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Call centre work

– characteristics, physical, and psychosocial exposure,
and health related outcomes

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Original papers

This thesis is based on the following five publications, which are referred to in the text by their Roman numerals:

- I.** Norman K, Nilsson T, Hagberg M, Wigaeus Tornqvist E, Toomingas A. 2004. Working conditions and health among female and male employees at a call center in Sweden. *American Journal of Industrial Medicine* 46 (1):55-62.
- II.** Norman K, Alm H, Toomingas A, Wigaeus Tornqvist E. Reliability of a questionnaire and an ergonomic checklist for assessing working conditions and health at call centres (Submitted to *International Journal of Occupational Safety and Ergonomics*)
- III.** Norman K, Toomingas A, Wigaeus Tornqvist E. Working conditions in a selected sample of call centre companies in Sweden (Submitted to *American Journal of Industrial Medicine*)
- IV.** Norman K, Kjellberg A, Herlin RM, Hagman M, Toomingas A, Wigaeus Tornqvist E. Psychosocial conditions, stress and energy in a selected sample of call centre companies in Sweden (Submitted to *Work & Stress*)
- V.** Norman K, Floderus B, Hagman M, Toomingas A, Wigaeus Tornqvist E. Musculoskeletal symptoms in relation to work exposures at call centre companies in Sweden (Submitted to *Work*)

Co-author statements

Norman has written all articles appended to this thesis, under the supervision of the co-authors. Norman has participated in the planning, data-collection and the statistical analyses in *study II-V*.

In *paper I*, the co-authors have planned and performed the data-collection.

In *paper II*, the co-authors have assisted in the interpretation of the analyses.

In *paper III*, the co-authors have assisted in discussing analyses, results.

In *papers IV and V*, the co-authors, have given advice about the statistical analyses, and their interpretation, and have assisted in discussing the results.

List of abbreviations

ACD	Automatic call distributor
CC	Call centre
CCs	Call centres
CI	Confidence interval (95%)
CTI	Computer Telephone Integration
MSD	Musculoskeletal disorder
OR	Odds ratio
SMS	Short message service
UEMSS	Upper extremity musculoskeletal symptoms

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Introduction

The development of computer and information technology is perhaps one of the most dominating factors in the ever-changing working life of today. The 1990s saw a rapid computerisation of Swedish working life (Aronsson et al., 1994; Lennerlöf, 1993) and the number of computer workers is continuously increasing. Thirty-seven per cent of the female working population and 35 per cent of the male workforce use computers, at least half of their working time (The Swedish Work Environment Authority, 2003). Computer technology has affected the work environment and the users in different ways, resulting for example in more constrained sedentary work. Technological developments in general have had a great impact on working life. With the help of technology, activities are no longer confined to a particular place or time, a phenomenon that is clearly illustrated by call centres (CCs).

The basis of this thesis is to describe characteristics of work, physical and psychosocial exposures and health related outcomes, for CC operators in Sweden.

What is a call centre?

There is no universally accepted definition of “call centre” or “operator”, although the following ones have been suggested: Call centre – a work environment in which the main business is conducted via the telephone whilst simultaneously using display screen equipment (www.hse.gov.uk/lau/lacs/94-1.htm). This includes both parts of companies dedicated to this activity, such as internal helplines as well as whole companies. CC operator (also known as customer service advisor/agent/handler) – is an individual whose job requires them to spend a significant proportion of their working time responding to calls on the telephone whilst simultaneously using display screen equipment (www.hse.gov.uk/lau/lacs/94-1.htm).

CCs are organisations or departments that are specifically dedicated to contacting clients and customers. These can either be a helpdesk, or client service department of an organisation, but companies may also have outsourced this to a CC company, which handles all client contacts for a variety of organisations. One important distinction is therefore between internal and external CCs. The term external CC is usually associated with an independent company that uses telecommunications technology to handle everything from advice, e.g. computer and mobile telephone support, to ticket booking and telemarketing. The number of independent CCs is rapidly increasing, as many companies are outsourcing their telephone services. The main new features are that operations on a larger scale are outsourced and have assignments from other companies. Internal CCs are departments or separate companies within a larger company, usually with another main core business.

It may be easier to vary the nature of work tasks in an internal company than in an external company. Another difference that may be of importance is that work tasks and type of customers may change more often in an external company. This could be both positive and negative for the operator. On the positive side it could be stimulating to work with different products and to learn new things. On the negative side it may be difficult to feel affiliated to the client company that the operator is currently working for and to get an understanding of the product and the business concept.

A CC is a business where the employees mainly handle incoming and/or outgoing telephone calls. Typical services with outgoing calls are advertising campaigns, market research and selling by telephone. Examples of activities with incoming calls are customer services, giving information, taking orders and providing helpdesk functions. In the last few years operators have also started to handle e-mail, fax and SMS (short message service).

The CC business has been characterised by high turnover. Internal CCs have an annual turnover of approximately 12.5 per cent and some of this turnover consists of persons that are moved to other positions at the company. At external CCs the picture is more varied. There are two categories of turnover. At companies where the operators work during the daytime, with larger assignments, the annual turnover is normally 10 per cent. At companies where the operators work evening- or night shift, with short projects or with telemarketing projects, the annual turnover is between 40 and 133 per cent. The differences could depend on how the employment is seen: as a permanent job with a regular income, or as an extra job on the side (Bulloc, 1999).

The history and development of the call centre business

CCs have their origin in the USA, where they started in 1908 when it became possible to use the telephone to sell advertisements in a telephone book. In the beginning of the 1960s Ford Motor Company started to search for possible buyers for their cars by making 20,000,000 phone calls to the consumers. One of the largest telemarketing campaigns in Sweden was carried out in 1978 when the Swedish telephone company (now Telia) decided to introduce the American concept "Yellow pages". Most of the advertisers had to buy their advertising space by telephone instead of being visited by a salesman. At the end of the 1980s the number of telemarketing companies started to grow, and more and more were established. The concept of CC was born in the year 1991; in 1994 Telia introduced a campaign for CCs and the concept became firmly established in Sweden (Nutek R 2000:10). During the last few years' companies that are called contact centres have been established in Sweden. The contact centre handles more than just telephone calls, e.g. SMS, e-mails and fax messages.

CCs constitute one of the most rapidly growing businesses in Sweden. In 1987 there were 52 telemarketing companies with 438 employees (Cohen, 2004). In 1997-99 there were 110 external CCs with 7051 employees. The number of employees is estimated to increase by 10 per cent per year during the period 2002 to

2007. In 2002, about 60,000 persons were working in the business, at 700-800 CCs in the country, according to Invest in Sweden Agency (ISA), which is equivalent to approximately 1.5 per cent of the working population in Sweden. Most of the CC companies are situated in the big cities, but almost 200 are situated in smaller towns or in rural areas.

Even internationally the CC business has grown very fast. In the USA, CCs employ about 5 per cent of the workforce, while the figure is 1.3-4 per cent (2003) in Europe (Nutek R 2000:10) and 2 per cent in the UK (Datamonitor, 1998, 1999). CCs are said to be the most rapidly growing form of employment in Europe today (Paul and Huws, 2002, p.19). Approximately 37 per cent of all new jobs within Europe during recent years have been in CCs. The overall trend is that more and more CCs are located at a distance from their customer base – even in other countries. It is estimated that, in South East Asia, India, the annual growth of CCs is 50 per cent.

What's new?

Telephone operator work has become progressively more computerised over the last few decades for example automatic distribution of calls and technical performance control has been introduced. These changes have resulted in a reduction of the variety of tasks performed by the operator, and increased repetitiveness and machine-regulation of the work. Computer-telephone interactive tasks, as performed in CCs are probably very special tasks to be studied, since in these jobs video display units are used interactively during telephone calls. This means that repetitive movements and prolonged static sitting postures occur in complex situations, where communications skills, responsibility and efficiency are expected from operators under the influence of time pressure, ambitious goals and sometimes direct monitoring of performance.

CCs use a range of information and communication technologies in order to maximise efficiency, and the technology that is the key to the CC is the ACD-computer (ACD = automatic call distributor). This computer directs the calls to the next available and logged-in operator. The computer also tracks how long it takes until the customer is connected, how long the call lasts and the time that the operator not is working actively with calls or is disconnected because he or she has left the workstation. This eliminates the need for a central telephone operator by automatically processing the distribution of incoming telephone calls to the operators, who receive them through their headsets and seldom have to dial telephone numbers themselves, or physically pick up a telephone receiver. Increasingly, ACD systems are connected to a range of databases using Computer Telephony Integration (CTI), which allows customer records to be transmitted to an agent's computer screen along with the call. In addition, many ACD systems have "voice response" mechanisms that are used to obtain basic information from the caller before they speak to an agent. In external companies, Predictive Dialling technology is used in order to telephone large pre-programmed lists of customers. In this case, when the customer answers a call, the ACD system automatically

transfers it to a waiting agent together with an on-screen computerised record of the customer's details.

Health related outcomes among call centre operators

High rates of upper extremity musculoskeletal symptoms have been reported among telecommunication workers or CC operators (Ferguson, 1976; LeGrand, 1989; Hadler, 1992; Smith et al., 1992; Hales et al., 1994; Hocking, 1997). Karlqvist et al., (2002) reported prevalences of symptoms for different occupational groups, including a group of CC operators. In that group 57 per cent of the men and 72 per cent of the women reported symptoms in the neck/shoulder during the previous month, which was higher compared with other groups of professional computer users (35 per cent of the men and 54 per cent of the women).

Knowledge about the causes of musculoskeletal symptoms has increased during the last years. Today, we have extensive knowledge about the consequences of computerisation in a work environment. Intensive and sedentary work with a computer is often associated with symptoms in the neck/shoulder and arm/hand region, eye discomfort, but also to stress-related problems (Haavisto, 1997; Hagberg, 1995; Karlqvist, 1998). Several studies have shown that long periods of constrained sitting or computer work are associated with musculoskeletal symptoms (Buckle, 1994; Hagberg, 1987; Karlqvist, 2002; Punnett and Bergqvist, 1997; Tittirononda et al., 1999). In other studies a combination of non-optimal physical and psychosocial working conditions, has been shown to increase the prevalence of musculoskeletal symptoms (Punnett and Bergqvist, 1997; Bongers, 1993; Fausett and Rempel, 1994, Fernström, 1997).

Several other risk factors can be identified in the CC environment, e.g. static workload, repetitive movements, high demands and low control (Ferreira et al., 1997; Hocking, 1987; Sprigg, 2003). These factors may be involved in the development of musculoskeletal symptoms in the neck/shoulder and arm/hand region. Multifactor models suggest that work-related risk factors can result from the work tasks and their performance, as well as from the organisation of work, and the physical and psychosocial work environment. Additionally, individual and lifestyle factors could be risk factors for musculoskeletal symptoms (Hagberg et al., 1995). Plausible models, supported by recent laboratory experimentation, have provided support for an interactive relationship between physical and psychosocial risk factors in the workplace (Davis and Heaney, 2000; Lundberg and Melin, 2002).

Most studies show that pain in the neck-shoulder region is more common among women than among men. According to the 2001 Work Environment Survey, 24.5 per cent of men and 40.4 per cent of women had pain in their neck-shoulder region every week. The differences seem only partly explainable by the gender-segregated labour market, with a higher proportion of women in jobs where exposure to repetitive work is common, such as cashiers, telephone operators, hairdressers and cleaners (Work Environment Authority and Statistics Sweden 2002).

An exposure-effect model focusing on work at call centres

The following model, figure 1, modified from Winkel and Mathiassen (1994), tries to describe work at CCs according to an ergonomic multifactor perspective. The work-related exposures are categorised as *organisation/characteristics of work*, e.g. work tasks and work quantity, complexity of work task, call logging and monitoring, salary and additional remuneration, type of calls; *physical exposures*, e.g. comfort related to work environment, time spent seated during a working day, duration of continuous computer work and work postures; *psycho-social exposures*, e.g. psychological demands (emotional and cognitive demands and time pressure), decision latitude, possibility of influencing the work, support from colleagues and supervisor; the non-work-related exposures, here called *life outside work/social exposure*, e.g. support from friends, family and financial situation. In addition, *individual characteristics*, e.g. age, gender, may act as modifying factors for different exposures. The *internal exposure*, comprises the strain in the body on e.g. a given muscle. The exposure causes an *acute response*, a consequence of internal exposures, e.g. muscular fatigue, metabolic changes, altered muscle blood flow.

If nothing is done to reduce the exposure, this could lead to *health related outcomes*, both short-term and long-term effects. *Short-term effects* could be divided into *symptoms* e.g. eye discomfort, headache, neck/shoulder, arm/hand, upper back and lower back and *other health related* e.g. stress-related somatic or mental symptoms, stress and energy. In the longer perspective this could lead to *long-term effects*, e.g. disability and sick leave.

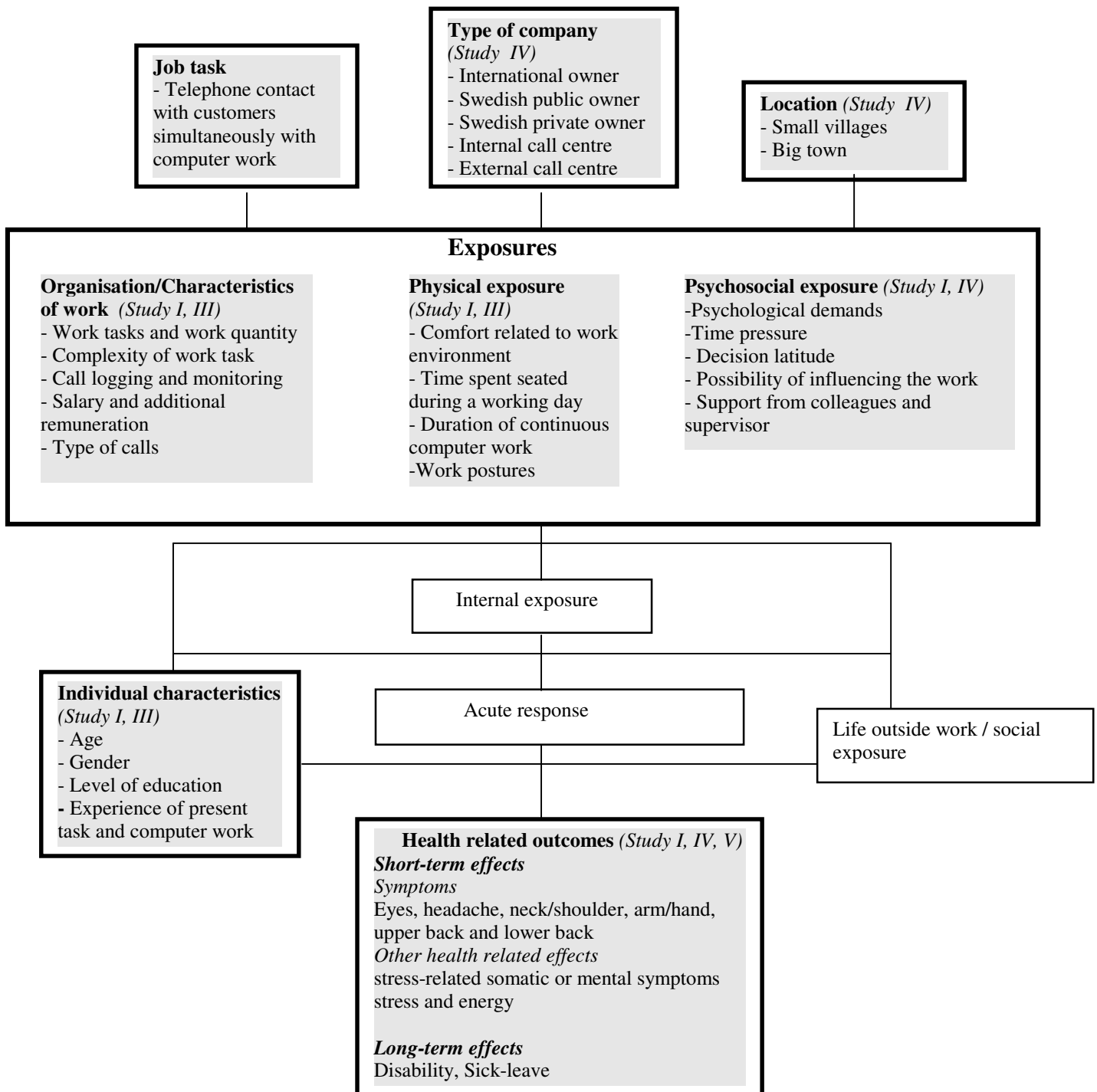


Figure 1. Exposure-effect model, modified by Winkel and Mathiassen (1994), focusing on work at call centres. Different factors that may influence the health effects in the human body. This thesis is based on five studies (study II not included in this model), which are referred to by their Roman numerals. Bold frames show the areas that have been studied.

Characteristics of work at call centres

The content and quantity of calls at CCs varies with the complexity of the phone calls. Work tasks of low complexity might give less variation in work content and a higher quantity of calls. The operators may sit in front of the computer most of the day, with both physical and mentally monotonous, and repetitive work.

Ferreira and co-workers showed that CC workers often spend 90 per cent of their working time on the telephone and in front of the computer (Ferreira, et al., 1997). In the extreme case a phone call could be as short as 15-20 seconds, which means that one operator, could handle 1,000 calls or more during a working day (Westin, 1992). The service degree, e.g. answering 80 per cent of the calls within a given time, may also be a stress factor, in the same way as high work intensity. Other negative factors that have been reported: working on a varying roster, working in the evening and at night-time, rapid changes in work content and insufficient information.

The salary among CC operators has been described as low (Ferne and Metcalf, 1998; Taylor and Bain, 1999). Additional remuneration seems to be common in this business.

Performance monitoring seems to be fairly widely accepted, although that acceptance has depended upon the style of supervision. (Amick and Smith, 1992; DiTecco et al., 1992; Aiello, 1993; Schleifer et al., 1996; Westin, 1992). Both call logging and monitoring could be a good way of showing the operator's performance. Monitoring could be a good way of showing the quality of the operator's services.

Physical exposures

Workstations located in open offices might give problems with disturbing noise. Sudden sounds, human voices and movements in the field of vision attract the focus of attention. This is involuntary and interferes with the work activity (Jones and Morris, 1992; Loewen and Suedfeld, 1992; Sundstrom et al., 1994). Other negative sides of noise are the speech comprehension that could be disturbed and that it could lead to tiredness and stress (Evans and Johnson, 2000; Kjellberg et al., 1996).

In open offices there are no possibilities for the operators to adjust the indoor climate (temperature, draught) or quality (humidity and dust) and lighting to an individual level, which could lead to negative effects e.g. tiredness and eye discomfort (Tham et al., 2003).

The increasing amount of computer work is a concrete example of modern change in working life that has affected the physical work environment. Considerable work has been done to improve the physical design of workplaces (Bernard, 1997; Cherniak, 1999; Dimberg, et al., 1989; Elivell, 1996; Fernström, 1997; Grandjean, 1988; Sauter, et al., 1991). Computer workstation design improvements can prevent awkward postures and increase worker health and performance (Grandjean et al., 1983, 1987, 1988; Verbeek 1991; Smith and Cohen 1997;

Bayeh and Smith 1999; Smith et al., 2003). It is common that operators at CC companies do not have their own workplace; instead they have to take any available workstation that is free. This means that there are higher demands for the furniture and equipment to be adjustable. CC operators need to be comfortable during the long, unbroken periods they spend at their workstations, so optimal environmental conditions are required.

CC operators often work with constrained awkward postures and with repetitive arm/hand movement. Therefore, work task variation is important. Regular breaks are known to have a beneficial effect on preventing upper extremity musculoskeletal symptoms (UEMSS) (Dul et al., 1994; Henning et al., 1997; McLean et al., 2001; Balci and Aghazadeh, 2004). Ten-minute breaks every hour reduced the development of disorders among CC operators (Ferreira et al., 1997). Another study showed increased productivity following ergonomic improvements (Smith and Bayehi, 2003).

Psychosocial exposures

Critical psychosocial risk factors are high psychological demands (emotional and cognitive demands and time pressure), little opportunity to influence the work and limited social support (Cooper et al., 2001; Cox et al., 2000; Karasek and Theorell, 1990; Theorell, 1996). For many CC employees, the daily experience is repetitive, intensive and frequently stressful work, based upon Taylor's principles, which can result in employee exhaustion. Taylor's principles are closely associated with mass production methods in manufacturing factories. It relied upon time and motion studies, to achieve optimisation of the work task. Some operators are forced to take calls one after another: calls that are of short duration and must be completed in a specific time. Service sector organisations have increased the pressure on CC workers by raising the expectations of customers about the service they can expect to receive (Ashforth and Humphrey, 1993).

The psychosocial work environment at a CC implies several simultaneous demands, on the operators. He/she should be stress-resistant, empathetic, able to work in a team, success-oriented; he/she should also have fast reactions, a wide vocabulary, be able to handle a huge amount of information, be able to handle different types of customer, be able to handle emotional demands etc (Wiencke and Koke, 1997; Köpf, 1998). There could be a risk of conflict between these demands and it is the operator who has to choose between serving a customer well and keeping the call-time down. At the same time the working activities of the operators are characterised by an extreme division of labour, by automatic distribution of calls and by technical performance control. Decision latitude for the operators may be rather restricted. Karasek (1979) proposed that we should study the extent to which the individual is able to influence work, and introduced the concept "job strain". "Job strain" occurs when high psychological demands are combined with too little decision latitude. This could lead to negative stress and mental or physical problems. The dimension of demand consists of parts such as work pace, time pressure and conflicting demands. The dimension of control

emphasises the individual decision latitude in the working situation, control over the work pace and the planning of the work, as well as the individual's opportunities to develop new skills in the occupation. Subsequent research expanded the Demand-Control model to the Demand-Control-Social support model of job stress (Johnson et al., 1989; Johnson and Hall, 1988; Karasek and Theorell, 1990). This model suggests that high level of social support can help protect against job strain, while low levels can exacerbate it.

In a Canadian study (DiTecco, et al., 1992) call-time pressures were strongly linked to the operators perceived stress level. A large majority of operators, 70 per cent reported difficulties in serving a customer well and still keeping call-time down, and this contributed to their feeling of stress to a great or very great extent.

Computer technology has become a critical component of workplace management in call centres (Batt, 1999). It can be used to monitor the speed of work, regulate the level of downtime when the operator is not available to take calls, and assess the quality of the interaction between the service provider and the customer. Furthermore, employees could be required to follow a tightly scripted dialogue with customers and conform to highly detailed instructions. This has left them with little flexibility in their interactions with customers (Wharton, 1993). The operators have little opportunity to influence their work task when it comes to length of calls, the time between calls and the amount of time they are logged-in and logged-off the system. Usually the call centre company in the contract with the client company decides this.

ACD (Automatic call distributor) technology may lead to the operator having less control and more limited possibilities of influencing her/his own work. The operator cannot direct his or her own work; instead it is the ACD system that directs the work.

The CC business is known as a branch with rapid changes. The assignment may change from one week to next, and sometimes they change even more often. The constant changes and amount of information concerning products and services could be a source of stress. On the other hand, these changes could be a possibility of variation for the operators. CC operators are faced with quick changes, not only regarding work tasks, but also as regards changes among the managers. Furthermore, it has been shown in several studies (Aronsson et al., 1992; Punnett and Bergqvist, 1997; Ferreira et al., 1997) that a combination of shortcomings in the work organisation and work with computers can result in symptoms in different body regions, especially when it comes to work content and distribution of work tasks.

Work with computers may lead to higher demands on cognitive resources, e.g. the working memory, and attentiveness, compared with more traditional work methods (Hockey, 1986; Norman, 1986; Salvendy, 1981). Receptiveness, working periods with short cycles, is often considered to be both physically and mentally demanding (Cox, 1985). The mental demands and several other demands that occur in CC work present the biological system with a challenge called Allostatic load. This concept, meaning literally "maintaining stability through change" was introduced by Sterling and Eyer (1988) to describe how the cardiovascular system

adjusts to resting and active states of the body. If this system is activated during long periods of time with little opportunity to recover, stress-related symptoms may be the result. Only a few senses may be used during the information process in CC work, and it is in principle the short-term memory that is needed to perform the work task. Monotonous repetition information that only bounces in and out of the short-term memory before it is time for the next telephone call could produce a considerable amount of tiredness.

Individual characteristics

The mean ages among international CC operators are generally low and the proportion of women is in some companies higher compared with men. They usually have an elementary and/or upper secondary school education (Austin Knight and Calcom Group, 1997).

Individual characteristics like age and gender could modify the response and long-term health outcomes of different exposures. Most of the computer equipment is still designed for men's dimensions. Small anthropometrics dimensions may cause women to work in more awkward postures or at higher relative muscle forces, which may cause greater mechanical stresses than for men. Inter-individual differences in working technique may also modify the effect of exposure. The worker may choose to use a specific method, or a specific work method may be inflicted upon her/him, for example by a policy at the workplace. Within the frames of the method the individual will perform the work task in her/his way and with her/his individual movements patterns. The choice of work technique is presumably also influenced by the worker's experience, training and knowledge's in the occupation and of the work task, motivation and problem-solving skills (Lindegård, 2004).

Life outside work, social exposures

Non-occupational factors, such as physical load outside work and poor social support from friends and family. This is likely to affect the body in a way similar to the occupational factors (Theorell, 1996).

Demanding conditions from life outside work include physical and psychosocial demands on the individual from husband/wife, children, elderly relatives and household tasks. The family chores are, in general, more burdensome for females than for males (Josephson, 1999; Lundberg et al., 1994). Other factors included in life outside work are poor social support, conflicts with family members or friends, lack of time for own interests and lack of time for physical and psychological recuperation after work.

Why study call centre work?

Despite the relatively extensive scientific literature of CC specific exposures and symptoms, increased knowledge is called for, concerning the specific features of

the CC work environment that may contribute to health related symptoms e.g. upper extremity musculoskeletal symptoms (UEMSS). The question is important, considering the high prevalence of symptoms observed among CC operators, and the rapid growth of the CC business. As the CC business employs more and more people, often-young people, characteristics of work, as well as physical and psychosocial exposures may affect the operators health in a negative way and therefore need attention.

It is therefore important to shed more light on them and at an early stage investigate potential risks that can occur, in order to create sustainable work conditions for the CC operators.

Aims of this thesis

The overall aim of this thesis was to describe characteristics of work, physical and psychosocial exposures and health related outcomes, for CC operators in Sweden.

The specific purposes were:

- to investigate the working conditions and musculoskeletal symptoms among female and male employees at one CC compared with a reference group of professional computer users in Sweden. (*Study I*)
- to assess the test-retest reliability and internal consistency of questions in a questionnaire covering symptoms, physical and psychosocial working conditions at CCs, and also the inter-rater reliability of observations and measurements according to an ergonomic checklist (*Study II*)
- to describe working conditions at CCs and compare work tasks of different complexity among operators at internal and external CC companies in Sweden (*Study III*)
- to describe psychosocial conditions, stress and mental energy for operators in different types of CC companies in Sweden. To identify risk indicators for stress and lack of energy. Further, to compare differences between female and male, differences between companies with different owners and between companies located in small villages and larger towns. (*Study IV*)
- to assess associations between exposures during CC work and symptoms in the neck/shoulders and in the upper extremities, respectively, among operators at internal and external CCs (*Study V*).

Study groups and methods

This thesis is based on two main projects, where *study I* is part of a project called “Epi-mouse study” and *studies II-V* are parts of a project called “Call centre study”. The “Epi-mouse study” was a cohort study aiming to identify risk – and preventive factors for musculoskeletal disorders among professional computer users. The “Call centre study” was a cross-sectional survey, with the overall aim to get a scientific basis for development of sustainable CC jobs.

Companies

Study I

Totally 46 different worksites in Sweden participated in the study. The worksites differed in size, the smallest including only seven persons and the largest 260. The study population represented both private and public sectors and included a variety of occupations. Together with the employers and Occupational Health Care Centres of the different worksites, departments or work groups were invited to participate. The worksites entered the study at different times between 1997 and 1999. Thus, the selection of computer users was not based on a random sample of the Swedish labour market, but was selected to cover a wide range of different computer work tasks and computer work intensity.

Studies II, III, IV, V

Totally 38 CC companies, with at least 50 employees, were invited to participate in the studies. The inclusion criteria for participation in the study were that the companies should represent different forms of ownership, be located in different parts of the country, in small villages or larger towns. Both internal and external companies should be included, with different work task complexity, and with incoming/outgoing calls. Sixteen companies representing 28 different CC sites agreed to participate; this included internal as well as external companies, companies with different task complexity, with different owners and with different location, table 1. The goal was not to obtain a representative sample of CCs, but rather to get a basis for comparisons between CCs of different types. The work tasks at the companies varied from tasks with low complexity (e.g. booking tickets) to high complexity (e.g. computer support, advice about medical drugs). The most common reasons for not participating in the study were lack of time, or that there was a reorganisation or change of management going on in the company.

Table 1. Number of worksites and participants, mean age and age range of the whole study group and subgroups, *studies II-V*.

	Number of worksites	Number of participants			Mean age, years (range)
		Total n	Women n	Men n	
Whole group	28	1183	848	335	35 (17-66)
Internal	16	510	365	145	38 (18-64)
External	12	673	483	190	32 (17-66)
Low task complexity, total	9	486	363	123	33 (17-62)
Internal	1	87	49	38	37 (18-60)
External	8	399	314	85	32 (17-62)
Medium complexity, total	12	370	265	105	35 (19-66)
Internal	9	144	116	28	41 (19-64)
External	3	226	149	77	31 (19-66)
High complexity, total	7	327	220	107	36 (20-61)
Internal	6	279	200	79	36 (20-61)
External	1	48	20	28	31 (21-43)
Swedish public owner	14	430	284	146	37 (18-64)
Swedish private owner	9	445	353	92	35 (19-62)
International owner	5	308	211	97	28 (17-66)
Large town (≥ 50 000 inhabitants)	17	704	563	141	36 (19-66)
Small village (<50 000 inhabitants)	11	479	285	194	32 (17-61)

Subjects

Study I

The study included 1,529 employees (895 women and 634 men). From totally 380 employees at one CC company, the CC management selected 35 female and 35 male operators to participate, table 2. The selection was made from operators who, according to the management, were assumed to remain at the company during the 10-month study period. The operators worked shifts and the main task was telephone-based customer support on PC-systems. A reference group consisted of all other computer users included in the cohort study, and included 757 women and 469 men.

Table 2. Participants in the call centre group and in the reference group, *study I*.

	Call centre group n (%)	Reference group n (%)
Study population	70	1,459
Non-participants	13	233
Study group	57	1,226
Women	28 (49)	757 (62)
Men	29 (51)	469 (38)

Study II, III, IV, V

Of altogether 1,802 CC operators, employed at the companies, 1,531 subjects, 984 women and 547 men, fulfilled the inclusion criteria for participation in the investigation, table 3. The inclusion criteria for participation in the investigation was that the subjects should have worked at the CC company for at least one month, and have had customer contacts. Subjects, who were on sick leave, holiday, parental leave or other leave, as well as those who had quit their employment, were excluded from the study. All included operators were asked to fill in a questionnaire, and 1,183 completed questionnaires were received after two reminder rounds (response rate 77 %).

Table 3. Description of study population, study group by gender, type of CC and complexity of work task, *study III, IV, V*.

	Total n (%)	Type of CC		Complexity		
		Internal n (%)	External n (%)	Low n (%)	Medium n (%)	High n (%)
Original sample	1,802	715	1,078			
Women	1,171 (65)					
Men	631 (35)					
Excluded	271 (15)	55 (8)	216 (20)			
Study population	1,531	660	871	578	513	440
Women	984 (64)					
Men	547 (36)					
Non-participants	348 (23)	150 (23)	198 (23)	92 (16)	143 (28)	113 (26)
Study group	1,183	510	673	486	370	327
Women	848 (72)	365 (72)	483 (72)	363 (75)	265 (72)	220 (67)
Men	335 (28)	145 (28)	190 (28)	123 (25)	220 (59)	107 (33)

Subjects were categorised into three different groups regarding complexity and then checked by comparing the categorisation with the average value for certain variables, table 4.

Table 4. The average value for five variables that was included in the categorisation of low, medium and high complexity of work task, *studies II-V*.

	Complexity		
	Low (n = 486)	Medium (n = 370)	High (n = 327)
Cognitive demands, % of the working hours	78	61	59
Customer calls, minutes/day	358	285	278
Length of calls, sec	183	298	341
Total training period, weeks	3	4	5
Time required to reach acceptable competence, weeks	11	16	31

Study II. From subjects who answered the questionnaire, 71 operators, 57 women and 14 men, were randomly selected to participate in a retest round, and 47 women and 10 men responded to the retest questionnaire (response rate 80%).

The CC company, in most cases the staff manager or a coach, selected 10 operators, from each of the 16 companies, who were invited to participate in

measurements and observations of working conditions and work postures, table 5. One operator refused to participate and no substitute could fill in, resulting in a total of 159 operators. The criterion for participation in the ergonomic investigation was that the operator had to work during the two days when the ergonomists visited the company. A sub-group of 60 operators, 46 women and 14 men, were randomly invited to participate in an inter-observer reliability test. Fifty-eight operators, 44 women and 14 men, agreed to participate.

Table 5. Descriptions of study population, study group by gender, *study II*.

	Questionnaire		Ergonomic checklist	
	Original n (%)	Retest n (%)	Original n (%)	Retest n (%)
Original sample	1,802			
Women	1,171 (65)			
Men	631 (35)			
Excluded	271 (15)			
Study population	1,531	71	160	60
Women	984 (64)			46 (77)
Men	547 (36)			14 (23)
Non-participants	348 (23)		1	2
Study group	1,183	57	159	58
Women	848 (72)	47 (82)	112 (70)	44 (76)
Men	335 (28)	10 (18)	47 (30)	14 (24)

Methods

Questionnaire

Study I. A questionnaire, specific for computer work, and covering physical and psychosocial working conditions and symptoms during the last month was used (Hagman, et al, 2001; www.niwl.se/datorarbete/pdf/Fragefrom_970814.pdf). The questionnaire was distributed and recollected by ergonomists at the Occupational Health Care Centres.

Study II-V. A questionnaire, specific for call centre work, and covering characteristics of work, physical and psychosocial working conditions and symptoms during the previous month were used (www.niwl.se/datorarbete/pdf/CCBaselineQuest.pdf). The questionnaire took about 35-40 minutes to complete and was answered during working time. The research team collected some of the questionnaires after the questionnaire was filled in at the company or the questionnaire was put in an envelope and were sent back to the project group. Two reminder rounds were made.

Study II, the reliability of the questions and the measurements were analysed by calculating Pearson's correlation coefficient for variables on ratio and interval level. Spearman's correlation coefficient was calculated for variables on ordinal level and Cohen's Kappa coefficient was calculated for variables on nominal level.

At retest, a copy of the original, was answered two to four weeks later and was mailed to the project group. This time period was considered to be long enough for the responders to forget their answers to the original questionnaire.

Study III, questions covering background, employment, working hours and remuneration, call logging and monitoring, duties, computer work and workplace design, during the last month was used.

Study IV, included a reduced version of a mood adjective checklist, the Stress-Energy questionnaire (Kjellberg and Wadman, 2002). From the mood adjective checklist a stress and an energy index were calculated, where the energy index covers positively evaluated high-activation states at one end (energetic) and negatively evaluated low-activation states at the other end (passive). Energy scores reflect how interested and motivated one feels. Both scales comprised four items, two positively loaded and two negatively loaded adjectives. The items included in the stress dimension were: “relaxed” and “calm” (the response scales were reversed for these items), “stressed” and “under pressure”. The items included in the energy dimension were: “active” and “energetic”, “ineffective” and “passive” (the response scales were reversed for the last two items). Four groups were formed representing the four combinations of high and low values in the two scales, *Worn-out* (high stress-low energy), *Committed under pressure* (high stress-high energy), *Bored* (low stress-low energy) and *Committed without pressure* (low stress-high energy). Cut-off points for dichotomisation of the stress and energy scales were 2.4 and 2.6, respectively, which corresponds to the subjective neutral point of the scales (Kjellberg and Wadman, 2002).

For all indices in this study, except for energy, a higher index values, mean less favourable conditions, e.g. more demands, more time pressure, less decision latitude, lower support and higher stress. A high index value for energy is favourable as it indicates high motivation.

Ergonomic checklist

Study I. Structured observations, in accordance with an ergonomic checklist, were used to assess workstation design during the subjects’ ordinary computer work (Hansson Risberg, et al., 2001; www.niwl.se/datorarbete/pdf/Checklista_970916.pdf). Observations were made only on subjects without symptoms (≤ 3 days during the preceding month).

A key was enclosed to the ergonomic checklist, explaining and defining all the exposure categories. The items regarding workstation design were classified into 2-5 categories according to predefined categories. The items were also categorised into “optimal” or “non-optimal” conditions according to known risk factors and what the research group believed to be “harmful” conditions. The observations were made by ergonomists from the occupational health care unit.

Study II. A checklist was developed as a tool to evaluate working conditions in call centre work (www.niwl.se/datorarbete/pdf/CCXlist.pdf). The checklist con-

sisted of 14 different parts: the size of the office, indoor air quality and climate, sound level, electromagnetic fields, illumination, lighting conditions and vision ergonomics, standard of office table and chair, computer equipment and its arrangements, work postures and movements, operator's knowledge about optimal adjustments of furniture and equipment, and work technique.

The project team observed, measured and interviewed the operators. Example of variables that were observed was backrest height, if the control device were positioned within forearm's length and shoulder width, the main source of disturbing noise, if there were visible reflections on the desk and working postures. Measurements of luminance and viewing angles were included in the inter-rater test. The inter-observer test included an interview part with the subject. Examples of questions that were asked were about the operator's knowledge of how to adjust the chair height, how to adjust the armrest and how to adjust the backrest.

The inter-rater reliability of 44 selected variables in the ergonomic checklist was tested by two experienced and trained ergonomists, who made the observations, measurements and interview coding independently of each other.

Evaluation of the work postures was carried out on the most common posture during the observation period (assessed through observation), representing a typical work situation. The work posture in the neck was evaluated when the operator was looking at the screen or the keyboard. The work posture in the shoulder, wrist and lower back was evaluated when the operator was using the input device, and if this was not possible the work posture was evaluated when the operator was using the keyboard. The observations of the work postures were carried out simultaneously by the ergonomists, but the different measurements were not made at exactly the same time, because there was only one measuring instrument of each kind. The time between the two measurements ranged from a few minutes to a maximum of 30 minutes.

The interviews were made by one ergonomist while the other was standing beside and listening to the answers from the operator.

Variables and indices used in the questionnaires and in the ergonomic checklists, *studies I-V* are presented in table 6. Besides these variables all remaining variables in the questionnaire are included in *study II*.

Table 6. Description of variables and indices used in the questionnaires and ergonomic checklists, *studies I-V*. Number of included items, response scale and Cronbach's alpha for the different indices.

Variables / Indices	Study	Number of questions (q) included in the index, Response scale	Cronbach's alpha
Questionnaires			
<i>Characteristics of work</i>			
Working hours	I, II, III		
Tasks	II, III		
Complexity of work task	II, III, IV, V		
Type of calls	II, V		
Total time of customer calls/day	II, III, V		
Number of calls/day	II, III, V		
Average duration of calls	II, III, V		
Call logging	II, III, V		
Monitoring	II, III, V		
Remuneration	II, III, V		
Disadvantages	II, III, V		
<i>Physical exposures</i>			
Comfort related to work environment	V	14 q, 1-5, very dissatisfied-very satisfied	0.88
Comfort of sound, lighting and air quality	II, III	5 q, 1-5, very dissatisfied-very satisfied	0.77
Comfort of furniture and equipment	II, III	9 q, 1-5, very dissatisfied-very satisfied	0.87
Time spent seated during a working day	II, V		
Continuous computer work without a break	II, V		
Disruption and technical support	II		
<i>Psychosocial exposures</i>			
Psychological demands	I, II, IV, V	14 q, 1-11, 0-100% of the working time	0.84
Cognitive demands	II, IV	7 q, 1-11, 0-100% of the working time	0.73
Emotional demands	II, IV	3 q, 1-11, 0-100% of the working time	0.49
High work intensity /time pressure	I, IV	3 q, 1-11, 0-100% of the working time	0.57
Lack of control	I, II, IV	7 q, 1-11, 0-100% of the working time	0.72
Decision latitude	I, II, IV, V	4 q, 1-11, 0-100% of the working time	0.66
Social support from colleagues	II, IV, V	7 q, 1-6, never-always	0.86
Support from management	I, II, IV, V	8 q, 1-6, never-always	0.93
Positive work	II	16 q, 1-11, 0-100% of the working time	0.65
Development/opportunities to take part in planning	II, V		
<i>Individual characteristics</i>			
Age	I, II, III, IV, V		
Sex	I, II, III, IV, V		
Level of education	I, II, III		
Mean experience of present task	I, II, III		
Mean experience of computer work	I, II		
<i>Symptoms</i>			
Eyes	I, II		
Headache	I, II		
Neck	I, II, V		
Shoulder/Scapular area	I, II, V		
Shoulder joints/upper arms	I, II, V		
Elbows/forearms	I, II, V		

Table 6. Continued

Variables / Indices	Study	Number of questions (q) included in the index, Response scale	Cronbach's alpha
Wrist	I, II, V		
Hand	I, II, V		
Fingers	I, II		
Numbness in the hands	II, V		
Upper back	I, II		
Lower back	I, II		
Summary of current health	II		
<i>Other health related effects</i>			
Muscle tension	I, II		
Irritation	I, II		
Not in the mood for work	I, II		
Anxiousness	II	4 q, 0-5, not at all-very, very	0.80
Worn-out	I, II	3 q, 0-5, not at all-very, very	0.95
Psychosomatic symptoms	II	5 q, 1-11, 0-100% of days	0.80
Stress	II, IV	4 q, 1-6, not at all-very much	0.84
Energy	II, IV	4 q, 1-6, not at all-very much	0.67
Tiredness	II		
Sleep	II		
Winding down and recovery	II		
Measures taken to reduce symptoms	II		
Use of medicine	I, II		
Sick leave	I, II		
Problems affecting working capacity	II		
Reported work-related injuries	II		
Eye-test, glasses	II		
Ergonomic checklist			
"Non-optimal" input device placement	I		
"Non-optimal" keyboard placement	I		
"Non-optimal" screen placement	I		
"Non-optimal" table placement	I		
"Non-optimal" chair placement	I		
Work postures	II		
Backrest height	II		
If the control device was positioned within forearm's length and shoulder width	II		
Visible reflections on the desk	II		
Measurements of luminance and viewing angles	II		
The main source of disturbing noise	II		
Interview with the subject – questions about knowledge of how to adjust the chair height, the armrest and backrest	II		

Ethical considerations

The Ethics Committee at Karolinska Institutet, Stockholm, approved all the studies in this work.

Data treatment and statistical methods

Study I

Prevalence of exposure conditions and pain was calculated for the study group and for the reference group. Prevalence ratios with test-based 95% CI were calculated for symptoms stratified by age (two groups divided at mean age) in the call centre group versus the reference group and analysed using the Mantel-Haenszel method (Mantel and Haenszel, 1959). The differences in prevalence of exposures and symptoms between women and men, respectively, in the call centre and reference groups were expressed as differences between proportions with 95% CI (Gardner and Altman, 2000).

Study II

The following categorisation were used for Pearson and Spearman correlation: High reliability ≥ 0.90 , good reliability 0.80-0.89, fair reliability 0.70-0.79, and poor reliability <0.70 (Currier, 1984). To simplify the presentation of data and accommodate to the classification of Kappa values we merged the good and fair category together and used three intervals for reliability: high reliability ≥ 0.90 , fair to good reliability 0.70-0.89, and poor reliability <0.70 . When Kappa was used for evaluation of the reliability, the following rules of thumb were used: high reliability >0.75 , fair to good reliability 0.40-0.75, poor reliability <0.40 (Fleiss, 1981).

Calculations of reliability were considered not meaningful when there were fewer than 10 pair wise comparisons. Kappa statistics could not be calculated when there was too uneven distribution of answers (98-100% of the variables in on cell) (Maclure & Willett, 1987).

Sixteen indices were constructed as arithmetic means of the answers to groups of questions: Comfort a) noise, lighting and air quality and b) furniture and equipment; social support from colleagues; support from supervisor; psychological demands; cognitive demands; emotional demands; time pressure; lack of control; limited decision latitude; positive work; stress; energy; feeling work out; anxiousness and psychosomatic symptoms.

For all indices except for energy (*study IV*), a higher index value, means less favourable conditions e.g. more demands, more time pressure, less decision latitude, lower support and higher stress. A high index value for energy is favourable as it indicates a high motivation and commitment in the work tasks.

Cronbach's alpha was used to analyse the internal consistency of the constructed indices. The internal consistency of indices was calculated from the original questionnaire and the retest questionnaire. The test-retest reliability of indices between the two occasions was also calculated.

Study III

Prevalence's and mean values of exposure conditions were calculated for the studied groups. Differences in proportions and mean values with 95% CI (Gardner and Altman, 2000), between internal and external companies, and between companies with different complexity in work tasks, were calculated.

Study IV

Prevalence of exposure conditions was calculated for different subgroups of CCs, type of CC, complexity of work task and gender. Differences were tested with chi-square test. Differences between the main subgroups in continuous variables were tested with three-way analyses of covariance (sex x internal/external x task complexity). Type of owner and geographical location were entered as covariates, each represented by two dummy variables with internationally owned and smaller villages as reference category, respectively. The group means presented were corrected for differences in the distribution of these covariates. To check the effect of the adjustment for the covariates, ordinary three-way analyses of variance were also performed. CIs for these corrected means were calculated. All analyses were made with a full regression model, i.e. all differences were tested after control for the effects of the other variables included in the model.

The differences between CCs with different types of owners were tested in separate analyses of covariance. The covariates in these analyses were selected from regression analyses of the psychosocial variables with respect to the following variables: geographical location, sex, internal/external and task complexity (represented by two dummy variables) and the interactions between task complexity and internal-external. The interactions were represented by multiplicative terms, calculated from deviations from means. Only variables that were associated with the tested psychosocial variable with a p-value < .05 were included as covariates in the analyses.

The same type of analyses was made of the difference between CCs at different geographical locations (big cities and small village), with ownership (represented by two dummy variables) added as a possible covariate. Interactions between ownership or geographical location and the other three variables were thus not tested. One-way analyses of variance were also made of both ownership and location.

Correlation (Pearson's r) was calculated between the psychosocial variables on the one hand, and stress and energy scores on the other hand. The psychosocial variables were also included in multiple regression analyses of stress and energy scores. To test possible interactions between demands and control or demands and support, two-way interactions were entered stepwise in a second block in these analyses (between on the one hand cognitive demands, emotional demands and time pressure, and on the other hand, lack of control, lack of social support from colleagues and lack of support from the supervisor).

Study V

Symptoms were compiled into two outcome categories: a) Neck/shoulder (neck and/or scapular area), b) Arm/hand (shoulder joints/upper arms, elbows/forearms, wrists or hands or numbness in the hands). The non-symptomatic group comprised individuals with no symptoms in any of these body regions.

The exposure variables were generally divided into four levels; reference group, and low, medium, high exposure. Cut-off points were set in order to obtain an even distribution of the study subjects across the four levels, approximately corresponding to quartiles (except for “time spent seated during a working day”, due to a skewed distribution).

The associations between the exposure variables and symptoms from the Neck/shoulder and Arm/hand, respectively, were estimated by ORs with 95% CI. The two symptom categories were both contrasted with having no musculoskeletal symptoms, i.e. none of the musculoskeletal symptoms considered. This means that the reference group, in principle, is free from symptoms with an aetiology similar to the studied outcome, and that unwarranted reductions of the estimates of association thus were reduced. It also means that the results for the two outcome measures may be compared since the reference group did not change. Firstly, the univariable associations between exposure variables and symptoms were assessed for the total study group and for external and internal CCs separately.

Subsequently, we analysed multivariable models for the two outcome measures and for external and internal CCs separately. In the first model all variables were combined (data not shown). Variables showing a clear or suggested association according to certain criteria were retained and analysed in a second model. Once more, variables fulfilling the criteria were then retained and analysed in a final model. The criteria for a suggested association were an $OR \geq 1.30$ ($CI_{lower} \geq 0.85$) or $OR \leq 0.77$ ($CI_{upper} \leq 1.14$), for any of the exposure levels. In table 13, we present the final model for internal and external CCs.

In all multivariable regression models, internal non-response in the exposure variables was included as separate categories in order to maintain the statistical precision.

An overview of measures and statistical analysis methods used in *studies I-V* is shown in table 7.

Table 7. Overview of measures and analysis methods used in *studies I-V*.

Measures and analytical methods	Study
Measures	
Frequencies	I, IV
Mean values	I, III, IV
Prevalences	I, III, IV
Prevalence ratios and 95% confidence intervals	I
Odds ratio and 95% confidence intervals	V
Differences between proportions and 95% confidence intervals	I, III
Minimum and maximum values	II
P10, P50, P90 ¹⁾	II
Pearson's correlation coefficient	II, IV
Spearman's correlation coefficient	II
Cohen's Kappa	II
Percentage agreement	II
Analysis methods	
Chi-square test	IV
Three-way analyses of covariance	IV
Univariable logistic analyses	IV, V
Multivariable logistic analyses	IV, V

¹⁾P = percentile of a distribution of values.

All statistical analyses, in *studies I and V* were performed with SAS statistical software (SAS, SAS/STAT User's guide, version 8.2, 1999-2001. Cary, NC: SAS Institute Inc.).

All statistical analyses, in *studies II, III, IV*, were performed with SPSS (version 11.5 for Windows; SPSS Inc, Chicago, Illinois).

Results/Summary of papers

Characteristics of work

In the female CC group, (*study I*), computer work constituted 73 per cent of the working hours, compared with 50 per cent among women in the reference group. In the male CC group, computer work constituted 66 per cent of the working time, and in the reference group 43 per cent.

The operators worked with customer calls on average 5 hours per day, which correspond to 64 per cent of the working hours (68 per cent of the working hours at external CCs and 59 per cent at internal CCs) (*study III*). At external companies the duration of customer calls was significantly longer, table 8.

Operators handled on average 106 calls/day. At external CCs they took on average significantly more calls/day compared with operators at internal CCs. The length of a call was on average 4 minutes and 23 seconds. There were significant shorter calls at external CCs.

It was most common to deal with incoming calls (79%), with no marked difference between internal and external companies (82% and 76%, respectively), and this was most common of all among operators with work tasks of low complexity at internal companies (100%).

It was more common with work task of low complexity at external CCs compared with internal CCs.

More than half of the operators had received additional remuneration during the previous 12 months. The most common type of remuneration was prizes (44%) e.g. trip, restaurant visit, cinema ticket, lottery ticket. This was significantly more common at external companies.

A majority of operators reported that call logging occurred at their workplaces. This was significantly more common at external companies. The most common reaction to call logging was that the operators felt controlled (46%), but also that it was a way of showing their performance (43%). Nearly a quarter of the operators experienced feelings of stress because of call logging. This was significantly more common at external companies.

More than half of the operators reported that monitoring of the calls occurred. Monitoring was significantly more common at external companies than at internal companies. The most common reaction to monitoring was that it was a way of showing the quality of their service (42%) and a way of developing their calls (41%), but also feelings of being controlled (21%) and feelings of stress (23%).

Table 8. Mean duration of customer calls/day, number of calls/day and length of the calls and prevalence (%) of any additional remuneration, call logging and monitoring, in the total sample and at internal and external CCs, *study III*.

	Total (n=1183)	Internal CCs (n=510)	External CCs (n=673)
Average time customer calls/day, min/day	319	292	341
Mean number of calls/day	106	58	143
Mean length of the calls (sec)	263	312	227
Received additional remuneration, %	63	50	73
Occurrence of call logging, %	84	78	86
Occurrence of monitoring, %	57	44	63

Physical exposure

Nearly all of the workplaces were located in open office landscapes. Only 4, out of 156, of the workplaces were located in separated room (*study III*). The comfort of the furniture and equipment was generally rated higher than the comfort of noise, light and air quality. Forty-three per cent of the operators were dissatisfied with the sound level at the workstation, while 27 per cent were satisfied. Forty-four per cent of the operators were dissatisfied with the climate (dust and humidity) in the office during the past month, while 27 per cent were satisfied. No major differences between internal and external CCs. Operators at external CCs reported significantly lower comfort related to furniture and equipment, whereas operators at internal CCs reported lower comfort related to noise, lighting and air quality.

There were more often deficiencies in worktables and chairs, as well as keyboard- and input device placement, at the CC compared with the reference group, table 9, (*study I*). The workstations were neither individually adjustable nor adjusted to the work task performed. Especially women at the CC worked with “non-optimal” workstation design and equipment placement. A higher proportion of CC employees had rather long periods of continuous work in front of the computer compared to the reference group.

Table 9. Prevalences (%) in the call center and reference groups of “non-optimal” ergonomic design of the workplace, based on observations among subjects without symptoms. Differences in prevalences between the call center and reference groups with 95% confidence intervals (95% CI), *study I*.

	Women			Men		
	Call center % (n=12)	Reference %(n=471)	Diff [95% CI]	Call center % (n=20)	Reference % (n=382)	Diff [95% CI]
“Non-optimal” input device placement	83	61	24 [1, 49]	78	61	28 [9, 46]
“Non-optimal” keyboard placement	100	62	44 [40, 48]	100	57	53 [48, 58]
“Non-optimal” screen placement	33	20	14 [-13, 41]	15	26	-10 [-26, 6]
“Non-optimal” table	100	80	22 [19, 26]	100	77	28 [23, 32]
“Non-optimal” chair	92	55	39 [23, 55]	45	47	2 [-21, 24]

On average, the operators reported that they spent 80 per cent of the working day sitting. Almost all operators, 93 per cent at internal companies and 97 per cent at external companies, spent more than half of a typical working day sitting.

On average, the operators worked for 2 hours (119 minutes) at the workplace before they took a break for at least 10 minutes, with no major differences between internal and external CCs.

Psychosocial exposure

The subjects reported a high level of work intensity in both call centre and reference group (*study I*). The subjects in the CC group also experienced deficiencies in the psychosocial environment – poor support from immediate supervisor, low control, and limited opportunities to influence their work compared with the reference group.

Emotional demands were experienced during almost the whole working hours (81%). Cognitive demands were experienced during more than 60 per cent of the working hours, (*study IV*). Cognitive demands occurred during fewer per cent of the working hours at high complexity CCs (59%) compared with the lower complexity CCs (78%).

Operators at international companies reported more limited decision latitude than operators in Swedish CCs. Operators at international CCs reported the most, and private Swedish CCs the least limited support from their supervisor. CCs located in smaller villages experienced higher levels of cognitive demands and time pressure than those from CCs in larger towns. On the other hand, limited social support and limited support from a supervisor, was judged to be less good in the large city CCs. Women experienced emotional demands and time pressure during a somewhat larger part of the working hours than men did. Men and

women reported the same degree of limited social support from colleagues and limited support from their immediate supervisor.

Individual characteristics

The CC operators were in average young (mean age 28 years, *study I* and 34 years, *study III*) compared with the reference group (mean age 44 years, *study I*). The CC operators had worked for a shorter time, both with their present tasks (mean 20 months, *study I* and 48 month, *study III*) and with a computer, only operators in *study I* (mean 4.5 years, *study I* and 10 years, *study III*), compared to the reference group (mean 143 months and 11.5 years, *study I*). The level of education was lower in the CC group compared with the reference group. Ten per cent of the CC operators had college or higher education, *study I*, and 25 per cent of the operators in *study III*, compared with the reference group were about half of them had college or higher education.

Women constituted 72 per cent of the CC group, (*study III*). The proportion of women was significantly higher at CCs with work tasks of low complexity (75%) than at CCs with work tasks of high complexity (67%). Operators at external CCs were significantly younger (32 years) than operators at internal CCs (38 years).

Health related outcomes

Compared with the reference group a higher proportion of the CC group reported symptoms from each of the body regions, except in the eyes, (*study I*). A majority, 86 per cent, of the women in the CC group reported musculoskeletal symptoms (at least 3 days during the preceding month) in one or more body regions. The corresponding figure for the women in the reference group was 72 per cent. More men in the CC group than in the reference group, reported musculoskeletal symptoms, 68 per cent compared with 50 per cent. Headache and neck-scapular symptoms were the most common symptoms for women in the CC group. Eye symptoms were more common in the reference group.

With the exception of women younger than 25 years of age, there was a higher prevalence of subjects reporting symptoms in all age groups in the CC group, compared with the reference group, table 10. The prevalence ratios, with control for age, (≤ 28 , > 28 years) were 1.2 (95% CI, 1.00-1.4) for women and 1.4 (95% CI, 0.99-1.91) for men in the CC group compared with the reference group.

Table 10. Prevalences (%) of subjects in the CC and the reference groups that reported symptoms from any of the body regions, lasting 3 days or more during the previous month in different age groups. Differences in prevalences between CC and reference groups with 95% confidence intervals (95% CI), *study I*.

Age group (years)	Women			Men		
	Call centre % (n=29)	Reference % (n=756)	Diff [95%CI]	Call centre % (n=28)	Reference % (n=470)	Diff [95%CI]
Younger than 25	85 (n=13)	93 (n=14)	-8 [-32, 2]	71 (n=7)	43 (n=14)	29 [-14, 70]
25 - 34	85 (n=13)	66 (n=126)	19[-2, 40]	63 (n=19)	51 (n=114)	12 [-11, 36]
35 - 44	- (n=0)	77 (n=193)	-	100 (n=1)	47 (n=126)	53 [44, 62]
45 - 54	100 (n=3)	70 (n=285)	30[24, 35]	100 (n=1)	54 (n=141)	46 [38, 54]
Older than 55	- (n=0)	72 (n=138)	-	- (n=0)	51 (n=75)	-

Three out of four operators reported symptoms in one or more of the requested body regions, with no major differences between the internal and external CCs, (*study V*). Sixty-five per cent of the operators were classified into the neck/shoulder category and 49 per cent of the operators into the arm/hand category. The prevalences of the symptoms considered were more common among women than among men, and overall, an association with increasing age was observed.

Stress and energy

The strongest risk indicators for stress were: limited social support from colleagues, limited support from the supervisor, limited decision latitude and time pressure; whereas the strongest risk indicators for lack of energy were: limited decision latitude, limited social support from colleagues, limited support from the supervisor (table 11) (*study IV*). Table 11, also summarises the results of multi-variable regression analyses of stress and energy with psychosocial indices as risk indicators in the first block of the regression model. The multivariable analyses showed that limited social support from colleagues and time pressure were the strongest association to stress, but that limited support from the immediate supervisor and limited decision latitude also contributed significantly to the association. For energy, indicators that contributed significantly to the association were limited decision latitude, limited social support from colleagues and cognitive demands. In contrast to the other psychosocial indices, cognitive demands showed a positive association, with energy.

Table 11. The psychosocial indices as risk indicators of stress and energy ratings. Pearson's correlation coefficient and standardised regression coefficient (Beta) from multivariable logistic analyses with psychosocial indices as association, *study IV*.

	Stress		Energy	
	Pearson r	Beta multivariate analyses	Pearson r	Beta multivariate analyses
Cognitive demands	.086**	-.007	.121***	.117**
Emotional demands	.099***	-.050	.027	-.033
Time pressure	.304***	.250***	.007	.021
Limited decision latitude	.314***	.159**	-.261***	-.189***
Limited social support	.418***	.258***	-.258***	-.161***
Limited support from the supervisor	.350***	.091**	-.233***	-.070

Coefficients are significant at * for $p > .05$, ** for $p < .01$ and *** for $p < .001$

The stress level was somewhat higher in the external CCs than in the internal CCs and energy ratings were slightly, but non-significantly, lower, (*study IV*). Operators at international companies reported the highest stress level and the Swedish private companies the lowest. Operators in small villages experienced higher levels of stress and higher levels of energy.

Many operators belonged to the Stress-Energy group “Committed under pressure” (46%) and a large number were found in the group “Committed without pressure” (36%), figure 2. Fourteen per cent of the subjects were classified as “Worn-out” and four per cent of the subjects were classified as “Bored”. A higher proportion of operators at external CCs belonged to the “Worn-out” group (16%) than among operators at internal CCs (10%), whereas the opposite held for the group “Committed without pressure”, 32 per cent among operators at external CCs and 40 per cent among operators at internal CCs. In the group with medium complexity tasks, a larger part belonged to the “Worn-out” group (19%), and a lower proportion to the group “Committed without pressure” (28%) than in the groups with low and high complexity tasks. There was no significant difference between the distribution of men and women in these four groups.

Operators that have reported high demands, low decision latitude and low social support from colleagues were found in the “worn-out” group, table 12. Significant differences were found between “Worn-out” group and “Bored” group and between “Worn-out” and “Committed without pressure” in time pressure, limited social support from colleagues, and in limited support from supervisor. Significant difference was found between “Worn-out” and “Committed under pressure” in social support from colleagues. Significant difference was found between “Committed under pressure” and “Bored” in time pressure. Significant differences were found between “Committed under pressure” and “Committed without pressure” in time pressure and limited support from supervisor.

Table 12. The mean values of the psychosocial indices for the four Stress-Energy groups, *study IV*.

	Stress-Energy groups			
	Worn-out (n=158)	Committed under pressure (n=544)	Bored (n=42)	Committed without pressure (n=411)
Cognitive demands ¹⁾	84.7	83.3	78.4	81.7
Emotional demands ¹⁾	66.7	67.4	58.7	66.7
Time pressure ¹⁾	66.0	65.6	51.8	52.9
Limited decision latitude ¹⁾	78.4	73.1	74.6	62.4
Limited social support from colleagues ²⁾	3.0	2.6	2.4	2.1
Limited support from the supervisor ²⁾	3.4	3.1	2.8	2.5

1) Mean value on a scale 0-100 per cent of the working hours. *High* value = *more* demands, *more* time pressure or *less* decision latitude, respectively, during the working hours

2) Mean value on a scale 1-6. *High* value = *Low* support

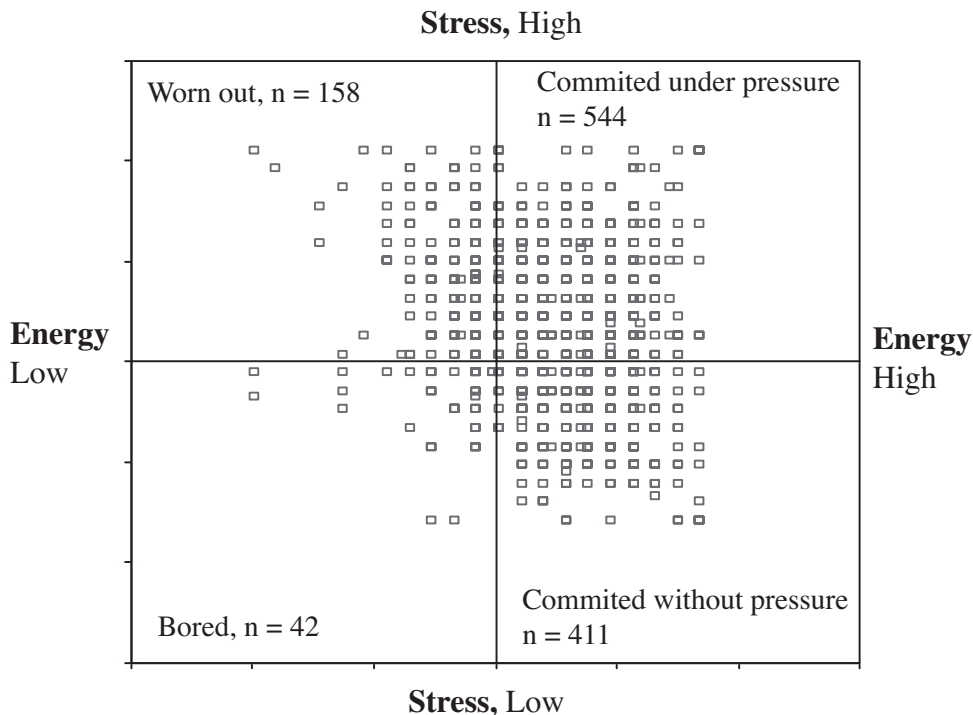


Figure 2. Distribution of stress- and energy rating in the four Stress-Energy groups, in the call centre study, (*study IV*). The four groups represents four combinations of high and low values in stress and energy: Worn-out (high stress-low energy), Committed under pressure (high stress-high energy), Bored (low stress-low energy), Committed without pressure (low stress-high energy).

Associations between work exposures and health related outcomes

In the univariable analyses, (*study V*), low comfort related to the work environment showed a strong association with Neck/shoulder and Arm/hand symptoms, both at the internal and external CCs. There was also a clear association for low

social support, low support from a supervisor, and few opportunities to take part in planning, for both outcome measures, with no major differences between the two types of CCs. A similar result was also observed for continuous computer work of more than 2 hours without a break and for low decision latitude.

Some exposure variables were associated with Neck/shoulder and Arm/hand symptoms, only in operators of the internal CCs, e.g. low complexity of work tasks, customer calls exceeding 4 hours per day, monitoring of calls, and high psychological demands. One variable was specific for operators at external CCs, e.g. being seated, for more than 6 hours, during working day.

In the multivariable analyses, low comfort related to work environment remained the most important factor, in that the association was seen for both types of CCs, with a suggestion of an exposure-response pattern, table 13.

Operators at internal CCs, reporting low complexity of work tasks, customer calls between 4-7 hours, and low support from supervisors, and showed higher odds for symptoms in the Neck/shoulder and Arm/hand region compared with operators at external CCs.

At external CCs, the odds for Neck/shoulder and Arm/hand complaints were increased in connection with continuous computer work for more than 2 hours without a break. In addition, low social support increased the odds for Neck/shoulder symptoms and low decision latitude increased the odds for Arm/hand symptoms among operators of external CCs.

Table 13. Multivariable ORs with 95% CI for Neck/Shoulder and Arm/Hand symptoms among operators at internal and external CCs, *study V*.

Exposure	Neck/shoulder		Arm/hand	
	Internal CCs OR (95%CI)	External CCs OR (95%CI)	Internal CCs OR (95%CI)	External CCs OR (95%CI)
<i>Gender</i>				
Men	1.00	1.00	1.00	1.00
Women	2.26 (1.35-3.76)	2.23 (1.42-3.48)	2.92 (1.62-5.25)	1.88 (1.17-3.03)
<i>Age, continuous</i>	1.01 (0.99-1.03)	0.99 (0.98-1.01)	1.03 (1.00-1.06)	1.01(0.99-1.03)
<i>Complexity of work task</i>				
High	1.00		1.00	
Medium	1.02 (0.57-1.82)		1.07 (0.57-2.01)	
Low	2.41 (1.08-5.40)		2.58 (1.07-6.26)	
<i>Total time of customer calls/ day</i>				
<= 240 min/day	1.00	1.00	1.00	1.00
> 240 - <= 330 min/day	3.47 (1.50-8.03)	0.65 (0.35-1.23)	5.89 (2.30-15.09)	0.57 (0.29-1.12)
> 330 - <= 420 min/day	1.76 (0.92-3.34)	1.16 (0.66-2.03)	2.05 (1.00-4.21)	1.01 (0.55-1.84)
> 420 min/day	0.98 (0.45-2.13)	1.21 (0.68-2.16)	1.61 (0.66-3.94)	0.91 (0.49-1.68)
<i>Continuous computer work without a break (break >10 min)</i>				
<= 90 min		1.00		1.00
> 90 - <= 120 min		1.00 (0.62-1.62)		0.93 (0.56-1.55)
> 120 - <= 150 min		2.33 (1.14-4.74)		2.48 (1.19-5.19)
> 150 min		1.31 (0.71-2.40)		1.46 (0.78-2.75)
<i>Comfort related to work environment (score 14-70)</i>				
High (<= 30)	1.00	1.00	1.00	1.00
(> 30 - <= 36)	0.72 (0.39-1.32)	1.25 (0.72-2.16)	0.68 (0.33-1.39)	1.66 (0.91-3.01)
(> 36 - <= 43)	1.33 (0.69-2.56)	1.88 (1.05-3.38)	1.63 (0.78-3.38)	2.59 (1.40-4.79)
Low (> 43)	6.63 (2.46-17.90)	3.07 (1.67-5.64)	9.61 (3.11-29.72)	4.07 (2.14-7.72)
<i>Decision latitude (score 6-66)</i>				
High (<= 36)			1.00	1.00
(> 36 - <= 45)			1.28 (0.63-2.60)	1.68 (0.94-3.02)
(> 45 - <= 51)			2.45 (1.06-5.69)	1.73 (0.96-3.12)
Low (> 51)			0.65 (0.29-1.46)	2.43 (1.25-4.75)
<i>Social support (score 7-42)</i>				
High (<= 14)		1.00		
(> 14 - <= 17)		1.66 (0.95-2.92)		
(> 17 - <= 21)		1.46 (0.88-2.43)		
Low (> 21)		1.99 (1.06-3.71)		
<i>Support from supervisor (score 8-48)</i>				
High (<= 18)	1.00		1.00	
(> 18 - <= 24)	2.00 (1.03-3.87)		3.59 (1.66-7.79)	
(> 24 - <= 29)	1.88 (0.92-3.87)		3.07 (1.34-7.05)	
Low (> 29)	1.75 (0.84-3.66)		2.58 (1.13-5.86)	

Reliability

A summary of the number of questions and variables that were classified into each reliability groups are shown in table 11.

Table 11. Number of questions in the questionnaire and variables in the ergonomic checklist that were classified into high, fair to good or poor test-retest reliability, *study II*.

	Reliability		
	High	Fair to good	Poor
Test-retest questionnaire	31 questions	111 questions	144 questions
Inter-rater reliability of ergonomic checklist	11 variables	16 variables	11 variables

Test-retest reliability of the questionnaire

Approximately half of the questions in the questionnaire were classified as having *poor* reliability (*study II*). The average value (and range) of Pearson's correlation coefficient was 0.61 (-0.031-1.00), Spearman correlation coefficient 0.59 (0.33-0.77) and Cohen's Kappa 0.59 (-0.028-1.00). There were a lower proportion of variables on nominal level classified as having poor reliability compared with variables on ratio, interval and ordinal level. Questions classified as having *poor* reliability were especially questions concerning perceptions or questions where the operators were to estimate times or proportion of times.

Internal consistency and test-retest reliability of indices

Twelve indices from the questionnaire were classified as having *satisfactory* internal consistency (Cronbach's alpha ≥ 0.7): comfort of sound, lighting and air quality, comfort of furniture and equipment, psychological demands, cognitive demands, lack of control, social support from colleagues, support from supervisor, stress, positive work, feeling worn out, anxiousness and psychosomatic symptoms. Four indices were classified as having *low* internal consistency (Cronbach's alpha ≤ 0.6): limited decision latitude, time pressure, emotional demands and energy.

Indices with *fair to good* test-retest reliability were: comfort of furniture and equipment, psychological demands, limited decision latitude, lack of control, cognitive demands, positive work, feeling worn out, anxiousness, psychosomatic symptoms. Indices with *poor* test-retest reliability were: comfort of sound, lighting and air quality, social support, support from supervisor, time pressure, emotional demands, stress and energy.

Inter-rater reliability of assessments in the ergonomic checklist

Among the variables on ratio and ordinal level, measurements of actual desk height and seat height adjusted by the operator had *high* reliability. Viewing angle, some of the luminance variables, e.g. risk for glare in the field of vision and luminance in the peripheral working area had *poor* reliability. Among variables on the nominal level, function of curtains, awnings etc, and neck posture when

looking at the screen and the operator's knowledge concerning how to adjust the armrest had *high* reliability. Variables such as visible reflections on the desk, risk of reflections on the desk, reflections on the screen, the keyboard positioned within forearm's length and shoulder width, were classified as having *poor* reliability.

Discussion

Main findings

Characteristics of work

This thesis has identified different CC-specific exposures that may be potential risk factors for the operator's health and also identified differences between internal and external CCs. CC work requires a balance of qualitative skills, such as communication, negotiation, empathy, patience, assertiveness and persuasiveness, together with the quantitative skills of keyboard, computer systems and product knowledge (Fernie, 2004). It is also a sedentary job with constrained postures, restrictive and excessively monitored. Although the operators work in teams, their job is solitary with little or no time to converse with team mates.

Opportunities for varying work tasks and also to influence the quantity of work are probably important factors for CC operators. Other studies have shown that less variation in work content and a higher quantity of calls may lead to more sedentary work with less variation in both physical and mental respects (Holman, 2003, Rabe and Rocha, 2002). There are concerns about monotonous work with lack of stimulation.

Supervision and control of the CC operators has often been discussed as a special stressor (Aiello, et al., 1995; DiTecco, et al., 1992; Schleifer, et al., 1996; Smith, et al., 1992; Westin, 1992). In this thesis, call logging was very common. Monitoring of calls was less common compared with call logging. Call logging and monitoring was most common at external CCs. Many reported a feeling of stress, experienced irritation, felt worried and anxious. Call logging emphasises the quantity, whereas monitoring focuses on quality, which easily leads to conflict.

It was common for the operators to receive additional remuneration. This could lead to the operators trying to increase their working speed in order to get more remuneration. Too much focus on remuneration may also affect the atmosphere among the operators and have a negative impact on solidarity at the company. A theoretical model is proposed to assess the adverse health effects of stressful experience at work: the effort-reward imbalance model (Siegrist, 1996). The focus in this model is that there has to be a balance between the reward (wages, promotion and benefits) and the effort that the work involves.

Physical exposures

Open-office design has been reported to create problems. Noise, vision ergonomics and air quality is parameters that could be affected in a negative way in this type of offices. The operators were dissatisfied with the air quality and noise environment in the premises. This maybe a consequence of that many operators dealing with customer calls and were working in the same room. When the operators sit close to each other there is a risk of disturbance, and problems can easily

arise if there is a lack of noise screening and noise reduction. Several studies have pointed out that people in open office landscapes feel disturbed by each other (Evans and Johnson, 2000; O'Neill, 1993).

Design of the working environment and equipment is important for the productivity and quality of the computer-produced work (Tharr, 1995; Tittiranonda et al., 1999; Jensen et al., 2001). In an occupational setting, a lack of fit between anthropometrics features and furniture or other equipment may mean that it is more difficult for the worker to find neutral work postures. This is crucial for the prevention of musculoskeletal problems (Hagberg et al., 1995). It is important that furniture and equipment can be adjusted to each individual, and also that the operator has the appropriate knowledge about how to adjust and use the equipment in an optimal way.

On average the operators spent 80 per cent of the working day seated. This may lead to fewer opportunities to get physical variation. Other studies, have shown that long periods of constrained sitting may lead to musculoskeletal disorders (Buckle, 1994; Hagberg, 1987; Karlqvist et al., 2002; Punnett and Bergqvist, 1997; Tittiranonda et al., 1999).

Psychosocial exposures

Emotional demands were one of the most prominent psychosocial workload among operators in this thesis. The operators experienced emotional demands almost the whole working time. Many operators also experienced cognitive demands during a large part of their working hours. The operator is faced with simultaneous emotional and cognitive demands. He/she is supposed to interact with the customer, computer and the telephone system, at the same time, automatic distribution of calls, as well as technical performance and control, characterises the work at many of the CCs in this study. The consequences of emotional and cognitive demands, which seem to occur during a large proportion of the working hours, could result in musculoskeletal symptoms, stress-related sickness and absence among the operators (Deery et al., 2002).

These risks could be further augmented by lack of influence over one's own work tasks, limited support from the supervisor and limited social support (Theorell, 1996). The operators' decision latitude is often restricted; they reported limited decision latitude for more than half of their working time. In other words, the job of many CC operators can be characterised as high-strain jobs with high demands and limited decision latitude, which has been shown to be a risk factor for many health problems (Karasek, 1979).

A positive aspect of the psychosocial working conditions was that a satisfactory level of social support from colleagues was generally reported. Operators also reported rather good support from their supervisor. It has been suggested that social support may provide buffering to reduce negative effects of high work demands (Leino, 1989; Leino and Magni, 1993).

Individual characteristics

The thesis confirms some of the earlier observations that employees at CCs are mainly women (Austin Knight and Calcom Group, 1997; Tengblad, 2001). In the light of the dominance of women in work tasks of low complexity, there is an obvious risk of a “women’s trap”, where women get the routine work tasks and not the ones that involve development (Belt and Richardson, 1999; Fenety et al., 1999). This thesis also showed that the mean age among the employees in the CC group is relatively low, but with a wide range and that the very young, less than 25 years of age, are not in the majority.

Health related outcomes

Subjective health complaints such as headache, muscle tension, irritation, not feeling in the mood for work and feeling worn out may represent a variety of disease conditions (Eriksen et al., 1999). The dominant symptoms were headache and neck/shoulder symptoms (*Study I*).

In *study V*, three out of four operators reported symptoms in one or more of the requested body regions, with no major differences between internal and external CCs. Pain or aching in the neck/shoulder region was the most common symptom, and operators at external companies belonged to the neck/shoulder category slightly more often than operators at internal CCs. The results confirm previously suggested associations between exposures related to computer work and symptoms in the neck/shoulder and arm/hand region (Punnett and Bergqvist, 1997; Tiitranonda, et al., 1999; Karlqvist, et al., 2002).

Several specific patho-physiological pathways have been hypothesised. For example, high mental load and job demand may increase muscle tension and decrease micro-pauses in muscle activity. This may lead to muscle fatigue, even in the case of low loads, due to continuous firing of low threshold motor units, which are not only triggered by low level physical loading, but also by mental loading (Westgaard, 1999; Sjøgaard et al., 2000). High mental load and job demands may also lead to adverse changes in immune response (Theorell et al., 2000). A certain work-style response to increased work demands can result in a cascade of physiological changes that if repeatedly evoked can contribute to the development, exacerbation, and/or maintenance of work-related upper extremity symptoms. Job stress may reduce the ability to reduce the physiological activation to resting levels during breaks and after work, and thus adversely influence recovery (Lundberg and Melin, 2002).

Alternatively, musculoskeletal symptoms caused by physical ergonomic stressors could contribute to psychological stress (Sauter and Swanson, 1996). In addition, stress responses may influence the transition from acute to sub-acute chronic musculoskeletal pain. Job stress may illicit responses that increase muscular co-activation and thus increase loading of the musculoskeletal system.

The strongest risk indicators for stress in this thesis were time pressure, limited decision latitude, limited social support from colleagues and from the supervisor. This agrees with theories presented by Folkman (1984) and Thompson (1981). There seems to be a connection between the distribution of operators in the Stress-

Energy groups and the reported levels of demands, decision latitude and social support. Operators that have reported high demands, low decision latitude, high time pressure and low support from colleagues and managers could be found in the “worn-out” and “committed under pressure” stress-energy groups. This agrees with theories presented by Dermerouti, et al., (2001). According to this theory, resources include demands, decision latitude and social support, are a decisive component for tiredness in the concept of burnout theories, while absence of resources is the critical factor for lower work commitment. In a comparison with a group of travel agents, a higher proportion of operators belonged to the “worn-out”, “bored” and “committed without pressure” group.

According to Knardahl (2002) pain could begin in connection with long-lasting psychological stress in work tasks with low physical load. Psychosocial stressors resulting in psychological stress may increase the awareness of musculoskeletal symptom and affect the perception of such problems (Sauter and Swanson, 1996). Several specific patho-physiological pathways have been hypothesised.

In recent work mental stressors, e.g. cognitive and emotional stressors have been observed as prominent risk factors in the development of musculoskeletal pain, with the neck, shoulders and head as the dominant body locations. The best-known model for characterising mental stressors is the 3-factor model of Karasek & Theorell (1990), which was developed to evaluate the risk of cardiovascular disorders in terms of psychological demands, decision latitude, and social support. The high prevalence of musculoskeletal disorders in psychologically stressful but light physical work, such as computerised data entry, has indicated that mental stress plays an important role (Moon and Sauter, 1996; Schleifer and Ley, 1996).

Associations between work exposures and health related outcomes

Among operators at internal CCs, *study V*, reported symptoms were associated with the length of work with customer calls, while among operators at external CCs the reported symptoms were associated with the time spent seated during a working day. An inconsistency between external and internal CCs was found regarding the effect of extra remunerations. Additional remunerations tended to decrease the odds of both neck/shoulder and arm/hand symptoms among operators at external CCs, while it seemed to increase the odds of the symptoms in operators at internal CCs. This could be a result of that operators working at external CCs are more familiar to work with extra remunerations compared to operators at internal CCs. At internal CCs extra remuneration become more a stressor than at external CCs.

Monitoring of performance showed an association with musculoskeletal symptoms, for internal CCs in the univariable analyses, but did not meet the criteria for inclusion in the final multivariable model. Based on theories discussed by Carayon et al., (1999), it seems reasonable to assume that monitoring, combined with a heavy workload, may create a pressurised work environment, in which occupational stress could play a mediating role in the development of musculoskeletal disorders. It is relevant to explore, in further studies among CC operators, to what

extent mental and physical aspects of work tasks contribute to the maintained muscle activity, in sedentary work with low physical demands.

Complexity of work task showed importance for neck/shoulder symptoms for operators at internal CCs. The quantity of work at CCs varies with the complexity of the phone calls, as shown in *study V*. Work tasks of low complexity may provide less opportunities to get variation in work content and a higher quantity of calls. Therefore, the task performed by the operators could become more repetitive and less varied, both physically and mentally. Fewer opportunities for variation in the work task and long working shifts in front of the display units leads to periods of constrained sitting, which may lead to musculoskeletal disorders (Buckle, 1994; Hagberg, 1987; Karlqvist, et al., 2002; Punnett and Bergqvist, 1997; Tittirononda, et al., 1999).

For external CCs in particular, about two hours of work without a break (at least 10 minutes) increased the occurrence of symptoms. Regular breaks have shown to have a beneficial effect on preventing musculoskeletal symptoms (Dul, et al., 1994; Henning, et al., 1997; McLean, et al., 2001; Balci and Aghazadeh, 2004). Others have emphasised that even low-complexity CC work tasks place high mental demands on the operator because of the constant attention required, often in combination with high qualitative and quantitative demands (Melin, 2003).

In the univariable and multivariable analyses, comfort related to work environment showed the strongest association with neck/shoulder and arm/hand at both external and internal CCs, and an exposure-response relationship was suggested. It is well known that a good ergonomic design of the computer workstation is important in order to avoid musculoskeletal symptoms (Sauter et al., 1991; Karlqvist, 1998; Aarås et al., 1999; Karlqvist et al., 2002).

As shown in the univariable and multivariable analyses, high psychological demands were linked to musculoskeletal symptoms. This was also the case for low decision latitude (control). The results are in agreement with theories and findings presented by several research groups (Sauter, et al., 1983; Pot, et al., 1987; Ryan and Bramptom, 1988; Hopkins, 1990; Theorell, et al., 1991; Hoekstra et al., 1994; Bongers et al., 2002; Ferreira and Saldiva, 1997). Resource to complete a complex task in a short amount of time has been shown to increase muscle tension in the shoulders (Waerstad et al., 1991).

Age showed association with the outcome measures, although there was a slight, increase of Arm/hand symptoms with increasing age. Female gender was clearly important for the prevalence of the symptoms; the ORs for both Neck/shoulder and Arm/hand symptoms were about twice as high for women compared with men, and the highest risk estimate was found for Arm/hand symptoms in the multivariable analyses of internal CCs. It may be, for example, that woman's smaller anthropometrics dimensions or lower muscle force, cause greater mechanical stress (Karlqvist et al., 2002; Lindegård, 2004). Punnett and Bergqvist (1997) stated that women appear to consistently report more neck and upper extremity symptoms than men. No definite explanations were found in the reviewed studies, but differences in total workload, including household work and childcare were mentioned as plausible explanations. In the present study, *study V*, there

seemed to be only small differences between women and men regarding the relationship between exposure variables and the symptoms considered. Wigaeus Tornqvist and co-workers (2001) analysed the influence of physical and psychosocial exposures at work on disorders of the neck and shoulders in a large population-based sample of Swedish women and men. They found that risk indicators differed between women and men. The differences between women and men seem to be explained, just partly, by the gender-segregated labour market, since differences are also observed within occupations (Melin and Wigaeus Tornqvist, 2005). On the other hand, the tasks performed by women and men within the same occupation may differ (Nordander et al., 1999).

Methodological issues

Reliability

The test-retest reliability of the questions, in *studies III, IV* and *V*, seems to be *fair to good* or better in 142 (46%) of the totally 312 questions. Variables on ratio, interval and nominal level had variables represented in all three categories of reliability, whereas no variables on the ordinal level were classified as having *high* reliability. Additionally, variables on the ordinal level had the smallest proportion of variables classified as having *fair to good* reliability. Only 15 per cent of the variables on nominal level were classified as having *poor* reliability, compared with 60 per cent of the variables on ratio or interval level and 76 per cent of the variables on ordinal level. In spite of the low test-retest reliability in some questions and indices used, we found rather high odds ratio. If the test-retest reliability had been high in all questions and indices the odds ratio might have been even higher. In *study V* eleven questions and two indices were classified as having *fair to good* or higher reliability. Four questions (duration of calls, time spent seated during a working day, duration of continuous computer work without taking a break, opportunities to take part in planning) and three indices (comfort of work environment, social support, support from supervision) were classified as having *poor* reliability.

Twelve out of totally 16 of the indices, in *studies III, IV* and *V*, were classified as having *satisfactory* internal consistency, and 4 indices were classified as having low internal consistency. Nine indices were classified as having *fair to good* test-retest reliability. Seven of twelve indices with satisfactory internal consistency had *fair to good* test-retest reliability. It is reasonable to assume that indices with satisfactory internal consistency are more likely get good test-retest reliability.

The correlation between the two measurements could be affected by lack of stability of the measured variables, type of questions, type of scale categories and differences in distribution of answers, reactivity and memory effects, differences in response rate to the questions and by random factors. The results from *study II* show how difficult it is to reach acceptable reliability in questionnaires. The questions in the questionnaire reflect several conditions that are variable, leading to notions and evaluations that could be under gradual development or change. Working conditions, health and well-being could therefore have changed between

the test and retest measurements. A low test-retest correlation may not indicate that the reliability, per se, of the test is poor, but may instead, signify that the underlying physical reality itself has changed. Test-retest correlations can underestimate the degree of reliability in measurements over time by interpreting true changes as measurement instability. It is questionable to what extent the exposure variables are stable over time, and to what extent musculoskeletal symptoms are recurring events, and how this might influence the prevalence odds ratios.

Design

A limitation of the *studies I, III, IV, V* is the cross-sectional nature, measuring work exposure and symptoms at one and the same point in time (Kuorinka et al., 1995). This precludes any conclusions about the time sequence and causality, and it also entails some potential for bias.

The cross-sectional study design also means that an association between exposures and disease or symptoms is influenced by the duration of the disease or symptoms (while still at work). Furthermore, the rate at which the symptoms leads to sickness absence or quitting the job may have an impact, and the rate may differ depending on exposure level – the higher the exposure, the sooner the individual will be on sick leave or quit the job.

In occupational health studies, at least two types of selection bias may occur: a) a selection of “healthy workers” into the work population studied, and b) an exclusion of “sick” workers who leave the active workforce. Both of these biases tend to cause an underestimate of the true relationship between a workplace risk factor and an observed health effect, because the workers who are in better health tend to be those in the workforce and available for study (Eisen et al., 1997)

The results were based on self-reported data, collected by questionnaire. Prevalences and ORs may be underestimated or overestimated in epidemiological studies where individuals rate both exposure and outcomes at the same point in time (Checkoway 1989; Faucett et al., 1996). The individuals with symptoms may be more aware of factors they perceive as causes of their pain, and overestimate their exposure to these factors. Such mechanisms, differential misclassification of exposures, might have led to overestimated ORs. However, it may also be, that subjects without symptoms overestimate their exposure, yielding underestimated risk estimates (Wictorin et al., 1993).

Representativity/Generalisability

A critical aspect of these studies is the selection of the call centre companies. They were not randomly chosen and they maybe not be representative for the whole Swedish call centre business. There are reasons to suspect that companies with strained conditions, e.g. high workload, reorganisation, psychosocial conflicts or unsolved problems did not participate in the study. However, there is no reason to believe, that the associations between work exposures and health related outcomes, in general would have been weaker, if these companies had been included. Another problem is that in the selection of CCs, consideration was given to just five characteristics: internal-external, task complexity, ownership, location

and incoming or outgoing calls. Obviously there are other characteristics that may be of importance and might have affected the results. Some selection bias could also be attributed to non-response on the individual level (23%). The prevalence of non-response was highest among men (39%) compared with women (14%), which has probably have inflated the prevalence values of the musculoskeletal symptoms of the total study group.

Conclusions

This thesis has described some characteristics and exposures at call centre work and their associations to health related outcomes.

Characteristics of work

The characteristics of work varied between different types of call centre companies (internal and external). External CCs showed somewhat more problematic conditions in the working environment compared with the internal CCs. Operators at external companies had longer duration of customer calls per day, handled more calls/day and had shorter calls compared with operators at internal CCs. The duration of customer calls per day was associated with symptoms in the neck/shoulder and arm/hand region for both internal and external CCs.

Physical exposures

“Non-optimal” furniture, equipment and workstation design were more common at a studied call centre company than among other professional computer users. Comfort related to the work environment showed the strongest association with both neck/shoulder and arm/hand symptoms both at external and internal CCs. Duration of continuous computer work without a break was also associated with symptoms in the neck/shoulder and arm/hand regions.

Psychosocial exposures

Emotional demands and limited decision latitude were often experienced among call centre operators. Differences in reported psychosocial exposures were found between women and men, between internal and external companies, and between different complexities of work tasks. Differences were also found between different types of owners, and between companies located in small villages and larger towns.

High psychological demands, low decision latitude and low support from colleagues and supervisors were linked to symptoms in the neck/shoulder and arm/hand.

Health related outcomes

Call centre operators had a higher prevalence of neck- and upper extremity disorders than other professional computer users.

This thesis confirms previously suggested associations between unfavourable work characteristics and management, as well as a poor physical and psychosocial environment, respectively, and musculoskeletal symptoms. Among operators at internal CCs symptoms were particularly related to the nature of calls during work, whereas at external CCs critical exposures were the time spent seated with continuous computer work. The results may also serve as guidance for implementing preventive actions in CC companies.

Positive examples might be a potential source of knowledge that could be spread among companies and thus a potential for change. A challenge will arise for the companies described here, when the CCs of today evolve into the next generation's contact centres.

Further research

With the proposed model as a framework, future research activities should aim to determine factors to understand both positive and negative aspects of call centre work. Recommendations for further work:

- To make a prospective study among call centre operators, where different exposures and health are studied over a time period. With a prospective study it is possible to explain if there is a causal relationship between work-related factors and health.
- To study the effects of work organisations on call centre operators.
- To study and make deeper analyses of the work content at call centres and try to identify potential stressors.
- Try to find explanations for the fact that women report more symptoms than men.

Summary

Norman K (2005) *Call centre work – characteristics, physical and psychosocial exposures, and health related outcomes*. Arbete och Hälsa 2005:11, National Institute for Working Life, Stockholm. Graduate school for Human-Machine Interaction, Division of Industrial ergonomics, Department of Mechanical Engineering, Linköping University.

Call centres (CCs) are one of the most rapidly growing forms of workplaces in Sweden. The overall aim of this thesis was to describe work characteristics, physical and psychosocial exposures, and health related outcomes, for CC operators in selected CC in Sweden. The purpose was also to study the test-retest reliability and internal consistency of questions, and the inter-rater reliability of observations and measurements in studies of CCs.

This thesis is based on two projects, where *study I* was a cohort study and *studies II-V* were a cross-sectional survey. Fifty-seven CC operators were compared with a reference group of 1459 professional computer users from other occupations, *study I*, and 1183 operators (848 women and 335 men) (response rate 77%) from 28 CCs were studied in *studies II-V*. Questionnaires covering organisation and work characteristics, physical and psychosocial exposures, individual characteristics and symptoms during the previous month was used, *studies I-V*. Structured observations in accordance with an ergonomic checklist were used to assess workstation design during the subject's ordinary work, *study I and II*.

Operators at external CCs spent longer time on customer calls and had less varied tasks. Additional remuneration, call logging and monitoring was more common at external CCs.

There were deficiencies in workspace, keyboard- and input device placement. External CCs showed somewhat more problems in the work environment compared with the internal CCs. The CC group spent longer continuous time in front of the computer than other professional computer users.

Emotional and cognitive demands and time pressure were reported considered high. Emotional demands and limited decision latitude were dominating features in CC work.

A higher proportion of the CC group reported musculoskeletal symptoms compared to other professional computer users. Three out of four operators reported symptoms in the Neck/shoulder or Arm/hand region, with no major differences between internal and external CCs. Comfort of the work environment showed the strongest association with symptoms in the Neck/shoulder or Arm/hand, in both types of CCs. Other exposures associated with symptoms in the Neck/shoulder or Arm/hand in either type of CC were: low complexity of work, long total time of customer calls per day, continuous computer work without a break, high psychological demands, low decision latitude, lack of social support from colleagues and lack of support from a supervisor. The thesis confirms previously suggested

associations between unfavourable work characteristics and management, as well as poor physical and psychosocial environment, and musculoskeletal symptoms in computer-interactive tasks. Among operators at internal CCs, symptoms were particularly related to the nature of calls during work, whereas at external CCs critical exposures were the time spent seated with continuous computer work.

About half of the questions were classified as having fair to good or higher test-retest reliability and can be recommended in further analyses. Other questions should be used with care. A majority of the variables on the ergonomic checklist are classified as having fair to good or higher inter-rater reliability.

Sammanfattning (Summary in Swedish)

Norman K (2005) *Call centre work – characteristics, physical, psychosocial exposures and health related outcomes*. Arbete och Hälsa 2005:11, National Institute for Working Life, Stockholm. Graduate school for Human-Machine Interaction, Division of Industrial ergonomics, Department of Mechanical Engineering, Linköping University.

Call centers (CCs) är en av de snabbast växande branscherna i Sverige. Det övergripande syftet med denna avhandling var att beskriva vad som är karaktäristiskt för CC arbete, fysiska och psykosociala exponeringar och symptom, för CC operatörer i ett urval av CC i Sverige. Syftet var också att studera test-retest reliabiliteten och den interna konsistensen för enkätfrågor och inter-bedömar reliabilitet för observationer och mätningar i studier av CCs.

Avhandlingen baseras på två projekt, där *studie I*, var en kohort studie och *studie II-V*, var en tvärsnittsstudie. Femtio-sju CC operatörer jämfördes med en referensgrupp som bestod av 1459 professionella datoranvändare från andra yrkesgrupper, *studie I* och 1183 operatörer (848 kvinnor och 335 män) (svarsfrekvens 77 %) från 28 CCs studerades i *studie II-V*. Frågeformulären omfattade organisatoriska, arbetets karaktär, fysiska och psykosociala förhållanden och symptom under den senaste månaden användes, *studie I-V*. Strukturerade observationer med stöd av en ergonomisk checklista användes för att uppskatta utformningen av arbetsplatsen under operatörens ordinarie arbete, *studie I*.

Operatörer på externa CCs arbetade längre tid med kundsamtal och hade mindre varierade arbetsuppgifter. Extra belöningar, samtalsmätning och medlyssning var vanligare på externa CCs. Det fanns brister i utrymmet kring arbetsplatsen, tangentbords- och styrkonsolplacering. Externa CCs visade något mer problem i arbetsmiljön jämfört med interna CCs. Emotionella och kognitiva krav samt tidspress rapporterades större delen av arbetstiden.

Emotionella krav och begränsade påverkansmöjligheter var ett dominerande inslag i arbetet på CC.

En större andel av CC-gruppen rapporterade symptom jämfört med andra datoranvändare. Tre av fyra operatörer rapporterade symptom i en eller fler av de efterfrågade kroppsdelarna (nacke/skuldra och arm/hand), med små skillnader mellan interna och externa CCs. Arbetsmiljökomforten visade sig ge den starkaste associationen med symptom i nacke/skuldra och arm/hand för båda typerna av CC. Andra exponeringar som visade association med symptomen var: låg komplexitet i arbetet, lång total arbetstid med kundsamtal per dag, kontinuerligt datorarbete utan paus, höga psykosociala krav, låg påverkansmöjlighet, brist på socialt stöd från kollegor och brist på stöd från arbetsledning. Avhandlingen bekräftar tidigare funna samband mellan ogynnsamma arbetsförhållanden och arbetsledning, även vad gäller fysiska och psykosociala miljö och symptom i samband med datorintensivt arbete. På interna CCs var rapporterade besvär relaterade till tid med

kundsamtalen, medan på externa CCs var de relaterade till den tid som tillbringades sittande med kontinuerligt datorarbete.

Omkring hälften av frågorna i enkäten klassificerades som ansenlig till bra eller högre test-retest reliabilitet och kan rekommenderas till fortsatta analyser. Andra frågor bör användas med försiktighet. I den ergonomiska checklistan hade majoriteten av variablerna ansenlig till bra eller högre inter-bedömar reliabilitet.

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