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ASSOCIATION BETWEEN WORK VISION AND WORK ABILITY AMONG OFFICE AND VISUAL INSPECTION WORKERS

MASTER OF PUBLIC HEALTH THESIS

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Contents

Abstract

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The aim of this study was to find out associations between perceived vision symptoms and work ability among visual inspection employees in industry and newspaper employees.

A cross-sectional study was carried out in both work places based on two questionnaires, Human resource questionnaire and Work vision questionnaire. A total of 259 workers returned the questionnaire in industry, and the response rate was 90 %. A total of 44 workers returned the questionnaire at the newspaper office, and the response rate was 96 %. 40.9 % and 43.2 % of the industry and newspaper office respondents, respectively, were aged 45 or more. 82.3 % and 70.5 % of the respondents in the industry and at the newspaper office were women, respectively.

The most remarkable vision symptoms, which have an association with physical work ability, were light sensitivity, glare, feeling that vision is poor, itching of eyes, watery eyes and smarting of eyes among visual inspection workers. The most remarkable vision symptom, which had an association with mental work ability was watery eyes. There were associations between gender and smarting of eyes, eye inflammation, light sensitivity and dry eyes. We also observed that women have considerably more smarting of eyes and they are also much more sensitive to light. Moreover, 11 % of women report that they suffer from dry eyes weekly or daily, but none of men reported such frequent dry eyes. There was also an association between age and difficulties to focus near among inspection workers. Majority of inspection workers (59.5 %) over 45 years old had difficulties to focus near, which is

typical for aging people.

Newspaper office employees' mental work ability had an association with itching eyes, difficulties to move from a row to another and watery eyes. And on the other hand, employees' reduced physical work ability had a significant association with light sensitivity and glare. However, there were no statistically significant associations between gender and vision symptoms among office workers. Nonetheless, there were statistical associations between age and smarting of eyes and eye inflammation.

The results show that there is an association between perceived vision symptoms and perceived work ability: the better the work ability, the less perceived vision symptoms there have.

Chapter 1

Introduction

A not so often recognized problem is poor vision among employees, although good vision is an essential part of the work demands in jobs, like at office work and visual inspection work in industry.

At the moment the workers are getting older, especially in the western countries, which causes changes in work life. Rantanen and Lehtinen [69] emphasize, that the main factors of the change in work life are computerization and ageing. The computerization has changed significantly job descriptions, while traditional work tasks, which are based on physical power, are becoming more and more rare. Information handling and tasks, in which social skills, good vision and power of deduction are needed, have increased enormously. It is well known that, for example, the visual inspection work loads vision, but there is only little information available about the association of work vision and work ability.

In the literature there is evidence that eye symptoms affect the person's work ability ([31], [83], [62]). The eye symptoms are widely common in indoor environments. Attention has been paid to the fact that occupationally meditated tired eyes and dry eyes are sometimes due to working conditions [62].

There are only few scientific studies about the association of work vision and work ability. However, there is lots of literature concerning separately work vision, especially an association with visual display work, and work ability and their implications in the context of work ability, work life and vision.

When people have good work ability they are capable of facing difficult situations and

solve problems. However, shortage of work ability like poor vision, can be compensated by the help of work environment improvements. Promoting vision friendliness at work places is a continuous process. Work ability and well-being improvements should be a basic target promoting work vision.

1.1 Aims

The first aim of this study was to find out, how concepts of work ability and work vision concern in the literature. The second aim of this study was to find out The second aim was to find connections between vision symptoms and work ability within the cross sectional research.

1.2 Structure of the study

This work has been started with a literature review to familiarize with abbreviations: vision, sense of sight, work ability, perceived health, perceived work ability, visual inspection, visual symptoms, optoergonomics, visual display unit (VDU), visual display terminal (VDT) work, and ageing. The material of this work is based on the research of the Development of screening methods in work vision and well-being of personnel [86].

1.3 Research problems

The general purpose of this study was to examine, weather there is an association between work vision and work ability. The study aim was to investigate, how work vision affect work ability both on mental and physical level.

The research questions are:

1. Which are the main vision symptoms among office workers and visual inspection workers?
2. Is there an association between work vision and work ability and how does age and gender affect work ability?

3. Which vision factors are associated to mental and physical work ability?

Chapter 2

Literature review

2.1 Human vision

Vision is the most important human sense. All work tasks require vision. Since the 1980's [51] it has been obvious that work tasks will change from physical muscle loading to mental function loading and according to Rey et al. [70] vision demanding work increases all the time.

Vision is an occasion, on which as a starting point is an arrival of a light stimulus to an eye and a final result is a formation of vision perception in the brains. The visual pathway and the function of eye affect vision. These functions are central visual acuity, vision fields, separation of color, accommodation for different lighting conditions, binuclear vision and stereo vision. [75]

2.2 Information work, work community and work environment

Information work can be defined as production, receiving, processing and transforming of information using the information and communication technology [68]. Many work tasks, like visual inspection and office work with visual display units (VDU) are information intensive works.

Müller et al. [53] stress that many researchers have found that rapid computerization affects the worker's work ability causing changes in the work content and work habits. They also pay attention to the fact that this can make especially ageing, over 45 years old workers' job more complicated.

Rissa [71] emphasizes, that characteristic for a healthy work community are good work climate, safe work environment, possibilities to manage changes, feedback, social support, life-long learning possibilities and risk management. Thus, work environment consists of environmental factors, which affect human's work performance. The work environment has a significant effect on human's capacity on a physical, mental and social level.

Work load occurs in interaction of work demands and action of worker. Work load can be positive: it gives resources and motivation, but it can also be harmful for well-being and health. [44] Sillanpää [84] says that work tasks can be divided in categories based on information management demands and mental functions: work task, which require speed and accuracy, sorting and quality inspection work, control work, office work and client service work. Nowadays work is more and more related to computers and other tasks, which causes work load for the eyes.

There are three phases at the information work according to Rantanen and Lehtinen [69]. These are vision information, cognitive data handling process and psychomotor responses. Rantanen and Lehtinen [69] have defined these three phases with the help of the following picture 2.1.

Rantanen [68] emphasizes, that information intensive work sets a huge challenge for vision and hearing. Parvi [61] accentuates that while work's physical load decreases, sense load increases, which in many cases demands work place lighting and development of ergonomics. Rantanen [68] also stress, that in poor work conditions the information work is extremely stressing.

Most workstation related ergonomic features are mainly related to eyes and vision [82]. Launis and Lehtelä [43] emphasize that the main principles of accurate work are dependent on the following eyes' function characteristic: 1) adaptation to changes of lighting 2) glare 3) accommodation.

Sillanpää [84] accentuates that lack of information ergonomics can be seen as lack of quality performance, accidents and mental stress. Lampi [42] stresses that poor lighting

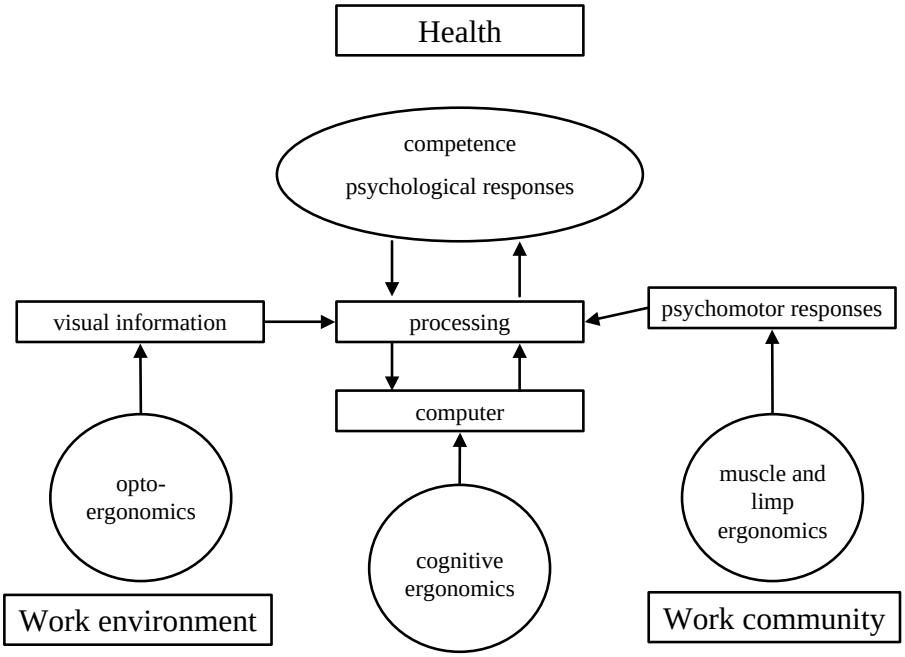

Figure 2.1: The model of visual information processing. [38]

worsens work performance. It is important to take ergonomics into account, when age-related functional vision changes rapidly.

2.3 Symptoms and vision

Many factors may cause visual symptoms according to Collins et al. [17]. Perceived health includes diseases, which are diagnosed by a physician and perceived, mostly subjective symptoms [66]. The most important symptoms of vision [76] are listed in the table 2.1. On the other hand Sheedy and Shaw-McMinn [83] define vision related symptoms:

visual symptoms

blurred, vision slow refocusing, doubling, squinting, changes in color perception.

ocular symptoms

irritated eyes, itching and burning eyes, watery eyes, dry eyes, excessive blinking, contact lens discomfort and sore or hurting eyes.

general eye symptoms

asthenopia are eyestrain, headache, eye fatigue and tired eyes.

lighting symptoms

flickers sensations, glare and light sensitivity.

Collins et al. [18] have studied visual discomfort associated with the use of VDT dividing symptoms into three categories: 1) ocular 2) visual 3) systemic symptoms. There is a significant association between work pressure and visual and systemic symptoms. While work pressure increases, the probability of reporting visual and systemic symptoms increases. While work interest increases, the incidence of ocular and systemic symptoms decreases.

Burdening of accommodation ability of lens may cause for ageing people different eye symptoms, headache and blurred vision. Poor vision acuity or vision problems may cause pain in the eyes, a head and a neck-shoulder area. Typical symptoms of aging vision are a need to increase illumination looking near and mild involuntariness for accurate near work. Ageing is connected to the degeneration of accommodation of central visual acuity. [76]

Visual symptoms

Sheedy et al. [83] stress that common visual symptoms are blurred vision, slow refocusing, frequently loosing place, doubling and changes in color perception.

Ocular symptoms

Typical ocular symptoms are irritated eyes, itching and burning eyes, watery eyes, dry eyes, excessive blinking, contact lens discomfort and sore or hunting eyes among others [83].

Table 2.1: The most important symptoms of eye patient [76]

1. Vision disorders

A Poor vision
- Near, far, for all distances
- From one or both eyes
- Temporary or permanent

B Changed vision
- Skewed lines
- Figures can be seen bigger or smaller than usually
- Double vision
- Glare
- Light sensitivity
- Changes in color vision

C Abnormal vision sensation
- Light phenomenon
- Vision field changes
- Colored rings around lights

2. Pain and corresponding sensation
- Sensitivity
- Burning sensation
- Sensation of trash
- Eye strain (asthenopia)

3. Visible abnormality

A Redness
- Mixed redness
- Redness

B Watery eyes and discharge

C Eyelid changes
- Position
- Edema
- Inflammation
- Bleeding
- Skin changes

D Exophthalmus

E Heterotropia

F Pupil changes
- Odd
- Size
- Shape

Ocular symptoms include tired eyes, sore eyes, pain behind eyes, itchy eyes, dry eyes, watery eyes, or other symptoms of ocular discomfort. Visual symptoms include blurred vision, double vision, or other visual difficulties. Systemic symptoms include headaches, neck pain, back pain, shoulder pain, or other systemic symptoms. [18]

According to Saari [76] poignant, itching or burning sensation may affect refractive error, lack of sleep, stress and smoking. Sheedy [83] emphasizes, that the high visual demands of the task, even small refractive errors can cause blur. According to Saari [76] burning, itching or poignant feeling in the eye can be connected to refraction error, inflammation of conjunctiva or cornea, lack of sleeping, stress, cigarette smoke, different kinds of dusts.

Tsubota [90] has found out that VDT use reduces blink rate, thereby inducing dry eye symptoms. Kivelä [40] stresses that a typical symptom of dry eyes is burning sensation. The causes of dry eyes are multifactorial and can be related to deficiencies in any one of the components of the ocular surface and tear film. A common cause of dry eyes syndrome is tear film deficiency resulting from progressive degeneration of the lacrimal glands with postmenopausal hormone deficiency and gland dysfunction during aging among women. Environmental causes, like air dryness or working with a computer monitor, may increase tear film dysfunction and cause dry eyes. [10]

Nakaishi et al. [55] have found in their research that dry eyes are more common cause of symptoms of asthenopia than refractive errors among VDT workers.

Sheedy et al. [83] say that there are many reasons why video display unit users are at greater risk for dry eyes. Most important reasons are decreased blink rate and low workplace humidity. Improvements of the vision of workers in an occupational setting require an assessment of the job related tasks as well as the environmental conditions, because various factors affect vision simultaneously.

Common eye symptoms are redness, smarting, deliquescent and tenderness Mäkitie [52]. Irritating feeling can be caused e.g. by the inflammation of conjunctiva and cornea, different kinds of allergies, disorders of tears or physical (e.g. glare, lighting), chemical (e.g. dusts, chemicals) and biological (e.g. organic dusts) factors' caused irritations.

In the longitudinal study of VDT work and health by Bergqvist et al. [13] concerning changes in work conditions between 1981 and 1987 VDT users had at least twice as high an incidence and a higher prevalence of eye discomforts compared to non-VDT users. The eye

discomfort increases while duration of work increase in their research concerning the relationship between VDT work and eye discomfort [12]. Overall increased monotony during VDT work was associated with increased risk of eye discomforts by Bergqvist [11].

Fenaga et al. [27] suggest that self-reported eye complaints have a high prevalence in subjects working in the operating rooms, which indicates that the room environment might have an effect on the eye disturbances.

General and systemic symptoms

Asthenopia (eyestrain, headache, tired eyes) is a general eye symptom. Era [24] emphasizes that other symptoms like diminishing of light sensitivity increase by age.

Aronsson et al. [6] had defined the various kinds of eye complaints using the term asthenopia.

”**visual**; for example, unclear sight, blurred image, flickering, and double vision **ocular**; for example, smarting, itching, redness, and dry eyes projected or **systematic**; for example, headaches, and pain in the neck or back **functional**; for example, behavioral changes.”

According to Mäkitie [52] symptoms of vision system in loading situation is called asthenopia. Mäkitie emphasizes that asthenopia can be connection with 1) vision, e.g. as a glare and blurred vision 2) eyes, e.g. the stinging feeling, deliquescent and smart 3) common symptoms, e.g. headache and neck pain.

Mäkitie [52] stresses that clinical asthenopia can be connected with environment factors and the load time of eyes and vision. Mäkitie defines asthenopia as symptoms of human’s vision problems. According to him asthenopia can be connected with vision (e.g. glare and blurred vision), eyes (smarting, watery eyes, burning sensation) and common symptoms (e.g. headache, neck pain).

The common symptoms of eye strain are 1) smarting eyes 2) itching eyes 3) redness of eyes 4) tired eyes 5) strained eyes 6) watery eyes 7) sensitivity to light 8) glare. Smarting of eyes, gritty feeling, light sensitivity and tiredness are typical symptoms, for which there are several reasons.

Visual fatigue is the most frequent complaint among video display terminal (VDT) users, according to Bergqvist and Knave [12]. Rocha et al. [72] have noticed that ”visual fatigue was associated with mental workload, inadequate equipment and workstation, and low level

of worker participation at work." Wolska et al. [103] stress that luminance distribution in the visual field is considered as one of causal factors with a significant influence on visual fatigue, especially for intensive VDT work. Rocha [72] claims that visual fatigue is more frequent among female.

Asthenopia can be connected with glare, poor vision and smarting [52], [57]. In addition, common symptoms can be for example headache and neck pain. Saari [76] accentuates that burning, inching or poignant sensation in the eye may relate to refraction error, inflammation of conjunctiva or cornea, lack of sleep, stress, cigarette smoking or different kinds of dusts.

Lighting and symptoms

Typical symptoms, which are connected with lighting are flickers sensations, glare and light sensitivity. Sheedy et al. [83] say that improper or poor lighting is one of the largest environmental factors contributing to visual discomfort. There are several aspects of the computer in the work environment that contribute to eye problems: 1) lighting quantity 2) screen reflections 3) glare from windows 4) computer display design 5) office air quality 6) work station arrangements [83].

Aarås et al. [1] stress that in order to reduce the visual discomfort for visual display unit (VDU) workers' lighting conditions play a fundamental role. Lampi [42] pays attention to the fact that proper light in work environment is important for work ability. According to 738/2002 Occupational Safety and Health Act (738/2002): "Lighting of workplaces (1) Suitable and adequately effective lighting as required by the work and the employees' capacities shall be provided at workplaces. As far as possible, enough natural light must come into the workplace."

In the book Työturvallisuuslain soveltamisopas [64] is emphasized, that in lighting elaboration and implementation at the workplace should be paid attention to both work and special demands of work premises especially work place locates partly or completely under the ground. Lighting should take care of human being's individual characteristic and age. Different workers have different needs lighting wise e.g. lighting can cause e.g. distracting glare, which could risk working safety and moving from place to place. Good lighting, which takes account of people's age and other personal factors and the nature of work is very important to the work results. [64]

Waris [102] emphasizes that lighting affects work ability and work motivation. Elsewhere Davies et al. [21] impress on good lighting as improver of vision and reducing the risk of accidents.

In their research Bergqvist et al. [12] came into the conclusion that symptoms of gritty feeling or redness of the eye and sensitivity to light were associated with VDU work. The improper luminance ratio is one of the factors causes visual fatigue during VDT work [103]. Wolska et al. [103] have named the following complaints as asthenopic symptoms: redness, sensitivity to light, burning, heaviness of eyelids, lacrimation, blurring, itching, double vision and gritty feeling.

The older age was associated with limited precision with some specific symptoms like sensitivity to light [12]. Dry eyes symptoms were associated with younger age. Light sensitivity, known also as photophobia, may be connected with asthenopia like refraction errors or heterophoria. Saari [76] points out that mild light sensitivity can be functional and it can be connected with tiredness.

Mäkitie [52] divides glare in two categories, which are discomfort glare and disability glare. According to Mäkitie [52] discomfort glare causes unpleasant sensation without harming sensation, which can divide into direct glare (e.g. caused by bright light) and indirect glare (e.g. caused by the light reflected by the surface). While disability glare weakens sight without causing an unpleasant feeling. The sensitivity of glare is affected by light, the size of light source, the distance from eye and the illumination of background [2]. Rey et al. [70] pay attention to the fact that on main principles of lighting planning is to prevent direct or indirect glare. According to them disability glare affect the vision performance and discomfort glare cause discomfort.

Launis and Lehtelä [43] stress that at VDT work eyes have a good accommodation, but vision fields bright targets can cause discomfort glare. Rey et al. [70] emphasize that usually glare can be avoided by using shades, but glare by reflection is difficult to avoid. Also the age affects to vulnerability to glare. Vision performance of ageing people is weaker than younger people if the contrast of target is weak. Symptoms of poor vision can be among others glare, difficulties to see at work, headache and blurred vision also known as asthenopia, tiredness, visual discomfort, irritation, bleeding and drying. [40], [57], [52]

As a conclusion can be said that the common symptoms of vision problems are double

images, difficult to focus on distant objects, difficult to focus on near objects and difficult to focus when looking at another object.

2.4 Health and work ability

Health

”Health is a state of complete physical, mental and social well-being, and not merely the absence of disease or infirmity.” (WHO) This definition of health by World Health Organization is widely use, but it has been criticized on its lack of flexibility.

Downey et al. [22] stress that health can be defined both in positive (dimensions of quality of life and well-being) and negative way (dimensions of diseases and injuries). Negative health sees disease and illness as disorders, unwanted and abnormal states. Downey et al. emphasize that these negative healths definitions are related to physical health. This definition is widely used in insurance medicine. During the past decade, there were two main schemes for diseases, which are the ICIDH scheme (The International Classification of Impairments, Disabilities, and Handicaps) and the Nagi scheme [99]. According to the ICIDH, the path to handicap starts from disease through impairment to disability and handicap. Disease can be said to be a disorder, impairment is a loss of health, disability is a lack of the ability to perform and handicap can be said to be a disadvantage due to impairment.

Capacity and work ability

The basis for good coping at work is human’s capacity [33]. Eskelinen [25] defines capacity as human’s ability to harness his resources to perform whatever function. Capacity can be defined with the help of three factors, which are physical, mental and social skills.

Capacity is important to work performance, job satisfaction, mental agility and physical condition [32]. The factors, which affect individual’s capacity according to Otala and Ahonen [60] are knowledge, skills and know-how, physical well-being, mental well-being, social skills and motivation.

Moilanen [54] has defined the most important ageing changes in capacity in a sense of work life:

Physical capacity

- decreasing of capacity after the year 30
- decreasing musculoskeletal capacity
- increasing risk falling injuries
- decreasing of sense of balance, vision and hearing

Mental capacity

- decreasing of observation (speed and accuracy)
- slowing in psychomotor performance
- changes in memory
- decreasing in learning distance
- experience of work and life
- work motivation increases

Social capacity

- ageism
- social skills.

Work ability and models of work ability

The concept of work ability is difficult to define unequivocally, because the work ability is dependent on many factors. Shortly, work ability can be defined as a relation between a human and his work. However, work ability is a human's ability to manage his work. Furthermore, the work ability consists of mental, physical and social capacity. Ilmarinen [35] has defined work ability including human resources related to physical, mental, and social demands of work, work community and management, organizational culture, and work environment. Mäkitalo and Palonen [50] have divided work ability concept to evaluation and promotion. They emphasize that in the context of evaluation the work ability consists of individual's capacity.

Above all work ability is an interaction between many factors. Järvikoski and Härkäpää [30] present dimensions of work ability with the help of the Figure 2.2.

Anttonen et al. [29] stress, that while evaluating work ability should be emphasize workers condition to cope with his work tasks basis employee's skills taking into consideration

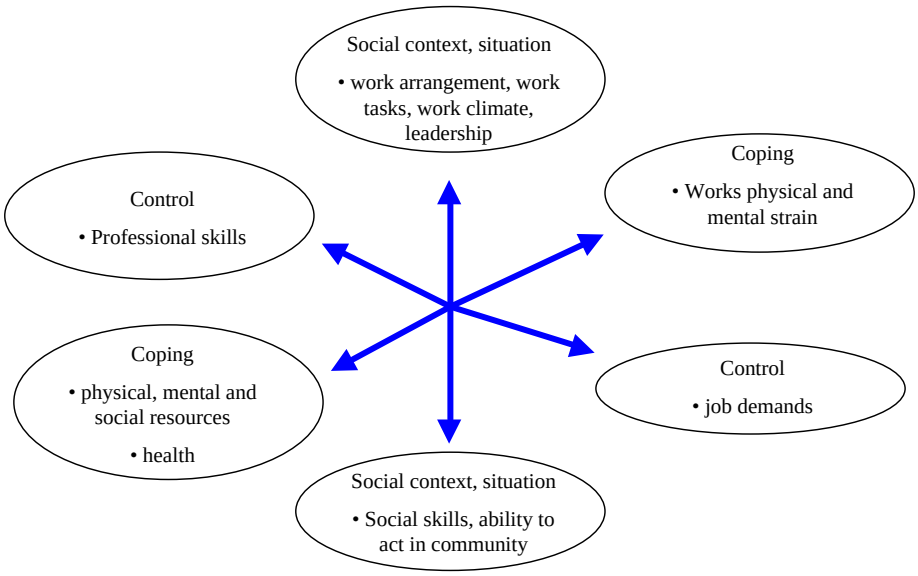

Figure 2.2: Dimensions of work ability.

work demands. Mäkitalo and Palonen [50] stress that a comparison between individuals characteristic and job demands are basis for the balanced model of work ability.

As before mentioned, according to Mäkitalo and Palonen [50] work ability can be defined with the help of three models, which are a medical model, a balanced model and an integrated model. The medical model assumes that work ability is individual's physiological character. According to this model work ability problems are diseases, disability and handicaps.

The medical concept of work ability is an individual characteristics, which is health status dependent but independent from the work Mäkitalo and Palonen [50], Mäkitalo [49]. Kivekäs and Rissanen stress that medical model evaluate work ability in the context of disease, failure or disability.

In the balanced model individual work ability is dependent on work demands. An individual's work ability is dependent on individual's characteristics. Kivekäs and Rissanen [39] illustrate that the balanced models a relation between individuals physical, mental and social capacity work characteristics. The balanced model presents that individual's work ability is balance between individual chance and work demands. They can use different

demands for different work purposes, for example firemen have to be in good condition that they can survive from the demands of their job. Work environment factors have a huge effect on people's work ability.

According to the integrated model, an individual, an employer, a work community and work environment form characters of system, which is tailored into the place and operations. The integrated concept of work ability is formed from the co-operation between an individual, community and operational environment.

The integrated model by Ilmarinen [33] is based on a stress-strain-model, which main idea is according to Kalimo [37], that work causes strain, if it overloads a human. The stress-strain model is developed by Selye [80]. The model, which was modified later by Rutenfranz [74], shows the strain of worker by stress factors at work and the individual characteristics of the worker. Tuomi et al. [92] have modelled a stress-strain model, which is showed in the picture 2.3, based on Rutenfranz's model.

Maintaining and promoting work ability focus according to Rantanen [67] on work, work environment, work organization, work community and especially worker's health. In which case individual's capacity defines keeping up with one's work with interaction with himself (health, know-how), his work, work environment, his work organization and work community. Matikainen [47] has denied factors of work ability for individual factors, for example skills, health, capacity, work environment and work community. Evaluation of work ability is based on among others capacity tests and other measurements. Practicing capacity and changing work environment suitable for human is promoted work ability. According to the integrated concept individual, work community and work environment form entity, in which evaluation of work ability is made by analyzing disorders of systems's action enabling to manage work well.

Vahtera and Pentti [97] define three main principles of good work management. These principles are 1) prevention of harmful stress and creating recondition for health resource 2) work commitment or rare absences together job demands 3) supports human's ability to create social networks (social support). Vertio [100] stresses, that work ability describes human's ability to work. He pays attention to the fact, that despite of work caused physical, mental and social loading, work is a resource. Because of this it, is very important to promote work ability.

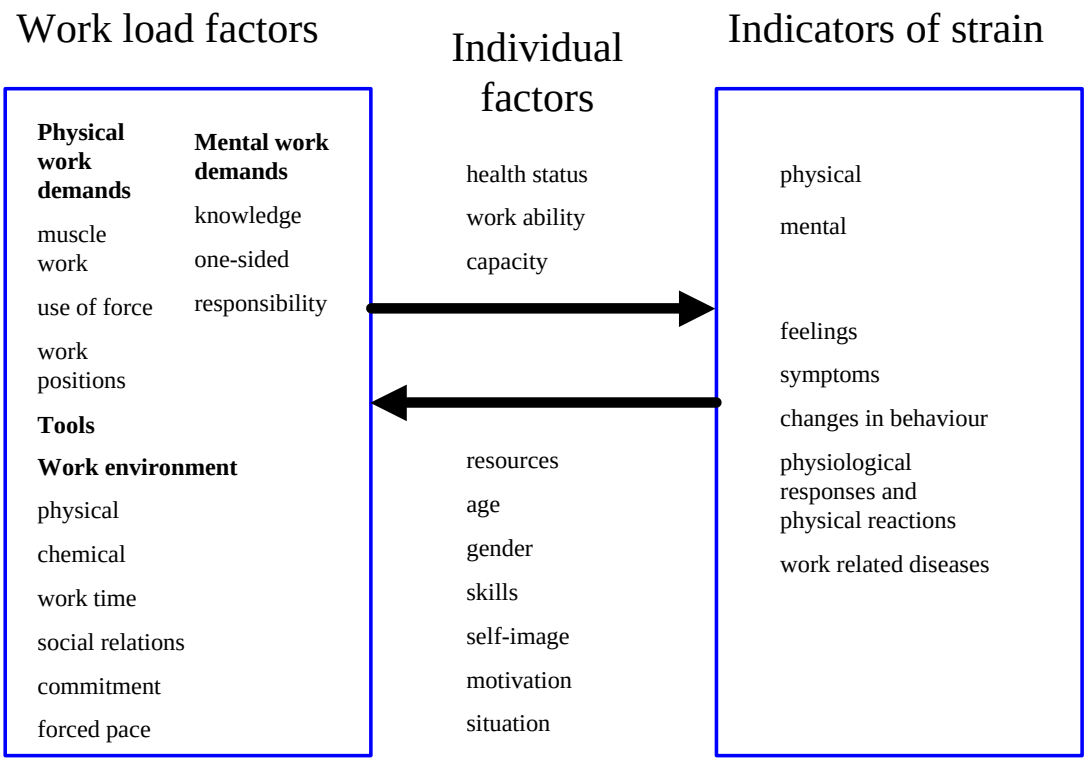

Figure 2.3: The stress-strain concept [92].

Mäkitalo and Palonen [50] pay attention to the concept of work ability in the context of promotion as the main idea to decrease the amount of retiring people because of disability. Matikainen [46] emphasizes that work is made more and more in communities, which makes demand interaction skills. The work ability relies on health, condition, proficiency, demands of the work, work community, social relationships, local retirement legislation and personnel policy. Matikainen [46] stresses factors, like exercise habits.

On the other hand, Ilmarinen [33] suggests that we can choose between three alternative positions, which are physical, mental and social. The concepts of work ability, work capacity and job performance have been used to mean the same thing in the literature. In many cases work ability has defined as an ability to cope with the daily work tasks during the work day.

The work ability creates the basis for the employability of an individual [34]. Antti-Poika [4] emphasizes that the promotion of work ability is very wide aggregate, which is

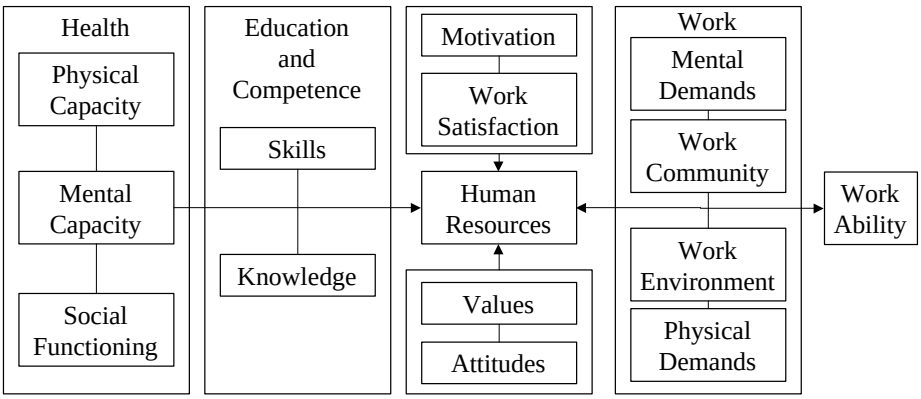

Figure 2.4: Factors influencing work ability from the individuals point of view.

built up from many elements. The most important element in terms of the work ability can be said to be health and work ability promotive acts. On the other hand, it has to view also problems and disability preventive acts. Work ability should be seen as a part of capacity being the individuals ability to cope with their job. [95]

2.4.1 Physical and mental work ability

Physical work ability can be regarded as a health resource with fundamental significance to the structure of a person's work ability. Ilmarinen [33] emphasizes that functional capacity can be perceived with respect to work ability. Ojala [59] has defined the functional capacity of an individual consisting of biological and psycho-social ability.

The main factors of individuals's mental work ability are work motivation, skills and knowledge. Kalimo [37] emphasizes that especially accurate perception and haste cause mental load for aging workers. It seems that the age of 45 is a remarkable both for physical and mental capacity. [14]

According to Ilmarinen [33] "mental reserves prevent, for example, work fatigue and release resources for additional training and the bettering of professional competency." Kalimo [37] says that negative experiences and evaluations concerning work environment and own coping cause usually negative feelings. These negative feelings decrease ability to concentrate, make decision making difficult, make observation field smaller and cause

challenges to normal working decreasing the individual's motivation to work. The theory concerning work motivation of Peltonen and Ruohotie [63] may explain this. While work is monotonous it is also mentally loading [11]. According to results it seems that office work, like mental workers usually, have better possibilities to affect their work.

Kalimo [37] stresses that stress affect human abilities in many ways. It has a huge effect on quality and efficiency. A good example of environmental factors, which can cause stress, is lighting conditions. Seitsamo and Klockars [79] emphasize that diseases increase strongly over age. Also perceived health seems to be getting worse with age. Ek [23] has pointed out in her research that there is a high correlation between a possibility to influence and demands and individual coping methods and mental work ability.

As a conclusion can be said that mental work ability is a relation between work's mental demands and worker's mental resources, health and personality.

2.4.2 Measuring work ability

Healthy people's work ability is evaluated by work health service [5], but perceived work ability is typically (e.g. in the research of Pohjonen [65]) measured by work ability index [91], which consists of series of questions. This questionnaire take into consideration the following issues: mental and physical demands of work and worker's resources and health status. The self-rating of work ability is not affected only by individual factors (perceived work ability; physical, mental and social resources), but also work community, work and work environment. To self-rated health are connected among others socio-demographic factors (e.g. age, gender, occupational and educational status), life style (among others drinking and smoking habits, physical, mental and social capacity) and health status (self-rated health, diseases).

The comprehensive promoting of work ability requires in addition to work ability supporting of mental capacity, for example employees possibilities to affect their own work [39].

2.4.3 Work ability and vision

In the near future promotion of mental and social work ability will be more and more important [67]. Mäkitie [52] says that work ability's ophthalmic medical evaluation consists of evaluation of different parts of vision and work's vision demands. Improving work ability is needed work's physical disadvantages prevention also work organization development, foreman managerial work and social support [94].

As conclusion, a work load factor can be whichever physical or mental job feature, if it causes load (both under or over load). The work load can be short or long and can as harmful cause health danger. The assumption concerning the association between poor vision and reduced work ability is based on Seppälä [81], Tuomi [93] and Sheedy [83].

2.5 Office work with visual display terminal (VDT)

It is generally known that VDU users have reported more eye complaints than non-VDU users. For example, in the research of Dainhoff et al. [20] was emphasized that activity time on VDT screen had a significant positive correlation with symptoms of visual fatigue. Sheedy et al. [83] emphasize that computer users commonly suffer from symptoms related to dry eyes [83]. They emphasize that these symptoms may include dry eyes, excessive tearing, irritated eyes, burning eyes, redness of eyes and itching eyes. This is shown by numerous studies like Bergqvist [12], Aronsson [8].

There have been many studies concerning health complaints of VDT work (Aarås et al. [1], Anshel [3], Aronsson [7], Bergqvist [11], Bergqvist et ali [13]). Aarås et al. emphasize that musculoskeletal illness and eye discomfort are the main problems reported by visual display unit operators. Moreover, Seppälä [82] stresses that physical and mental well-being at computer-based office work is related to various characteristics of work and the work environment, as well as the use of a computer. Chung [16] emphasizes that many occupational hazards like eye strain, visual fatigue and musculoskeletal stress have increased while VDT tasks have increased. Wahlström et al. [101] have investigated whether perceived muscular tension, psychological demands and emotional stress were associated with physical load or working technique during VDT work. Ansley [3] emphasizes that VDT workers suffer from tension headache, which is connected with anxiety, eye conditions and improper workplace

conditions like improper workstation setup glare, poor lighting. Nakazawa et al. [56] have found out in their study that symptoms increase with duration of daily VDT use without threshold, while mental and sleep related symptoms increase with VDT work of more than five hours per day. Fisher [28] has studied the problem concerning the effects on performance of stressful conditions for example in work life. It is commonly known like Fisher [28] has emphasized, that many conditions that normally can produce discomfort and all environmental conditions such as noise, heat or glare.

A good display unit work, requires a critical evaluation of working positions [73]. The work station should be set up for a worker, in order to not to cause together with the other work environment any health problems for the worker. The characteristics of VDT use from the viewpoint of the accommodative function of the eyes is that a VDT user fixates their eyes on near points (50–70 cm from the eyes) for a long time to maintain clear vision of the VDT screen. [36] In addition, Tyrrell et al. [96] had paid attention to the fact that various terms have been used as descriptors, including eyestrain, visual fatigue and asthenopia effects of prolonged near work with computers and video display terminals.

The primary vision- and eye-related complaints among computer users are follows: eyestrain (sore eyes or eye fatigue), headache, near blurred vision, slowness in changing the focus of the eyes, blur in the distance after near work, glare, light sensitivity, eye irritation (burning, dry eyes, redness), contact lens discomfort, neck and shoulder pain, back pain. [83] Aronsson et al. [7] stress that various environmental conditions have been assumed having an association to eye discomfort.

Ocular symptoms start to appear when a person uses computer terminal four hours per day or longer. Nakazawa et al. [56] have found in their research that physical symptoms increase with duration of daily VDT use without threshold but mental symptoms increase with VDT work after more than five hours per day. On the other hand in the research of Travers et al. [88] has been found out that longer duration of exposure resulted in statistically significant increases in the reporting of eye symptoms of both tired, aching eyes and eyes and eyes bothered by glare and an increase in the reporting of blurred vision, although not statistically significant.

To conclude the literature survey concerning VDT work, it is clear that VDT work causes among others job stress, visual fatigue and musculoskeletal problems.

2.6 Visual inspection work

There are many factors, which have an effect on the work performance of inspectors. The factors are according to Megawin (1979) in the study of Seppälä [81]:

1) Inspectors factors: visual acuity, color vision, eye movements strategies, age, experience, personality, gender, intelligence

2) Environmental factors: lighting, facilities, noise, ergonomics

3) Work task factors: inspection time, monotonous work, the direct of movement, errors.

4) Organizational factors: amount of inspectors, instructions, social factors, motivation to work, job rotation.

Inspection functions in manufacturing provide decisions concerning the fitness for use of either an item of product or a production process. Inspectors prime responsibility is to decide quality. Decisions should be precise, valid and reliable. [78] Industrial inspection refers to the confirmation of the correctness of a part and the most common inspections is visual inspection. [15]

In a modern industrial-vision-system research and development, most applications are related to at least on one the following four types of inspection [45]:

1. Inspection of dimensional quality
2. Inspection of surface quality
3. Inspection of correct assembling
4. Inspection of accurate or correct operation (operational quality).

Usually the information of the industrial process concerns the visual quality of product. An inspection worker has to quickly recognize and inform production fault, in order to quality problems in early stage and to guarantee, that inspection will be enough systematic and effective. [26]

For attribute defects, the inspection is straightforward and can easily be automated. On the other hand, variable defects inspection is a subjective decision making process based on qualitative observations. It is, therefore, difficult to be automated with numerical computations.

Industrial visual inspection can be thought of as a process to find out the discrepancies between a template product with comforts to the design data and the tested product. Inspec-

tion effectiveness is affected by among others individual factors; physical and environment connected factors; work task connected factors and work arrangement connected factors. Individual factors are vision acuity (a target is stable, a target does not move, peripheral vision), color vision, the movement strategies of the eye, age, experience, personality, gender, intelligent and the estimation of inspector the probability of the mistake. Physical and environmental factors are lighting (the intensity, colors and special lighting), device and the palling of the work place. Task connected factors are named inspection time, occurrence density of products, the probability of the mistake, mistake combinations, fault oversight, different characteristics of the product (e.g complexity, reflectivity, color and form) and characters of mistakes (form, size, reflectivity and contrast). Factors which are affected with work arrangement are among others the number of visual inspectors, introductions, feedback, work environment and job circulation. [19]

Manual, visual inspection has problems, because inspectors are often affected by fatigue, boredom, mood etc. [81], [15]. As problems can be, for example, different eyes (accuracy and speed of decision making vary), change of visual acuity because of tiredness and change of mental agility and human errors. [77]

Valtatie [98] pays attention to the fact that monotonous visual inspection work may cause straining eyes inreasing a risk to abandon good products. Vision tests can find out in some inspection task difficulties, but the final result of inspection is not always based on fault observation. Environmental factors, like lighting has a huge effect on the success of visual inspection work.

There is few research concerning the work load of the visual inspection work. However, Seppälä [81] has researched in his dissertation mental load in visual inspection. He has found out that the information flow and monotonous nature of work increase mental load causing human errors and both subjective and physiological exertion, while job demands and human resources are in balance.

As a conclusion can be said that visual inspection causes problems, when the human and the work environment are not compatible [81].

The research frame is based on the literature review. In Figure 2.5 is shown the main theories, background variables and central topics used in this research.

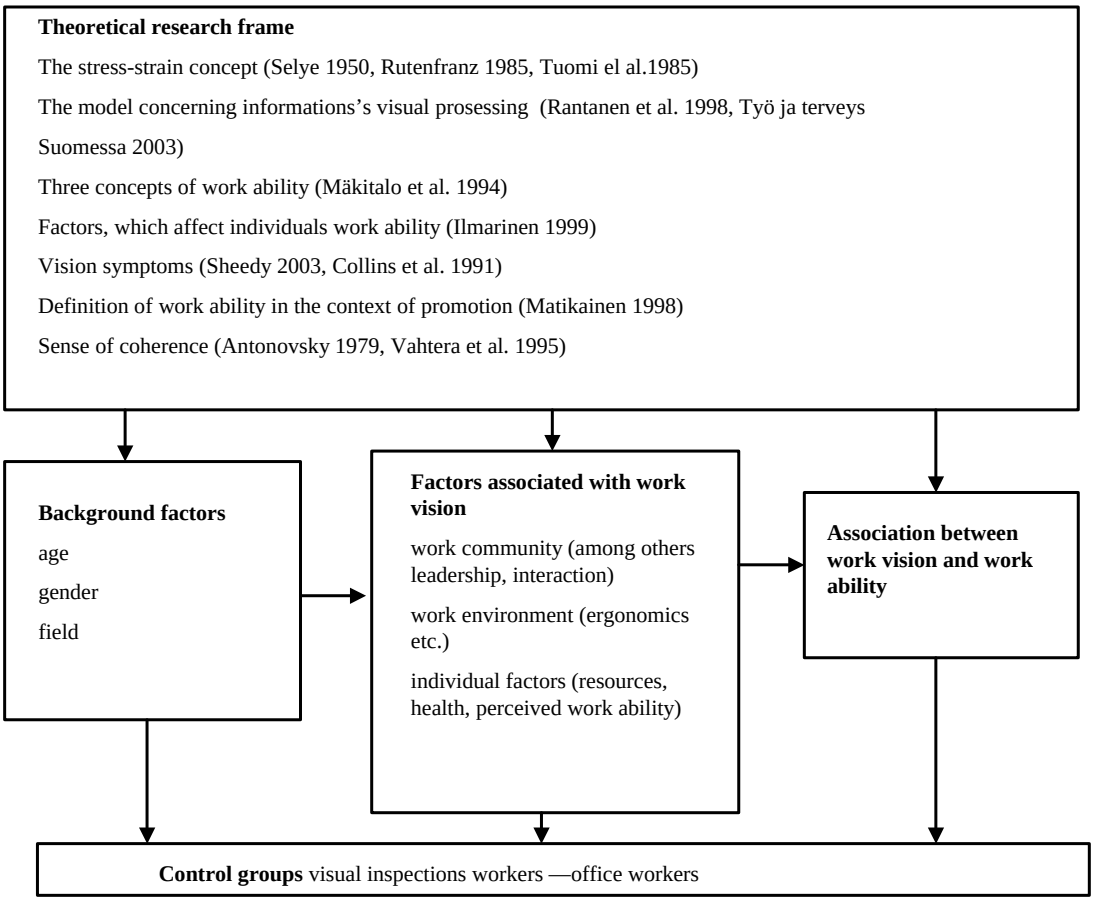

Figure 2.5: Research frame

Chapter 3

Material and methods

Research material was a cross-sectional study, which was performed in Finland in 2003 in two companies, which were a visual inspection work place and a newspaper office. The data was collected with questionnaires between December 2002 and October 2003. The material is divided into two parts, which are visual inspection work and newspaper office work. The office employees worked at a newspaper office. The visual inspector employees worked in plastics product industry as visual inspection workers.

3.1 Subjects

All answerers, who gave their permission to use the data in a scientific work were selected from the original 303 subjects for an analysis. Information about workers' perceived vision symptoms was gathered in two questionnaires in both companies. The other workers were visual inspection workers (n=259) and the other were office workers at news paper office (n=44). Most subjects answered all questions, but a small minority left few questions unanswered. The material was collected by using two questionnaires: human resource questionnaire and work vision questionnaire.

The mean age of the visual inspection workers was 43.0 years (SD 10.9 years). 136 (52.5 percent) from the visual inspection workers were below 45 years old and 106 (40.9 years) over 45 years old. Female were 204 (82.3 percent) and men 44 (17.7 percent). The mean age of the newspaper office workers was 40.8 years (SD 11.1 years). 25 (56.8 percent) from

the newspaper office workers were below 45 years old and 18 (43.2 years) over 45 years old. Female were 31 (70.5 percent) and men 13 (29.5 percent). The response rate was 90 % for visual inspection employees and 96 % for office employees. The sample was representative of all the categories of employees.

3.2 Questionnaires

Two structured questionnaires were included in the study. Human resource questionnaire, which was mostly standardized, contained 30 questions and all together with sub questions 72 questions. Question areas were leisure time exercise, work description, mood, sleeping and work ability. Only a part of the questionnaires was used in this study. Used questions were informative for this research topic and answered to problems of research questions. The selected questions were connected to work ability and vision at work place. Work vision questionnaire, which was mostly standardized, contained 17 and all together with sub questions 68 questions. Question areas were common state of vision and vision history, job description and work place, vision problems, possible pains, diseases and pain. In this study were used questions, which were informative for this research topic and answered to problems of research questions. The selected questions were connected to work ability and work vision. Work ability was evaluated with a question in the questionnaire [33]. Work ability was based on perceived work ability (work ability in relation to the demands of the job), which was measured by the following questions: How do you rate your current work ability with respect to the physical demands of your work, How do you rate your current work ability with respect to the mental demands of our work. The scale was very good (5), quite good (4), moderate (3), quite poor (2) and very poor (1).

3.3 Statistical methods

The population was categorized by age and gender. All the analysis were performed using SPSS (version 11.5, Statistical Package for Social Sciences). Background variables were age and gender. Mean, standard deviation (SD) and percent distribution was used as key figures concerning age and gender.

Due to non-normally distributed data, median and range of vision parameters and statistical differences of vision parameters between the study groups were tested with the Mann-Whitney U-test and Kruskall-Wallis test. Correlations between vision parameters and perceived work ability tested with Spearman correlation coefficient. Spearman rank correlation analysis was used to estimate the correlations between work ability (physical, mental) and different kinds of visual symptoms. With the help of correlations was researched variables, which were perceived work ability (scale 1–5) and visual symptoms (1–3). Visual symptoms were divided in categories according to classification of Sheedy et al. [83] visual symptoms 1) blurred vision 2) slow refocusing 3) frequently loosing place 4) doubling 5) squinting 6) changes in color perception, ocular symptoms: irritated eyes, itching and burning eyes, watery eyes, dry eyes, excessive blinking, contact lens discomfort and sore or hurting eyes. general eye symptoms: asthenopia are eyestrain, headache, eye fatigue and tired eyes. lighting symptoms: flickers sensations, glare and light sensitivity.

According to Törmäkangas [89] dependency can be measured with a correlation factor, when variable scale is higher than nominal scale. The coefficient is always determined by the weakest measure scale. When interpreting correlations, the following rough method, according Törmäkangas [89], can be used $r < 0.3$ dependency is weak $0.3 < r < 0.7$ dependency is moderate $r > 0.7$ dependency is strong. For some variables cross tabulation analysis was used. The sum factors with Cronbach alfa coefficient can be found from a study by Siukola et al. [86]. For all tests statistically significance level was 5 %.

Chapter 4

Results

Studied workers were healthy with some few exceptions. Diseases connected to vision (Siukola et al. [86]) were eye diseases, neurological diseases, diabetes, hypertension and allergy. One percent of the visual inspection workers and two percent of the office workers had eye diseases. One percent of the visual inspection workers had neurological diseases. Two percent of the visual inspection workers and five percent of the office workers had diabetes. Seven percent of the visual inspection workers had hypertension, while 12 percent of the office employees had hypertension. Most important vision symptoms that we observed in this study are listed in tables 4.1, 4.2 and 4.3. Both physical and mental work ability statistics are reported in table 4.4. Majority of visual inspection workers perceived their physical and mental work ability quite good. On the other hand, majority of office workers perceived their physical work ability very good and mental work ability quite good.

The only statistical significance was between mental work ability and watery eyes (see table 4.5) among visual inspection workers. There were statistical significance between physical work ability and watery eyes, smarting of eyes, feeling that vision is poor, glare, light sensitivity and itching eyes (see table 4.6) among visual inspection workers. Also there was a statistical significance with gender and smarting of eyes, eye inflammation, light sensitivity and dry eyes (see table 4.7) among visual inspection workers. In addition, there was a statistical significance with age and difficulties to focus near. This is described in table 4.8 among visual inspection workers. We have also analyzed how visual inspection workers, who had vision symptoms, felt their own work ability. Figure 4.5 shows the dis-

Table 4.1: Most important symptoms observed in this study. Part 1 of 3, continues.

	Visual insp. workers		Office workers	
Vision symptoms	N	%	N	%
emasculation of far-sightedness				
never	138	57.7	20	46.5
monthly or rarely	62	25.9	14	32.6
daily or weekly	39	16.4	9	20.9
jumping rows				
never	161	66.5	26	60.5
monthly or rarely	53	21.9	10	23.3
daily or weekly	28	11.6	7	16.2
difficulties to move				
from the row to the another				
never	168	70	27	62.8
monthly or rarely	59	24.6	11	25.6
daily or weekly	13	5.4	5	11.6
disappearance of text				
never	196	80.7	38	88.4
monthly or rarely	34	14	5	11.6
daily or weekly	13	5.3	0	0
double images				
never	171	72.2	30	69.8
monthly or rarely	42	17.7	9	20.9
daily or weekly	24	10.1	4	9.3
difficulties to focus far				
no	158	67.2	24	55.8
yes	77	32.8	19	44.2
difficulties to focus near				
no	175	72	31	72
yes	68	28	12	28

Table 4.2: Continued. Most important symptoms observed in this study. Part 2 of 3, continues.

	Visual insp. workers		Office workers	
Vision symptoms	N	%	N	%
blurred vision				
no	151	62.7	28	66.7
yes	90	37.3	14	33.3
difficulties to evaluate distances				
no	202	83.5	34	79
yes	40	16.5	9	21
light sensitivity				
no	169	69.8	25	58.1
yes	73	30.2	18	41.9
glare				
no	163	67	27	64.3
yes	80	33	15	35.7
dry eyes				
never	177	74	24	55.8
monthly or rarely	42	17.6	14	32.6
daily or weekly	20	8.4	5	11.6
watery eyes				
never	112	46.3	17	39.5
monthly or rarely	73	30.2	19	44.2
daily or weekly	57	23.5	7	16.3
redness eyes				
never	147	60.5	24	55.8
monthly or rarely	76	31.3	14	32.6
daily or weekly	20	8.2	5	11.6

Table 4.3: Continued. Most important symptoms observed in this study. Part 3 of 3.

	Visual insp. workers		Office workers	
Vision symptoms	N	%	N	%
itching of eyes				
never	101	41.7	16	37.2
monthly or rarely	108	44.6	23	53.5
daily or weekly	33	13.7	4	9.3
smarting of eyes				
never	122	50.2	19	44.2
monthly or rarely	83	34.2	19	44.2
daily or weekly	38	15.6	5	11.6
eye inflammation				
never	147	60.2	21	48.8
monthly or rarely	96	39.3	22	51.2
daily or weekly	1	0.5	0	0
poor vision as tired				
never	93	38.3	15	35.7
monthly or rarely	116	47.7	21	50
daily or weekly	34	14	6	14.3
feeling that vision is not good				
no	170	72	28	65.1
yes	66	28	15	34.9

Table 4.4: Physical and mental work ability in visual inspection and office workers.

	Visual insp. workers				Office workers			
	Physical		Mental		Physical		Mental	
scale	N	%	N	%	N	%	N	%
very good	61	24.8	74	30.3	26	59.1	16	36.4
quite good	123	50.0	123	50.4	15	34.1	20	45.5
moderate	58	23.6	46	18.9	3	6.8	8	18.2
quite poor	4	1.6	1	0.4	0	0	0	0

tribution of perceived work ability compared to their perceived vision symptom. We can see from the Figure without no doubt that there is a correlation between vision symptoms and both physical and mental work ability: those who have more symptoms feel their work ability significantly poorer. Furthermore, these visual observations are verified by Spearman correlation calculations.

There was a statistical significance with mental work ability and watery eyes, itching eyes and difficulties to move from a row to another (see table 4.9) among office workers. There were also statistical significance with physical work ability and light sensitivity and glare among office workers. This is depicted in table 4.10. It was also noticed that there was a statistical significance with age and eye inflammation and smarting among office workers (see table 4.11). But there was not statistical significance between vision symptoms and age among office workers.

In the questionnaires workers realized their own resources at work. Our main concern was workers physical and mental work ability. Figures 4.1, 4.2, 4.3 and 4.4 clearly show that workers both mental and physical work ability declines with increasing age among visual inspection workers. In Figures 4.1 and 4.3 visual inspection workers have been divided into 5 equal size groups, where for example youngest 20 % of workers are 19–32.8 years old (gabs in the age scale are due to the fact that there were no subjects of that age and shown number are rounded to 0.1 year precision but the study used higher precision in

Table 4.5: Association between mental work ability and watery eyes among visual inspection workers. Differences were tested by the Kruskall Wallis Test.

Symptoms	very good (n)	quite good (n)	moderate (n)	quite poor (n)	p-value	N
watery eyes					0.014	228
never	37	53	11			
monthly or rarely	19	36	16			
weekly or daily	11	30	14	1		
Total	67	119	41	1		

the calculations). Also by observing these Figures, one can get a rough idea on the age distribution of the company and conclude that company has a quite even age distribution and we can say that our study group consists of people of all ages except people younger than 20 years old.

Table 4.12 shows are statistically significant correlations between vision symptoms and both physical work ability and mental work ability at visual inspection work. Strongest correlations were found between watery eyes, smarting, light sensitivity, glare and physical work ability. Strongest correlations were found between watery eyes and mental work ability. However, correlations are weak, $r < 0.3$.

Table 4.13 shows that the association between vision symptoms and mental work ability among office workers is statistically significant for itching eyes, distortions and difficulties to focus near. However, the correlations are moderate, $r < 0.7$. It also worth noticing that none of the symptoms had significant correlations with physical work ability.

In table 4.14 is presented all statistically significant Spearman's correlation coefficients between physical and mental work ability and various symptoms for two age age groups. In the first age group were people younger than 45 years old and in the second group people older than 45 years. The table shows that at visual inspection work the most significant symptoms in terms of physical work ability are glare, light sensitivity, smarting and itching

Table 4.6: Association between physical work ability and watery eyes, smarting of eyes, feeling that vision is poor, glare, light sensitivity and itching eyes among visual inspection workers. Differences were tested by the Kruskall Wallis Test.

Symptoms	very good (n)	quite good (n)	moderate (n)	quite poor (n)	p-value	N
watery eyes					0.027	230
never	31	54	17	1		
monthly or rarely	18	30	22	1		
weekly or daily	7	30	17	2		
Total	56	114	56	4		
smarting of eyes					0.002	231
never	38	59	21	1		
monthly or rarely	14	41	18	2		
weekly or daily	4	15	17	1		
Total	56	115	56	4		
feeling that vision is poor					0.033	226
no / yes	45/11	85/28	30/23			
Total	56	113	53			
glare					0.018	231
no / yes	43/13	79/36	28/28	2/2		
Total	56	115	56	4		
light sensitivity					0.007	230
no	47	79	33	1		
yes	9	35	23	3		
Total	56	114	56	4		
itching eyes					0.040	230
never	29	50	17	3		
monthly or rarely	24	44	31			
weekly or daily	3	20	8	1		
Total	56	114	56	4		

Table 4.7: Association between gender and smarting of eyes, eye inflammation, light sensitivity and dry eyes among visual inspection workers. Differences were tested by the Mann-Whitney test.

Symptoms	Gender			
	Male (n)	Female (n)	p-value	N
smarting of eyes			0.029	232
never	28	91		
monthly or rarely	12	64		
weekly or daily	3	34		
Total	43	189		
eye inflammation			0.011	233
never	34	107		
monthly or rarely	9	82		
weekly or daily		1		
Total	43	190		
light sensitivity			0.008	242
no	38	131		
yes	6	67		
Total	44	198		
dry eyes			0.026	228
never	37	130		
monthly or rarely	6	35		
weekly or daily		20		
Total	43	185		

Table 4.8: Association between age groups and difficulties to focus near among visual inspection workers. Differences were tested by the Mann-Whitney U-test.

Symptoms	Age			
	< 45 years (n)	> 45 years (n)	p-value	N
Difficulties to focus near			0.002	232
no	13	138		
yes	30	51		
Total	43	189		

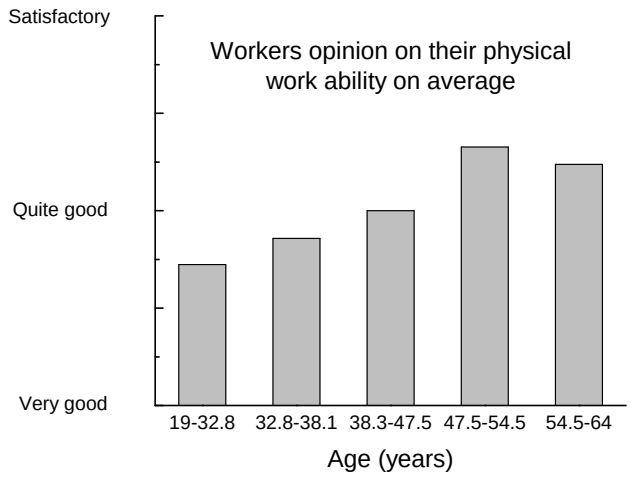

Figure 4.1: Visual inspection workers opinion on their physical work ability on average. Questionnaire scale was ’1’ Very good, ’2’ Quite good, ’3’ Satisfactory, ’4’ Quite poor ’5’ Poor.

Table 4.9: Associations between mental work ability and and watery eyes, itching eyes and difficulties to move from a row to another among office workers. Differences were tested by the Kruskall Wallis Test.

Symptoms	very good (n)	quite good (n)	moderate (n)	p-value	N
watery eyes				0.032	43
never	9	3	5		
monthly or rarely	5	13	1		
weekly or daily	1	4	2		
Total	15	20	8		
difficulties to move from a row to another				0.049	43
to another					
never	13	9	5		
monthly or rarely	1	7	3		
weekly or daily	1	4			
Total	15	20	8		
itching eyes				0.031	43
never	10	3	3		
monthly or rarely	4	16	3		
weekly or daily	1	1	2		
Total	15	20	8		

Table 4.10: Associations between physical work ability and light sensitivity and glare among office workers. Differences were tested by the Kruskall Wallis Test.

Symptoms	very good (n)	quite good (n)	moderate (n)	p-value	N
light sensitivity				0.026	43
no	13	12			
yes	12	3	3		
Total	25	15	3		
glare				0.003	42
no	15	12			
yes	9	3	3		
Total	24	15	3		

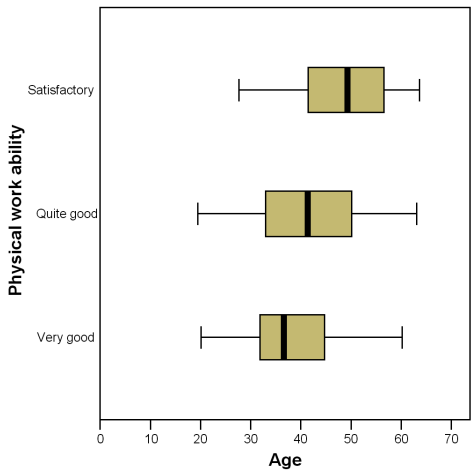

Figure 4.2: Visual inspection workers opinion on their physical work ability. Black bar represents the median, shaded box has the left limit on 25 % level and 75 % level on the right and line segment ends represents the minimum and maximum.

Table 4.11: Association between age groups and eye inflammation and smarting among office workers. Differences were tested by the Mann-Whitney U-test.

Symptoms	Age			
	< 45 years (n)	> 45 years (n)	p-value	N
eye inflammation			0.002	42
never	7	14		
monthly or rarely	17	4		
weekly or daily				
Total	24	18		
smarting of eyes			0.002	42
never	15	3		
monthly or rarely	8	11		
weekly or daily	1	4		
Total	24	18		

Figure 4.3: Visual inspection workers opinion on their mental work ability on average. Questionnaire scale was ’1’ Very good, ’2’ Quite good, ’3’ Satisfactory, ’4’ Quite poor. ’5’ Poor.

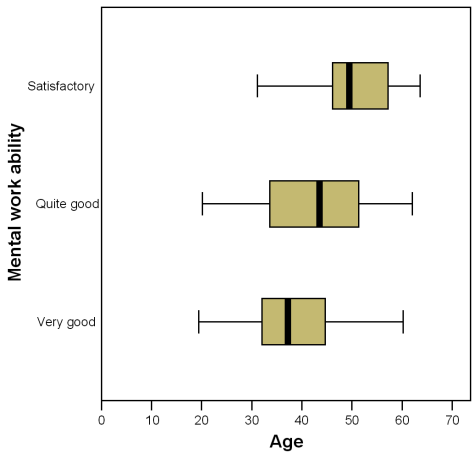

Figure 4.4: Visual inspection workers opinion on their mental work ability. Black bar represents the median, shaded box has the left limit on 25% level and 75% level on the right and line segment ends represents the minimum and maximum.

Table 4.12: Statistically significant Spearman's cross correlation coefficients (r) between physical and mental work ability and various symptoms (visual inspection work, n=259).

	Physical work ability		Mental work ability	
Symptoms	r	p-value	r	p-value
Watery eyes	0.20	0.002	0.20	0.002
Smarting	0.25	0.000	0.14	0.030
Dry eyes	0.15	0.022		
Itching eyes	0.18	0.007		
Light sensitivity	0.22	0.001		
Glare	0.20	0.002	0.14	0.039
Poor vision	0.17	0.004		
Difficulties to focus near	0.14	0.036		
Emasculation of far-sightedness			0.14	0.031
Vision problems as tired			0.14	0.040

Table 4.13: Statistically significant Spearman's cross correlation coefficients (r) between physical and mental work ability and various symptoms (newspaper office, n=44).

	Physical work ability		Mental work ability	
Symptoms	r	p-value	r	p-value
Itching eyes			0.34	0.027
Distortions			0.31	0.045
Difficulties to focus near			0.30	0.050

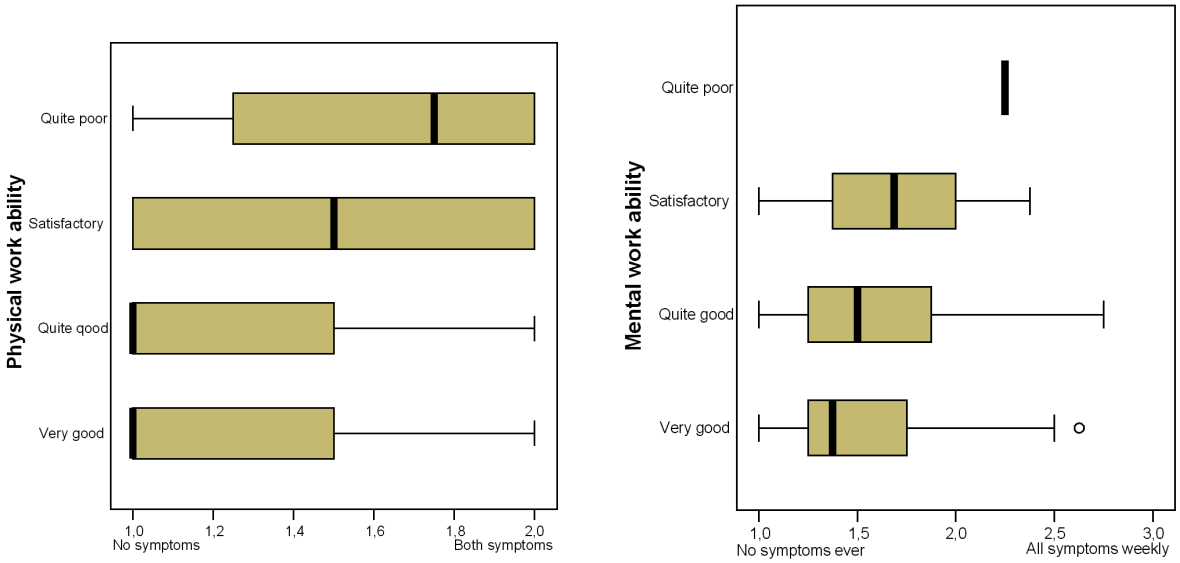

Figure 4.5: Vision inspection employees opinion on their (left) physical work ability versus vision problems (sensitivity to light and increased glare) that they have perceived, (right) mental work ability versus vision problems: watery eyes, smarting of eyes, feeling that vision is poor, glare, light sensitivity, itching eyes. Black bar represents the median, shaded box has the left limit on 25% level and 75% level on the right and line segment ends represents the minimum and maximum. A circle represents an outlier, which is a point that was excluded from the data because it diverges significantly from the other points.

eyes. However, no clear tendencies by age are visible in the results. This is partially due to the fact that only few symptoms had statistically significant correlation with work ability in both age groups simultaneously. Even then, the correlations were weak and differences between age groups were small. Biggest change was with sensitivity to light, where correlation to physical work ability was increased for older people by 0.042 into 0.230. Correlations with mental work ability and vision symptoms were weak and older age group did not have any significant correlations for comparison.

For newspaper office workers the correlations between work ability and visual symptoms were higher than with visual inspection workers. Result show that office workers suffered most from (a) difficulties to move from a row to another and from (b) difficulties to evaluate distances. Correlations with younger age group's (<45) mental work ability were moderate

Table 4.14: Spearman's cross correlation coefficients (r) between physical and mental work ability and various symptoms (quality inspection work, n=259).

	Physical work ability				Mental work ability			
	<45 years		>45 years		<45 years		>45 years	
Symptoms	r	p-value	r	p-value	r	p-value	r	p-value
Glare	0.184	0.038	0.196	0.048				
Light sensitivity	0.188	0.034	0.230	0.021				
Emasculation of far-sightedness					0.248	0.005		
Smarting	0.237	0.007	0.217	0.030				
Eye inflammation					0.217	0.014		
Vision problems as tired					0.182	0.041		
Difficulties to evaluate distances					0.208	0.019		
Itching eyes	0.199	0.024						

and r=0.454 (p=0.026) for (a) and r=0.549 (p=0.005) for (b). However, due to quite small size of test group and lack of correlations in all the other symptoms and with older age group (>45), we cannot say anything conclusive about office workers work ability by age.

Chapter 5

Discussion

The newspaper office workers' difficulties to move from a row to another, itching eyes and watery eyes had an association with mental work ability. The newspaper office workers' light sensitivity and glare had an association with physical work ability. There were no statistical significant associations between gender and vision problems among office workers, but there were statistically significant associations between smarting of eyes and eye inflammation and age.

There were significant associations between the visual inspection workers' watery eyes, smarting of eyes, feeling that vision is poor, itching of eyes, light sensitivity and glare and physical work ability. The visual inspection workers' mental work ability had a significant association between watery eyes. In addition there were also statistically significant associations between gender and smarting of eyes, eye inflammation, light sensitivity and dry eyes among visual inspection workers. We also observed commonly known dependence between age and difficulty to focus near.

Results show that visual symptoms and mental work ability do not have strong correlation at any examined age. This could be explained by the fact that our sample of workers is limited and that their mental work ability is good on average, as can been seen from Figure 4.3. We can also conclude that these factors have little or no significance to workers mental well-being and should not be considered a key factor when promoting mental work ability.

The most remarkable vision symptoms, which have the association with physical work ability among visual inspection workers (see Figure 4.2), were light sensitivity, smarting,

watery eyes and glare. For the mental work ability (see Figure 4.4) the main association was with watery eyes but even then the correlation was weak.

People reported light sensitivity (photophopia), which indicates similar results like Saari [76]. This kind of light sensitivity can be functional and be connected with tiredness. Glare was a common symptom among visual inspection employees. This could be explained by poor lighting. Aine [2] stresses that sensitivity to glare can be explained by retina's adaptation, glare caused object's location in the vision field.

5.1 Evaluation of methods

The research questions were selected based on the literature review. Based on a former study [86] and the source material, the questions were valid. The answering percentage was high. The results illustrate the opinion of the whole personnel in both companies.

This research was a cross-sectional research and therefore it measures the phenomena at a specific moment. The answering to the research questions was retrospective. Because of the research frame and the retrospective nature of the research, causal deductions are difficult make and the research results can be seen as indicative. According to the results, it cannot be argued that people with poor vision would have reduced work ability or vice versa. But we can assume that there is an association between vision and work ability. The research results can be generalized for research work places, because the sample size was large enough and representative.

The entire study group was quite heterogenous even though clear majority were women. In the broader concept of work ability, ocular, visual and systemic symptoms were covered in the analysis.

Collins et al. [18] paid attention to the fact that in reporting self-administrated ocular, visual or systemic symptoms the worker can e.g. suffer from flu, which can be a confounder factor. In this case symptoms are not related to work, especially VDU work. When discussing the study results the confounder factors should be taken into consideration. Balci et al. [9] have noticed that physiological and psychological discomfort and the performance of VDU users are affected by various factors including workstation design, work environment, social environment and the users.

In the questionnaire was not asked about problems in the work environment, like noise, humidity and temperature, which may have an huge effect on the work performance, vision symptoms Seppälä [81] and perceived work ability. The self-rated, perceived work ability has been an object of many studies [33]. It has to be remembered that the work ability is, however, a multidimensional concept.

Work ability topic is current, because typical workforce is ageing and vision problems are common among the ageing workforce. The aim of this study was to expand the concept of the association between work vision [52] and work ability [33]. As a starting point to this study, we assumed that poor work vision reduces work vision at work. One explanation to results can be the selection of workers (the healthy worker effect). Dos Santos Silva [85] explains that people, who have a better work ability work longer than the people, who have reduced work ability [33]. In the further studies it is import to concentrate on workers, who feel their work ability poor by using interviews.

One explanation to the fact that people, who have poor vision, can perceive good work ability, because they can compensate their vision problems with their work experience. This was also reported by Seppälä [81]. The incidence of poor work ability seems to increase with vision deprivation, though the association may be confounded by other factors.

The research indicates that the differences between individuals can affect the fact, how their work vision affects their perceived work ability. These results are largely consistent with the results, which have been reported among others by Collins et al. [18]. It would be interesting to know what will be the correlation between sick leaves and vision problems, because in many studies there has been a connection between poor work ability and absences.

The interpretation of the results presented here also requires some caution. Validity and reliability of this research is evaluated according to similar and earlier research. For example Yin [104] stresses that research results can be analyzed by comparing the research frame and empirical results.

The definition of work ability was based on peoples own perception and there are many research concerning perceived work ability. It was far more challenging to define poor vision with the help of vision symptoms, because vision symptoms are personal perceptions. When interpreting vision problems, we need to remember that the problems are individual's own

interpretation on perceived symptoms.

5.2 Visual inspection workers

The most remarkable vision symptoms, which have a association with physical work ability, were light sensitivity, glare (lighting symptoms), feeling that vision is poor (general eye symptoms), itching of eyes, watery eyes (ocular symptoms) and smarting of eyes. The most remarkable vision symptom, which had an association with mental work ability, was watery eyes.

Lighting symptoms, like sensitivity to light and glare problems are typically cased by work environment's poor lighting and optoergonomics [48]. Ocular symptoms, like watery eyes, smarting of eyes, itching or typical symptoms of eye irritation (e.g. strained or dry eyes) are typically caused by the high visual demands of the work tasks, like visual inspection work.

General symptoms, like feeling that vision is poor, are called asthenopia. Mäkitie [52] emphasizes that asthenopia can be connected with 1) vision, e.g. as a glare and blurred vision 2) eyes, e.g. the stinging feeling and smart 3) common symptoms, e.g. headache, neck pain. However, only statistical significant associations were between gender and smarting of eyes, eye inflammation, light sensitivity and dry eyes. Women have considerably more smarting of eyes and they are also much more sensitive to light. Moreover, 11 % of the women report that they have dry eyes weekly or daily, but none of men reported such frequent dry eyes. The causes of dry eyes are multifactorial Kivelä [40]. Hormonal factors and environmental causes like air dryness may explain high frequency of dry eyes among women based then study of Baudouin et al. [10]. The only statistically significant correlation was between age and difficulties to focus near among inspection workers. Majority of inspection workers (59.5 %) over 45 years old had difficulties to focus near, which is typical for aging people.

5.3 Office workers

With newspaper office employees' mental work ability had a significant association with itching eyes, difficulties to move from a row to another (visual symptom) and watery eyes (ocular symptom). With newspaper office employees' physical work ability had a significant association with light sensitivity and glare (lighting symptoms). However, there were no statistically significant associations between gender and visual symptoms among office workers. But there were statistically significant associations between age and eye inflammation and smarting among office workers. Ocular symptoms, like itching eyes, are associated the high visual demands of the tasks [83].

Association between symptoms and VDT tasks seem to be related to the VDT characteristics, work patterns that use VDTs, work station characteristics or psycho-social-factors. [18] Like Thomson [87] suggests in his study the prevalence of eye problems among visual display unit users is disturbed because there are many confounding factors in VDT studies. Proper work station design, worker-rest cycles and training of operators are other essential considerations in the prevention of symptoms associated with VDT usage [88].

Visual symptoms, like difficulties to move from a row to another, are caused by work pressure [18], which are common at office work. Visual symptoms, like difficulties to focus far, difficulties to focus near, blurred vision, distortion of images/lines, difficulties to estimate distances can be caused by work pressure [18] are common among office workers. Lighting symptoms, like sensitivity to light and glare are typically caused by work environment's poor lighting and improper opto ergonomics [48].

5.4 Work ability

In this research work ability model consists especially of the balanced model (Seley [80] and Mäkitalo et al. [50]) and Ilmarinen's model concerning factors influencing work ability from the individual's point of view [33]. To receive a deeper understanding concerning work ability, other work ability models like Härkäpää's model [30] will also be needed, because work ability is a complex concept.

Majority of visual inspection workers perceived their physical and mental work ability

quite good. On the other hand, majority of office workers perceived their physical work ability very good and mental work ability quite good.

It was interesting to notice that even when the visual inspection workers perceived that their mental work ability is weakening over age, but still the oldest felt it a bit better again. The theory concerning work motivation of Peltonen and Ruohotie [63] may explain this. They have found out in their research that while work is monotonous, it is also mentally loading. According to results the office workers, like mental workers usually, have better possibilities to affect their work. Also Kalimo [37] stresses that monotonous work causes boring and difficulties to concentrate, which reduces work motivation.

The age had a significant association with work ability, because the older the people the worse they perceived their work ability [33]. Both improving and worsening of work ability in longitudinal studies explain same factors: ergonomics, managerial work and exercise. [32] Information about managerial work (for example about foreman work) was not available in this study, but according the previous studies (Nygård et al. [58], Ilmarinen [33]) it can be assumed that it has a huge effect on perceived work ability.

Also improving ergonomics, especially optoergonomics, will increase work ability. As Aarås et al. [1] have concluded that combined ergonomic, lighting, and optometric interventions is of great importance while reducing visual discomfort and musculoskeletal pain for VDU worker. The finding can also be suitable for visual inspection workers' work.

We need to remember that perceived work ability's nature is subjective. In this study was not taken into consideration occupational specialists opinion on workers's work ability. Because the material was gathered by questionnaires, there may be a memory bias. However, the research questionnaires were suited for researching the association between work ability and vision at work. Using these questionnaires and selected questions from them can been showed some associations between certain factors with relation to perceived work ability and work vision, which was the aim of this study.

5.5 Association of work vision to perceived physical and mental work ability

Lighting symptoms, like sensitivity to light and glare, were associated with physical work ability both among visual inspection workers and office workers. The association can be explained by increased non-ergonomic activity during working day (Seppälä [81] and Mäkitie [52]). Also improper or poor lighting is a major environmental factor contributing to visual discomfort. [83] We also found out that watery eyes was associated with mental work ability in both work places. This result is quite expected due to the nature of work tasks performed in both study groups. It is well-known that staring at monitor or VDT work causes dry eyes and thus activates tear ducts.

Middle-aged office workers may suffer from a heavier visual-load effect than younger workers. Because most middle-aged workers tend to gradually loose their ability to focus near and thus, they have difficulties in focusing well. This is a natural condition known as presbyopia. [36]

Work vision related symptoms are only generally discussed in this work. Work ability is a contractual concept. Because of this, in this research work ability is measured using one question of work ability index concerning both mental and physical work ability, which was perceived, self-rated work ability (scale 1–5).

Chapter 6

Conclusions

Different visual symptoms appear in all age groups, but the symptom density is considerably higher among the older employees. Symptoms become more common with age, and the employees perceive their work ability worse, both physically and mentally. The oldest, 55–65 years old, employees have better vision and higher work ability than ten years younger employees among visual inspection workers. This may due to the fact that the people in worst condition have already retired before reaching the oldest age group and hence do no longer appear in this kind of study.

Rantanen et al. [69] emphasize that automatic process control equipment and information technology transfer handmade work into machines, where people need good vision. This is a challenge for vision, the work place development and promoting and developing work ability.

The balance between work and work environment is captured by Kukkonen [41], who said that at well designed work an employee has a possibility for productive and good work without jeopardizing his or others health. This can also be applied to work vision research. In order to best preserve work vision and work ability in the work life, it should be paid attention to the individual, the work environment and the work arrangement factors. According to the literature, the central factors are age, lighting, safety and work arrangements.

The evaluation of work vision requires multi professional know-how with a co-operation with occupational health care, ophthalmologists and opticians. Only with the help of this co-operation, it can ensured that workers's perceived, subjective symptoms and, on the other

hand the physician's diagnosed symptoms and diseases are connected to work vision. In this way can also be ensured that symptoms are not caused by common diseases, but are caused by office or inspection work. When other than work environment caused symptoms and diseased are precluded, we can find out work environment related factors, for example light sensitivity or glare. Reduced work ability is also closely related to aging, gender and changes in the human vision. By improving work vision, one can alleviate work related problems.

In future studies, other methods, like interviews, could be used for studying the associations between work ability and work vision. Also longitudinal studies may help to understand better the association between work vision and work ability.

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