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Tuulikki Sjögren

Effectiveness of a Workplace Physical Exercise Intervention on the Functioning, Work Ability, and Subjective Well-being of Office Workers

A Cluster Randomised Controlled Cross-over Trial with a One-year Follow-up

JYVÄSKYLÄN YLIOPISTO

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ABSTRACT

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The main aim of this study was to investigate the feasibility and the effects of workplace physical exercise intervention on physical and psychosocial functioning, work ability, and general subjective well-being. Dose of exercise and other physical activity outside the intervention were controlled for (MET). The other aims were to investigate the changes in outcomes 12 months after the intervention baseline measurements and to investigate the relationships between the prerequisites of functioning, work ability and general subjective well-being. Framework of the study was the International Classification of Functioning, Disability and Health (ICF).

90 volunteer workers from four municipal administrative departments took part in a 15 weeks' cluster randomised cross-over design intervention, consisting of light resistance training (30%1RM) and guidance, and 15 weeks with no training or guidance. During the first 5-week period training was to be performed once each working day and during the second and third 5-week periods 7-8 times a week. Both physical and psychosocial questionnaires and physical measurements were used. Follow-up questionnaires were mailed to the volunteers of whom 72 (80%) returned the questionnaires.

The average training time of 5 minutes per working day decreased the prevalence of headache (p=0.041-0.047), neck (p=0.003), shoulder (p=0.007) and low back (p=0.000) symptoms and alleviated the intensity of headache (p=0.001), neck (p=0.002) and low back (p=0.020) symptoms among the subgroups of symptomatic office workers. The intervention improved subjective physical well-being (p=0.015), but it did not affect the other psychosocial functioning and general well-being variables. After 12 months the prerequisites of functioning, work ability and general subjective well-being were at a higher level than at the baseline measurements. The physical prerequisites of functioning variables related better to work ability, whereas the prerequisites of psychosocial functioning related better to general subjective well-being.

A better understanding of physical exercise intervention and connections between human functioning and contextual factors can be helpful in maintaining work ability and preventing impairment in work ability among persons in sedentary occupations, particularly at older ages.

Keywords: CR10, dose-response, exercise, functioning, ICF, MET, musculoskeletal symptoms, physical activity, occupational health, rehabilitation, sedentary work, well-being, work ability

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LIST OF ORIGINAL PUBLICATIONS

This thesis is based on four original publications which will be referred to in the text by the following Roman numerals:

I Sjögren T, Nissinen K, Järvenpää S, Ojanen M, Vanharanta H, Mälkiä E. 2005. Effects of a workplace physical exercise intervention on the intensity of headache and neck and shoulder symptoms and upper extremity muscular strength of office workers: A cluster randomized controlled cross-over trial. Pain 116, 119-128.

II Sjögren T, Nissinen K, Järvenpää S, Ojanen M, Vanharanta H, Mälkiä E. 2006.Effects of a workplace physical exercise intervention on the intensity of low back symptoms of office workers: A cluster randomized controlled cross-over design. Journal of Back and Musculoskeletal Rehabilitation 19, 13-24.

III Sjögren T, Nissinen K, Järvenpää S, Ojanen M, Vanharanta H, Mälkiä E. Effects of a physical exercise intervention on the subjective well-being, psychosocial functioning and general well-being among office workers: A cluster randomized controlled cross-over design. Scandinavian Journal of Medicine and Science in Sports (in press).

IV Sjögren-Rönkä T, Ojanen MT, Leskinen EK, Mustalampi ST, Mälkiä EA. 2002. Physical and psychosocial prerequisites of functioning in relation to work ability and general subjective well-being among office workers. Scandinavian Journal of Work Environment & Health 28, 184-190.

In addition, this thesis contains unpublished data on the CRT study (Intervention study) and follow-up study.

ABBREVIATIONS

Body Functions and Structures:

1RM	One repetition maximum
HR	Heart rate
$\%HR_{max}$	Percentage of maximal heart rate
%HRR	Percentage of heart rate reserve
VO_{2max}	Maximal oxygen uptake
VO_2R	Percentage of oxygen uptake reserve
CR10	Rating on the perceived pain scale
RPE	Rating on the perceived exertion scale

Activities and Participation:

MET	Metabolic equivalent, the relative energy expenditure associated with aerobic activity
TWA MET	Time-weighted intensity average MET in measured activities
Max MET	Maximum MET intensity in measured activities
PA	Physical activity
OPA	Occupational physical activity
LTPA	Leisure-time physical activity
AT	All activities

Environmental Factors:

ACSM	American College of Sports Medicine
ICF	International Classification of Functioning, Disability and Health
WHO	World Health Organization
PEDro	Physiotherapy evidence database

RCT	Randomized controlled trial
CRT	Cluster randomized trial
ICC	Intraclass Correlation Coefficient
SD	Standard Deviation
ITT	Intention to treat

DEFINITIONS

Gross cost of PA	Total energy expenditure, resting metabolic rate and cost of the activity
Net cost of PA	Physical activity energy expenditure over resting metabolic rate
Frequency	Number of active sessions per day, week or month
Duration	Number of minutes of activity in each session
Intensity	The power associated with the physical activity
Cross–over study	The administration of two or more experimental design treatments one after the other in a specified or random order to the same group of subjects
Intention-to-treat	A method of analysis for randomized trials in which all subjects randomly assigned to one of the treatments are analyzed together, regardless of whether or not they completed or received that treatment.
Efficacy	Benefit that can be achieved in ideal circumstances
Effectiveness	Benefit in real life

CONTENTS

1 INTRODUCTION

In Finland, according to the Health 2000 study, approximately 4% of people in the labour force had during the past 12 months participated in rehabilitation programmes designed to promote their ability to manage in their current work, or received retraining because of illness or injury. Almost one fifth of the labour force aged 30 to 64 felt they needed rehabilitation to improve their work ability, and among those aged 45 to 54 the corresponding proportion was one in four (KTL 2004). In heath care evidence-based practices may rationalize allocation of recourses as well as improve quality and effectiveness of treatments. Despite this, it seems difficult to implement randomized controlled studies in the workplace (Shephard 1996, Tveito et al. 2004). In physiotherapy, occupational health and rehabilitation more practices and guidelines based on randomized controlled trials and systematic reviews are needed (Waddell and Burton 2001), as strong or moderate evidence of treatment can only be concluded for outcomes from randomized controlled trials (RCT) of high quality.

The reviews by Kesäniemi et al. (2001) and in ACSM (1998) show that there is scientific evidence of physical activity dose-response effects on all-cause mortality, cardiovascular disease, blood pressure, hypertension, overweight, obesity, fat distribution, diabetes mellitus and cancer. But in the field of low back pain, osteoarthritis and osteoporosis physical activity or exercise may have both beneficial and detrimental effects. However it appears that information about dose-response effects on musculoskeletal symptoms in the reviewed studies is largely lacking and therefore it is not possible to quantify the specific health benefits of physical activity. There is an even greater lack of valid information about the effects of physical activity on depression, anxiety (Dunn et al. 2001, Kesäniemi et al. 2001), and other psychological functioning or work-related social environmental factors (Griffiths 1996). Though musculoskeletal and psychosocial variables are important in physiotherapy, occupational heath and rehabilitation in maintaining work ability and preventing impairment in employees' work ability, the dose-response effects on musculoskeletal symptoms and psychosocial functioning are not yet fully understood.

Although physical exercise interventions are commonly used in the workplace to promote employees' physical and psychosocial functioning and work ability there is limited scientific evidence of the effectiveness of such programmes (Griffiths 1996, Shephard 1996, Drisman et al. 1998, Macher 2000, Proper et al. 2002, Proper et al. 2003, van Poppel et al. 2004, Twieito et al. 2004) and dose-response effects on health-related factors are unknown. Also largely unknown are occupational-related type of exposure-response relationships (Viikari-Juntura 1997) and their interactions with workplace physical exercise interventions.

Further randomised and controlled physical activity or exercise studies are needed to investigate the acute or chronic dose-response effects on musculoskeletal functioning, psychological functioning and social work-related environmental factors (Griffiths 1996, Kesäniemi et al. 2001, Shepard 2001) among different type of working populations or among different level of functioning populations. In addition to dose-response effects, study reports should provide information about clinically important differences or changes on functioning and work ability (Farrar et al. 2000, Farrar et al. 2001, Hägg et al. 2003), the long-term effects of interventions (Dworkin et al. 2005) and how controlling confounding factors, such as other physical activity outside the intervention, have been controlled for.

As far as author knows no randomized-controlled studies exist in which the dose-response effectiveness of a workplace physical exercise intervention has been evaluated while controlling for other physical activity. The main purpose of this study was to examine in a natural working environment the effectiveness of a cluster randomised and controlled workplace physical exercise intervention on physical and psychosocial functioning, work ability, and subjective well-being to create data for evidence-based physiotherapy, occupational health and rehabilitation, where physical exercise dose-response effects and confounding factors have been controlled for. In addition the purposes were to investigate the long-term effects of interventions and the complex interactions between functioning, work-related social environmental factors, individual factors, work ability and subjective well-being.

2 REVIEW OF THE LITERATURE

The first aim of the review of the literature was to provide the basis for an understanding of the International Classification of Functioning, Disability and Health (ICF) in health, measurements and outcomes. The second aim was to review musculoskeletal and psychosocial functioning and work ability among the working population, especially among office workers and to review factors associated with musculoskeletal symptoms, psychosocial functioning and work ability. The third aim was to investigate the effectiveness of physical activity or exercise programs in the workplace on Body Functions and Structures, Activities and Participation, and social work-related Environmental Factors as well as evaluate the methodology of the trials.

2.1 International Classification of Functioning, Disability and Health

The aim of the ICF classification is to provide a unified and standard language and description of health and health-related states. The ICF organizes information in two parts. Part 1 deals with components of Functioning and Disability, while Part 2 covers components of contextual factors. The Functioning and Disability domains are described from the perspective of the body, the individual and society in two basic lists: (1) Body Functions and Structures; and (2) Activities and Participation. Functioning is an umbrella term encompassing all Body Functions and Structures, Activities and Participation. Similarly, disability serves as an umbrella term for impairments, activity limitations or participation restrictions. Contextual factors represent the complete background of an individual's life and living. They include two components: Environmental Factors and Personal factors. Environmental factors make up the physical, social and attitudinal environment in which people live and conduct their lives. These factors are external to individuals and can have a positive or negative influence on the individual's performance as a member of society, on the individual's capacity to execute actions or tasks, or on the individual's function or structure. Personal factors are the particular background of an individual's life and living, and comprise features of the individual that are not part of health. These factors may, for example, include gender, race, age, lifestyle, habits, upbringing, coping styles, social background, education, profession, past and current experiences, overall behaviour pattern and character style, individual psychological assets and other characteristics, all of which may play a role in disability at any level. Personal factors are also a component of Contextual Factors but they are not classified in the ICF because of the large social and cultural variance associated with them. However, they are included in the ICF model to show their contribution, which may have an impact on the outcome of various interventions (WHO. ICF/ICIDH-2. 2001). The ICF model and interactions between its components are presented in FIGURE 1.

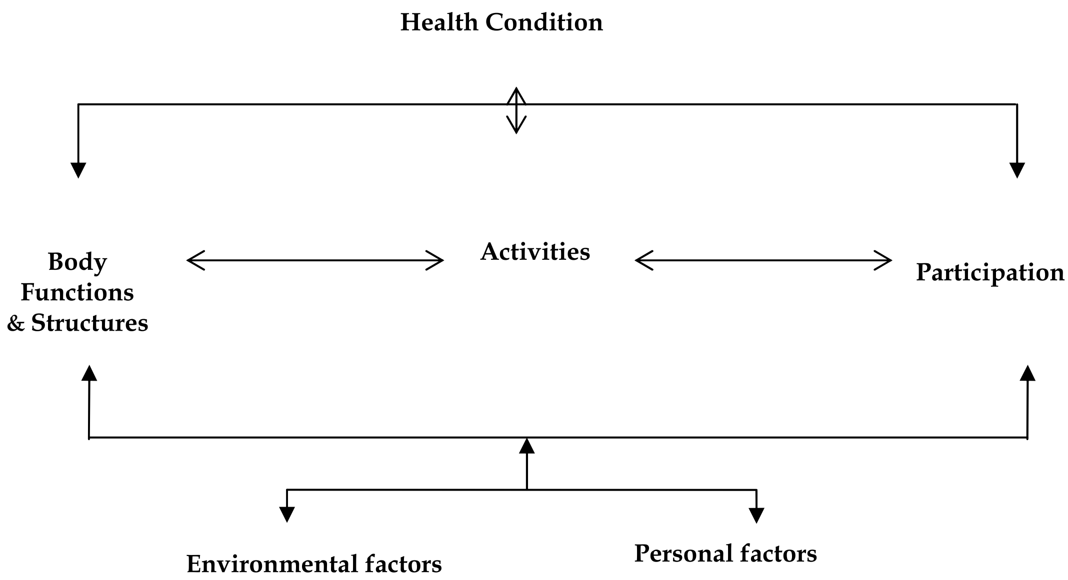


FIGURE 1 The ICF model and interactions between its components (WHO 2001)

The health parameters of the ICF form the framework of this study. The ICF helps us to consider human physical and psychosocial functioning in both the individual and the social context. The "Body Functions and Structures components" of the ICF model concern the physiological and psychological functioning of the individual. The "Activities and Participation" components involve both individual and social perspectives. "Environmental factors" concerns the physical, social and attitudinal environment in which people live or work. "Personal factors" refers to for instance background factors in the individual's life. In this framework, the level of functioning of the individual in a specific domain is the outcome of a complex relationship between health condition, functioning and contextual factors (WHO. ICF/ICIDH-2. 2001, Talo et al. 1996).

2.2 Musculoskeletal and psychosocial functioning among the working population

In general population and working population women and older subjects had more musculoskeletal diseases and symptoms than men and younger subjects (Mäkelä et al. 1991, Bovim et al. 1994, Ekberg et al. 1995, Seistamo and Klockars 1997, Eriksen et al. 1998, Ilmarinen 1999, Hellsing and Bryngelsson 2000, KTL 2004, Strazdins and Bammer 2004). Subjects who were middle aged or female also had more psychosocial troubles and disabilities (Eriksen 1998, KTL 2004, STM 2004). The prevalence of subjective health complaints is high in the northern European countries: 51% of respondents complained about tiredness, 42% reported headache, 37% reported worry, 35% reported low back pain, 3% reported pain in the arms/shoulders, 32% reported neck pain, 25% reported depressive mood, 22% reported pain in the upper back, 21%reported pain in their feet and 7% reported migraine. The prevalence of multiple complaints was rather high: 23% had one complaint, 20% two complaints, 15% three complaints and 17 % four or more complaints. Women were three times as likely as men to have multiple complaints. Compared to a younger group (<30 years), individuals in the middle (30-49 years) and oldest age groups (≥50 years) were significantly less likely to complain about tiredness, depressive mood, headache or migraine. However, the older group was more likely to report low back pain, arm/shoulder pain, and pain in the feet (Eriksen 1998**)**.

Among the Finnish population over the past 20 years chronic low back and neck syndromes have become less frequent, but self-reported pain in back and neck and weight-bearing joints are equally frequent in Finns of working age today as they were 20 years ago. For example the prevalence of back pain experienced (>30 years) during the past month among women was 36% and among men 30%. The corresponding values for neck pain were 40% and 26% and for shoulder pain 40% and 23% (STM 2004). Although the prevalence of musculoskeletal symptoms has been found to be higher in physically demanding occupations than in physically light occupations (Tola et al. 1988, Luoma et al. 2000, TTL 2000 and 2003), the prevalence of symptoms in the latter occupation has also been rather high, especially in the neck, shoulders, upper extremities and low back area (Tola et al 1988, Linton and Kamwendo 1989, Luoma et al. 2000, Thorbjörnsson et al. 2000, Forsman et al. 2002).

According to the Health 2000 study the majority of the Finnish population feels psychologically quite well. Only 5% in the age groups 30 or over reported a major depressive episode during the past 12 months. Major depressive episodes were more common among women (7%) than among men (4%), and the highest prevalence was found in the working age group (KTL 2004). Also among the Finnish working population the experience of feelings of mental stress were rather stable from the year 1997 to 2000. In the year 2000 14% of working population experienced quite a much or very much feeling of mental stress (TTL 2003).

In the year 2000 among the Finnish working population 35% experienced feelings of mental stress at work, which was slightly less than three years before (TTL 2003). However, the Finnish Health 2000 study reported that among those in gainful employment 25% suffered from mild and 2.5% from severe burnout (STM 2004). Women, compared to Finnish men, have reported more experience of feelings of mental stress at work and a worse work atmosphere. In addition women's mental stress is reported to increase with age (Seistamo and Klockars 1997, TTL 2000 and 2003). Public administration employees reported the worst working atmosphere, with 28% reporting that their working atmosphere was strained, while the corresponding mean value for all occupations was 19% (TTL 2003).

2.3 Work ability and factors related to work ability

Work ability is the result of the interaction between individual resources and work. According to Ilmarinen (1999), a person's individual resources included health, functional capacity, education and know-how. Individual resources are influenced by the person's values and attitudes, motivation and job satisfaction. A person realizes his or her recourses at work and the result is influenced by the community and the work environment, as well as by the physical and mental demands of the work. Good resources do not transform into good work ability unless the content of the work, the community and the work environment provide the proper conditions. On the other hand, a well-operating work community or work environment cannot fully compensate for weakened resources (Ilmarinen 1999).

Among the Finnish working age population (30 to 64 years), over 90% said they were completely fit for work. Of those respondents (30 to 44 years) who had been working within the past year, more than 90% said that their subjective work ability in relation to the physical and mental demands made upon them was quite good or very good (KTL 2004), although subjective work ability in relation to physical demands tends to decline with age more than work ability in relation to mental demands (Ilmarinen et al. 1997, TTL 2000 and 2003, KTL 2004). Subjective estimations of present work ability compared with the lifetime best were 9 on the scale 0-10 in age group 30-44 years, while in the age group 55 to 64 years the average was one point less (TTL 2000, 2003 and KTL 2004). Most persons (97%) in the age group 30 to 44 years reported that they would still be able to continue in their current job in two years' time. In the age group 55 to 64 still 74% thought they would be able to manage their job two years (KTL 2004).

In the year 2000 among the Finnish working population about 25% of administration and office workers reported long-standing or repeated physical or psychological symptoms during the past six months that were caused by work or increased at work and 7% reported symptoms which caused problems at work (TTL 2003). So despite good averages of self-estimated work ability the reported inability to work and increase in the number of disability pensions owing to musculoskeletal diseases and mental problems are worrying signs of problems in physical and psychosocial functioning, and in the work ability and working life generally of certain groups in the population (STM 1999, Hytti et al. 2002, Erlich 2003, KTL 2004).

In Finnish non-experimental epidemiological studies of municipal employees, associations have been found between work ability and leisure-time physical activity, possibilities for development at work (Tuomi et al. 1991b, Tuomi 1997), work and life satisfaction, and basic education (Tuomi et al. 1991a). Work disability has been associated with musculoskeletal and psychological symptoms, aging, being overweight, smoking (Tuomi 1991a, Tuomi 1991b, Pohjonen 2001a, Pohjonen 2001b) and physical performance (Nygård et al. 1991, Pohjonen 2001b). Factors in the physical, social or attitudinal working environment which caused inability to work were poor working posture, repetitive movements, high physical demands, physically disturbing working conditions, lack of freedom, decrease in recognition and esteem at work, role ambiguity at work and dissatisfaction with supervisor's attitude (Tuomi et al 1991a, Tuomi et al.1991b, Tuomi et al 1997, Pohjonen 2001a). Strong correlations have been found among health, life-style, work ability and life satisfaction (Seistamo and Ilmarinen 1997).

2.4 Physical and psychological functioning, environmental and personal risk factors and their interactions with musculoskeletal symptoms

Comparing risk factors among different occupations is difficult, because of the different outcomes and the fact that occupational physical activity (OPA) was not determined well enough in previous studies (Howley 2001). In the general population and especially among workers in physically demanding jobs there are several physical and psychological functioning, environmental and personal risk factors and obstacles which are related to musculoskeletal symptoms (Kiblom et al. 1987,Tola et al. 1988, Viikari-Juntura et al. 1988, Batie´ et al. 1989, Linton 1990, Blåder et al. 1991, Mäkelä et al. 1991, Stock 1991, Holmström et al 1992, Johansson and Rubenowitz 1994, Ekberg et al. 1995, Cole and Hudack 1996, Pope et al. 1997, Bruilin et al. 1998, Estlander et al. 1998, Thörbjornsson et al 1998, Hoogendoor 1999, Tuomi et al. 1999, Fredriksson et al. 2000, Hellsing and Bryngelsson 2000, Hoogendoor et al. 2000a, Hoogendoor et al. 2000b, Linton 2000, Luoma et al 2000, Thorbjörnsson et al 2000, Vingard et al. 2000, Hakkanen et al. 2001, Hoogendoor et al. 2001, Leclerc et al. 2001, Palmer 2001, Trop et al. 2001, Viikari-Juntura et al. 2001, Lee at al. 2005, Waddel and Burton 2005). In contrast, in persons in physically light work and who use a visual display terminal (VDT) the risk factors are not so well known; possible risk factors have only been studied later and there are less available published studies (Linton and Kamwendo 1989, Takala et al. 1992, Levoska 1993, Hales 1994, Bergqvist et al. 1995, Nelson and Silverstein 1998, Smith et al. 1999, Fredriksson et al. 2000, Fogelman and Lewis 2002, Omokhodion and Sanya 2003, Strazdins and Bammer 2004, Hannan et al. 2005).

Among a Swedish population (n=22180), in different age groups, monotonous work was found to be risk factor for back (Odds ratio (OR) 1.58-1.94) and neck pain (OR 2.25-2.95) (Linton 1990) and in a United Kingdom population (n=500) for shoulder pain (Relative risk (RR) 2.7) (Pope et al. 1997). In another Swedish population (n=484) VDT work (among women OR 1.5), and frequent hand and finger movements (in both men and women OR 1.5) were found to be risk factors for neck and shoulder symptoms (Fredriksson et al. 2000). The combination of exposure to monotonous work and a poor psychosocial work environment produced high risk factors for neck (OR 2.85), and shoulder (OR 3.32) symptoms (Linton 1990). Monotonous work and few possibilities of development (OR 2.6) or low influence over conditions of work (OR 1.7) also increased neck and shoulder symptoms (Fredriksson et al. 2000). According to Ekberg et al. (1995) and Fredriksson et al. (2000) musculoskeletal symptoms may be also signs of ergonomic deficiencies in the workstation and organizational working conditions.

In the general working population there is a link between psychological variables and the prevalence of neck and back symptoms (Pope et al. 1997, Linton 2000, Thorbjörnsson et al. 2000). Prospective studies indicate that psychological variables were related to the onset of pain, and to acute, sub acute and chronic pain. Stress, distress, or anxiety as well as mood and emotions, cognitive functioning, and pain behaviour all were found to be significant factors for musculoskeletal symptoms. Personality factors produced inconclusive results (Linton 2000). In a retrospective nested case-control study, factors at work were seen to be risk indicators for low back pain among both sexes. Low influence over working conditions among women and poor social relations at work among men, in combination with other factors, seems to be of high relevance for the occurrence of low back pain (Thorbjörnsson et al. 2000). In a systematic review of psychological factors at work and outside work it was found that a strong risk factor for back pain was low social support in the workplace and low job satisfaction. Insufficient evidence was found for an effect of a high pace of work, high qualitative demands, low job content, low job control, and psychosocial factors outside work (Hoogendoorn et al. 2000a). In addition, the association between the meaning of work and musculoskeletal symptoms was found to be moderate (Baker et al. 2003).

2.5 Risk factors related to human interaction with computers

The critical review by Smith et al. (1999) indicates risk factors that are related to work activities where human interaction with computers occurs. Many of the stressors in human computer interaction are similar to those that have historically been observed in other automated jobs. These included high workload, high work pressure, diminished job control, inadequate employee training in the use of new technology, monotonous tasks, poor supervisory relations, and fear for job security. In addition, new stressors have emerged that can be linked primarily to human computer interaction. These include technology breakdowns, technology slowdowns, and electronic performance monitoring. In the workplace the effects of these stressors are increased arousal; somatic complaints, especially of the musculoskeletal system; mood disturbances, particularly anxiety, fear and anger; and diminished quality of working life, such as reduced job satisfaction.

Bergqvist et al. (1995) found among VDT workers (n=260) several individual, ergonomic and work organizational factors associated with various upper-body muscular problems: age, gender, women with children at home, use of spectacles, smoking, stomach related stress reactions, negative affectivity, static work posture, hand position, use of lower arm support, repeated work movements, keyboard or vertical position of VDT. Other occupational risk factors which have been associated with self-reported musculoskeletal symptoms were an increased number of hours of keyboard use and improper monitor and keyboard position among college students (n=6) in an experimental laboratory study (Liao and Drury 2000) and among VDT operators (n=292) (Fogleman and Lewis 2002).

Strazdins and Bammer (2004) investigated Public Service employees (73% women and 73% clerical workers) and found gender differences in risk factors. Women's working conditions were more likely to involve physically repetitive work demands. For example, 34% of women compared to 21% of men sat in the same position for long periods of time, 81% of women compared to 73% of men worked longer than 5 hours per day on a computer, and 30% of women compared to 16% of men reported that their job involved repetitive movements all of the time. Women were also more likely to work in poorly designed and uncomfortable environments. 15% of women compared to 10% of men described their work environments as either uncomfortable or very uncomfortable. In addition, women spent considerably less time than men exercising or relaxing during leisure-time. 20% of women did not exercise at all and 14% did not spend time relaxing, over the previous month. This compares to 12% and 10%, respectively, for men. Female gender was determined to be a risk factor in other studies as well (Bergqvist et al. 1995, Ekberg et al. 1995, Hakkarainen et al. 2001, Viikari-Juntura et al. 2001).

A prospective cohort study among occupational computer users by Nelson and Silverstein (1998) found that a reduction in hand and arm symptoms was associated with improved satisfaction with the physical workstation. In contrast VDT workers who reported high job strain were more likely to develop neck-shoulder symptoms during follow-up (Hannan et al. 2005).

One explanation for the increased number of musculoskeletal symptoms reported in sedentary work or among computer users concern with the existence of low-threshold motor units, which are always recruited as soon as the muscle is activated, and stay active until total muscular relaxation. In the long run and due to lack of recovery, metabolic overload at the membrane level may occur, resulting in degenerative processes leading to cell damage, necrosis and pain (Hägg 1991, Hägg 2000, Sjøgaard et al. 2000, Forsman et al. 2002, Kadefors and Läubli 2002).

In Finland the percentage of the work force engaged in sedentary work rose four per cent unit between 1997 (31%) and 2003 (35%) (TTL 2003). For example, in a population of Finnish administration and office workers studied in 2000, 76% reported that their working positions were most often sedentary (TTL 2003). A similar trend has been found also in other industrialized countries such as Sweden (Fredriksson et al. 2000).

Linton and van Tulder (2001) suggest that workplace programs should assess risk and be tailored to the risk profile of individual or the workplace. Also Hales et al. (1994) and Fogelman and Lewis et al. (2002) successes that among VDT workers the main foci in reducing musculoskeletal symptoms are workstation ergonomics, the need to limit the number of uninterrupted hours at the keyboard and the psychosocial work environment.

2.6 Physical activity

Most of the evidence in the field of workplace physical exercise interventions currently available seems to be related to the effects of regular physical activity rather than to the relationship between dose and response on health-related changes (Kesäniemi et al. 2001). In order to analyse the relationships between these factors, we must first define the concepts. Physical activity (PA) is defined as any bodily movement produced by a contraction of skeletal muscle that substantially increases energy expenditure. PA is an umbrella term encompassing leisure time activity (LTPA), occupational type of activity (OPA) and commuting (Mälkiä et al. 1994, Mälkiä 1996, ACSM 1998, ACSM 2000, Howley 2001, Kesäniemi et al. 2001). LTPA or OPA can be categorised into specific physical exercise and physical training.

The gross cost of an activity is the total energy expenditure, which includes the resting metabolic rate and the cost of the activity itself. The net cost is that associated with the activity alone. The dose of physical activity, or exercise, is described by the characteristics of frequency, duration, intensity, and type of activity. Frequency is described as the number of activity sessions per time period (e.g., day or week). Duration refers to the number of minutes of activity in each session. Intensity describes, in relative or absolute terms, the measured or estimated efforts associated with the physical activity. With these over above measurements, it is possible to calculate the required dose of PA, LTPA, OPA or exercise (ACSM 1998, ACSM 2000, Howley 2001, Kesäniemi et al. 2001).

Acute effects to responses of physical activity or exercise refer to health-related changes that occur during and in the hours after physical activity. Chronic effects associated with physical activity or exercise occurs over time due to changes in the structures or functions of various body systems, independent of acute effects or responses. Acute responses to exercise and chronic adaptations to exercise cannot be viewed in isolation because the frequent repetition of isolated sessions with transient responses produces more permanent adaptations (i.e., chronic effect or responses). In some instances, exercise may have an acute but rapidly disappearing effect. Acute exercise, if repeated, can also have a cumulative effect or one that diminishes gradually. The effect of repeated, acute, low-intensity, physical activities or exercise may also result in small changes that may not be detectable in clinical studies but nonetheless have a discernible effect if adopted by large populations (ACSM 1998, ACSM 2000, Kesäniemi et al. 2001, Linton and van Tulder 2001).

2.7 The effectiveness of physical activity programs at workplaces

Studies of effectiveness of physical activity programs in the workplace were examined with respect to physical, psychological functioning, environmental factors and general subjective well-being outcomes. A computerized literature search, a reference search, and a manual search of personal databases from 1996 to November 2005 were utilized to find the latest published workplace physical exercise intervention review studies, RCTs and cluster randomized trials (CRT). The computerized literature search was conducted in Medline, PEDro and Psychlit. The key search words used were divided into four headings; work, exercise, pain, and well-being. Key words under work were words such as workplace, worksite, and work ability. Under exercise the key words were exercise, exercise therapy, physical fitness, physical activity, training, and physical exercise. Under pain the key words were back pain, low back pain, headache, neck pain, and shoulder pain. Under well-being such key words as well-being, psychosocial functioning, self-confidence, somatic symptoms, anxiety, mood, and stress (psychological) were searched. Studies were included that were published in English. Reviews and RCT studies on the effectiveness of workplace physical exercise interventions are presented in TABLE 1 (in TABLE 1 RCT studies were presented only if they were not included in the reviews).

TABLE 1 Reviews and RCT studies on the effectiveness of workplace physical exercise interventions

a) Review studies on the effectiveness of workplace physical exercise interventions

Study	Materials	Study designs	Methodological description	Outcomes
Griffiths (1996)	no reported	no reported	Methodological problems	Benefits: 1) for individuals 2) more for physical health than psychological well-being
Shephard (1996)	52 studies	5 RCT 13 CT	Methodological problems	1) Small positive changes: body mass, skin folds, aerobic power, muscle strength, flexibility, overall risk-taking behaviour, systemic blood pressure, serum cholesterol, cigarette smoking 2) Improved mood state based only on uncontrolled studies
Drisman et al. (1998)	26 studies	13 RCT 13 CT	Generally poor	1) Inconclusive effect: physical activity, physical fitness
Maher (2000)	13 studies	5 RCT	Moderate quality - Mean value 4.8 (range 1-8) in scale 0-11	Back pain: 1) Effective: workplace exercise 2) Ineffective: braces and education 3) Unknown: workplace modification plus education
Linton (2001)	27 studies	20 RCT - exercise 6 - lumbar support 4	Not assessed	Back and Neck problems: - Effective: exercise - Ineffective: lumbar supports,

		- back school and education 10		back school - Unknown: ergonomic intervention
Proper et a. (2002)	8 studies	4 RCT 4 CT	Generally poor - Mean value 4.1 (range 1-7) in scale 0-9	1) Limited: absenteeism 2) Inconclusive: job satisfaction, job stress, employee turnover 3) Nil: productivity
Proper et al. (2003)	26 studies	15 RCT 11 CT	Generally poor - Mean value 3.2 (range 0-6) in scale 0-9	1) Strong: physical activity, musculoskeletal disorders 2) Limited: fatigue 3) Inconclusive or no evidence: physical fitness, general health, blood serum lipids, blood pressure
van Poppel et al. (2004)	16 studies	11 RCT	In most studies low - Mean value 6.1 (range 1-12) in scale 0-15	Back pain: 1) Positive effect, indicating limited evidence for the effectiveness of exercise. 2) No evidence for education and lumbar supports.
Tveito (2004)	26 studies	25 CT - education 11 - exercise 6 - back belts 5 - multidisciplinary 2 - pamphlet 1	Overall low - Medium in exercise studies in scale: low, medium, high	Exercise studies (6 studies) 1) Limited evidence: episodes of LBP, sick leave, cost 2) No evidence: pain

b)RCT studies on the effectiveness of workplace physical exercise intervention not reported in the review studies

Study	**Materials**	**Study designs and methodological description**	**Intervention**	**Outcomes**
Nurminen et al. 2000; 2002	Cleaning company's workers, Finland n=260	RCT -PETro Score 7/10 in scale 0-10	1) Group gymnastics: 60 min, 1x week 8 month (26 sessions) 2) Control croup	1) Positive effects: Muscle strength and endurance Neck, upper extremity and knee pain 2) Slightly effects: Physical activity Perceived work ability 3) No effects: Cardiorespiratory fitness, sick leaves, job satisfaction, work ability index
Horneij et al. 2001	Female home-care personnel Sweden n=282	RCT -PETo Score 4/10 in scale 0-10	1) *Individually designed physical training programme (IT)* *(4 sessions)* 2) Work –place stress management (SM) (7 sessions) 3) Control croup (C)	- The IT group reported less interference with work and/or leisure activities due to discomfort in the low back compared wit the control group at the 12month follow-up - The SM group reported increased perceived amount of training at 18 month follow up compared C - The SM group reported greater dissatisfaction with supervisor compared IT and C.
Eriksen et al. 2002	Working population, Norway n=860 employees	RCT -PETro Score 6/10 in scale 0-10	12 weeks Groups: 1) Management training **2**) *Physical exercise* 3) Integrated health programme 4) Control	Specific positive effects in groups: 1) Improved stress management 2) Improved general health, physical fitness and muscle pain 3) Showed the strongest effects affecting most goals set for treatment 4) -

RCT= Randomized controlled trials, CT= Controlled trials

Following paragraphs describe the main findings and give a summary of the results of intervention studies. These reviews mainly concerned physically demanding occupations, physically light occupations being less represented. For example, in these six latest review studies (Macher 2000, Linton and van Tulder 2001, Proper et al. 2002, Proper et al. 2003, van Poppel et al. 2004, Tveito et al. 2004) there were 6 RCT physical exercise interventions studies among sedentary workers (Grønningsäter et al. 1992, Kerr and Vos 1993, Takala et al. 1994, Gerdle et al. 1995, Lee and White 1997, Pritchard et al. 1997). The weakness of these studies was that OPA was not adequately determined in any of them. Usually, occupation was the only variable which describes the subject's OPA or physical workload. Other PA effects on the study results were not even discussed.

In their review article Proper et al. (2003) investigate the effectiveness of workplace physical activity programs on physical activity, physical fitness, and health in which questions about somatic symptoms, psychological complaints and well-being were included. According to the results they found strong evidence that workplace physical activity programs increase the level of physical activity and reduce the risk of musculoskeletal disorders. Limited positive evidence was found on fatigue and inconclusive or no evidence on general health. This limited or inconclusive scientific evidence on the effectiveness of such a program is mainly because of the small number of high-quality trials. The results of Drisman et al. (1998) indicate that the typical workplace intervention has yet to demonstrate a statistically significant increase in physical activity or fitness. They also found out that the effects were smaller in randomized studies compared with studies using quasi-experimental designs. The review by Shephard (1996) reported that participation in workplace fitness programs can enhance health-related fitness and reduce risk-taking behaviour, but that the population effect is limited by low participation rates. Claims of improved mood state are largely based on uncontrolled studies.

In their review article Proper et al. (2002) investigated the effectiveness of physical activity programs in the workplace with respect to work-related outcomes. The evidence was limited for absenteeism, inconclusive for job satisfaction, job stress and employee turnover, and nil for productivity. In the randomized controlled trials in two out of four studies the study population's work was probably physically light (insurance company workers and bank workers). Because of the few high-quality randomized controlled trials, it is strongly suggested that such studies be carried out. In Tveito et al. (2004) exercise interventions (n=6) among physically demanding occupations showed limited evidence of effects on sick leave, costs and new episodes of low back pain, and no evidence of an effect on level of pain.

TABLE 2 The effectiveness of a workplace physical exercise intervention within a modified ICF framework according to reviews

Effect of workplace physical activity programs at workplaces according to review articles	**Part 1: Functioning and Disability**		**Part 2: Contextual Factors**	
Components	Body Functions and Structures	Activities and Participation	Environmental Factors	
Domains	Body functions Body structures	Life areas (tasks, actions)	External influences on functioning and disability	
Constructs	**Changes in** **Body functions and structures** (physiological and psychological)	**Changes in** **Capacity** Executing tasks in a standard environment **Performance** Executing tasks in the current environment	**Changes in** Facilitating or hindering impact of features of the **physical, social and attitudinal world**	**Changes in** **General subjective well-being**
I. Statistically significantly positive effect				
1) Griffiths 1996	1) Risk for coronary heart disease ↓, cancer↓, osteoporosis↓, osteoarthritis↓, inflammatory joint disease↓, low back pain ↓			
2) Shephard 1996	2) Body mass↓, skin folds↓, aerobic power↑, muscle strength↑, flexibility↑			
3) Drisman et al. 1998	3) Physical fitness↑	3) Physical activity ↑		
4) Maher 2000	4) Low back pain↓			
5) Linton and van Tulder 2001	5) Neck and low back pain↓			
6) Proper et al. 2002		6) Absenteeism ↓		
7) Proper et al. 2003	7) Musculoskeletal disorders↓	7) Physical activity↑		
8) van Poppel et al. 2004	8) Low back pain ↓			
9) Tveito et al. 2004	9) Low back episodes ↓	9) Sick leave ↓	9) Cost ↓	
II. No statistically significantly effect				
1) Griffiths 1996	1) Psychological health	1) Absenteeism	1) Work related stress, financial benefits	
2) Proper et al. 2003	2) Physical fitness, General health			
3) van Poppel et al. 2004	3) Low back pain		3) Job satisfaction, job stress, employee turn over, productivity	
4) Tveito et al . 2004	4) Low back pain			
III. Statistically significant negative effect	-	-	-	

In sum, although it is commonly held that physical exercise interventions in the workplace promote employees' physical and psychosocial well-being, the scientific evidence on the effectiveness of such programmes remains limited (Griffiths 1996, Shephard 1996, Drisman et al. 1998, Macher 2000, Proper et al. 2002, Proper et al. 2003, van Poppel et al. 2004, Tveito et al. 2004). Exercise programs confer more significant benefits on the physical functioning of subjects, especially musculoskeletal symptoms, than on psychological functioning (Griffiths 1996, Shephard 1996, Drisman et al. 1998, Maher 2000, Proper et al. 2003, van Poppel et al. 2004) or work-related outcomes (Proper et al. 2002). In addition in the ICF framework the benefits of physical exercise interventions, according to the reviews, were connected more to the physiological Body Functions and Structures component than to the Activities and Participation or Environmental components. Also several results from RCTs (Nurminen et al. 2000, Horneij et al. 2001, Eriksen et al. 2002, Nurminen 2002) support these review studies findings. TABLE 2 presents the results of reviews according to the components of the modified version of ICF: Body Functions and Structures, Activities and Participation, Environmental factors and General subjective well-being.

2.8 Study designs and the methodology of trials in the workplace

Many previous studies have recommended performing more randomised, controlled trials of high methodological quality. Internal validity scores like randomization, treatment allocation, drop-out rate, blinding, intention-to-treat analysis, relevant outcome measures and definition of the intervention should be taken into account (Shephard 1996, Drisman et al. 1998, Proper et al. 2002, Proper et al. 2003, Liddle et al. 2004, van Poppel et al. 2004, Tveito et al. 2004, Dworking et al. 2005). In addition to that co-interventions should be avoided and compliance with the treatment (van Tulder et al. 1997 a b, van Tulder 2000) and the adverse effects reported (Liddle et al. 2004). It is difficult to implement randomized controlled studies in the workplace (Shephard 1996, Tveito et al. 2004), as both management and staff should accept a random assignment of employees between two alternative types of treatment. The study design is also often less than satisfactory because the supposed control groups are contaminated by extensive daily contact with the treatment intervention participants in the workplace (Shephard 1996). In addition it is very difficult, and perhaps impossible, to blind subjects and therapists in studies of exercise therapy (Shephard 1996, Koes and Hoving 1998, van Tulder 2000, Liddle et al. 2004).

In the cluster randomized and cross-over study design each cluster and also each employee within each cluster receives both the treatment and control interventions, but in a different order. In the intervention studies of workplace few examples of CRT have been described, Simpson et al. (2000) used CRT in their workplace health project and Menzies et al. (1993) used CRT and crossover designs in their sick building syndrome study. Neither of these studies used physical exercise as a treatment in their interventions. Takala et al. (1994) used a RCT cross-over study design among women employed in a printing company with light sedentary work. To the best of our knowledge, there is no evidence that CRTs and cross-over studies have been used in the context of a physical exercise intervention in the workplace.

3 PURPOSE OF THE STUDY

The aims of this study were, among office workers, to investigate

1. the feasibility of the physical exercise intervention

2. the effects of a 15-week physical exercise intervention on Body Functions and Structures, Activities and Participation, social Environment Factors at work and general subjective well-being

3. the changes in physical and psychological functioning, work ability, work-related environmental factors and general subjective well-being 12 months after the physical exercise intervention baseline measurements

4. the relationships between physical and psychosocial prerequisites of functioning, work ability and general subjective well-being

4 MATERIAL AND METHODS

4.1 Subjects, study designs and randomization in the CRT study

Study subjects, cluster randomisation, the cross-over study design and the groups analysed in the study population (Studies I-III, Intervention stydy) are presented in a flow chart in FIGURE 2. The flow chart was designed according to Consort statement: extension to cluster randomized trials information by Campbell et al. (2004).

At the level of the cluster the criterion for inclusion was physically light work performed by workers in various departments of the City of Kuopio's central administration. Four different-sized departments, with a combined population of 123 office workers were selected. Average intensity of OPA was 1.5 metabolic equivalent (MET) measured according to questionnaires (Mälkiä 1994, Mälkiä 1996).

90 volunteer workers (73%) from the four departments took part in the physical exercise intervention [66 women and, 24 men, mean age 45.7 (SD 8.5) years]. The volunteers' level of education was mainly college or university (86%), and they had spent an average of 13 years in their current workplace.

The volunteers` state of health was assessed in collaboration with an occupational health physician, and was based on the answers given to the working ability questionnaire and the intensity of pain or discomfort experienced during the past 7 days. Telephone contact was used to confirm the time of an accident, possible degree of disability and the factors underlying pain or discomfort [Borg CR10 scale ≥5 (Borg 1998)] (n=28). Two volunteers were advised to contact their physician personally. None of the subjects met the exclusion criteria, which were as follows: difficult or neglected diseases, acute injury, postoperative state, inflammation, or neurological signs.

Among the study population of office workers the most common areas of musculoskeletal complaint in the 12-month and 7-day recall were shoulders, head, neck and low back. Women reported more symptoms in the shoulders and low back in the 12-month recall and 7-day recall and the intensity of symptoms were higher among women than men in the shoulders and low back area. The older workers (46 years≥) did not differ substantially from their younger counterparts. There were no statistically significant differences in the prevalence of headache or neck, shoulder and low back symptoms, and older workers compared to their younger counterparts (≤ 45 years) reported stronger symptoms only in the low back (p=0.048).

The level of psychosocial functioning and work ability of the study populations were quite high. In the 12-month recall men had better psychosocial functioning than women; men had fewer somatic symptoms and less anxiety than women and better self-confidence, mood and meaning of life than women. The younger subjects had a better physical well-being (p=0.043) and work ability index (p=0.000). TABLE 3 gives physical and psychological functioning, work ability, social environmental factors at work and general subjective well-being means and standard deviations by gender. The ICF terminology was used in separating different domains. The prevalence and percentages (%) of musculoskeletal symptoms according to gender are presented in TABLE 4.

TABLE 3 Individual-level baseline information on physical and psychosocial functioning, work ability and general well-being by gender

	Mean (SD)			
	All (n=90)	Women (n=66)	Men (n=24)	p-value*
Age, years	45.7 (8.6)	45.4 (8.6)	46.6 (8.6)	0.559
Height, cm	167.7 (7.7)	164.5 (5.7)	176.3 (5.5)	0.000
Weight, kg	71.3 (13.2)	67.7 (11.4)	81.2 (13.1)	0.000
Current workplace, years	12.7 (8.5)	13.1 (9.4)	12.7 (8.1)	0.856
PHYSICAL FUNCTIONING				
1. Sensory functions and pain				
Intensity of musculoskeletal symptoms (0= Noting at all, 10=very, very strong)				
Headache	1.6 (2.1)	1.9 (2.1)	1.0 (2.0)	0.069
Neck symptoms	1.1 (1.9)	1.8 (2.0)	1.1 (1.7)	0.180
Shoulder symptoms	2.0 (2.4)	2.4 (2.4)	1.0 (1.8)	0.004
Low back symptoms	1.4 (2.0)	1.8 (2.3)	0.6 (1.5)	0.005
Sum index average (10 different areas)	1.0 (1.0)	1.2 (1.0)	0.6 (0.8)	0.000
2. Functions of metabolic system				
Body fat percentage (%)	26.9 (7.2)	29.3 (6.2)	20.3 (4.8	0.000
3. Neuromusculoskeeletal and movement-related functions				
Strength (kg)				
Hand grip strength				
- Right	41.2 (11.8)	36.8 (7.1)	53.6 (12.7)	0.000
- Left	36.6 (10.7)	32.1 (5.4)	49.4 (11.4)	0.000
Upper extremities muscles				

(continues)

- Extension	40.1 (14.9)	32.5 (6.2)	59.0 (12.5)	0.000
- Flexion	52.2 (13.9)	44.8 (5.9)	71.3 (8.7)	0.000
Lower extremities muscles				
- Knee extension	49.5 (16.0)	47.9 (13.1)	63.5 (17.3)	0.000
- Knee flexion	58.8 (14.4)	52.3 (9.7)	74.9 (10.6)	0.000
4. Functions of the cardiovascular and respiratory systems				
Maximum oxygen uptake				
- mL 0_2 x kg^{-1} x min^{-1}	29.1 (8.3)	25.8 (6.3)	38.1 (6.1)	0.000
- MET	8.3 (2.2)	7.2 (1.4)	10.6 (2.0)	0.000
5. Mobility				
Physical activity (MET)				
Leisure time (LTPA)				
- Time-weighted intensity	3.7 (2.5)	3.6 (1.9)	5.6 (3.1)	0.005
- Maximum intensity	5.1 (3.3)	4.3 (2.4)	6.9 (4.2)	0.019
All actives time (AT)				
- Time-weighted intensity	2.0 (0.5)	1.9 (0.6)	2.1 (0.6)	0.388
- Maximum intensity	6.0 (2.7)	5.3 (1.8)	7.2 (3.9)	0.063
PSYCHOLOGICAL FUNCTIONING AND GENERAL SUBJECTIVE WELL-BEING (0=worst possible, 100= best possible)				
1. Orientation functions				
Self-confidence	72.7 (14.4)	69.0 (14.2)	82.3 (9.6)	0.000
2. Emotional functions				
Anxiety	74.3 (14.2)	71.8 (13.6)	81.1 (13.7)	0.005
3. Carrying out daily routine				
Physical well-being	77.3 (14.1)	75.7 (14.0)	81.8 (13.8)	0.072
Somatic symptoms	80.1 (14.9)	77.9 (15.6)	86.3 (11.1)	0.018
Mood	73.3 (15.5)	70.9 (16.3)	79.8 (10.7)	0.015
4. Life satisfaction	74.0 (14.6)	72.4 (14.7)	78.2 (13.6)	0.098
5. Meaning of life	80.7 (15.7)	78.2 (17.1)	87.3 (8.5)	0.009
WORK ABILITY (7=worst, 49=best) **AND SOCIAL ENVIRONMENTAL FACTORS AT WORK** (0=worst possible, 100= best possible)				
Work ability index	40.9 (5.6)	40.1 (5.9)	42.3 (4.7)	0.108
Mental stress at work	58.2 (22.6)	57.2 (23.3)	61.0 (20.9)	0.483
Working atmosphere	67.5 (21.2)	65.5 (22.5)	73.1 (16.3)	0.134

* Independent Sample b-test or Mann-Whitney test

TABLE 4 Prevalence and percentages of musculoskeletal symptoms during the 12-month period preceding the physical exercise intervention by gender.

	12 month prevalence of musculoskeletal symptoms (%)			
	All (n=90)	Women (n=66)	Men (n=24)	p-value*
Headache	73 (81.1)	58 (87.9)	15 (62.5)	0.013
Neck symptoms	66 (73.3)	52 (78.8)	14 (58.3)	0.063
Shoulder symptoms	73 (81.1)	62 (93.9)	11 (45.8)	0.000
Low back symptoms	63 (70.0)	51 (77.3)	12 (50.0)	0.019

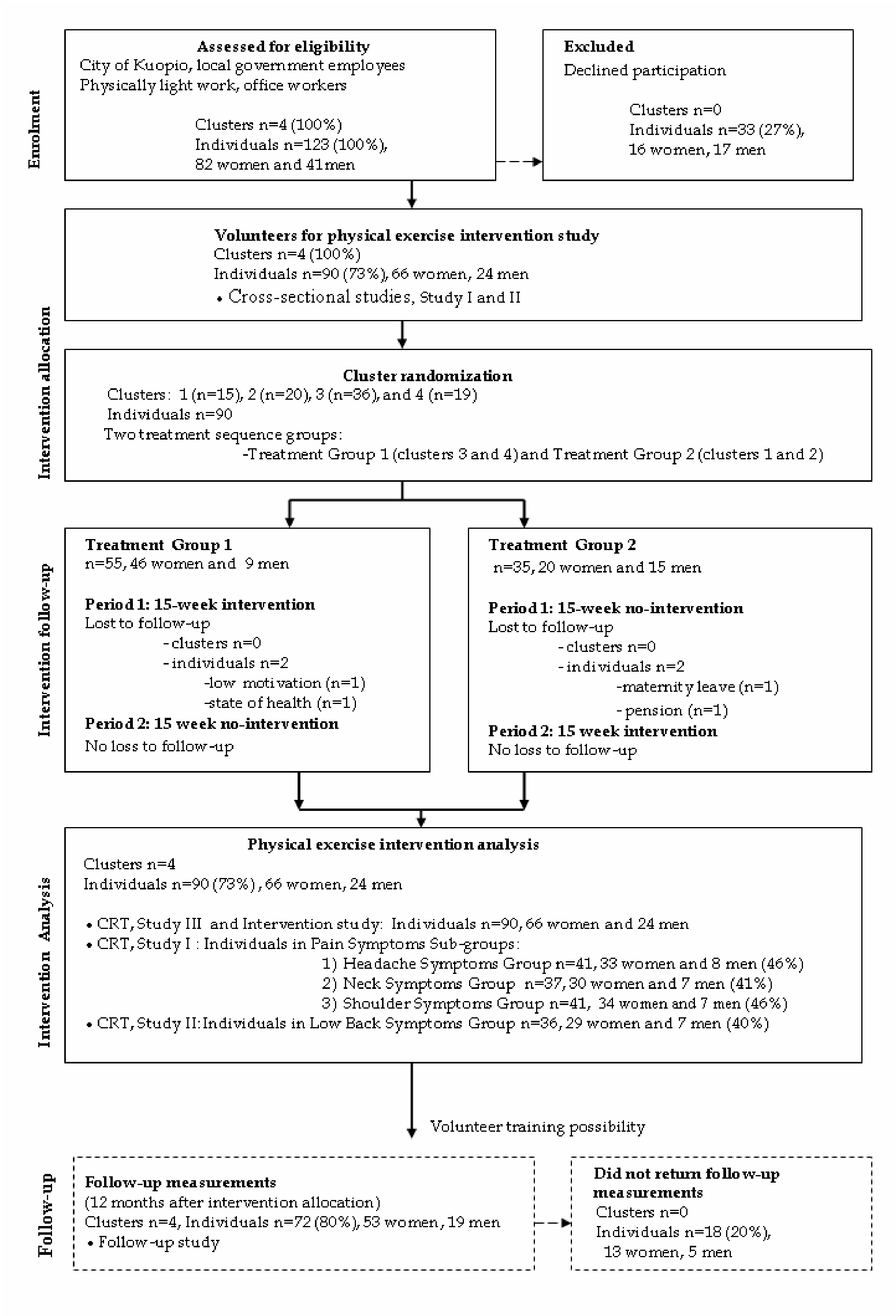
* Fisher's Exact Test

The rate of participation in the physical exercise intervention study was higher among the women (p=0.019). There were no other differences in the personal factors, e.g. age, or education, between those who volunteered to take part in the physical exercise intervention study and those who refused to participate. The only difference was in maximum oxygen uptake, according to the self-reported "Non-exercise" (N-Ex) questionnaire (Jackson 1990), which was slightly better (p=0.012) among those who refused (n=21) to participate in the physical exercise intervention study.

The physical exercise intervention study was a cluster randomised – controlled cross-over design. We used cluster randomization in our clinical trial for logistic, ethical and financial reasons. We also wanted to minimize contamination between control and treatment groups. In the individual-based randomization the possibility of contamination of control group subjects by extensive daily contact in the workplace with treatment group subjects should be considered.

Baseline measurements were performed before the first intervention period in September, 1999. After the baseline measurements, the "blind" measurers allocated the workers into the two treatment sequence groups, Treatment Group 1 and Treatment Group 2, using cluster randomization. Treatment Group 1 contained clusters 3 (n=36) and 4 (n=19), and Treatment Group 2 contained clusters 1 (n=15) and 2 (n=20). In the first period (autumn), Treatment Group 1 took part in the intervention while Treatment Group 2 did not. In the second period (spring), the roles were reversed so that now Treatment Group 2 took part in the intervention while Treatment Group 1 did not. The cross-over design was conducted without any washout time between the two treatments periods. Therefore, the second period commenced immediately after the first period in January. Both periods lasted for 15 weeks. The sequence was not revealed until the interventions were assigned.

FIGURE 2 Study design, randomisation, and study subjects in the CRT and follow-up study



Effects of a physical exercise intervention on the prevalence of headache and musculoskeletal symptoms in neck, shoulder and low back (Intervention study) and on the subjective well-being, psychosocial functioning and general well-being among office workers (Study III) were analysed in a group of 90 volunteers` [66 women, 24 men, mean age 45.7 (SD 8.5) years]. In studying the effects of a workplace physical exercise intervention on the intensity of headache and neck and shoulder symptoms and upper extremity muscular strength in office workers (Study I) the criteria for inclusion were headache or pain or discomfort (=symptoms) in the neck or shoulders, which to some degree had restricted participation in daily activities during the 12-month period preceding the intervention. Of the 90 volunteers, 53 met one or more of the inclusion criteria. These 53 subjects [43 women, 10 men, mean age 46.6 (8.4) years] were labeled the Pain Symptoms Group and were categorized into three partially overlapping Pain Symptoms Sub-groups: the Headache Symptoms Group (n=41; 33 women, 8 men), the Neck Symptoms Group (n=37; 30 women, 7 men), and the Shoulder Symptoms Group (n=41; 34 women, 7 men). The criteria for exclusion from this study were no restriction in daily activities during the last 12 months due to headache, neck or shoulder symptoms (n= 37, 23 women, 14 men). In studying the effects of a workplace physical exercise intervention on the intensity of low back symptoms in office workers (Study II) the criteria for inclusion were low back pain and discomfort (=low back symptoms), which to some degree had restricted participation in daily activities during the 12-month period preceding the intervention. Of the 90 volunteers, 36 subjects [29 women, 7 men, mean age 47.1 (SD 8.4) years] who met the inclusion criteria formed the Low Back Symptoms Group. The criteria for exclusion from this study was no restriction in daily activities during the last 12 months due to low back symptoms (n=54, 37 women, 17 men).

4.2 Study subjects and study designs in the follow-up study

The follow-up measurements were conducted 12 months after the baseline measurements by postal questionnaires. Of the 90 volunteers, 72 (80%) subjects returned the mailed questionnaires [53 women, 19 men, mean age 47.5 (SD 7.9) years], 18 subjects (13 women, 5 men) did not return the questionnaires.

There were no statistically significant differences in personal factors, anthropometric measurements, maximum oxygen uptake, intensity of musculoskeletal symptoms, psychosocial functioning or work ability in the baseline measurements between the subjects who returned the questionnaires and those who did not. At the baseline there was only a minor difference in PA: maximum MET intensity during LPTA was reported as slightly higher (p=0.033) among those who returned the questionnaires (n=72) in the follow-up study. Because of the cross-over study design in the CRT the follow-up study design was no longer a CRT.

4.3 Study subjects and study designs in descriptive cross-sectional investigation at the baseline

Physical and psychosocial prerequisites of functioning in relation to work ability and general subjective well-being among office workers (Study IV) was a descriptive cross-sectional investigation, using path analysis, of office workers. The subjects comprised 88 volunteers, 24 men and 64 women [mean age 45, 7 (SD 8.6)].

4.4 Measurements

The measurements were performed in the research institute or in the departments' own training facilities using identical physical fitness testing equipment and questionnaires. During the intervention physical and psychosocial functioning was measured at 5-week or 15-week intervals. The main measurements were performed in the research institute (baseline, 15-week, 30-week) and lasted two hours per subject, and the interval measurements (5-week, 10-week) performed in the departments' own training facilities lasted one hour per subject. Follow-up measurements were performed 12 months after the intervention baseline measurements by mailed questionnaires. APPENDIX 1 shows the measurement schedule and the position of the physical exercise intervention in Treatment Groups 1 and 2 and the measurements used at each measurement point. FIGURE 3 shows the measured components in physical exercise intervention; dose, responses and controlled factors.

In this study measurements which were common in rehabilitation studies were used. These measurements are well standardized, reference values exist and the validity and reliability values are considered acceptable. Even so, in this study we investigated the consistency of our measurements by means of a pilot study conducted among a similar sedentary occupational population (n=14-15). Intraclass correlation coefficients (ICC) or percentages of agreement of questionnaires were used to calculate the consistency of our measurements. Physical and psychosocial questionnaires were administered twice with a one week interval and physical measurements performed three times at intervals of three days. According to the scale by Baumgartner (1989), the ICC consistency values were acceptable, varying between fair and high. The physical and psychosocial questionnaire test-retest ICC values ranged between 0.61 and 0.96, the physical testing intraobserver ICC values between 0.75 and 0.98 and the interobserved ICC values between 0.69 and 0.98. The test-retest percentage of agreement for the modified standardized Nordic questionnaire was 60-100%. Details of the data collection, measurement scales, the consistency and validity of the measurements, the indicators of standardization, and the reference values for measurements are presented in the tables of APPENDIXES 2-4.

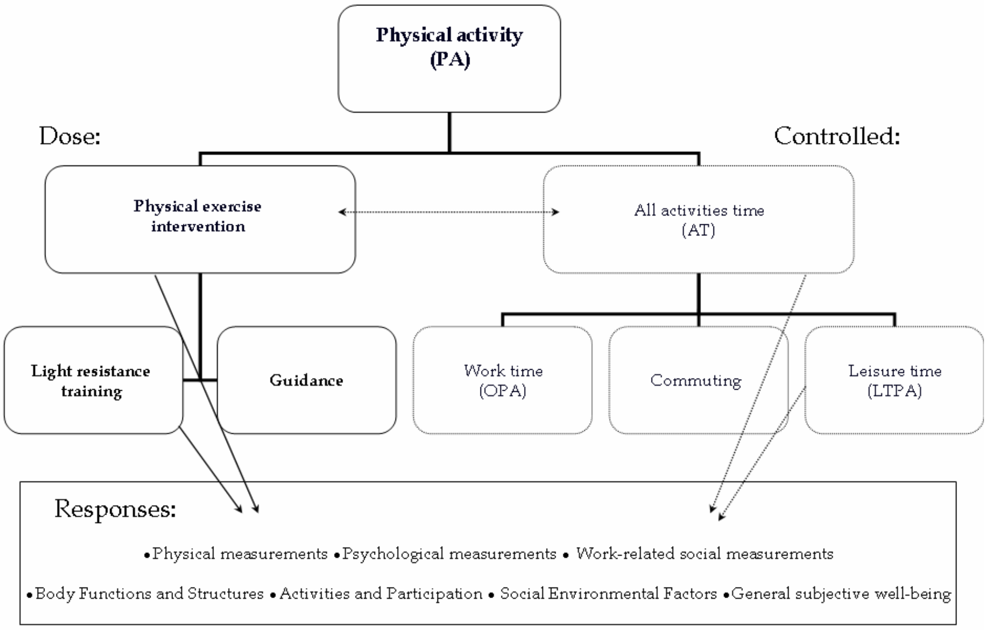


FIGURE 3 Measured components in physical exercise intervention; dose, responses and controlled factors

In this study the modified ICF model was taken as the framework in classifying physical and psychosocial measurements. Meaurements were done according to components in Body Functions and Structures, Activities, Participation, Environmental factors and Personal factors. In addition general subjective well-being measurements and measurements of feasibility of the physical exercise intervention were performed. FIGURE 4 presents the measurements used in this study according to the component of the modified version of the ICF and the numerical classification of ICF is presented in APPENDIXES 2-4.

The ICF classification was performed according to the World Health Organization ICF general coding rules (WHO 2001). As the functioning of a person can be affected at the body, individual and societal level, the user should always take into consideration components of the classification, namely Body Functions and Structures, Activities and Participation, and Environmental factors. Users will select the most salient codes for their purpose to describe a given health experience. Information that reflects the person’s feeling of involvement or satisfaction with level of function is currently not coded in (WHO 2001).

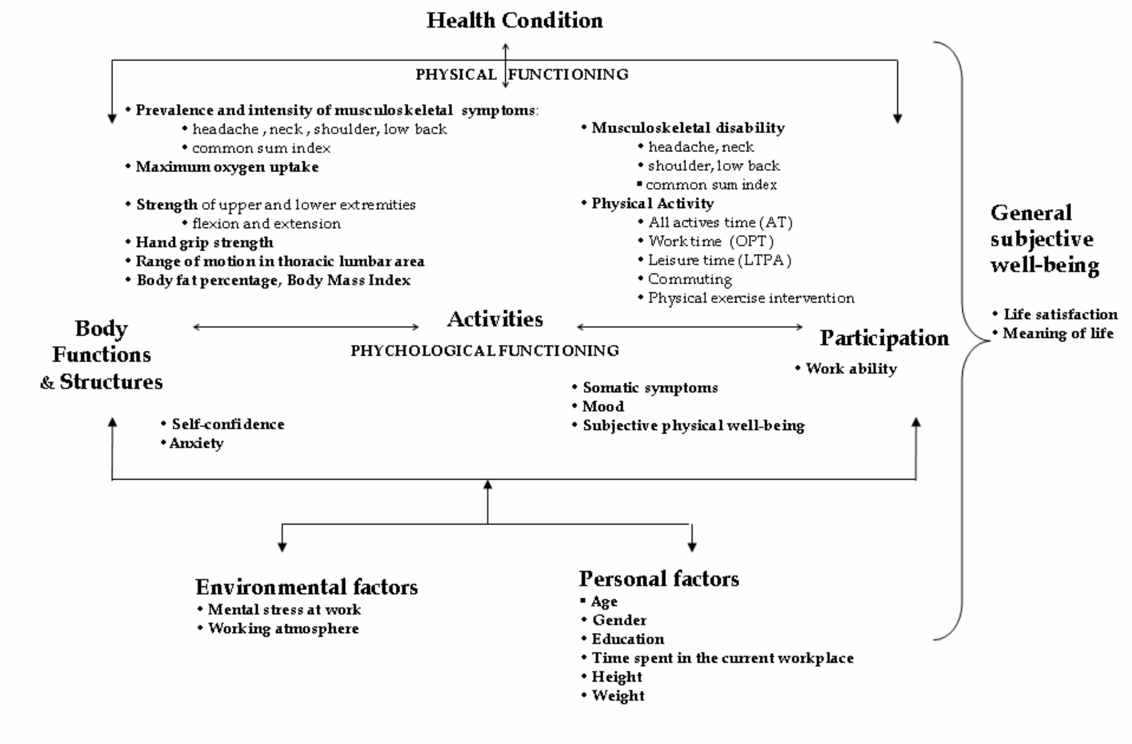


FIGURE 4 Interactions between the components of the modified version of the International Classification of Functioning, Disability and Health (ICF) and the variables used in this study

The following paragraphs describe the measurents used in this study according to components in Body Functions and Structures, Activities and Participation, Environmental factors and Personal factors. In addition, the general subjective well-being measurements and measurements of the feasibility of the physical exercise intervention are described.

4.4.1 Measurements of Body Functions and Structures

Body Functions are the physiological functions of body systems, including psychological functions (WHO 2001). First we reported our physical functioning measurements an, second, our psychological functioning measurements.

4.4.1.1 Sensory functions and pain

Prevalence of musculoskeletal symptoms

The prevalence of musculoskeletal ache, pain, discomfort (= symptoms) during the past 12 months and 7 days was measured by modified Standardised Nordic questionnaires. In the Standardised Nordic questionnaires the general questionnaire was designed to answer the following question: Do musculoskeletal symptoms occur in a given population and, if so, in what parts of the body are they localised? The estimated nine anatomical areas were neck/back of the head (=neck), shoulders, elbows, wrists/hands, upper back, low back, hips, knees and ankles/feet. (Andersson et al. 1987, Kuorinka 1987). In addition to the preceding list we added headache as symptom. (Study II, Intervention study, Follow-up study).

Intensity of musculoskeletal symptoms

The intensity of musculoskeletal symptoms experienced during the previous seven days was measured using the Borg CR10 scale. The scale describes the subjective level of symptoms. The scale varies from "nothing at all" (0) to "extremely strong" (10) symptoms. "Extremely weak" corresponds to 0.5 on the scale and is the threshold of what it is possible to perceive. Subjects start with a verbal expression and then choose a number. The reliability and validity of the Borg CR10 scale are good (Borg, 1998), and it has been recommended for use in exercise studies (ACMS, 2000). (Study I, II, IV, Follow-up study).

4.4.1.2 Functions of the cardiovascular and respiratory systems

Maximal oxygen uptake

Maximum oxygen uptake (=$V0_{2max}$) is accepted as the criterion of cardiorespiratory fitness. VO2max is the product of maximal cardiac output (L/min or mL 02x kg-1 x min-1) and arterial-venous oxygen difference (mLO_2/L) (ACSM 2000). Maximal oxygen uptake was measured by a questionnaire without using an exercise test (N-Ex) according to gender, age, body mass index (=BMI), and self–reported activity. In a variable sample of normal adults, the N-Ex models were more accurate than the well established Åstrand sub maximal models. The major limitation of the N-Ex models is poor discrimination between highly fit individuals. This may be related to the scoring of the activity code scale (Jackson et al.1990). (Study IV).

4.4.1.3 Neuromusculoskeletal and movement-related functions

Muscular strength is specific to the muscle or muscle group, the type of muscular contraction (static or dynamic; concentric or eccentric), the speed of muscular contraction and the joint angle being tested. Muscular strength refers to the maximal force that can be generated by a specific muscle or muscle group.

Strength of upper and lower extremities

The one-repetition maximum (1RM) for the upper and lower extremities was estimated with the sub-maximal 5RM test (McDonagh and Daves, 1984, Braith et al. 1993, ACSM 2000) using air resistance equipment (HUR Ltd, Finland). The standardized test movements were upper extremity extension and flexion and knee flexion and extension. A metronome was used to define the speed of muscular contraction. The average movement performance time for a single repetition of a testing movement was 3.0 seconds. The subjects performed five sets of repetitions with loads of 10 kg, 20 kg, 30 kg etc., until they were unable to perform the defined sets properly. Pain was not allowed to increase during testing by more than 5 units on the Borg CR10 scale (Borg 1996). The resting period between the 5RM test sets was 1 minute, with 3 minutes between the different test movement stations. The upper extremity extension and flexion and knee flexion and extension 1RM values were estimated according to the 5RM value according to scheme [(-4.18 x R.M. value of load) + 103] published by McDonagh and Daves (1984). In this study 1RM and training load (30% 1RM) was read from the TABLE 5. (Study I, II, III, Intervention study).

TABLE 5 Table of 5RM, 1RM and 30% 1RM

5 RM*)	1RM*)	30% 1RM*)
10	12	4
20	24	7
30	37	11
40	49	15
50	61	18
60	73	22
70	85	26
80	97	29

*) kg

Hand grip strength
Hand grip strength was measured with an anatomically adjusted strength gauge in the standardized sitting position (Mälkiä 1983, Mathiowetz 1990). The test was repeated three times in each hand. Hand grip strength was defined as the best of three trials. (Study IV).

Active range of motion in thoracic lumbar area
Flexibility is the ability to move a joint through its complete range of motion. It is important in athletic performance and in the ability to carry out the activities of daily living. Flexibility depends on a number of specific variables, including distensibility of the joint capsule, adequate warm-up, and muscle viscosity. Additionally, compliance of various other tissues such as ligaments and tendons affects the range of motion (ACSM 2000). Lumbar and thoracic active range of flexion (=spine forward flexion) was measured with a Myrin goniometer (Kuntoväline Oy, Finland) in the sitting position (Mellin 1986, Mellin 1987) after one training movement. Pain was not allowed to increase during testing by more than 5 units on the Borg CR10 scale (Borg 1996). (Study IV).

4.4.1.4 Functions of metabolic system

Body fat percentage was measured using bioelectrical impedance with the manufacturer's equations (Spectrum II, RJL Systems, Detroit, MI, USA). The coefficient of variation between two consecutive bioelectrical impedance measurements has been in the order of 2-3% (Sipilä et al. 1996) (Study IV).

Body mass index was (BMI) used to assess weight relative to height and is calculated by dividing body weight in kilograms by height in meters squared (kg/m^2). (Follow-up study).

4.4.1.5 Mental functions

Self-confidence and anxiety
Self-assessed subjective anxiety and self-confidence were measured by descriptive visual rating scales. On the scale, 0 represented the worst possible and 100 the best possible self-confidence or anxiety. 50 represented the neutral position (Ojanen, 1994; Ojanen, 2000). In descriptive visual rating scale subjects draw a short line across the vertical line at the point that best corresponds to their self assessment. (Study II, III, IV).

4.4.2 Measurements of activity

An activity is the execution of a task or action by an individual (WHO 2001). First, we reported our physical functioning measurements and, second, our psychological functioning measurements.

4.4.2.1 Mobility

Physical activity at work, and during commuting, leisure time and miscellaneous time
Physical activity is defined as any bodily movement produced by contraction of the skeletal muscles that substantially increases energy expenditure (Mälkiä 1994, Crespo 1999, Howley 2001). Physical activity was measured by the one-month all-time recall questionnaire, where activity was divided into work, commuting, leisure time and miscellaneous time such as gardening or homework. The type of activity, frequency, duration and intensity of physical activity were converted to MET values with the aid of a special computer programme (MetPro®, SciReha Ltd, Jyväskylä, Finland). The intensity of physical activity was assessed on the basis of getting out of breath and sweating (Mälkiä, 1994, Mälkiä, 1996). 1MET represents the approximate rate of 0_2 consumption of a seated individual at rest = 3.5 $mlxkg^{-1}xmin^{-1}$ (ACSM 2000, Howley 2001). In our study we used gross cost of physical activity values, which included the resting metabolic rate and the cost of the activity in OPA, LTPA and all activities time (AT), which included OPA, commuting and LTPA.

We used three MET-parameters in our study. First, the time-weighted intensity average (TWA), which was calculated for the activity categories by dividing the sum of MET minutes by the total time in minutes. Second, maximum MET intensity (MaxMET), which is the highest observed value in the activity categories, and, third, maximal oxygen consumption were expressed as MET values (Mälkiä et al., 1994, Mälkiä 1996, ISO/FDIS 8996, 2004). (Study I, II, III, IV, Intervention study, Follow-up study).

OPA was assessed with a seven-point scale, which was accompanied by illustrations and descriptions of the various types of work corresponding to each scale point. The scale units are in METs from 1.5 (light work) to 10 (extremely strenuous work). In addition, there were two questions about the length of the working day (hours and minutes) and the number of working days during one week. Physical activity during commuting was assessed according to three categories: motor vehicle, bicycle, or on foot. LTPA expressed in the type of activity, frequency, duration and intensity of physical activity (Mälkiä, 1994; Mälkiä, 1996; Ainsworth et al. 2000). Physically harder miscellaneous activity like domestic or gardening activities was analyzed in the category of physical activity in leisure time (LTPA).

Physical activity during the physical exercise intervention

Physical activity during the physical exercise intervention was measured by a diary. Each subject maintained a weekly diary to record training sessions, including the time in minutes spent performing light resistance training during each session. (Study I, II, III, Intervention study).

4.4.2.2 General tasks and demands

Musculoskeletal disability

Self-reported restriction on participation in daily activities because of musculoskeletal symptoms experienced during the last 12 months was measured with a modified version of the standardized Nordic questionnaire (Kuorinka 1987). We changed the scale from a dichotomous (yes/no) answers to an ordinal scale (0-4). On the scale, 0 represented situations where there had been no restrictions on daily activities due to certain musculoskeletal symptoms and 4 a situation where there had been a continuous restriction on daily activities due to certain musculoskeletal symptoms during the last 12 months. (Study I, II, IV, Follow-up study)

Somatic symptoms, mood and physical well-being,

Self-estimated subjective somatic symptoms, mood and physical well-being were measured by descriptive visual rating scales. On the scale, 0 represented the worst possible and 100 the best possible situation, and 50 represented the neutral position (Ojanen 1994, Ojanen 2000). Somatic symptoms, mood and physical well-being were assessed in relation to work and leisure. (Study II, III, IV, Follow-up study)

4.4.3 Measurements of participation and social work-related environmental factors

Work ability

Work ability was measured by the work ability index (Tuomi et al. 1991c, Ilmarinen et al. 1997). The work ability index consisted of assessments of the physical and mental demands of the individual's work, diagnosed diseases, and effect of diseases on working ability, sick leave, work ability prognosis, and psychological resources. (IV, Intervention study, Follow-up study)

Mental stress at work and working atmosphere
Self-estimated subjective mental stress at work and the working atmosphere were measured by descriptive visual rating scales and assessed in relation to the social environment at work. On the scale, 0 represented the worst possible and 100 the best possible situation, and 50 represented the neutral position (Ojanen 1994, Ojanen 2000). (Study II, III, IV, Follow-up study)

4.4.4 Measurements of personal factors

Personal factors consisted of age (years), gender, education, time spent in the current workplace and height (cm) and weight (kg) (I, II, III, IV, Intervention study, Follow-up study).

4.4.5 Measurements of general subjective well-being

Subjective life satisfaction and meaning of life
Subjective well-being is important because personal satisfaction or subjective well-being is of paramount importance to human life (Ojanen 2000). Self-estimated life satisfaction and meaning of life were measured by descriptive visual rating scales. On the scale, 0 represented the worst possible and 100 the best possible situation, and 50 represented the neutral position (Ojanen 1994, Ojanen 2000). (Study III, IV, Follow-up study)

4.4.6 Measurements of feasibility of the physical exercise intervention

Measurements of feasibility of the physical exercise intervention were measured according to various measures of adherence. The first of these training sessions adherence is the percentage ratio of self-reported training sessions and guided training sessions. The second, training adherence is the average percentage ratio of self-reported training time and guided target time. Self-reported resistance training time was calculated according to the weekly training diary and target training time was calculated according to the guided training frequency and the average time spent being physically active in a single session (6 minutes). The third, guidance adherence, is the percentage rate of participation in the three group sessions. The fourth, measurement adherence, was the average rate of return of the physical and psychological and work-related environmental questionnaires. In addition the light resistance training percentage proportion of other physical activity (LTA and AT) was measured.

4.5 Physical exercise intervention in CRT study (Study I, II, III, Intervention study)

The intervention consisted of progressive light resistance training and guidance. The participants were entitled to take time out during the working day to train by themselves in the departments' own training facilities when they felt the need to counterbalance their sedentary work or to obtain relief from monotonous and fixed working positions. The time at which training could be performed during the working day was not restricted. During the first five-week period, the non-supervised light resistance training was to be performed once each working day (5 times a week). During the second and third 5-week periods, the resistance training was to be performed 1-2 times each working day (a total of about 7-8 times a week). Individual training resistances were controlled twice during the 15-week period at the research institute or in the departments' own training facilities. At the department level, a physiotherapist gave three group sessions on how to train and general guidance on postural and movement control.

The resistance training was defined as light according to previous studies (ACSM 1998, Borg 1998, Kaikkonen et al. 2000). In our two pilot studies before the start of the physical exercise intervention we utilized participants´ perceptions of exertion (Borg RPE 6-20) during light resistance training to set the training load to 30 % of 1RM and participants´ opinions to select suitable training equipment for the workplace.

4.5.1 Light resistance training

The light resistance training consisted of six dynamic symmetrical movements: upper extremity extension, upper extremity flexion, trunk rotation to the right, trunk rotation to the left, knee extension and knee flexion (FIGURE 5). The training movements were carried out 20 times with a 30-second pause between the training movements. There was no defined sequence between the training movements, except that the physiotherapist recommended that the upper extremity movements' flexion should be performed after extension. The training resistances of 30% of one 1RM (McDonagh & Daves, 1984) for each movement were estimated at five-week intervals for each individual with a sub-maximal 5RM test performed using air resistance equipment (HUR Ltd, Finland). The training load for the right and left trunk rotation movements was determined from the result for the upper extremity flexion movement. The training load averages during the physical exercise intervention period in upper extremity extension were 17 kg among men and 10 kg among women, and in upper extremity flexion and trunk rotation to the right and left 21 kg among men and 14 kg among women. Among men knee extension was 19 kg and knee flexion was 21 kg. Among women the corresponding values were 13 kg and 15 kg. The average movement performance time for a single repetition of a training movement was 1.8 seconds and average training time in one light resistance training session was 6.2 minutes. The estimated target training time in minutes per the first 5-week period was 150 minutes and in the second and third periods 210 minutes, the equivalent of 30/42 minutes per week and 6/8 minutes per working day.

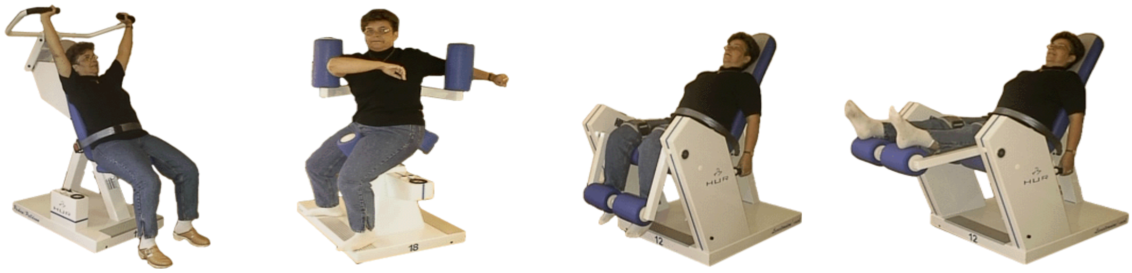


FIGURE 5 Light resistance training consisted of six dynamic symmetrical movements: upper extremity extension, upper extremity flexion, trunk rotation to the right, trunk rotation to the left, knee extension and knee flexion.

Because we also wanted to ensure that our 30% 1RM resistance training was intensive enough, we conducted a third pilot study at the beginning of the physical exercise intervention to measure cardiovascular response (HR, VO_2,RPE) during a light (30% 1RM) exercise session among a similar sedentary occupation population (n=11) (Rönkä et al. 2000). MET values were analyzed using as basic values the 0_2 consumption of a seated individual at rest (3.5 mlxkg^{-1}xmin^{-1}), the heart rate (average 63% HR_{max}) and oxygen consumption (average 35% VO_{2max}), which were measured by the direct method (Cosmed, Italy). The calculated average TWA was 4.2 (SD 1.0) MET during one light resistance training session and the average RPE of all sessions was 12 (SE 0.3). Because in our study population (n=90) the average maximal oxygen uptake in METs was 33% lower than in the pilot study population, the estimated average TWA during one light resistance training session was also lower, being 2.8 (SD 0.7) MET.

4.5.2 Guidance

During the baseline measurement subjects received feedback on their physical functioning from assessors. At the department level, a physiotherapist provided training instructions and general guidance on postural and movement control in three group sessions (3x20 minutes) at 5-week intervals. The subjects learned to use the Borg Rating of Perceived Exertion (RPE 6-20) and pain (CR10) scales (Borg 1998, ACSM 2000) to control their training. The general instruction given was that the perceived exertion should be light (RPE 10-12) and pain levels on the CR10 scale should not temporarily increase by more than one unit from the starting level during an active training session. Moreover, neck, upper extremities and low back position, dynamic muscle contraction, sufficient ranges of motion and respiration were emphasized. Subjects were guided to train under both eyes-open and eyes-closed conditions. Motor control of training movements move from extrinsic feedback (knowledge of performance, knowledge of results) to subjects own intrinsic feedback (muscle force, length, joint position, body position, and vision) (Schmidt 1991). The physiotherapist encouraged the subjects to use the same ergonomic principles: no-loaded positions of neck, upper extremity and low back and dynamic muscle contraction, in work and leisure.

4.5.3 No-physical exercise intervention

During the 15-week no-physical exercise intervention (= no-intervention) period, no light resistance training was performed nor was any guidance provided. The participants simply took part in the measurements.

4.5.4 Avoiding physical and psychosocial co-interventions

Excluding the light resistance training, the participants were asked to keep the level of intensity and amount of their physical activity unchanged during the intervention and no-intervention periods. The occupational health service personnel were told that they should not initiate any new activities in the field of occupational health and safety during the study.

4.6 Training and guidance during the follow up period after the CRT study

After the last intervention measurements the physiotherapist provided all the individuals their own physical and psychosocial intervention results, individual feedback discussions and new instructions for both 30%1RM and 60%1RM training. The participants were also encouraged to take time out during the working day to train by themselves. Three out of four departments were able to keep the training equipment in the departments' own training facilities. One department (number 1) surrendered their training facilities because they needed the space for additional workers.

4.7 Statistical analyses

4.7.1 Statistical analyses in the CRT study (Study I, II, IIII)

We used cluster-specific methods because departments rather than individuals were randomized. The effects of the intervention on the physical and psychosocial functioning were analyzed using linear mixed models (Brown & Prescott 1999, Goldstein 1995). This approach has several advantages over traditional analyses such as ANOVA. Firstly, the clustering effect of department can easily be taken into account in the analysis (people within a certain department tend to be homogeneous). Secondly, there is no need to exclude any subject for whom complete data are not obtained, because data lost during the CRT follow-up can be considered random. Thirdly, it is possible to lighten the familiar assumption of equal error variances with mixed models. Randomisation of departments makes the study design hierarchical, as the subjects are nested within departments and treatment groups. It also brings department as a random part of the model.

The main advantage in cross-over designs is that the intervention and no-intervention are compared within subjects, that is, the response of a subject to an intervention will be contrasted with the same subject's response to no-intervention. Removing subject variation in this way makes cross-over trials potentially more efficient than similar-sized, parallel group trials in which each subject is exposed to only one treatment. In principle, exercise effects can be estimated with greater precision given the same number of subjects (Sibbald & Roberts 1998).

The essential features of the cross-over design were modelled as fixed effects: main effects of treatment (intervention or no-intervention), treatment group [Treatment group 1 (order of treatments ab), Treatment group 2 (order of treatments ba)], treatment period (1=autumn, 2= spring) measurements within the treatment period (1-3), as well as their possible interactions. The random part of the model consisted department effects, the effects of individuals within departments, and their (random) interactions with the fixed factors. The random part is required to account for the clustering effects of departments (on individuals) and individuals (on repeated measurements) in order to obtain standard errors and significance tests that correctly reflect features of the design. Time spent performing light resistance training in the current 5-week period (1-3) in minutes and physical and psychosocial functioning measurements at the baseline were added into the model as covariates.

The model described above was estimated and evaluated first. Then we hierarchically simplified this original model as far as possible by removing the non-significant effects one by one, beginning with the most complex least significant interactions. The model that could not be simplified any further without dropping a significant effect or violating the hierarchy principle (that is, non-significant lower-order effects cannot be removed if a significant higher-order interaction of the same factors is present) was then evaluated against the original model using the Akaike information criterion (AIC) (Sakamoto et al., 1986). If it appeared to fit the data better than the original model, it was selected as the final one. Otherwise we used the original model.

The estimation and significance testing was carried out by the MIXED procedure in the SAS software (SAS 1999), which involved the restricted maximum likelihood (REML) method of estimation (Patterson & Thompson 1971) with related *F* tests. The estimates from the final model were used in calculating the confidence intervals (CI) and performing the significance tests for the effects of the physical exercise interventions.

The effects of the physical exercise intervention on other physical activity performed outside it were evaluated using the same statistical principles as for physical and psychosocial functioning, using linear mixed models (Brown & Prescott 1999, Goldstein 1995).

4.7.2 Statistical analysis in the CRT intervention study

The models and principles in analyzing the effect of the physical exercise intervention on the prevalence (dichotomous yes/no responses) of headache and neck, shoulder and low back symptoms during the past 7 days were the same as in the analysis of the continuous responses mentioned above, with the exception that logistic mixed models were now applied instead of linear mixed models. The modelling and analysis were carried out with the GLIMMIX macro in the SAS software.

4.7.3 Statistical analysis in the follow-up study

The 12-month follow-up measurements were analyzed using the t test for paired samples with normal continuous variables, Wilcoxon signed ranks test for non-normal continuous variables, Marginal Homogeneity test for ordinal scale variables and McNemar test for dichotomous variables. In the paired samples, Wilcoxon and Marginal Homogeneity tests we used means and SD as descriptive parameters. In the McNemar tests we used the percentage values of `yes` answers. For the continuous variables, the validity of the normality assumption was examined by the One-Sample Kolmogorov-Smirnov test.

4.7.4 Statistical analysis in the in descriptive cross-sectional study at the baseline (Study IV)

These statistical analyses were carried out by SPSS 9.0. (SPSS). Path analyses were carried out by the PRELIS 2.30 and LISREL 8.30 programs. In path analysis model fit was assessed using the likelihood ratio test (Jöreskog and Sörbom 1999). The path analysis was performed as follows: first, the physical prerequisites of functioning were inserted into the model as independent variables; second, the psychological prerequisites of functioning and the social environment at work variables were added into the model; and third, age and gender were included in the adjustment analysis as independent variables in both final models.

4.8 Ethical concerns

The study was approved by the ethical committee of the University of Kuopio and the University Hospital of Kuopio.

5 RESULTS

5.1 The feasibility of the CRT physical exercise intervention (Study I, II, III, Intervention study)

Among the office workers (n=90) various measures of adherence were conducted. The first, according to the weekly questionnaire, the self-reported adherence average during a 5-week period was 17 times, which was 53% of the guided sessions. The second, self-reported training time adherence average during a 5-week period was 125 minutes, which was 66% of the estimated target minutes, according to the 6 minutes average training time in one light resistance training session. The third, According to our note, 69% of the subjects participated two or three times in the training guidance sessions. The fourth, measurement adherence, was the average rate of return of the subjective psychosocial functioning and general well-being questionnaires (90%), the Standardised Nordic questionnaires and the Borg CR10 scale questionnaires (85%) and work ability index questionnaires (94%). The self reported and guided mean training sessions, training times (in minutes and MET minutes) and adherence percentage ratios during the intervention according to the training periods are presented in TABLE 6.

The average estimated MET hours (METh) during light resistance training over 5 weeks was 5.8 METh, which was 1.4% of AT (386.9 METh) and 7.4% of LTPA (76.1 METh). The MET hours during 15 weeks' light resistance training and its percentage proportions of AT and LTPA is presented in the framework of physical activity, in FIGURE 6.

TABLE 6 Mean numbers of training sessions, mean training times in minutes and MET minutes as well as adherence percentage ratios during the intervention

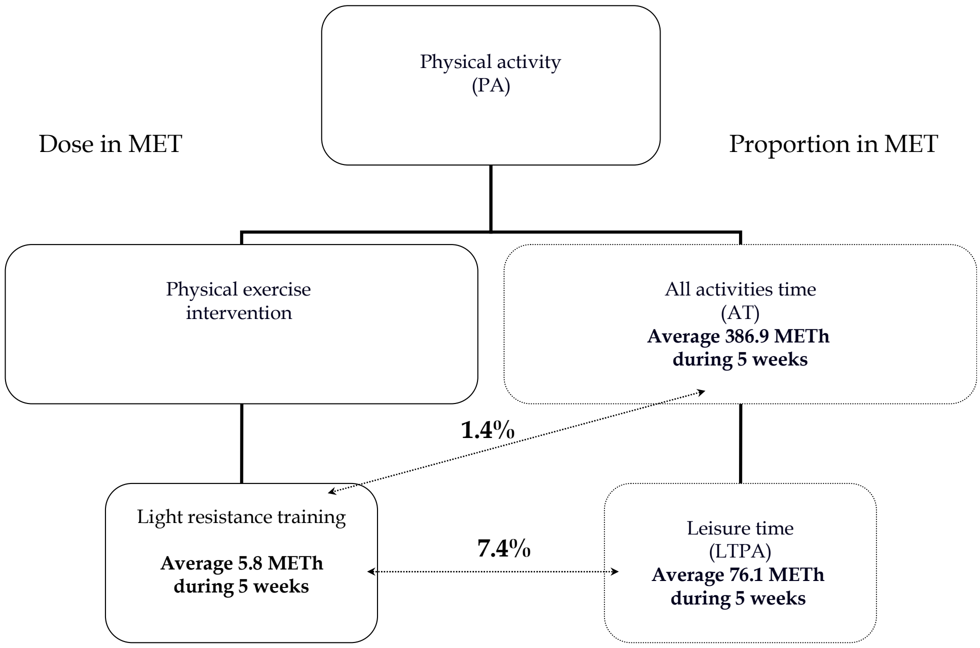
Average number of training sessions of light resistance training

Periods	Self-reported	Guided	Adherence %
First 5-week	14	25	56
Second 5-week	21	35	60
Third 5-week	15	35	43
Total 15-week	50	95	56
Average during 5-week	17	32	53

Average number of training minutes of light resistance training

Periods	Self-reported minutes* (MET minutes) †	Estimated target ‡ (MET minutes) †	Adherence %
First 5-week	116 (325)	150 (420)	77
Second 5-week	145 (406)	210 (588)	69
Third 5-week	115 (322)	210 (588)	55
Total 15-week	376 (1053)	570 (1596)	66
Average during 5- week	125 (350)	190 (532)	66

* Light resistance training time in minutes during the intervention (15 weeks) in 5-week periods
† MET minutes were calculated according to TWA 2.8 MET.
‡ Estimated target training time in minutes in 5-week periods: first period, 5 sessions x 6 minutes x 5 weeks = 150 minutes; second and third period, 7 sessions x 6 minutes x 5 weeks = 210 minutes



Training time	Training hours	Training in MET hours	LTPA in MET hours	AT in Met hours	Training in MET hours/LTPA in MET hours (%†)	Training in MET hours /AT in MET hours (%‡)
First 5 week	1.9	5.3	69.4	383.6	7.6	1.4
Second 5 week	2.4	6.7	77.9	390.3	8.6	1.7
Third 5 week	1.7	4.8	83.8	386.9	5.7	1.2
Total 15 week	6.0	16.8	231.1	1160.7	7.3	1.4
Average over 5 weeks	**2.0**	**5.6**	**76.1**	**386.9**	**7.4**	**1.4**

* MET=Metabolic equivalent, the relative energy expenditure associated with aerobic activity
† Light resistance training as percentage of LTPA
‡ Light resistance training as percentage of AT

FIGURE 6 Light resistance training, leisure time and all activities time in MET hours and training as percentage of leisure time and all activities time

5.2 Effectiveness of a CRT workplace physical exercise intervention on the functioning, work ability, and subjective well-being of office workers

The study results are reported according to the modified version of the ICF classification in components of Body Function and Structures, Activities and Participation, Environmental factors and general subjective well-being. First, the effect of physical exercise intervention on physical functioning is reported and, second, the effect of physical exercise intervention on psychological functioning.

5.2.1 Effects on Body Functions and Structures (Study I, II, III, Intervention study)

Effects of workplace physical exercise intervention on prevalence of headache and musculoskeletal symptoms in neck, shoulder and low back among office workers (Intervention study)

The active component of the intervention, light resistance training, resulted in a significant decrease in the prevalence of headache (p=0.047) and musculoskeletal symptoms in neck (p=0.003), shoulders (p=0.007) and low back (p=0.001) during the past 7 days in the study group (n=90). Also the physical exercise intervention, resistance training and guidance together significantly degreased the prevalence of headache (p=0.041).

The results of the statistical tests of the final model are presented in TABLE 7. Observed prevalence and percentages of musculoskeletal symptoms over previous 7 days during intervention are present in TABLE 8.

TABLE 7 The results of statistical tests of the final model for prevalence of musculoskeletal symptoms in CRT physical exercise intervention study

Prevalence of musculoskeletal symptoms (n=90)		Statistical tests*		
		t	df	p
Headache				
	Light resistance training (minutes)	3.95	439	0.047
	Treatment (intervention, no-intervention)	4.20	427	0.041
Neck	Light resistance training (minutes)	9.15	406	0.003
Shoulder	Light resistance training (minutes)	7.49	417	0.007
Low back	Light resistance training (minutes)	29.36	397	0.000

*Results from the final logistic mixed model estimated by the GLIMMIX macro of the SAS software program

TABLE 8 Observed prevalence and precentages of musculoskeletal symptoms over the 7 days before the baseline and between each 5-week period during the intervention

Measurements *	Treatment Group 1 (n=55)	Treatment Group 2 (n=35)
	n (%)	n (%)
Headache		
0)	26 (47.3)	11 (31.4)
1)	12 (24.0)	12 (38.7)
2)	6 (12.5)	7 (26.9)
3)	17(34.0)	10 (29.4)
1)	16(41.0)	2 (6.7)
2)	14 (31.8)	2 (7.1)
3)	16 (33.3)	5 (14.7)
Neck Symptoms		
0)	24 (44.4)	18 (51.4)
1)	11(22.4)	5 (16.1)
2)	6 (12.5)	5 (19.2)
3)	9 (18.0)	13 (38.2)
1)	9 (23.1)	2 (6.7)
2)	9 (20.5)	2 (7.1)
3)	11 (22.9)	6 (17.6)
Shoulder Symptoms		
0)	33 (60.0)	14 (40.0)
1)	15 (30.6)	9 (29.0)
2)	14 (29.2)	8 (32.0)
3)	17 (34.0)	15 (44.1)
1)	15 (38.5)	6 (20.0)
2)	15 (34.1)	6 (21.4)
3)	21 (43.8)	14 (41.2)
Low back Symptoms		
0)	24 (43.6)	11 (31.4)
1)	7 (14.3)	8 (25.8)
2)	8 (16.3)	4 (15.4)
3)	11 (22.0)	6 (17.6)
1)	9 (23.1)	6 (20.0)
2)	14 (31.8)	2 (7.1)
3)	14 (29.2)	5 (14.7)

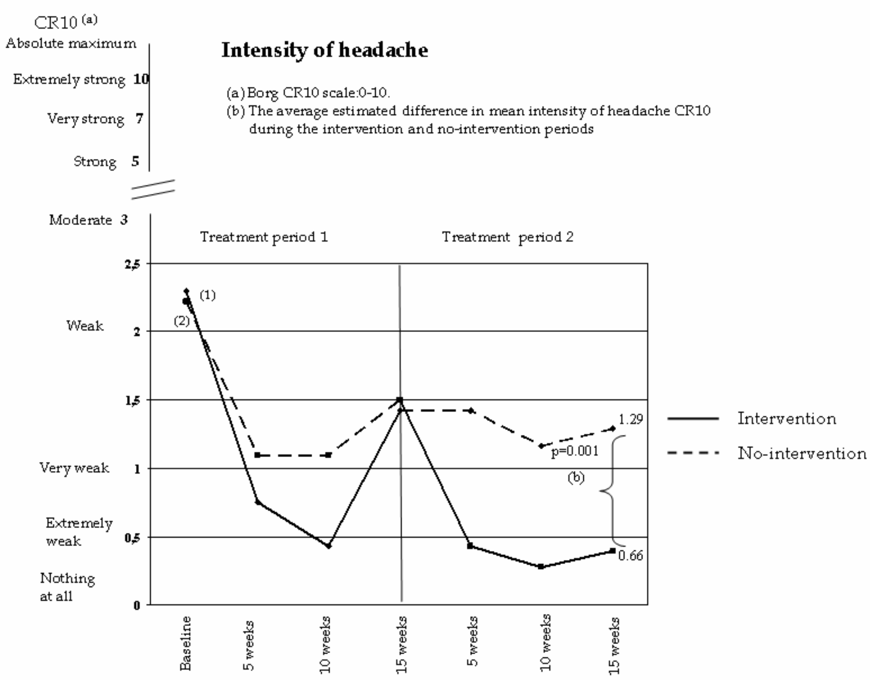
* 0= Baseline, 1-3 =Measurements within the treatment period (1 and 2)

Intervention
No intervention

Effects of workplace physical exercise intervention on intensity of headache and neck and shoulder symptoms in the subgroups (Study I)

Subgroups were formed at the individual level, the criteria being headache or symptoms in the neck or shoulders which to some degree had restricted participation in daily activities during the 12-month period preceding the intervention. In the Headache Symptoms group (n=41) the physical exercise intervention, resistance training and guidance together significantly decreased the intensity of headache (p=0.001), and also in the Neck Symptoms groups (n=37) the intensity of neck symptoms decreased (p=0.002) following the intervention. In the Shoulder Symptoms group (n=41) no significant effect of physical exercise intervention or light resistance training on the shoulder area was found.

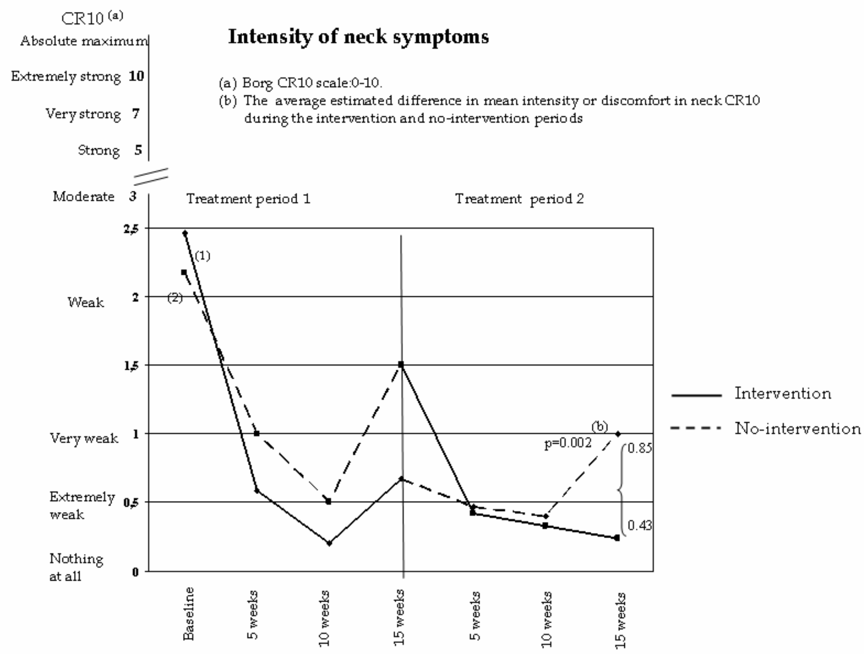
The estimated mean intensity of headache in the CR10 during the intervention was 0.66 (SE 0.19), and during the no-intervention period 1.29 (SE 0.19), the mean difference being 0.64 (95% CI 0.28-1.00). Compared to the corresponding no-intervention period, the intervention led to a 49% (95% CI 22-77) decrease in the intensity of headache. The estimated mean intensity of neck symptoms in the CR10 during the intervention was 0.43 (SE 0.15), and during the no-intervention period 0.85 (SE 0.16), the mean difference being 0.42 (95% CI 0.11-0.72). Compared to the corresponding no-intervention period, the intervention led to a 49% (95% CI 13-85) decrease in the intensity of neck symptoms. FIGURES 7 and 8 present the observed mean intensity of symptoms and standard deviations (SD) for headache and neck symptoms at the baseline, and during the intervention and no-intervention.



Observed mean (SD) intensity of headache

	Baseline	**Intervention**			No-intervention		
Treatment Group 1 (1) n=27	2.30 (2.26)	0.75 (1.22)	0.43 (1.20)	1.42 (1.69)	1.42 (2.10)	1.16 (1.48)	1.29 (1.81)
	Baseline	No-intervention			**Intervention**		
Treatment Group 2 (2) n=14	2.21 (2.82)	1.09 (1.80)	1.09 (1.81)	1.51 (1.65)	0.43 (1.34)	0.27 (0.90)	0.39 (1.08)

FIGURE 7 Intensity of headache (CR10) during intervention and no-intervention



Observed mean (SD) of neck symptoms

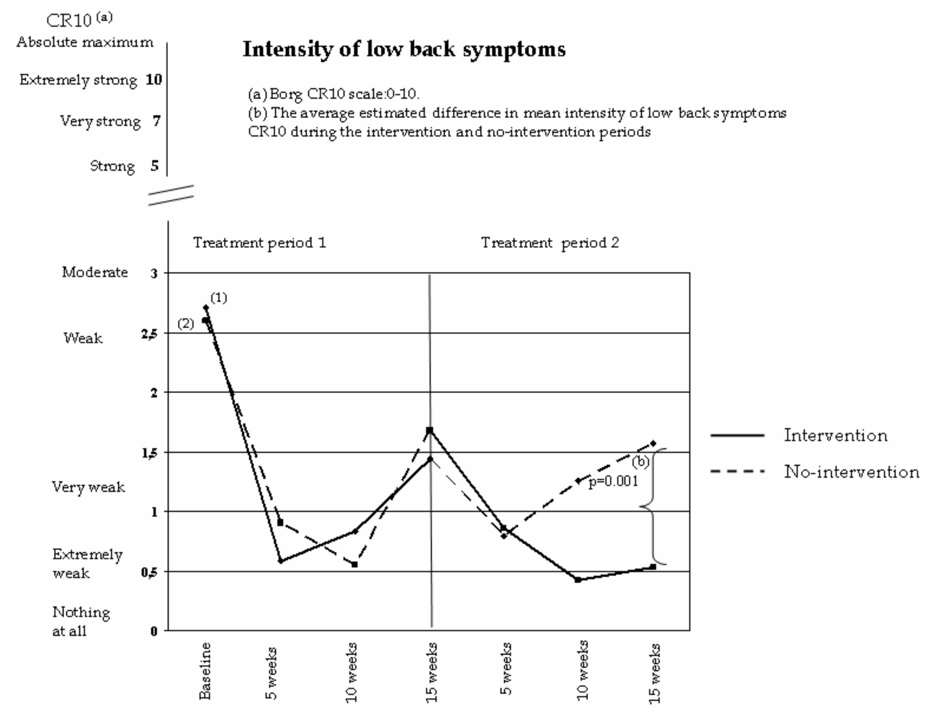
	Baseline	**Intervention**			No-intervention		
Treatment Group 1 (1)	2.46 (2.29)	0.59 (1.14)	0.20 (0.62)	0.67 (1.46)	0.47 (1.07)	0.40 (0.88)	1.00 (1.41)
n=25	Baseline	No-intervention			**Intervention**		
Treatment Group 2 (2)	2.17 (1.96)	1.00 (1.70)	0.50 (1.41)	1.50 (1.68)	0.42 (1.0)	0.33 (1.0)	0.24 (0.72)
n=12							

FIGURE 8 Intensity of neck symptoms (CR10) during intervention and no-intervention

Also investigated in the same study population were the effects of the workplace physical exercise intervention on upper extremity muscle strength in Pain Symptoms subgroup (study I). In the most common Pain Symptoms subgroups (=headache, neck and shoulder symptoms subgroups, n=53) the active component of the intervention, light resistance training, resulted in a statistically significant (p=0.001) increase in upper extremity extension strength. The estimated mean of upper extremity extension strength during the intervention was 37.4 kg (SE 0.5), and during the no-intervention period 36.1 kg (SE 0.5), the mean difference being 1.3 kg (95% CI 0.5-2.1). Compared to the corresponding no-intervention period, the intervention led to a 4% (95% CI 1-6) increase in muscle strength. In upper extremity flexion strength, no significant effect of physical exercise intervention or light resistance training was found.

Effects of workplace physical exercise intervention on intensity of low back symptoms in the subgroups (Study II)

Subgroups were formed at the individual level, the criteria being low back symptoms which to some degree had restricted participation in daily activities during the 12-month period preceding the intervention (n=36). The active component of the intervention, light resistance training, resulted in significantly (p=0.020) reduced intensity of symptoms in the low back (FIGURE 9). The average estimated reduction in low back symptoms was calculated from the regression coefficient: -0.00322 (95% CI -0.00054, -0.00590). The regression coefficient indicates the reduction in symptoms if one minute is added to the training time during a given 5-week period. During the 5-week period, the average reduction in low back symptoms was 0.42 CR10 (95% CI 0.07-0.77) when the average training time during the 5-week period was 130 minutes (26 minutes per week, 5 minutes per working day). The intervention, ignoring the time spent performing light resistance training, did not have a significant effect on the intensity of low back symptoms (CR10).



Observed mean (SD) intensity of low back symptoms

	Baseline	**Intervention**			No-intervention		
Treatment Group 1 (1) n=21	2.71(2.01)	0.58(1.35)	0.83(1.72)	1.44(2.33)	0.79(1.25)	1.25(2.09)	1.57(2.18)
	Baseline	No-intervention			**Intervention**		
Treatment Group 2 (2) n=15	2.60(3.38)	0.90(1.38)	0.55(1.13)	1.68(2.57)	0.86(1.35)	0.42(1.00)	0.53(1.25)

FIGURE 9 Intensity of low back symptoms (CR10) during intervention and no-intervention

According to the 0.42 CR10 value, in Treatment Group 1 the average reduction was 16% (95% CI 3-28) compared to the baseline measurement (2.7/CR10). In Treatment Group 2, it was 25% (95% CI 4-46) compared to the last no-intervention measurement (1.7/CR10). FIGURE 9 presents the observed mean and standard deviations (SD) for the intensity of low back symptoms.

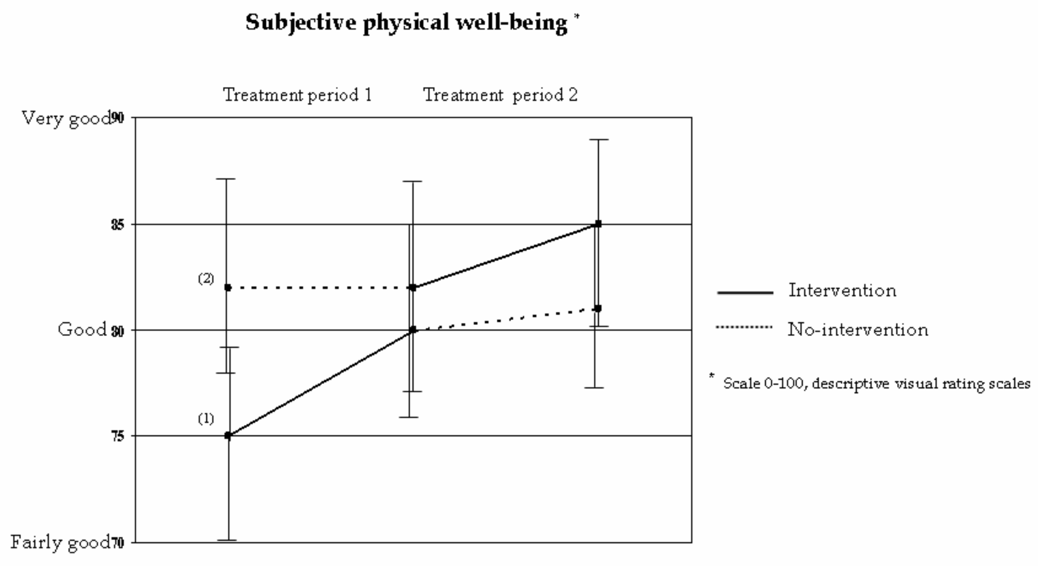
Effects of workplace physical exercise intervention on self-confidence and anxiety (Study II, III)

The physical exercise intervention had no effect on self-confidence or anxiety in the whole study group (n=90).

5.2.2 Effects on Activities, Participation, work-related social Environmental factors and general subjective well-being (Study II, III, Intervention study)

Effects of workplace physical exercise intervention on somatic symptoms, mood, subjective physical well-being (Study III, V) and work ability

Somatic symptoms, mood and physical well-being were assessed in relation to work and leisure. The active component of the present intervention, light resistance training, significantly increased (p=0.015) subjective physical well-being (FIGURE 10). The average estimated increase in subjective physical well-being was calculated from the regression coefficient: 0.03253 (95% CI 0.006756, 0.058304). The regression coefficient indicates the increase in subjective physical well-being if one minute is added to the training time during a given 5-week period. During the 5-week intervention period, the average increase in subjective physical well-being was 4 units (95% CI 1, 7) when the average training time was 125 minutes (25 minutes per week, 5 minutes per working day). Compared to the baseline measurement, the intervention led to a 5% (95% CI 1- 9) increase in subjective physical well-being. The physical exercise intervention had no effect on somatic symptoms, mood, work ability (index), mental stress at work, work atmosphere, life satisfaction or meaning of life. FIGURE 10 presents the observed mean changes and 95% confidence intervals in subjective physical well-being between the treatment groups during the intervention and no-intervention.



Observed mean (SD)

	Baseline	**Intervention**	No-intervention
Treatment Group 1 (1) -n= 55	75 (14)	80 (15)	81 (13)
	Baseline	No-intervention	**Intervention**
Treatment Group 2 (2) -n=35	82 (12)	82 (14)	85 (12)

FIGURE 10 Subjective physical well-being during intervention and no-intervention

TABLE 9 The effectiveness of the workplace physical exercise intervention according to the CRT study. The elements of effectiveness were light resistance training in minutes and treatment.

Statistical tests *

Variables	Light resistance training (minutes)			Treatment (intervention, no-intervention)		
	t	df	p- value	t	df	p- value
Body Function and Structures, Activities and Participation						
a) Physical functioning						
Intensity of musculoskeletal symptoms						
- Headache	0.40	198	0.528	12.31	171	**0.001**
- Neck symptoms	0.34	164	0.563	9.79	93	**0.002**
- Shoulder symptoms	0.10	188	0.756	1.03	173	0.311
- Low back symptoms	5.55	159	**0.020**	0.20	147	0.654
- Sum index average	16.76	124	**0.000**	0.12	126	0.734
Strength						
- Upper extremity muscles						
- Extension	17.31	170	**0.001**	0.02	169	0.896
- Flexion †	0.00	100	0.977	0.04	63	0.834
b) Physiological functioning						
Subjective physical well-being	6.12	150	**0.0145**	2.24	117	0.137
Somatic symptoms	0.64	151	0.423	0.34	120	0.563
Anxiety	0.86	376	0.355	1.25	193	0.265
Self-confidence	0.11	386	0.738	1.35	323	0.247
Mood	1.20	431	0.274	0.00	405	0.959
Work ability and social Environmental factors at work						
Work ability index †	1.22	80	0.272	1.42	81	0.237
Mental stress at work	0.45	116	0.503	0.12	100	0.728
Working atmosphere	0.98	376	0.323	0.64	161	0.426
General subjective well-being						
Life satisfaction	1.05	147	0.308	0.56	117	0.456
Meaning of life	0.14	145	0.711	0.83	116	0.365

* Estimates from the final model utilizing the MIXED procedure of the SAS software program, † Carry-over effect exists. The results analyzed according to the first training period

TABLE 10 The effectiveness of a workplace physical exercise intervention in modified ICF framework

CRT Physical exercise intervention results - Study I, II, III and Intervention study	**Part 1: Functioning and Disability**		**Part 2: Contextual Factors**	
Components	Body Functions and Structures	Activities and Participation	Environmental Factors	
Domains	Body functions Body structures	Life areas (tasks, actions)	External influences of functioning and disability	
Constructs - changes during 15 weeks physical exercise intervention	**Changes in** **Body functions and structures** (physiological and psychological)	**Changes in** **Capacity** Executing tasks in a standard environment **Performance** Executing tasks in the current environment	**Changes in** Facilitating or hindering impact of features of the **physical, social, and attitudinal world**	**Changes in General subjective well-being**
1) Statistically significant positive effect	**1) Prevalence of headache[1)] ↓** *p=0.047 †p=0.041 **2) Intensity of headache[1)] ↓** †p=0.001 **3) Prevalence of neck symptoms[2)]↓** *p= 0.003 **4) Intensity of neck symptoms[2)]↓** †p=0.002 **5) Prevalence of shoulder symptoms[3)] ↓** *p= 0.007 **6) Prevalence of low back symptoms[5)] ↓** *p= 0.001 **7) Intensity of low back symptoms[5)] ↓** *p=0.020 **8) Extension strength in upper extremities [4)]↑** *p=0.001	**9) Subjective physical well-being ↑** *p= 0.015	-	-
2) No statistically significant effect	1) Intensity of shoulder symptoms[3)] p=0.756 2) Flexion strength in upper extremities[4)] p=0.900 2) Self-confidence p=0.738 3) Anxiety p=0.355	1) Somatic symptoms p=0.423 2) Mood p=0.274 3) Work ability p=0.237	1) Mental stress at work p=0.503 2) Working atmosphere p=0.323	1) Life satisfaction p=0.308 2) Meaning of life p=0.711
3) Statistically significant negative effect	-	-	-	-

Groups analysed:
1) Headache Symptoms Group (n=41; 33 women, 8 men),
2) Neck Symptoms Group (n=37; 30 women, 7 men),
3) Shoulder Symptoms Group (n=41; 34 women, 7 men),
4) Pain Symptoms Group (n= 53; 43 women, 10 men consisted of three over mentioned (1-3) partially overlapping Sub-groups,
5) Low back Symptoms Group (n=36; 29 women, 7 men)
* Light resistance training in minutes
† The physical exercise intervention (light resistance training and guidance).

TABLE 9 presents a summary of statistical tests used in the final model in the CRT study and TABLE 10 summarise the changes during the CRT study in terms of the modified ICF classification, changes in Body Functions and Structures, changes in capacity and in performance changes in the physical, social, and attitudinal world and changes in general subjective well-being.

5.2.3 Controlling for confounding factors

Other physical activity:
Excluding the light resistance training, the participants were asked to keep the intensity and amount of their physical activity unchanged during the intervention and no-intervention periods. Also, occupational health services were not initiated new activities in occupational health and safety during the study. Other physical activities were controlled using metabolic equivalent (MET) values. During the interventions, no statistically significant changes in physical activity were found in the time-weighted intensity average or maximum intensity of activity in OPA, LTPA, or in AT in Treatment Groups 1 and 2. As the level of other physical activity performed was not statistically significant, this was not added into the statistical model as a covariate.

Clustering effects:
We found no clustering effects of workplace in our data as all the random department effects were non-significant; that is, department effects, the effects of individuals within departments, as well as their (random) interactions with the fixed factors. As the effect of the physical exercise intervention was similar in all four departments, we were able to simplify the original hierarchical model by leaving the department level out of the model.

Carry over:
In cross-over designs, the results of the latter intervention period may be contaminated by some transference from the earlier period. According to the statistical analyses, there were no carry-over effects in the intensity of symptoms, psychosocial measurements or upper extremity extension strength measurements in our data: the effects of the treatment group (Treatment Group 1, Treatment Group 2), and the effect of measurements within the treatment groups, were not statistically significant. Since there was a carry-over effect in the upper extremity flexion strength measurements and work ability index, we analyzed these results according to the first training period as parallel group trials.

Learning effects:
We assumed that in this study population learning effects did not play a significant role in the musculoskeletal of symptoms or in the psychosocial or work ability measurements, because the main effect of the measurements was not statistically significant. Instead, a positive learning effect ($p=0.001$) was found in the upper extremity sub-maximal muscular strength tests.

Seasonal effects:
The intervention period was statistically significant only in neck symptoms and in the upper extremity sub-maximal muscular strength tests. In the spring, the general intensity of neck symptoms was lower, (p=0.043) and the extension (p=0.001) strength of the upper extremities was higher than in the autumn. In the intensity of other symptoms or in the psychosocial measurements there were no observed seasonal effects.

5.3 Permanency of the effects of the physical exercise intervention 12 months after the baseline measurements (follow-up study)

The effects of the physical exercise intervention were studied 12 months after the baseline measurements in the study group who returned the mailed follow-up questionnaires, [n=72, 53 women, 19 men, mean age 47.5 (SD 7.9) years]. The average adherence in volunteer resistance training during the previous 4 weeks was 4 sessions and 44 minutes (10 minutes per week, 2 minutes per working day). There were no statistically significant gender differences. The physical prerequisites of functioning continued to remain on a higher level after 12 months than at the baseline. In addition, there were also improvements in the psychological prerequisites of functioning and subjective work ability; some of which did not emerge during the intervention. After 12 months the prevalence and intensity of musculoskeletal symptoms as well as degree of disability were lower, and subjective physical well-being, self-confidence and mood were higher than at the baseline. There were also some improvements in subjective work ability in relation to the physical and mental demands of work, life satisfaction and optimism about the future. TABLE 11 presents the changes within the framework of the modified ICF; changes in Body Functions and Structures, changes in capacity and in performance, changes physical, social, and attitudinal world and changes in general subjective well-being. In addition, APPENDIXES 5 and 6 show the baseline and 12-month follow up measurement means (SD) and statistical tests.

TABLE 11 The effectiveness of the physical exercise intervention within the modified ICF framework at the 12-month follow-up

Physical exercise intervention follow-up study n=70	**Part 1: Functioning and Disability**		**Part 2: Contextual Factors**	
Components	Body Functions and Structures	Activities and Participation	Environmental Factors	
Domains	Body functions Body structures	Life areas (tasks, actions)	External influences of functioning and disability	
Constructs - changes during 12 months from baseline to follow-up measurement	**Changes in** **Body functions and structures** (physiological and psychological)	**Changes in** **Capacity** Executing task in a standard environment **Performance** Executing tasks in the current environment	**Changes in** Facilitating or hinder impact of features of the **physical, social, and attitudinal world**	**Changes in** **General subjective well-being**
1) Statistically significant positive changes	**1) Prevalence of musculoskeletal symptoms ↓** during 12 month/7 days - headache p= 0.001/0.031 [3] - neck p= 0.000/0.009 [3] - shoulder p= 0.000/0.001 [3] - low back p= 0.001/0.052 [3] **2) Intensity of musculoskeletal symptoms ↓** during 7 days - headache p= 0.004 [2] - neck p= 0.12 [2] - shoulder p= 0.000 [2] - low back p= 0.013 [2] - common sum index p= 0.000 [2] **3) Subjective physical well-being ↑** p= 0.013 [1] **4) Self-confidence↑** p= 0.000 [1]	**1) Degree of disability of musculoskeletal symptoms ↓** during 12 months - headache p= 0.015 [4] - neck p= 0.023 [4] - shoulder p= 0.009 [4] - low back p= 0.016 [4] - common sum index p= 0.000 [2] **2) Mood** ↑p= 0.000 [2] **3) Subjective work ability↑** in relation to - physical (p= 0.008) [4, 5] and - mental (p=0.009) [4,5] demands of the work **4) Subjective estimation of work impairment due to diseases↓** p= 0.042 [2, 5]		**1) Life satisfaction↑** p=0.005 [2] **2) Optimistic about the future ↑** p=0.003 [4, 5]
2) No statistically significant changes	1) Aerobic capacity p= 0.815 [1] 2) BMI [1] p= 0.93 3) Anxiety p= 0.166 [1]	1) Mobility - LTPA: TWA-MET p=0.150 [1], Max-MET p=0.161 [1] - AT: TWA-MET p=0.653 [2], Max-MET p=0.155 [2] 2) Somatic symptoms p= 0.287 [1] 3) Work ability index p= 0.070 [1] 4) Absence of sickness p= 0.513 [4, 5] 5) Absence of musculoskeletal symptoms p= 0.840 [3] 6) Own prognosis of work ability after two years p= 0.180 [4,5] 7) Activity and life spirit p= 0.157 [4, 5]	1) Mental stress at work p=0.743 [1] 2) Working atmosphere p=0.791 [2]	1) Meaning of life p=0.080 [2] 2) Enjoying daily tasks p=0.206 [4, 5]
3) Statistically significant negative changes	–	–	–	–

1) Paired samples test, 2) Wilcoxon signed ranks test, 3) McNemar test, 4) Marginal Homogeneity test, 5) Items of work ability index

5.4 Physical and psychosocial prerequisites of functioning in relation to working ability and general subjective well-being among office workers (Study IV)

According to our descriptive cross-sectional investigation by path analysis at baseline, the physical prerequisites of functioning variables which related to a good score on the work ability index were low sum index of intensity of musculoskeletal symptoms, good flexibility in spine forward flexion and good aerobic capacity. These independent variables indirectly affected general subjective well-being through work ability, and work ability directly affected general subjective well-being. This model explained 52% of work ability and 18% of general subjective well-being. The physical and psychosocial prerequisites of functioning variables which related to a good score on the work ability index were high self-confidence, low mental stress at work, good spine forward flexion and low sum index of the intensity of musculoskeletal symptoms. These independent variables had indirect effects on general subjective well-being through work ability. Good mood, self-confidence and work ability affected general subjective well-being directly. This path analysis model explained 58% of work ability and 68% of general subjective well-being.

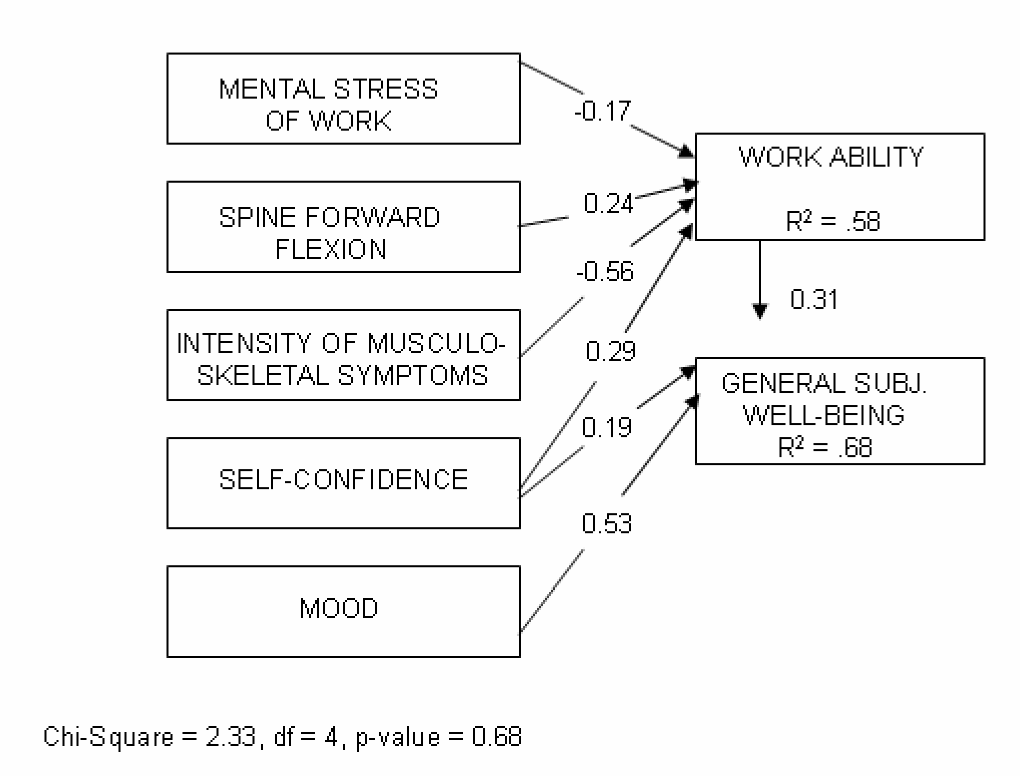


FIGURE 11 Physical and psychosocial prerequisites of functioning variables associated with working ability and general subjective well-being in office workers (n= 88).

In the adjustment analysis, when age and gender were added into the above-described model, gender was not significant and age displaced spine forward flexion and mental stress at work as a predictor of work ability; otherwise the explanation rates remained the same. The results of path analysis with statistical estimates and explanation rates for the work ability and general subjective well-being are presented in FIGURE 11.

6 DISCUSSION

6.1 Subjects, study designs, methods and results on CRT study

6.1.1 Methodological quality of CRT study (I, II, III, Intervention study)

The methodological quality of the RCT study (studies I-III), which were assessed according to the Physiotherapy evidence database (=PEDro) quality score and Cochrane Collaboration criteria (van Tulder et al. 1997a, van Tulder et al. 1997b, Koes and Hovin 1998, Maher 2000), were high (8/10). TABLE 12 lists the CRT study reports ranked according to methodological quality.

The PEDro quality score lacks adequate details on the description of the interventions. In contrast to the Cochrane Collaboration, descriptions of treatment and control interventions as well as avoiding criteria for co-interventions are included. In physiotherapy and rehabilitation intervention studies, both the PEDro and the Cochrane Collaboration criteria should be considered when evaluating physiotherapy and rehabilitation studies the methodological quality of randomized controlled trials or, alternatively, the criteria governing should be improved. In particular other physical exercise outside the intervention should be controlled for and the possible effect reported. Also total PA, including OPA, commuting, LTPA and the physical exercise intervention should be determined to a sufficient level of accuracy, for instance according to METs (Mälkiä et al. 1994, Mälkiä 1996,ACSM 1998, ACSM 2000, Howley 2001, Kesäniemi et al. 2001).

TABLE 12 Methodological scores assigned to the CRT study

RCT	1	2	3	4	5	6	7	8	9	10	11	Total
Study I*	(1)	1	1	1	0	0	1	1	1	1	1	8
Study II	(1)	1	1	1	0	0	1	1	1	1	1	8
Study III	(1)	1	1	1	0	0	1	1	1	1	1	8
Intervention study	(1)	1	1	1	0	0	1	1	1	1	1	8
Total	4	4	4	4	0	0	4	4	4	4	4	

Item score 0=absent 1=present. The PEDro criteria are: (1) Eligibility criteria; (2) Random allocation; (3) Concealed allocation; (4) Baseline comparability; (5) Blind subjects ; (6) Blind therapists ; (7) Blind assessors; (8) Adequate follow up; (9) Intention-to-treat analysis; (10) Between-group comparisons ; (11) Point estimates and variability. Note: The eligibility criteria item does not contribute to the total score.
* Methodological scores assigned by PEDro

In our CRTs the methodological quality was lowered by the fact that neither the subjects nor the therapists were blinded. In the PEDro criterion for rating these items "Blinding" means that the person in question (subject, therapist or assessor) did not know to which group the subject had been allocated. In addition, subjects and therapists are only considered to be blinded if it is assumed they would be unable to distinguish between the treatments applied to different groups.

In physical exercise studies, it is very difficult or even impossible to blind subjects by including a placebo treatment, because it is not easy to develop a good and trustworthy placebo (Ojanen 1994, Shephard 1996, Koes and Hoving 1998, van Tulder et al. 2000, Liddle et al. 2004). In physical exercise interventions, in particular, the subjects cannot be made unaware that they have received treatment. Therefore, we maintain that physical exercise studies always include some non-specific effects, attraction or placebo effects. In the study I and II we investigated the effect of the physical exercise intervention on the intensity of headache and neck, shoulder and low back symptoms among the study population subgroups. The inclusion criteria in these two studies were determined after the physical exercise intervention. This kind of allocation, in practice, resulted in a more blinded study design, because neither subjects nor therapist knew who was included in the studied subgroup.

In the standard cross-over design the order of the interventions is randomized for each cluster and a time period (called the "washout" period) is often allowed between the two interventions so that the first intervention does not affect the second. In our study we did not have a washout period between the two treatment periods, but we analysed the carry-over effects. If there were signs of carry-overs the results were analysed according to the first treatment period.

The strengths of our physical exercise intervention study were the randomisation by clusters in the natural working environment, controlling for possible confounding factors, such as department, learning, and seasonal effects, other physical activity (Guyatt et al. 1993, Liddle et al. 2004), and careful documentation of the training dose (Hide and Bø, 1998). Moreover, a cross-over trial is ethically more acceptable and statistically more efficient than similar-sized parallel group trials.

The intention-to-treat approach is often inadequately described and inadequately applied. Authors should describe the handling of deviations from randomised allocations and missing responses and discuss the potential effect of any missing response (Hollis and Campbell 1999). The absence of an intention-to-treat analysis in intervention studies can lead to a bias since subjects may drop out because for reasons that make them non comparable with the group that completes the study with respect to the outcome variable. If the intention-to-treat analysis is not performed the effectiveness of treatment may be overestimated (Proper 2002). In their critical review Proper et al. (2002) found that only one out of eight workplace intervention studies had included an intention-to-treat analysis, and this study was a controlled trial. In our CRT cross-over study the intention-to-treat analysis meant that all subjects, who were randomly assigned to the two treatment sequence groups (Treatment Group 1 and Treatment Group 2), were analysed together, regardless of whether or not they completed or received the physical exercise intervention treatment. An advantage of mixed models (Brown & Prescott 1999, Goldstein 1995), compared to ANOVA (or MANOVA) for repeated measures, is that there is no technical need to exclude subjects with incomplete data from the analysis. Instead, all the available observations, whether from completers or non-completers, contribute to the statistical inference (parameter estimation, significance testing) by virtue of the likelihood-based estimation method. In the mixed model approach we assume that each single observation obeys the same specified model, even where the observation is lacking no matter if it is observed or not. The model compensates for the missing data. The validity of this model assumption (and inference) requires, however, that the possible drop-out mechanism is random. In our study the number of non-completers was small and we can assume that the drop-out were random. Thus we do not see any problems of bias due to the incompleteness of the data.

6.1.2 Results of the CRT study

Among our population of office workers, the prevalence of musculoskeletal symptoms in the neck, shoulders and low back was on the same level as in the general population, in workers in physically demanding jobs or in workers in other sedentary occupations.

We found that the physical exercise intervention decreased the prevalence and intensity of headache and neck, shoulder and low back symptoms. These findings support those of the previous studies according to which workplace-based physical exercise interventions can reduce musculoskeletal symptoms (Griffiths 1996, Linton and van Tulder 2001, Maher 2000, Proper et al. 2003, van Poppel et al. 2004, Tveito et al. 2004). The frequency, duration and intensity of the resistance training and guidance observed in the workplace in our study, seems to be adequate to alleviate musculoskeletal symptoms, although the dose was lower than we recommended.

We found a statistically significant correspondence between light resistance training and increased subjective physical well-being, but not between training and the other psychosocial functioning and general well-being variables studied. In the other words, our study supports the findings of previous studies that the effect of physical exercise interventions in the workplace on psychosocial functioning among healthy middle age populations is inconclusive (Griffiths 1996, Proper et al. 2003). The meagre results obtained in our study are probably due to the ceiling effect, as the subjects were middle-aged healthy volunteers whose level of psychosocial functioning and general subjective well-being was already high at the baseline. We can also assume that the dose of physical exercise intervention was not high and/or prolonged enough to be effective in this study population.

Future studies should investigate the efficacy of different training loads (40, 50, and 60 %) and also the use of different training movements. However from psychological point of view a 30 % load is both supportive and agreeable. In a study population with lower baseline values the physical exercise intervention used here might have shown different results for psychosocial functioning and general well-being. Hence there is also a need to study the effectiveness of exercise on psychosocial functioning and general well-being in populations with a lower baseline level of well-being.

The efficacy of the physical exercise intervention on musculoskeletal symptoms and subjective physical well-being might be more due to training specificity, because the estimated MET hours of light exercise training and its percentage of LTPA (average 7.4%) and AT MET hours (average 1.4%) were on a low-level, as can be seen in Figure 6. The percentage proportion of OPA should be measured more carefully in the future studies. However according to the averages (1.5 MET of OPA, eight hours working days, 5-week period) the training MET was 9.7% of OPA, although the absolute time spent on training during the same time period was only 1%. In this study the cost-benefits and cost-effectiveness of the physical exercise interventions were not evaluated. In future studies this should be taken into account.

Liddle et al. (2004) reviewed the sixteen RCT studies and discovered that among chronic low back pain patients the outcome measurements did not adequately represent the components of the ICF. In our study we used measurements of all the components: Body Functions and Structures, Activities and Participation and also Environmental and Personal factors. In addition, we added the general subjective well-being aspect to our study framework. The efficacy of our physical exercise intervention was most evident in physical functioning and in the Body Functions and Structures component of the ICF. Our findings were similar to those of previous physical exercise intervention studies. First, interventions seemed to enhance physical, especially musculoskeletal functioning, more than psychological functioning (Griffiths

1996, Shephard 1996, Drisman et al. 1998, Proper et al. 2002, Proper et al. 2003,) and, second, the benefits of interventions were observed in the physiological Body Functions and Structures component, than in the Activities and Participation or Environmental components (APPENDIX 7).

Our physical exercise intervention program focused more on physical functioning and the component of physiological Body Functions and Structures, in order to counterbalance sedentary work or allow the office workers to obtain relief from monotonous and fixed working positions. Hence it was understandable that the first detectable chronic effects of intervention were found in the same component. Changes in this component were important, as in study IV we found that the intensity of musculoskeletal symptoms had the greatest negative effect on work ability and also that other variable in the physiological Body Functions and Structures component were important in maintaining work ability among our sample of office workers.

Recommendations for ways to reduce the stress of human computer interaction at work have included proper ergonomic conditions, increased organisational support, improved job content, an appropriate workload to decrease pressure of work, and enhanced opportunities for social support (Smith et al. 1999). Fogelman and Lewis et al. (2002) successes that among VDT workers the main foci in reducing musculoskeletal symptoms are workstation ergonomics, the need to limit the number of uninterrupted hours at the keyboard and the psychosocial work environment. The main idea behind our physical exercise intervention was to counterbalance sedentary work or to obtain relief from monotonous and fixed working positions. However, as a whole, the intervention also showed willingness by the employer to do something about the physical and psychosocial functioning and work ability of the employees and to enhance opportunities for organisational and fellow worker support. Our results show that the physical exercise intervention was successful in alleviating musculoskeletal symptoms. The next need following on from the physical exercise intervention would be an intervention targeted at improving job content and decreasing psychosocial pressure at work.

In our study, as in previous workplace physical exercise interventions, self-reported data on musculoskeletal symptoms, psychosocial functioning and well-being, subjective measurement was applied (Proper et al. 2003). If more objective instruments had been used the results might have been different. Pain Assessment in Clinical Trials (IMMPACT) has recently recommended domains that should be considered when designing chronic pain clinical trials. These six core outcome domains were pain, physical functioning, emotional functioning, participant ratings of improvement and satisfaction with treatment, symptoms and adverse events, and participant disposition (Dworkin et al. 2005, Turk et al. 2003). In our study we considered five out of these six outcome domains. We did not consider participant ratings of improvement and satisfaction with treatment systematically, but we interviewed some of the voluntary participants (n=58) after the CRT and they reported that they enough reserved guidance to learn the light resistance training program and how to use the training equipment and that physical exercise intervention was suitable for the work environment of office workers.

6.1.3 Clinical importance and generalization of the RCT study findings

The comparability of clinically important differences or changes between previous studies and our study is difficult because of different study populations, pain measurements and treatments. In previous intervention studies, clinically important positive changes from the subject's perspective, the changes in intensity of musculoskeletal symptoms (scales 0-10) have been defined on average among different patient populations as 30 percentual or to 2 absolute points (Farrar et al. 2000, Farrar et al. 2001, Hägg et al. 2003). The corresponding values among a rheumatoid arthritis patient population were 20% or 1.2 (Goldsmith et al. 1993). However in less disabled populations even small changes can be clinically important (Farrar et al. 2000, Farrar et al. 2001, Hägg et al. 2003). In the critical review by Proper et al. (2003) of workplace physical activity programs, health-related benefits were considered to have a positive effect where statistically significant results or a relevant effect size, determined as over 20% difference between study groups, were obtained. Among our healthy middle age population the physical exercise intervention led to changes of 19-49 per cent or to absolute changes 0.4-0.62 in the intensity of musculoskeletal symptoms. We can assume that our specific exercise was clinically important in alleviating the intensity of symptoms, especially headache and neck symptoms, but also in low back symptoms and subjective physical well-being. When planning intervention studies the participants' ratings of improvement not only in their musculoskeletal functioning but also in their physical and psychosocial functioning should be taken account.

Although, there was a low level of systematic error during the physical exercise intervention and follow-up study (selection bias, information bias, confounding factors), care must be taken in generalizing the study results beyond the target population (office workers, sedentary workers) as we were not able to control for all non-specific effects, and as the study samples were relatively small. To confirm assumptions of the effectiveness of physical exercise interventions, more randomized and controlled follow-up studies among different sedentary occupations and workplaces are required. There is also a need to study the effects of different training doses and movements, using different training tools and methods of guidance, to clarify the role of PA for physical and psychosocial functioning. Follow-up studies of long duration are also needed to explore the possibility that even slight positive changes could be important in preventing impairments in people's physical and psychosocial prerequisites of functioning, work ability and general well-being.

6.2 Subjects, study designs, methods and results of follow-up study

Linton and van Tulder (2001) and Dworkin et al. (2005) emphasize the importance of reporting the long-term benefits of treatments. In our follow-up study, 12 months after the baseline measurements, there were still significantly better values, especially in musculoskeletal symptoms variables, continued to be found. In addition, psychological prerequisites of functioning, subjective work ability, life satisfaction and optimism about the future were better than at the baseline, although significant changes in these variables were not observed during the intervention. In the work-related environmental variables, slightly negative changes were observed in mental stress at work and working atmosphere; however these were not statistically significant. Our follow-up results are clinically important, despite the absence of a control group, which may mean a high risk of bias and overestimating the results**.** In the follow-up study, it is not possible to say whether the positive changes found at the follow-up are due to the intervention or to other changes in the working life situation.

In terms of the ICF the component of Activity and Participation was more prominent in the follow-up study than in the CRT study along, with the Body Functions and Structures component. Some changes were also found in general subjective well-being. The effectiveness of the intervention on psychological prerequisites of functioning and on variables within the component of Activities and Participation was expected to be visible after a longer, non-randomized or controlled follow-up period.

In future it would be interesting to do additional analyses, using Path analyses, as in study IV, to investigate which baseline variables and variables which were associated with changes during the intervention affected the follow-up results. Because no positive changes in the work-related social environmental factors occurred during the intervention or follow-up period, this component should be taken into account more carefully when planning further intervention studies.

6.3 Subjects, study designs, methods and results of descriptive cross-sectional investigation at the baseline (Study IV)

High intensity of musculoskeletal symptoms was the greatest negative risk factor for work ability. The physical prerequisites of variables were more prominent in relation to work ability and the psychosocial prerequisites of functioning variables showed a greater association with general subjective well-being. Intensity of musculoskeletal symptoms, flexibility in spine forward flexion and good aerobic capacity explained 52% of the work ability index. When we added the psychosocial variables into the model the degree of explanation increased slightly to 58%. To maintain working ability and to improve the effectiveness of physical exercise or rehabilitation it is important to identify all the independent variables which may have an effect in the workplace. Only 18% of general subjective well-being was explained by the physical prerequisites of functioning and working ability variables. This increased to 68% when the psychosocial prerequisites of functioning variables were entered into the model. Self-confidence, mood and working ability directly affected general subjective well-being. Work ability explained general subjective well-being better than vice versa. When age and gender were incorporated into the models by adjustment analysis, the explanatory power of working ability or of general subjective well-being did not increase, as age displaced the other independent variables. Because the sample was small (n=88), the results can be considered to be tentative only.

Comparing the above-mentioned results with those of previous studies is problematic owing to differences in study populations and work demands. However, in our study work ability results are mostly in agreement with those of previous epidemiological studies of municipal workers, where musculoskeletal and psychological symptoms (Tuomi et al. 1991b, Pohjonen 2001a), and age (Tuomi et al. 1991b, Pohjonen 2001a) had a negative effect on the work ability index, and social environment factors at work have been shown to be important in terms of such factors as freedom, recognition, esteem at work, division of labours and supervisor's attitude (Tuomi et al. 1991a, Tuomi et al. 1991b,Tuomi et al. 1997, Pohjonen 2001a). Leisure time physical activity has previously been associated with the work ability index (Tuomi et al. 1991b, Tuomi et al. 1997), but no association was found in either our study or in that by Pohjonen (2001a). Our results also differ with respect to muscular strength, as we found no correlations between the latter and the work ability index; instead, in previous studies correlations have been found between the work ability index and both aerobic capacity and muscular strength (Pohjonen 2001b, Nygård 1991).

More studies need to be carried out among different types of OPA working populations or among populations with different levels of prerequisites of functioning to learn more about physical and psychosocial risk factors for work ability and general subjective well-being.

6.4 Physical exercise intervention study in the workplace within the ICF framework

The general aims of the ICF was to establish a common language for describing health and health-related states in order to improve communication between different users, such as health care workers, researchers, policy-maker and the public, including people with disabilities. It also can help to permit comparison of data across countries, health care disciplines, services and time and to provide a systematic coding scheme for health information systems (WHO. ICF/ICIDH-2. 2001). In our study it also enables the effectiveness of physical exercise intervention on physical and psychosocial functioning to be studied in more detail, i.e. in terms of the components of Body Functions and Structures, Activities and Participation and Environmental Factors. Our light resistance training and the content of guidance were mostly aimed at the component of Body Functions and Structures. In future studies it would also be important to determine the content and aims of physical exercise interventions in more detail according to the ICF classification.

An alternative framework for such studies could be the conceptual model of work by Ilmarinen (1999), where a person's individual recourses include health, functional capacity, education and competence, personal values and work. These elements are very similar in both the ICF and Ilmarinen framework. In this study the component of participation and construct of performance were determined for work ability, which was measured according to the work ability index. According to Ilmarinen (1999) the CRT physical exercise intervention had an effect on health, as it decreased musculoskeletal symptoms and increased subjective physical well-being. The main reasons for choosing ICF framework instead of the conceptual model of work ability by Ilmarinen (1999) was first, that in the ICF model functioning is an umbrella term encompassing all physiological and psychological Body Functions and Structures, Activities and Participation. According to this classification it is possible to describe exercise intervention effects in terms of constructs such as changes in Body Functions and Structures as well as in capacity and performance. Second, the overall aim of the ICF classification is to provide a unified and standard language and framework for the description of health and health-related states.

7 MAIN FINDINGS AND CONCLUSIONS

The main findings and conclusions of the present study can be summarized as follows:

1. Among office workers the physical exercise intervention conducted during the working day was more effective with respect to subjects' physical functioning than psychosocial functioning. The intervention decreased the prevalence of headache and neck, shoulder and low back symptoms. Among the subgroups of symptomatic office workers the intervention decreased the intensity of headache and neck and low back symptoms as well as increased upper extremity extension strength. The intervention had no effect on the intensity of shoulder symptoms or upper extremity flexion. The intervention increased subjective physical well-being, but had no effect on the other psychological functioning, work ability or work-related environmental factors or on general subjective well-being. Feasibility of the physical exercise intervention was satisfactory.

2. Physical prerequisites of functioning remained on a higher level 12 months after the baseline measurements. In addition, there were improvements in prerequisites of psychological functioning, subjective work ability and general subjective well-being; including improvements that did not emerge during the physical exercise intervention itself. After 12 months the prevalence and intensity of musculoskeletal symptoms and degree of musculoskeletal disability were at a lower and subjective physical well-being, self-confidence and mood at a higher level than at the baseline. Some improvements were also observed in subjective work ability in relation to the physical and mental demands of the work, life satisfaction and optimism about the future.

3. The physical prerequisites of functioning factors were the most important in maintaining work ability. High intensity of musculoskeletal symptoms

had the greatest negative effect on work ability. The psychological prerequisites of functioning, however, turned out to be more important than the physical in maintaining general subjective well-being. Age displaced spine forward flexion and aerobic capacity or mental stress at work as a predictor of working ability. In this study population gender did not play a significant role.

YHTEENVETO

Työpaikalla tapahtuvan fyysisen harjoitteluintervention vaikuttavuus toimistotyöntekijöiden toimintakykyyn, työkykyyn ja yleiseen subjektiiviseen elämänlaatuun – ryhmätasolla satunnaistettu vaihtovuorokoe ja vuoden seuranta

Tämän neljästä osajulkaisusta ja yhteenvedosta koostuvan tutkimuskokonaisuuden tarkoituksena oli ensisijaisesti tutkia työpaikalla tapahtuvan kevyen (30 % 1RM) kuntosaliharjoittelun vaikutusta toimistotyöntekijöiden fyysiseen ja psykososiaaliseen toimintakykyyn, koettuun työkykyyn ja yleiseen subjektiiviseen elämän laatuun. Harjoitteluvaikutusten lisäksi tutkimme fyysisen harjoitteluintervention osallistumista, arvioimme harjoitteluvaikutusten pysyvyyttä alkumittausten ja 12 kuukauden seurantamittausten perusteella sekä tutkimme alkumittauksissa kootun poikkileikkausaineiston avulla, mitkä fyysiset ja psykososiaaliset toimintakyvyn edellytykset olivat yhteydessä koettuun työkykyyn ja yleiseen subjektiiviseen elämänlaatuun. Tutkimuksen viitekehyksenä oli toimintakyvyn, toimintarajoitteiden ja terveyden kansain-välinen luokitus. (ICF).

Tutkimuksen kohteena olivat Kuopion kaupungin keskushallinnon työpaikat, joiden työ oli fyysisesti kevyttä (4 toimipistettä, fyysinen aktiivisuus työssä 1.5 MET). Lähdeväestönä oli 123 työntekijää, joista 90 vapaaehtoista [73 %, 66 naista ja 24 miestä, keski-ikä 45.7 (SD 8.5) vuotta] osallistui fyysiseen harjoitteluinterventioon. Seurantakyselyn palautti 72 koehenkilöä [(80 %), 53 naista, 19 miestä].

Fyysisen harjoitteluintervention koeasetelmana oli ryhmittäin satunnaistettu vaihtovuorokoe (CRT cross-over trial), joka sisälsi 15 viikkoa kestävän kuntosalilaiteharjoittelun paineilmalaitteilla ja siihen liittyvän ohjauksen sekä 15 viikon kontrollijakson, jolloin koehenkilöt eivät harjoitelleet eivätkä saaneet ohjausta. Työntekijöitä ohjattiin suorittamaan harjoitusohjelma oman työn lomassa kerran työpäivän aikana (5x/vko) ensimmäisen viiden viikon aikana ja yksi – kaksi kertaa työpäivän aikana (7-8x/vko) toisen ja kolmannen viiden viikon jakson aikana. Harjoitusohjelma sisälsi kuusi dynaamista liikettä: polven ojennus ja koukistus, yläraajojen ojennus ja koukistus sekä vartalonkierto oikealle ja vasemmalle. Fyysinen aktiivisuus kontrolloitiin harjoitusintervention aikana viikoittaisella kyselyllä ja kuntosaliharjoittelun ulkopuolinen muu aktiivisuus työssä, työmatkoilla ja vapaa-aikana 4 viikon kokonaisaktiivisuuden kyselyllä. Tutkimuksessa käytettiin kuntoutustutkimuksissa yleisesti käytettyjä fyysisiä ja psykososiaalisia kyselylomakkeita sekä fyysisiä mittauksia. Pilottitutkimuksessamme tehdyssä toistettavuustutkimuksessa mittareiden toistettavuus oli tasoltaan hyväksyttävää. Satunnaisen vaihtovuorokokeen tulokset analysoitiin lineaarisella ja logistisella sekamallilla (SAS- ohjelmalla).

Spesifi fyysinen harjoitteluinterventio vähensi tilastollisesti merkitsevästi työntekijöiden päänsäryn (p=0.041 - 0.047) esiintyvyyttä sekä niskan (p=0.003), hartioiden (p=0.007) ja alaselän (p=0.020) oireiden esiintyvyyttä. Lisäksi oireiden voimakkuuden lievittymistä tapahtui päänsäryssä (p=0.001) sekä niskan (p=0.002) ja alaselän (p=0.020) alueella henkilöillä, jotka alkumittausta edeltäneenä 12 kuukauden aikana, olivat kivun vuoksi kokeneet haittaa päivittäisissä työtehtävissään. Tuki- ja liikuntaelinten oireiden vähentyminen on myös kliinisesti merkittävää. Interventio paransi koehenkilöiden koettua vointia (p=0.015), mutta sillä ei ollut vaikutusta muuhun psykososiaaliseen toimintakykyyn tai yleiseen subjektiiviseen elämän laatuun.

Harjoitteluohjelman toteutukseen käytetty aikakeskiarvo oli 125 minuuttia viiden viikon aikana (25 minuuttia viikossa, 5 minuuttia työpäivänä), joka on noin 1 % henkilöiden keskimääräisestä työajasta. Harjoitteluohjelman keskimääräinen fyysinen aktiivisuus oli 7.4 % vapaa-ajan voimakkaammasta fyysisestä aktiivisuudesta ja 1.4 % koehenkilöiden kokonaisaktiivisuudesta.

Tutkimustuloksemme ovat samansuuntaisia kuin aikaisempien kokoomaartikkelien tulokset, jossa fyysisen harjoitteluintervention todetaan vaikuttavan parhaiten työntekijöiden fyysiseen toimintakykyyn, etenkin tuki- ja liikuntaelinten oireisiin. ICF-luokituksen mukaan vaikutukset näkyvät selkeimmin Ruumiin/kehon toiminnot ja ruumiin rakenteiden osa-alueella. Lisätutkimuksia tarvitaan selvittämään harjoittelun vaikutusta fyysiseen ja psykososiaaliseen toimintakykyyn, työkykyyn sekä yleiseen subjektiiviseen elämänlaatuun. Tutkimuksia tulisi tehdä erilaisissa työpaikoissa ja erilaisten toimintakyvyn edellytysten, koetun työkyvyn ja yleiseen subjektiiviseen elämänlaadun omaavilla henkilöillä. Lisäksi tarvitaan tutkimusta erilaisilla harjoitteluannoksilla ja -laitteilla.

Työpaikalla toteutettuja satunnaistettuja kontrolloituja harjoittelututkimuksia on vähän ja tämä tutkimus on tiettävästi ensimmäinen tutkimus, jossa harjoitteluintervention vaikutusta on tutkittu ryhmätasoista satunnaistamista ja vaihtovuorokoeasetelmaa käyttäen. Tämä tutkimus on myös ensimmäinen työpaikalla tapahtuva kuntoutustutkimus, jossa fyysisen harjoitteluintervention annos-vastesuhteita on tarkasteltu samalla kun harjoittelun ulkopuolinen fyysinen aktiivisuus on kontrolloitu.

Satunnaistetun vaihtovuorokokeen jälkeen työntekijöille annettiin yksilöllinen palaute harjoitteluintervention tuloksista ja heitä kannustettiin jatkamaan harjoittelua työpaikallaan. Seurantamittauksissa, 12 kuukautta alkumittausten jälkeen työntekijöiden fyysiset toimintakyvyn edellytykset olivat tilastollisesti merkitsevästi korkeammalla tasolla kuin alkumittauksissa. Tämän lisäksi positiivista muutosta oli tapahtunut psykologisten toimintakyvyn edellytysten, koetun työkyvyn sekä yleisen subjektiivisen elämän laadun muuttujissa. Työpaikan sosiaalisissa ympäristötekijöissä ei ollut tapahtunut tilastollisesti merkitseviä muutoksia. Tulokset analysoitiin toistomittaustesteillä (SPSS-ohjelmalla). Seurantamittausten tuloksien luotettavuutta heikentää koe-kontrolli asetelman puuttuminen.

Polkuanalyysillä (LISREL-ohjelmalla) tehdyn analyysin mukaan poikkileikkausaineiston fyysiset toimintakyvyn edellytykset näyttäisivät olevan yhteydessä enemmän koettuun työkykyyn, kun taas psykososiaaliset toimintakyvyn edellytykset olisivat yhteydessä yleiseen subjektiiviseen elämän laatuun. Poikkileikkaustutkimuksen heikkoutena on pieni koehenkilömäärä. Tutkimuksessa esiintyneiden puutteiden vuoksi seurantatutkimuksen ja poikkileikkaustutkimuksen tuloksia voidaan pitää suuntaa-antavina.

Fyysisen aktiivisuuden annoksen määrittely, muun fyysisen aktiivisuuden kontrollointi sekä harjoitteluvaikutusten raportointi ICF toimintakyvyn luokituksen osa-alueiden mukaan selkeyttävät fyysisen harjoitusintervention vaikuttavuuden tutkimista työpaikoilla sekä edesauttavat osaltaan työkykyä ylläpitävän toiminnan kehittämistä.

Avainsanat: annos-vaste, CR10, fyysinen aktiivisuus, fyysisesti kevyt työ, harjoittelu, hyvinvointi, ICF, kuntoutus, MET, toimintakyky, tuki- ja liikuntaelinten oireet, työkyky, työterveys

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APPENDIX 1 The cross-over design; Treatment groups, measurements, periods and treatments

A= Intervention
B= No-intervention
C= Follow-up

Measurement 0 1 2 3 1 2 3 4

	5 weeks	10 weeks	15 weeks	5 weeks	10 weeks	15 weeks	
Treatment Group1	A	A	A	B	B	B	C
Treatment Group2	B	B	B	A	A	A	C
	Period 1			Period 2			

Measurements:

0 =
Baseline Research institute
a) Physical functioning testing, Prevalence of musculoskeletal symptoms during the past 12 months and 7 days, Self-reported restriction on participation in daily activities because of musculoskeletal symptoms experienced during the last 12 months, Intensity of musculoskeletal symptoms during the past 7 days, Mobility during past 4 weeks
b) Psychological functioning, Environmental factors and General subjective well-being during the past 12 month.
c) Work ability index.

3=
Intervention Research institute
a) Physical functioning testing, Prevalence and intensity of musculoskeletal symptoms during the past 7 days, Mobility during past 4 weeks.
b) Psychological functioning, Environmental factors and General subjective well-being during the past 4 weeks.
c) Work ability index.

1 and 2 =
Intervention Departments' own training facilities
a) Physical functioning testing, Prevalence of musculoskeletal symptoms and intensity of musculoskeletal symptoms during past 7 days, Mobility during past 4 weeks.
b) Psychological functioning; Anxiety, Self-confidence and Mood during the past 4 weeks,
c) Environmental factors; Working atmosphere during the past 4 weeks

4=
Follow-up Mail questionnaires
a) Prevalence of musculoskeletal symptoms during the past 12 months and 7 days, Self-reported restriction on participation in daily activities because of musculoskeletal symptoms experienced during the last 12 months, Intensity of musculoskeletal symptoms during the past 7 days, Mobility during past 4 weeks
b) Psychological functioning, Environmental factors and General subjective well-being during the past 12 months.
c) Work ability index

APPENDIX 2 The validity and consistency of physical functioning measurements, ICF classification, data collection and measurement scales

Measurement **A. PHYSICAL FUNCTIONING**	**Data collection**	**Original reference**	**Scale**	**Consistency*/ Our study measurements n= 14-16**	**Validity of measurement /Referees**	**Standardization / Reference**	**Classification of ICF**
Sensory functions and pain 1. Prevalence of musculoskeletal symptoms 1.1.The prevalence of musculoskeletal symptoms during 12 month: a) headache b) neck c) shoulder d) low back 1.2 The prevalence of musculoskeletal symptoms during 7 days: a) headache b) neck c) shoulder d) low back 2. Intensity of musculoskeletal symptoms during 7 days 2.1 Sum index of intensity of musculoskeletal symptoms 2.2 Intensity of headache 2.3 Intensity of neck symptoms 2.4 Intensity of shoulder symptoms 2.5 Intensity of low back symptoms	1.1-1.2 Questionnaire No/ Yes 2. 1 Questionnaire/Borg CR10 on 10 different anatomical areas (0-100) 2.2- .2.5 Questionnaire/Borg CR10 (0-10 CR10)	1.1-1.2 Kuorinka et al. 1987 2.1-2.5 Borg 1998	1.1-1.2 Nominal scale 2.1-2.5 Interval scale	1.1 Identical answers: 60-100% (87-100%)§ 1.2 Identical answers: 67-100% (73-80%)§	1.1-1.2 Criterion validity (Andersson et al. 1987; Kuorinka et al. 1987) 2.1-2.5 Construct validity, Predictive validity, Content validity (Borg 1998)	+/+	1. b2801 1.1. a) b28010 b) b28010 c) b28014 d) b28013 1.2 a) b28010 b) b28010 c) b28014 d) b28013 2.1 b2801 2.2 b28010 2.3 b28010 2.4 b28014 2.5 b28013
Functions of the cardiovascular and respiratory systems 1. Maximum oxygen uptake	1. Questionnaire/N-Ex- test (mL 0_2x kg^{-1} x min^{-1})	1. Jackson et al. 1990	1. Ratio scale	1. ICC 0.95	1. Criterion validity (Jackson et al. 1990)	+/+	1. b4550

Neuromusculosskeeletal and movement-related functions 1. Hand grip strength 2. Strength of upper extremities muscles - flexion and extension 3. Strength of lower extremities muscles - knee flexion and extension 4. Active spine forward flexion - lumbar and thoracic range of motion	1. Testing/ Anatomically adjusted strength gauge (kg) § 2.- 3. Testing/5 RM, Air resistance equipment, HUR Ltd, Finland (kg) § 4. Testing/ Myrin goniometer (°) §	1. Mälkiä 1983; Mathiowetz 1990 2. –3. McDonagh & Daves, 1984 4. Mellin 1986; 1987	1. Ratio scale 2.- 3. Ratio scale Ratio scale	1. ICC 0.95- 0.97 (intratester) 0.94-0.95 (intertester) 2. ICC 0.98 (intratester) 0.95-0.97(intertester) 3. ICC 0.93- 0.97 (intratester) 0.80-0.98 (intertester) 4. ICC 0.75 (intratester) 0.69 (intertester)	2-3. Criterion validity (Braith et al. 1993)	+/+ +/ (+) +/+	1. b7300 2. b7300 3. b7300 4. b7101
Functions of metabolic system 1. Body fat percentage 2. Body Mass Index (BMI)	1. Testing/Spectrum II, RJL Systems, Detroit, MI USA (%) 2. Questionnaire/ Body height (cm) and weight (kg)	1. Sipilä et al. 1996	1. Ratio scale 4.2 Ratio scale			+/+ +/+	1. b530 2. b530
General tasks and demands 1. Self-reported restriction on participation in daily activities because of musculoskeletal symptoms experienced during the last 12 months a) sum index from 10 different anatomical area b) headache c) neck d) shoulder e) low back	1. Modified Standardized Nordic questionnaire/ Degree of restriction, scale 0-4 0= not at all 1= quite seldom 2= once in a while 3= quite often 4= non-stop	1. Kuorinka et al. 1987	1. Ordinal scale	1. Identical answers: 73-93% on 10 different anatomical areas in scale 0-4	1. Criterion validity (Andersson et al. 1987; Kuorinka et al. 1987)	(-/-)	1. d230
Mobility 1. All activities (AT) - TWA-MET† - Max-MET‡ 2. Leisure physical activity (LTPA) - TWA-MET† - Max-MET‡	1.– 2. Questionnaire/MetPro®	1.-.2. Mälkiä et al. 1994; 1996	1.-2. Ratio scale	1 ICC AT 0.91 - 0.94 2. ICC, LTPA 0.62 - 0.76		+/+	1.-2. d920

*In this study the consistency of the measurements varied between high and fair (>.80 high, .80-.61 fair and .60-.40 poor) on the intraclass correlation scale (Baumgartner 1989)

†) The time-weighted intensity average in METs (=TWA-MET), ‡) Maximum intensity in METs (Max-MET)

§ Headache, neck, shoulders and low back

APPENDIX 3 The validity and consistency of psychological functioning and general subjective well-being measurements, ICF classification, data collection and measurement scales

Measurement **B. PHYCHOLOGICAL FUNCTIONING AND GENERAL SUBJECTIVE WELL-BEING**	**Data collection**	**Original reference**	**Scale**	**Consistency*/ Our study measurements**	**Validity of measurement /Referees**	**Standardization/ Reference**	**Classification of ICF**
Mental functions **1. Orientation functions** 1.1 Self-confidence	1.1 Questionnaire/ Descriptive visual rating scales (0-100)	1.1 Ojanen 1994; 2000	1.1 Ratio scale	1.1 ICC 0.70 (last month) 0.78 (last year)	1.1 Construct validity (Ojanen 1994; Ojanen 2000)	+/+	1.1 b 11420
2. Emotional functions 2.1 Anxiety	2.1 Questionnaire/ Descriptive visual rating scales (0-100)	2.1 Ojanen 1994; 2000	2.1 Ratio scale	2.1 ICC 0.80 (last month) 0.73 (last year)	2.1 Construct validity (Ojanen 1994; Ojanen 2000)	+/+	2.1 b 152
General tasks and demands **1. Carrying out daily routine** 1.1 Somatic symptoms 1.2 Mood 1.3 Subjective physical well-being	1.1-1.3 Questionnaire/ Descriptive visual rating scales (0-100)	1.1-1.3 Ojanen 1994; 2000	1.1-1.3 Ratio scale	1.1 ICC 0.77 (last month) 0.61(last year) 1.2 ICC 0.93 (last month) ICC 0.85 (last year) 1.3 ICC 0.79 (last month) 0.64(last year)	1.1 Construct validity (Ojanen 1994; Ojanen 2000) 1.2 Construct validity (Ojanen 1994; Ojanen 2000) 1.3 Construct validity (Ojanen 1994; Ojanen 2000)	+/+ +/+ +/+	1.1-1.3 d 230
General subjective well-being 1. Life Satisfaction 2. Meaning of life	1.-2. Questionnaire/ Descriptive visual rating scales (0-100)	1.-2. Ojanen 1994; 2000	1-2 Ratio scale	1. ICC 0.84 (last month) 0.95 (last year) 2. ICC 0.95 (last month) 0.87(last year)	1. Construct validity (Ojanen 1994; Ojanen 2000) 2. Construct validity (Ojanen 1994; Ojanen 2000)	+/+	-

* In this study the consistency of the measurements varied between high and fair (>.80 high, .80-.61 fair and .60-.40 poor) on the intraclass correlation scale (Baumgartner 1989)

APPENDIX 4 The validity and consistency of work ability and work-related environmental factors measurements, ICF classification, data collection and measurement

Measurement **C) WORK ABILITY AND WORK-RELATED SOCIAL ENVIONMENTAL FACTORS**	**Data collection**	**Original reference**	**Scale**	**Consistency*/ Our study measurements**	**Validity of measurement /Referees**	**Standardiz ation/ Reference**	**Classification of ICF**
Major life areas **- Work and employment** 1. Work ability index (sum index) 2. Absence because of musculoskeletal symptoms	1. Questionnaire/ Work ability index (7-49) 2. Modified Standardized Nordic questionnaire/ 1= 0 days 2= 1-9 days 3= 10-24 days 4= 25-99 days 5= 100-365 days	1. Tuomi et al. 1991c, Ilmarinen et al. 1997 2. Kuorinka et al. 1987	1. Interval scale 2. Ordinal scale	1. ICC 0.94 2. Identical answers: 100% from scale 1-5	1. Criterion validity (Eskelinen et al. 1991), 4=predictive validity (Tuomi et al. 1991d, Pohjonen 1991) 2. Criterion validity (Fredriksson et al. 1998)	+/+ +/+ -/-	1. d 845 2. d 845 3. d 845
Attitudes 1. Mental stress at work 2. Work atmosphere	1.-2. Questionnaire/ Descriptive visual rating scales (0-100)	1.-2. Ojanen 1994; 2000	1.-2. Ratio scale	1. ICC 0.84 (last month) 0.92 (last year) 2. ICC 0.76 (last month) 0.79 (last year)	1. Construct validity (Ojanen 1994; Ojanen 2000) 2. Construct validity (Ojanen 1994; Ojanen 2000)	+/+	1. e 425 2. e 460

* In this study the consistency of the measurements varied between high and fair (>.80 high, .80-.61 fair and .60-.40 poor) on the intraclass correlation scale (Baumgartner 1989)

APPENDIX 5 The changes in physical and psychological functioning and work ability, work-related environmental factors and general subjective well-being 12 months after the physical exercise intervention baseline measurements

	Mean (SD)		
	Baseline (n= 72)	12- month follow up (n= 72)	p-value
Age, years	46.5	47.5	0.000
PHYSICAL FUNCTIONING			
1. Sensory functions and pain			
Intensity of musculoskeletal symptoms (0-10) †			
Sum index average (10 different areas)	1.2 (1.1)	0.6 (0.8)	0.000
Headache	1.6 (2.0)	0.8 (1.6)	0.004
Neck symptoms	1.6 (2.0)	0.8 (1.7)	0.012
Shoulder symptoms	2.2 (2.4)	1.0 (19)	0.000
Low back symptoms	1.3 (2.1)	0.8 (1.9)	0.013
2. Functions of metabolic system			
BMI*	24.8 (3.9)	25.0 (4.1)	0.093
3. Functions of the cardiovascular and respiratory systems			
Maximum oxygen uptake (mL 0_2 x kg^{-1} x min^{-1}) *	29.2 (8.1)	29.2 (8.1)	0.815
4. General tasks and demands			
Degree of disability of musculoskeletal symptoms (0-4) ‡			
Sum index average (10 different areas)			
Headache	0.7 (0.9)	0.5 (0.8)	0.015
Neck symptoms	0.74 (1.0)	0.41 (0.9)	0.023
Shoulder symptoms	0.86 (1.1)	0.54 (0.9)	0.009
Low back symptoms	0.72 (1.1)	0.38 (0.9)	0.016
5. Mobility			
Physical activity (MET)			
LTPA Time-weighted intensity *	4.4 (2.4)	4.1 (2.1)	0.150
AT Time-weighted intensity †	2.0 (0.5)	2.0 (0.5)	0.653
LTPA Maximum intensity *	5.4 (3.1)	5.0 (2.9)	0.161
AT Maximum intensity †	5.9 (2.6)	5.6 (2.6)	0.155
PSYCHOLOGICAL FUNCTIONING (0-100)			
1. Orientation functions			
Self-confidence*	72.7 (14.9)	77.2 (13.1)	0.000
2. Emotional functions			
Anxiety*	74.6 (14.9)	76.6 (17.2)	0.166
3. Carrying out daily routine			
Mood†	73.6 (16.1)	77.9 (13. 0)	0.000
Subjective physical well-being*	76.1 (14.6)	79.6 (13.3)	0.013
Somatic symptoms*	79.9 (15.5)	82.1 (15.9)	0.287
WORKA BILITY AND SOCIAL ENVIRONMENTAL FACTORS AT WORK			
Work ability index (7-49) *	40.4 (6.1)	41.3 (6.1)	0.700
Item (‡):			
- Subjective estimation of present work ability compared the lifetime best (0-10)	8.3 (1.4)	8.5 (1.3)	0.056
- Subjective work ability in relation to physical demands of the work (0-5)	4.1 (0.8)	4.3 (0.8)	0.008
- Subjective work relation to mental demands of the work (0-5)	4.1 (0.8)	4.4 (0.7)	0.009

- Subjective estimation of work impairment due to diseases (1-6)	5.3 (0.8)	5.5 (0.8)	0.044
- Sickness absence during past year (1-5)	4.1 (0.9)	4.0 (0.9)	0.513
- Own prognosis of work ability after two years (1.4.7)	6.6 (1.2)	6.5 (1.3)	0.180
- Enjoying daily tasks (0-4)	3.2 (0.8)	3.4 (0.8)	0.206
- Activity and life spirit (0-4)	2.9 (0.8)	3.0 (0.6)	0.157
- Optimistic about the future (0-4)	2.9 (0.9)	3.2 (0.7)	0.003
Mental stress at work (0-100) *	58.2 (22.7)	57.4 (25.3)	0.743
Working atmosphere (0-100) †	68.0 (21.8)	67.4 (24.7)	0.791
GENERAL SUBJECTIVE WELL-BEING (0-100)			
Life satisfaction †	74.6 (15.2)	78.1 (13.9)	0.005
Meaning of life†	80.8 (16.8)	84.1 (12.6)	0.080

* Paired samples test, † Wilcoxon signed ranks test, ‡ Marginal Homogeneity test,

APPENDIX 6

Prevalence of musculoskeletal symptoms	Yes answers (%) during past 12 months*			Yes answers (%) during past 7 days *		
	Baseline (n= 72)	12- month follow up (n= 72)	p-value	Baseline (n= 72)	12- month follow up (n= 72)	p-value
Headache	61	47	0.001	32	19	0.000
Neck	54	33	0.000	34	19	0.009
Shoulder	59	39	0.000	42	22	0.001
Low back	47	29	0.001	27	17	0.052

* McNemar test