of the cochlea at about 2–4 kHz, which react to higher-

frequency sounds (treble). The outer hair cells are thought to amplify incoming sounds and thereby increase the ability and precision of the inner hair cells to perceive sound. This mechanism improves the ability of the individual to hear speech, especially in noisy environments. The inner hair cells can also be damaged, probably mainly through acoustic trauma or as a result of prolonged noise exposure. These hair cells are of great importance for perceiving sound near the hearing threshold in a quiet environment, and damage to them can most clearly be demonstrated as a decrease in hearing threshold using pure tone audiometry. Structures other than hair cells can also be damaged by noise, including highly vascularised parts of the cochlea (stria vascularis), synapses (the biochemical junction between two nerve cells), the space in between the inner hair cells and ascending nerve fibres in the auditory nerve, and supporting cells adjacent to the hair cells.[9]

The greatest body of knowledge concerning hearing loss as measured by tone audiometry concerns damage caused by prolonged exposure to continuous noise at high levels (e.g. industrial environments with machine noise) and impulse noise (e.g. shooting). In contrast, we know much less about the consequences of short-term and long-term exposure to noise that varies greatly over time and noise exposure at somewhat more moderate levels. This type of exposure is commonly found in many female-dominated occupations, where the source of noise is typically other people. Because of the gender-segregated labour market, we lack knowledge on whether hearing function in men and women is equally vulnerable to occupational noise exposure, since men and women are generally exposed to different environments. We know even less about what happens to their hearing when exposed to loud noises at an early age, in preschool and school and during adolescence. Moreover, we have little knowledge about the impact on hearing of noise in combination with other types of exposure such as stress, and to some extent to solvents, vibrations, etc.

Prevalence of noise-induced hearing damage

Noise-induced hearing damage, usually loss of hearing, is one of the most common reasons for occupational injuries reported in Europe and is the third to fourth most common reason in Sweden. A total of 17 per cent of women and 29 per cent of men report such high noise levels at work that they cannot hear what is being said at least one quarter of the time. Currently, more women report injuries caused by noise to the Swedish Work Environment Authority than do men (Work Environment Statistics, Work-Related Disorders 2014:4). Men who report such injuries usually work in manufacturing and are primarily exposed to noise generated by machinery, while women are primarily exposed to noise generated by human activities and usually work in education.

Hearing loss

According to a recent review of the literature[10], work-related noise is the cause of hearing loss in 7–21 per cent of workers in various countries. Unfortunately, the data do not address men and women separately, but most workplaces in these studies should be considered as typically male-dominated. These figures are generally in line with data from the European Agengy (Ref. 1 Extra), which indicated that 7 per cent of workers in Europe report that their hearing is affected by their work conditions. The corresponding figure in 1995 was 6 per cent (Ref. 2 Extra). The prevalence of hearing loss varies among countries, with the lowest prevalence in industrialised countries and the highest in developing countries. However, since the definition of hearing loss varies, it is difficult to make comparisons between studies and countries.[11] For example, one large study from Norway suggests that hearing loss from work-related noise correlated better with the average pure tone thresholds of 3000 and 4000 Hz, compared with the more commonly used 500 to 4000 Hz.[12]

In 2012 the European Agency for Safety and Health at Work pointed out that traditional female occupations such as education and health care expose employees to potential risk environments. However, research and preventive interventions are very limited.[13]

Tinnitus

Tinnitus occurs within all age groups, but becomes somewhat more common with advancing age. Swedish studies indicate that 6–9 per cent of young adults have tinnitus, compared with 19 per cent in the age group 50–60 years.[6/14] According to Axelsson and Ringdahl, the overall prevalence of constant or frequently occurring tinnitus exceeded 14 per cent.[14] Among a group of individuals without occupational exposure, the prevalence of tinnitus was 9 per cent among women and nearly 18 per cent among men.[6]

The correlation between hearing loss and tinnitus is pronounced among older individuals, but less clear for younger individuals. One part of the explanation may be that the diagnostic criteria used for hearing loss are too blunt an instrument to detect early hearing loss and the association with hearing loss may thereby be overlooked. A second reason may be that age-related degenerative changes, besides hearing loss, also may contribute to tinnitus.

Hyperacusis

Hyperacusis is defined as an extreme sensitivity to everyday noises such as cutlery against china, and rustling paper, sounds that normally do not bother other people. For the individual, hyperacusis manifests partly as pain and discomfort from certain sounds, partly as noise annoyance and finally as fear of being hurt.[15] Individuals with

hyperacusis usually have normal hearing, but the problems can probably make it very difficult to work in environments where sounds arise suddenly and without warning, such as in work with people. A Polish study involving more than 10,000 men and women reported a 15 per cent prevalence[16], while a Swedish study of men and women (16–79 years)[6] demonstrated an 8–9 per cent prevalence. The reason for these differences is unclear, but the question or interpretation of the question will likely affect the outcome.

OTHER FACTORS THAT MAY AFFECT THE RISK OF HEARING DAMAGE

Early noise exposure and its significance for hearing damage later in life

Studies on mice indicate that noise exposure early in life may increase susceptibility to noise-induced hearing loss later in life.[17] Human studies show that individuals with noise-induced hearing loss (audiogram with typical noise findings) follow a different course in age-related hearing loss[4], which may be due to an effect of the noise-induced damage on development of age-related hearing loss. However, the current state of knowledge is ambiguous. The earliest noise exposure occurs during foetal life. Experimental animal studies have examined foetal reactions to noise of different frequencies and shown that dampening by tissue and amniotic fluid is clearly frequency dependent. Frequencies over 500 Hz are well dampened up to 50 dB, while lower frequencies are less well dampened, and concerning the lowest frequencies there may even be a question of some amplification. Epidemiological studies examining adverse effects on the foetus are often plagued by inadequate descriptions of exposure. However, there is some support that noise exposure during pregnancy may contribute to lower birth weight and negatively affect hearing. A small number of studies have shown lower birth weight when the mother is exposed to daily noise levels exceeding 85 dB LAeq, particularly when combined with shift work or standing work.[18] A few earlier small studies have shown an effect on the hearing of the child, and further support is lent by a recent Swedish study which found that the child is at increased risk of having a hearing-problem diagnosis if the mother worked full time during pregnancy in workplaces where noise is classified at 85 dB LAeq,8h or more.[19] Concerning mothers who worked in occupations with noise classified at 75–84 dBA, the study shows a small increase in risk, but since the noise exposure interval is quite broad, the authors state that the results should be interpreted with caution. Pending more knowledge, current recommendations[20] stipulate that noise levels should not exceed the lower safe level of 80 dB LAeq, 8h, above which employers must take corrective measures, as stated in AFS 2005:16.

Effects of combined exposure on hearing and health

The following section presents some other types of exposure which, when combined with noise, may affect hearing and health. A more detailed review can be found in a compilation of information by Arlinger 2013.[20]

Stress

Noise by itself may be considered a stressor, while a stressful work environment is likely to make individuals more sensitive to the effects of noise. A noisy workplace can impair concentration, the ability to work effectively and make communication more difficult, while also leading to stress and fatigue.[21] In noisy workplaces where requirements for communication are high, such as a preschool, a high rate of the symptom "sound induced auditory fatigue" can be found, which may be related to the cognitive load incurred by attempting to hear speech in a noisy environment. Knowledge concerning sound induced auditory fatigue is still limited, but it is likely to have ramifications for the ability to recover after a day at work. Inadequate recovery contributes in turn to increased levels of stress and thereby to an increased risk for stress related outcomes inclusive cardiovascular disease. A growing body of knowledge also suggests that occupational noise is a risk factor for both cardiovascular disease and stroke.[22]

Chemicals and noise

Several animal studies have shown that combined exposure to chemicals and noise can damage hearing. The Nordic Criteria Group conducted a review of this field of knowledge in 2010.[23] The results in most cases were based on animal studies; there is some support that several substances have an effect on hearing when combined with noise. According to the authors, strongest support for an effect on humans can be found for styrene, toluene, carbon disulfide, mercury and carbon monoxide, and there are indications that other substances such as ethyl benzene, hydrogen cyanide and p-xylene may also have an effect. The European Agency for Safety and Health at Work has also published a review of the literature in this field (EU-OSHA 2009, Ref. 3 Extra), in which they conclude that in the presence of combined exposure to noise and organic solvents, the solvents may (depending on level and concentration) amplify the effects of noise, even at noise levels below current safe thresholds. Epidemiological studies also suggest that pesticides and lead may adversely affect hearing.[20]

Exposure characteristics

In addition to noise levels and time, the variation and impulsiveness of noise may be significant regarding the risk for hearing damage.[24] Both animal experiments[25] and studies on humans[26] suggest that the risk of hearing loss is underestimated in exposure where noise levels

vary greatly compared with constant noise. Large variations in noise level may arise in situations where impulse noise occurs against the background of other more continuous noise, for example, in mechanical workshops, metalworking shops and auto repair shops. Other places where noise levels may vary greatly include preschools, schools, restaurants, commercial kitchens and in certain hospital environments, such as intensive care units. No studies have investigated whether this risk varies with age or gender.

Risk of hearing injury from a gender perspective

The Swedish labour market is among the most gender-equal in the world (fourth place out of 145), but it is also one of the most gender-segregated.[27] Women mainly work in health care and social services, while men work in manufacturing and construction, which means that men and women are exposed to different risks. As in many other medical disciplines, research on noise-induced hearing loss has mainly been conducted on men, and the majority of studies were also conducted in male-dominated occupations such as mining and construction.[10] Research on how women are affected when exposed to high noise levels resulting from sources such as screaming and human activities is far more limited. Women are also far less likely to receive recognition of occupational injuries caused by physical factors (most of which pertain to loud noise).[28] It is less accepted and more difficult to use personal protective equipment in such occupations, and for understandable reasons it is difficult to dampen noise at the source.

Consequently, there is a lack of knowledge, tradition and preventive measures, which may explain why reported problems caused by noise have increased among women in recent years, but not among men (Work Environment Statistics, 2014: 4). The highest reported rate for women is in education.

A small study of healthcare workers in labour and delivery found a correlation between aggregate noise exposure and sound induced auditory fatigue, tinnitus and difficulty understanding speech.[29] This indicates that hearing problems may also occur in workplaces previously neglected in regard to hearing loss prevention. There is an urgent need to identify workplaces that place workers at risk for hearing damage and to expand preventive initiatives. Ramifications of hearing damage among individuals in high-communication work environments are likely to differ in a crucial manner from those who work in traditional male-dominated occupations, and it is likely that injuries such as hyperacusis and perhaps sound induced auditory fatigue strongly affect the ability of individuals to remain at work, especially with advancing age.

CONSEQUENCES AND CORRECTIVE MEASURES

Consequences

Two individuals with similar performance on audiogram hearing tests may experience hearing impairment in different ways, depending on factors such as the nature of the injury, their age, life style and working situation. To obtain a better description of consequences hearing damage for daily life, the "Hearing Handicap Inventory" of self-assessment instrument is used. [30/31] This tool does not focus on defining measurable physiological hearing damage, but instead on identifying the perceived social and emotional effects resulting from the difficulties experienced by the individual when communicating through speech. The tool is available for both working adults (HHIA) and the elderly (HHIE).

The International Classification of Functioning (ICF, Ref. 4 Extra) provides a framework to describe how a health condition (such as a physiological injury or disease) is perceived to affect function and limit participation and activity. The ICF provides a common language to describe health and health-related conditions. It is based on a biopsychosocial model that combines the scientific-based medical model and the social model's approach to obtain a broader and more complex understanding of the functioning and health of the individual. Consequently, function is not described solely from the standpoint of medically obtained measurements, but also in qualitative terms based on how individuals perceive that they are functioning and the impact on health and well-being. The WHO initiated the development of the classification system and the ICF has become an accepted framework in various medical disciplines. However, knowledge about the ICF and its use in daily work is not yet widespread in audiological contexts.[32] In her thesis, Sara Granberg evaluated the ICF from the perspective of the patient, the researcher and the clinician. A compilation of these three perspectives showed that hearing, memory, attention, energy and emotions were significant components. Aspects related to everyday life were considered important, including conversations, various communication strategies, family relationships and work. Environmental factors that affected the individual included noise, technical hearing aids, design of public buildings, social support and people's attitudes. It should be possible to use the findings of this thesis as starting points to better support people with hearing damage in the workplace.

Studies on tinnitus have been carried out in a similar manner as those relating to hearing impairment to determine perceived effects. Most studies that use self-assessment questionnaires have shown that tinnitus has a clear negative impact on quality of life.[33]

Hearing rehabilitation

Communication – the ability to hear, understand and remember what is said – is considerably more difficult for people with hearing damage, even with hearing aids. Hearing aids do not always function optimally and rehabilitation largely involves getting them to function as well as possible.

Hearing rehabilitation is provided by audiologists – the licensed occupational group that works with hearing rehabilitation. Rehabilitation may be carried out in various ways and address different aspects, but the focus is generally on improving communication for people with hearing impairment or alleviating problems caused by tinnitus. Often, fitting of hearing aids is involved, but other interventions include communication strategies such as group rehabilitation or training in lip reading. Of central importance is a supportive, motivating and helpful conversation between patient and audiologist. The aim is for patients to understand the impact of hearing damage on their lives, to motivate them to carry out the rehabilitation programme, and to help them find suitable solutions for the problems they experience.

Importance of a good acoustic environment

In addition to patient-focused hearing rehabilitation, other measures can specifically target the workplace. Occupational health services or the employment office can visit workplaces and provide practical suggestions on how to modify the environment to help people with hearing impairments. Speech perception and learning are particularly difficult in environments where noise makes it difficult to hear. Experiments have also shown that people with hearing aids find it more difficult than others to cope with difficult listening environments.[34] Studies also show that noise at work, such as from conversations, affects people with hearing loss as a group to a greater extent than the group with normal hearing.[35/36] Both working capacity and effort were negatively affected. Other studies have also shown that difficulties increase when multiple speakers talk simultaneously, likely due to a reduced ability of a damaged ear to perceive fine discrimination in the presence of simultaneous speech. Environments with a great extent of spoken communication such as office landscapes, and similar work places with multiple sources of noise and with noise coming from different direction, pose a particular problem for persons with hearing damage. If possible, this should be acknowledged in the systematic work environment management.

A difficult listening environment is an environment with a high level of background noise and/or hard surfaces that reflect sound waves, the latter can be measured in terms of reverberation time. According to Toppila et al.[1], a worker with hearing loss requires warning

signals to be up to 25 dB louder than the background noise (signal to noise ratio) compared with people who have normal hearing in order to clearly detect and locate a warning sound, and up to a 10 dB higher signal-to-noise ratio to be able to hear speech.

In order to reduce the risk of injury to people with hearing damage in jobs with acoustic warning signals, special organisational and personal measures are required, such as additional warning signs that are not only sound-based.

In general, a short reverberation time < 0.6 s is desirable, and for sensitive groups such as workers with hearing damage it should be even lower. In recent years, however, the question has arisen whether it is appropriate to use reverberation time alone as a measure of good speech intelligibility and work is underway to develop additional measures. Experiments have shown that the negative effects on speech intelligibility of the signal-to-noise ratios and reverberation time are greater than the sum of their two separate parts. A hearing loss in the treble may be susceptible for masking of the higher frequency consonants by the low-frequency vowels, which is why it is likely easier to understand speech when reverberation time is evenly dampened over the frequency range of 125–4000 Hz. More knowledge in this field is though needed.

Children under 15 years and adults over middle age, regardless of noise-induced hearing loss, need good acoustic environments since it is more difficult for them to understand speech in noisy surroundings. Also people who need to listen to languages other than their native language find it significantly more difficult to understand speech in noisy environments.

Prevention in a life-cycle perspective

In order to reduce the risk of hearing damage, current research holds that people should avoid unnecessary exposure to high noise levels and strong impulse noise throughout their entire lives. Consequently, the foetus, preschoolers, school children, adolescents and adults should be protected from overly high noise levels. It is important that a systematic approach to the workplace environment include an assessment of risk for hearing damage even in workplaces that traditionally have not been considered to have noise levels harmful to hearing. A number of studies using animal models show that noise exposure that causes a temporary decrease in hearing (temporary threshold shift, TTS) can cause injuries that are believed to permanently cause hearing disorders such as the ability to understand speech. Therefore, by way of precaution, people should also avoid noise levels that were previously only thought to cause a ”temporary” threshold shift. From this perspective, it is reasonable to tighten limits to avoid hearing damage.

THANK YOU

Sincere thanks to Sofie Fredriksson, licensed audiologist, who provided valuable comments on the text. The author is, however, wholly responsible for the conclusions.

REFERENCES

1. Toppila E, Pyykko I, Paakkonen R. *Evaluation of the increased accident risk from workplace noise.* Int J Occup Saf Ergon 2009;15(2):155-62.
2. Danermark B, Hanning M. *Hearing and vision: Health in Sweden: The National Public Health Report 2012.* Chapter 17. Scandinavian Journal of Public Health 2012;40(9 suppl):287-92.
3. Danermark B, Gellerstedt LC. *Psychosocial work environment, hearing impairment and health.* International Journal of Audiology 2004;43(7):383-89.
4. Gates GA, Mills JH. Presbycusis. Lancet 2005;366(9491):1111-20.
5. Rosenhall U. [Presbyacusis--hearing loss in old age]. Lakartidningen 2001;98(23):2802-6.
6. Johansson MS, Arlinger SD. *Prevalence of hearing impairment in a population in Sweden.* International Journal of Audiology 2003;42(1):18-28.
7. Goycoolea MV, Goycoolea HG, Farfan CR, et al. *Effect of life in industrialized societies on hearing in natives of Easter Island.* Laryngoscope 1986;96(12):1391-6.
8. Ruggles D, Bharadwaj H, Shinn-Cunningham BG. *Normal hearing is not enough to guarantee robust encoding of suprathreshold features important in everyday communication.* Proc Natl Acad Sci U S A 2011;108(37):15516-21.
9. Wong AC, Ryan AF. *Mechanisms of sensorineural cell damage, death and survival in the cochlea.* Front Aging Neurosci 2015;7:58.
10. Lie A, Skogstad M, Johannessen HA, et al. *Occupational noise exposure and hearing: a systematic review.* International Archives of Occupational and Environmental Health 2016;89(3):351-72. 11.
11. Rabinowitz PM, Galusha D, McTague MF, et al. *Tracking occupational hearing loss across global industries: a comparative analysis of metrics.* Noise & Health 2012;14(56):21-7.
12. Engdahl B, Tambs K. *Occupation and the risk of hearing impairment -results from the Nord-Trondelag study on hearing loss.* Scandinavian Journal of Work, Environment & Health 2010;36(3):250-7.
13. Flaspler EaH, A. and Koppisch, D. and Reinert, D. and, Koukoulaki TaV, G. and kio, L.Z. and Martnez-Casariego, M.A. and Martnez

MBaL, L.G. and Martnez, S.V. and Ri-, et al. *Risks and Trends in the Safety and Health of Women at Work- European Risk Observatory.* A summary of an agency report 2012.
14. Axelsson A, Ringdahl A. *Tinnitus--a study of its prevalence and characteristics.* Br J Audiol 1989;23(1):53-62.
15. Andersson G, Juris L, Kaldo V, et al. [Hyperacusis--an unexplored field. *Cognitive behavior therapy can relieve problems in auditory intolerance, a condition with many questions].* Lakartidningen 2005;102(44):3210-2.
16. Fabijanska, A. T., V.Hendrickx,J et al. *Epidemiology of tinnitus and hyperacusis in Poland.* International Tinnitus Seminar; 1999.
17. Kujawa SG, Liberman MC. *Acceleration of age-related hearing loss by early noise exposure: evidence of a misspent youth.* The Journal of Neuroscience : the official Journal of the Society for Neuroscience 2006;26(7):2115-23.
18. Ristovska G, Laszlo HE, Hansell AL. *Reproductive outcomes associated with noise exposure - a systematic review of the literature.* International Journal of Environmental Research and Public Health 2014;11(8):7931-52.
19. Selander J, Albin M, Rosenhall U, et al. *Maternal Occupational Exposure to Noise during Pregnancy and Hearing Dysfunction in Children: A Nation wide Prospective Cohort Study in Sweden.* Environmental Health Perspectives 2016;124(6):855-60.
20. Arlinger S. *Hearing and hearing impairment in working life - knowledge compilation:* Swedish Work Environment Authority, 2013:2.
21. Hygge S, Kjellberg A, Landström U. *Disturbing noise in working life Knowledge compilation.* Rapport 2013:3 2013.
22. SBU. *The significance of the work environment for symptoms of depression and exhaustion.* A systematic literature overview. Stockholm: Swedish agency for health technology assessment and assessment of social services, 2014:240.
23.Johnson AC, Morata TC. *Occupational exposure to chemicals and hearing impairment.* Arbete och Hälsa 2010:4 (4).
24. Suvorov G, Denisov E, Antipin V, et al. *Effects of peak levels and number of impulses to hearing among forge hammering workers.* Appl Occup Environ Hyg 2001;16(8):816-22.
25. Davis RI, Qiu W, Hamernik RP. *Role of the kurtosis statistic in evaluating complex noise exposures for the protection of hearing.* Ear Hear 2009;30(5):628-34.
26. Zhao YM, Qiu W, Zeng L, et al. *Application of the kurtosis statistic to the evaluation of the risk of hearing loss in workers exposed to high-level complex noise.* Ear Hear 2010;31(4):527-32.
27. GGG. *Global, gender gap report 2015* (GGG http://www3.weforum.org/docs/GGGR2015/cover.pdf2015.

28. Weiner J, Bildt C, Ochterlony H, et al. *Gender differences in compensation during a 10-year follow-up of work-related injuries in 1994* Arbete och hälsa 2009:43(2).
29. Fredriksson S, Hammar O, Torén K, et al. *The effect of occupational noise exposure on tinnitus and sound-induced auditory fatigue among obstetrics personnel: a cross-sectional study.* BMJ open 2015;5(3):e005793.
30. Weinstein BE, Ventry IM. *Audiometric correlates of the hearing handicap inventory for the elderly.* Journal of Speech and Hearing Disorders 1983;48 (4):379-384.
31. Newman CW, Weinstein BE, Jacobson GP et al. *The Hearing Handicap Inventory for Adults.* Psychometrics Adequacy and Audiometric Correlates. Ear and Hearing 1990; 11 (6): 430-433.
32. Granberg S, Pronk M, Swanepoel de W, et al. T*he ICF core sets for hearing loss project: functioning and disability from the patient perspective.* International Journal of Audiology 2014;53(11):777-86.
33. Langguth B. *A review of tinnitus symptoms beyond 'ringing in the ears': a call to action.* Curr Med Res Opin 2011;27(8):1635-43.
34. Hallgren M, Larsby B, Lyxell B, et al. *Speech understanding in quiet and noise, with and without hearing aids.* International Journal of Audiology 2005;44(10):574-83.
35. Larsby B, Hallgren M, Lyxell B, et al. *Cognitive performance and perceived effort in speech processing tasks: effects of different noise back grounds in normal-hearing and hearing-impaired subjects.* International Journal of Audiology 2005:44(3):131-43.
36. Jahncke H, Halin N. *Performance, fatigue and stress in open-plan offices: the effects of noise and restoration on hearing impaired and normal hearing individuals.* Noise & Health 2012:14(60):260-72.

EXTRA REFERENCES

1. European agency for Safety and Health at Work. *Reducing the risks from occupational noise.* 2005, ISBN 92-9191-167-4. Retrieved Aug 2017. https://osha.europa.eu/en/tools-and-publications/publications/reports/6805535
2. European agency for Safety and Health at Work. *Noise in figures, Risk observatory.* Retrieved Aug 2017, https://osha.europa.eu/tools-and-publications/publications/reports/6905723
3. European agency for Safety and Health at Work, 2009. *Combined exposure to noise and ototoxic substances.* Luxembourg: Office for Official Publications of the European Communities
4. World Health Organization, 2001a. *Fifty-Fourth World Health Assembly, WHA 54.21.* Agenda Item 13.9, 22 May 2001. International Classification of Functioning, Disability and Health. Retrieved, Aug 2017, http://www.who.int/classifications/icf/en/

Final recommendations

Employers and workers can do much to achieve a sustainable working environment. These are some of the most important measures:

- Include active prevention work against known work environment factors such as noise, poor lighting, chemicals and high physical loads in the ongoing safety work.
- Give everyone access to functioning ergonomic and technological assistance
- Ensure that the work demands and physical and mental loads are proportional to the organizational and human resources.
- Be very careful when hiring managers, and value both organizational, professional and social skills. Then give the managers continued support.
- Reduce fatigue and exhaustion by introducing health promoting work schedules.
- Ensure that communication works down, up and sideways in the organization and allow there to be free and open discussions on specialist and other issues.
- Include and inform all concerned about change and improvement measures in the workplace.
- Ensure that the organization is fair, that is, that the same rules apply to everyone and that these are well known and accepted.
- Reduce all forms of bullying and victimisation.
- Help to ensure that all receive adequate training and competence development throughout working life
- Encourage the organization to take advantage of the good experience knowledge available.
- Organize rotation and change of duties to prevent and reduce the one-sided physical and mental load and thus increase motivation.
- Obtain and use a good and well-equipped occupational healthcare service as support and active resource in health work.

www.av.se

Our vision: Everyone wants to, and can, create a good working environment

ARBETSMILJÖ VERKET

Swedish Work Environment Authority | 112 79 Stockholm | Tele +46 (0)10 730 90 00 | E-mail: arbetsmiljoverket@av.se | www.av.se