

Leisure-time physical activity, health related functioning and retirement
a prospective cohort study among middle-aged employees

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ACADEMIC DISSERTATION

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LIST OF ORIGINAL PUBLICATIONS

- I Lahti J, Laaksonen M, Lahelma E, Rahkonen O. The impact of physical activity on physical health functioning - A prospective study among middle-aged employees. *Preventive Medicine* 2010; 50: 246-250.
- II Lahti J, Laaksonen M, Lahelma E, Rahkonen O. The impact of physical activity on sickness absence. *Scandinavian Journal of Medicine and Science in Sports* 2010; 20: 191-199.
- III Lahti J, Rahkonen O, Lahelma E, Laaksonen M. Leisure-time physical activity and disability retirement: A prospective cohort study (submitted March 2011).
- IV Lahti J, Laaksonen M, Lahelma E, Rahkonen O. Changes in leisure-time physical activity after transition to retirement: a follow-up study. *International Journal of Behavioral Nutrition and Physical Activity* 2011; 8: 36.

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ABBREVIATIONS

BMI	Body Mass Index
CI	Confidence Interval
HR	Hazard Ratio
LLI	Limiting Longstanding Illness
MCS	Mental Component Summary
MET	Metabolic Equivalent
OR	Odds Ratio
PCS	Physical Component Summary
RR	Rate Ratio
SF-36	Short Form 36 Health Survey

ABSTRACT

Physical inactivity has become a major threat to public health worldwide. The Finnish health and welfare policies emphasize that the working population should maintain good health and functioning until their normal retirement age and remain in good health and independence later in life. Health behaviours like physical activity potentially play an important role in reaching this target as physical activity contributes to better physical fitness and to reduced risk of major chronic diseases.

The aim of this study was to examine first whether the volume and intensity of leisure-time physical activity impacts on subsequent physical health functioning, sickness absence and disability retirement. The second aim was to examine changes in leisure-time physical activity of moderate and vigorous intensity after transition to retirement.

This study is part of the ongoing Helsinki Health Study. The baseline data were collected by questionnaires in 2000–02 among the employees of the City of Helsinki aged 40 to 60. The follow-up survey data were collected in 2007. Data on sickness absence were obtained from the employer's (City of Helsinki) sickness absence registers and pension data were obtained from the Finnish Centre for Pensions. Leisure-time physical activity was measured in four grades of intensity and classified according to physical activity recommendations considering both the volume and intensity of physical activity. Statistical techniques including analysis of covariance, logistic regression, Cox proportional hazards models and Poisson regression were used.

Employees who were vigorously active during leisure time especially had better physical health functioning than those physically inactive. High physical activity in particular contributed to the maintenance of good physical health functioning. High physical activity also reduced the risk of subsequent sickness absences as well as the risk of all-cause disability retirement and retirement due to musculoskeletal and mental causes. Among those transferred to old-age retirement moderate-intensity leisure-time physical activity increased on average by more than half an hour per week and in addition the occurrence of physical inactivity reduced. Such changes were not observed among those remained employed and those transferred to disability retirement.

This prospective cohort study provided novel results on the effects of leisure-time physical activity on health related functioning and changes in leisure-time physical activity after retirement. Although the benefits of moderate-intensity physical activity for health are well known these results suggest the importance of vigorous physical activity for subsequent health related functioning. Thus vigorous physical activity to enhance fitness should be given more emphasis from a public health perspective. In addition, physical activity should be encouraged among those who are about to retire.

TIIVISTELMÄ

Liikunnallinen passiivisuus on merkittävä kansanterveysongelma. Suomalainen hyvinvointipolitiikka pyrkii siihen, että työssä oleva väestö säilyy terveenä ja toimintakykyisenä entistä pidempään. Terveyskäyttäytyminen ja erityisesti liikunta-aktiivisuus voi olla keskeisessä asemassa ikääntyvien työntekijöiden terveyden, toimintakyvyn ja työkyvyn ylläpitämisessä.

Tutkimuksen tavoitteena oli selvittää vaikuttaako vapaa-ajan liikunnan määrä ja rasittavuus myöhempään fyysiseen toimintakykyyn, sairauspoissaoloihin ja työkyvyttömyyseläkkeisiin. Lisäksi tutkittiin, muuttuuko kohtuullisesti rasittavan ja rasittavan liikunnan harrastaminen eläkkeelle siirtymisen myötä.

Tutkimuksen aineistona on käytetty Helsingin kaupungin henkilöstön terveystutkimusta (Helsinki Health Study), jossa tarkastellaan työntekijöiden terveydentilaa, toimintakykyä ja hyvinvointia sekä niihin vaikuttavia tekijöitä. Aineisto muodostuu vuosina 2000, 2001 ja 2002 toteutetuista peruskyselyistä (n=8960), vuonna 2007 toteutetusta seurantakyselystä (vastausprosentti 83%) sekä rekisteritiedoista. Peruskyselylomake lähetettiin kyseisinä vuosina 40, 45, 50, 55, ja 60 vuotta täyttäneille Helsingin kaupungin työntekijöille ja seurantalomake peruskyselyyn vastanneille. Sairauspoissaolotiedot perustuvat työnantajan rekisteriin ja tiedot työkyvyttömyyseläkkeistä Eläketurvakeskuksen rekisteriin. Liikunnan harrastamista viimeksi kuluneiden 12 kuukauden aikana kysyttiin neljässä rasitusasteessa. Samaa mittaria käytettiin molemmissa kyselyissä. Liikunta-aktiivisuus luokiteltiin terveysliikuntasuosituksen mukaan ja siinä huomioitiin sekä liikunnan määrä että sen rasittavuus. Tilastomenetelminä käytettiin kovarianssianalyysiä, logistista regressioanalyysiä, Coxin suhteellisten riskien mallia sekä Poissonin regressioanalyysiä.

Etenkin rasittavaa liikuntaa, kuten juoksua harrastavilla oli parempi fyysinen toimintakyky kuin liikunnallisesti passiivisilla. Runsas liikunta auttoi erityisesti ylläpitämään hyvää fyysistä toimintakykyä. Liikunta-aktiivisuus vähensi myös sairauspoissaolojen riskiä kuten myös riskiä siirtyä työkyvyttömyyseläkkeelle tuki- ja liikuntaelinten sairauksien ja mielenterveysongelmien vuoksi. Vanhuuseläkkeelle siirtyneet lisäsivät rasittavuudeltaan kohtuullista liikuntaa, kuten kävelyä tai reipasta kävelyä keskimäärin yli puolella tunnilla viikossa. Liikunnallisesti passiivisten osuus väheni merkittävästi vanhuuseläkkeelle

siirtyneiden joukossa. Vastaavia muutoksia ei työssä jatkaneilla ja työkyvyttömyyseläkkeelle siirtyneillä tapahtunut.

Tämä tutkimus tuotti uutta tietoa liikunnan vaikutuksesta terveyteen liittyvään toimintakykyyn ja liikunta-aktiivisuuden muutoksesta eläkkeelle siirryttäessä. Kohtuullisesti rasittavan liikunnan hyödyt terveydelle ovat ennestään tunnettuja. Tutkimuksen tulokset kuitenkin painottavat rasittavan liikunnan tärkeyttä terveyteen liittyvän toimintakyvyn kannalta. Kansanterveyden näkökulmasta rasittavaa kuntoliikuntaa tulisikin korostaa entistä enemmän. Lisäksi liikunnan harrastamiseen tulisi kannustaa eläkeiän kynnyksellä olevia.

1. INTRODUCTION

In Finland, more than a third of the working population engages in physical activity less than is recommended for health (Fogelholm et al. 2007, Husu et al. 2011). According to the physical activity recommendations (Fogelholm et al. 2005, Haskell et al. 2007, Physical Activity Guidelines Advisory Committee 2008), brisk walking for 30 minutes on at least five days per week or an equivalent amount of other physical activity is sufficient to reduce the risk of most health outcomes. Such amounts of physical activity are associated with a reduction in mortality of up to 30% (Kesäniemi et al. 2001). Further benefits for health can be achieved by increasing the amount of physical activity. For healthy weight maintenance physical activity corresponding to brisk walking up to 60 minutes on most days of the week is important (Goldberg and King 2007). In addition to increased energy expenditure, physical activity is important for cardiorespiratory and musculoskeletal fitness. Thus, sufficient intensity of physical activity and the recommended weekly amount are both important in terms of beneficial health effects.

Physical activity is an important part of healthy ageing (Peel et al. 2005, Rowe and Kahn 1987). In Finland, the population is ageing even faster than in other Western societies (Antolín et al. 2001). Post-war baby boomers born between 1945 and 1950 form a cohort of about 10% of the population. Also, the age structure of employees is changing; currently about half of all employees are aged 45 or more. The Finnish health, welfare and work life policies emphasize that the working population should maintain good health and functioning until their normal retirement age and also maintain their health and independence after retirement (Ministry of Social Affairs and Health 2001). There is economic pressure to prevent disability retirement and lengthen work careers throughout Europe (Ylikoski et al. 2006). In addition to work-related factors (Laine et al. 2009, Lund and Csonka 2003, Vahtera et al. 2010) healthy lifestyles including sufficient leisure-time physical activity may be important in terms of lengthening working life and preventing work disability.

The scientific evidence linking physical activity to health and fitness originates from a few epidemiological studies in the 1950s examining aerobic physical activity in occupational settings and cardiovascular disease outcomes (Morris et al. 1953, Morris and Crawford 1958). One of the early experimental studies

showed that physical activity with an intensity of at least 60% of the heart rate range was needed to gain increased fitness (Karvonen et al. 1957). In the late 1970s it was shown that energy expenditure of approximately 2000 kcal per week in physical activity was associated with reduced risk of heart attack (Paffenbarger et al. 1978). Within the last few decades a massive amount of scientific evidence has been published showing that regular physical activity has many beneficial health effects (Physical Activity Guidelines Advisory Committee, 2008). Physical activity is associated with reduced risk of all-cause mortality (Byberg et al. 2009, Lee and Paffenbarger 2000), type 2 diabetes (Hu et al. 2003), cardiovascular disease (Kohl 2001) including coronary heart disease (Sesso et al. 2000), hypertension (Haapanen et al. 1997) and stroke (Lee et al 2003). Physical inactivity is also associated with musculoskeletal diseases (Kujala et al. 2000, Vuori 2001) and mental disorders (Ströhle 2009, Teychenne et al. 2008) which are the most common reasons for sickness absence and work disability among the middle-aged in Finland (The Social Insurance Institution of Finland 2010).

Although musculoskeletal diseases and mental disorders are common causes of functional limitation many other diseases and health problems also affect functioning. Considering all health problems equally in the environment of people's everyday life is highly important. In addition, every individual experiences some grade of health related functioning. Therefore also good health related functioning is a relevant topic along with ill-health and functional problems.

There are two main types of physical activity studies, i.e. observational epidemiological studies and experimental intervention studies such as randomized controlled trials, which have contributed to the knowledge base of physical activity and health (Thomas and Nelson 2001). For a comprehensive view on the possible health effects of physical activity both observational epidemiological studies and experimental intervention studies are needed. Intervention study designs enable to examine e.g. the effect of controlled physical activity dose on disease risk factors. Associations between physical activity and the emergence of diseases or other health outcomes can be examined by observational epidemiological studies. Many epidemiological studies have been cross-sectional, which is a limitation in terms of establishing causality between physical activity and health outcomes. Although the temporal order between physical activity and health outcome is essential, confounding also needs to be taken into account in order to establish causal relationships better.

Observational epidemiological physical activity studies are challenging particularly because poor health may restrict engagement in physical activities. Ideally, in prospective epidemiological designs an initially healthy cohort is followed until certain health outcomes occur. This is rarely the case in practice, however, as some health problems are usually present when physical activity is measured and potentially affect engagement in physical activity. Thus existing health differences before the measurement of physical activity need to be considered in analysis. Equally important is to take into account confounding factors that may be associated with the health outcome and are unequally distributed between physical activity groups.

The physical activity recommendations for health are based on available scientific evidence mostly from observational studies. In the first recommendations given by the American College of Sports Medicine in 1978 the focus was on enhancing fitness and vigorous physical activity was therefore recommended (American College of Sports Medicine 1978). In the 1990s the recommendations started to promote moderate-intensity physical activity as many studies showed that physical activity is beneficial for health even without gains in fitness (Pate et al. 1995). In the most recent recommendations muscle strengthening exercise is given more emphasis among the middle-aged (Physical Activity Guidelines Advisory Committee 2008, UKK Institute 2009).

Regardless of all the scientific evidence and efforts to promote physical activity, physical inactivity now presents a major threat to public health worldwide (Beaglehole et al. 2011). Although many chronic diseases are major public health issues it is important to study health related functioning in general among the middle-aged. Among those of working age health related functioning is strongly related to occupational settings and therefore in addition to self-reported measures of health functioning alternative measures such as sickness absence and disability retirement are important. This prospective observational study aims to provide novel evidence of the impact of leisure-time physical activity of moderate and vigorous intensity on various measures of health related functioning and changes in leisure-time physical activity after transition to retirement among middle-aged municipal employees.

2. REVIEW OF THE LITERATURE

2.1 Physical activity

As a health related behaviour physical activity is considered to be an important part of a healthy lifestyle (Pate et al. 1995). Physical activity is by definition any bodily movement produced by the skeletal muscles that markedly increases energy expenditure (Bouchard et al. 2006, Caspersen et al. 1985). Physical activity can be done in different contexts and divided, for example, into occupational and leisure-time physical activity. Occupational physical activity constitutes work-related tasks such as lifting, standing and walking. Leisure-time physical activity constitutes activities that one prefers to do outside working time that markedly increase energy expenditure. Motivation to engage in leisure-time physical activity is often related to health and fitness benefits but other objectives such as fun and social contacts may also apply.

Leisure-time physical activity includes commuting, non-exercise, exercise and sports (Bouchard et al. 2006). Commuting physical activity may be done simply as a means of travel or for other reasons such as exercise. Non-exercise physical activity is done for other purposes than conditioning exercise or fitness itself. For example, snow shovelling, heavy gardening or wood chopping increase energy expenditure but the ultimate goal is not to enhance fitness. Exercise is a form of leisure-time physical activity that is performed repeatedly over a longer period to maintain or enhance fitness. Jogging regularly on a weekly basis or regular aerobics a few times per week for example is exercise. Lower-intensity activity such as walking can also constitute exercise for a previously sedentary unfit individual. Sport is a competitive form of physical activity which can vary from low-intensity activity such as bowling to more strenuous activity such as marathon running.

Different dimensions of physical activity can be expressed by the frequency, intensity, duration and type of activity (Bouchard et al. 2006). Frequency is how often one engages in physical activity e.g. during a day or a week. Intensity refers to the strenuousness of physical activity. In epidemiological studies intensity is measured as relative or absolute. Measuring relative intensity requires a measure of fitness as well. For example, walking at the pace of 5 km/hour is more strenuous for a less fit person than for a person with a better fitness level.

Duration refers to the time used in one physical activity session. Type is the activity that one engages in such as jogging, skiing, aerobics or strength training.

The volume of physical activity is often expressed as the metabolic equivalent (MET). The weekly volume of physical activity (MET hours per week) is a product of the time, frequency and intensity of physical activity. Physical inactivity refers to the volume of physical activity that is less than recommended for gains in health. Sedentary behaviour differs from physical inactivity in that it refers to behaviours that do not increase energy expenditure such as sitting at a computer or watching television (Pate et al. 2008).

Engagement in physical activity is affected by many individual and extra individual factors (Trost et al. 2002). The reasons most often cited for not engaging in physical activity relate to factors such as lack of time, poor health and lack of motivation. Age and gender are associated with physical activity. Other health behaviours as well as socioeconomic position and work characteristics are correlated with engagement in physical activity.

In the present study, leisure-time physical activity is studied with regard to the recommended weekly volume as well as the intensity of physical activity. A detailed description of the leisure-time physical activity questionnaire and classification is given in section 4.2.

2.2 Health related functioning

Health related functioning is an important part of health as it is related to the environment in which an individual functions in his or her everyday life, doing such things as house chores, leisure-time activities and occupational tasks. Although health measures such as specific diseases and mortality are important indicators of health they do not consider the individual perspective, which is extremely important. Health related functioning can be seen as a continuum in which the good end describes optimal health and functioning without restrictions in everyday life whereas the poor end describes severe health problems and restricted functioning.

Health related functioning is a broad concept covering aspects of health that influence functioning in everyday life. Every individual has some grade of disability or lack of functioning. The most widely used measure of health related functioning is the Short Form 36 Health Survey (SF-36) which measures health

functioning in everyday life such as work and home (Ware et al. 1994). In the literature, the SF-36 is often referred to as a measure of health related quality of life (Aalto et al. 1999). In the present study, the term health functioning is used and previous studies using the SF-36 are also referred to as health functioning. Among employees, occupational settings are relevant part of the everyday living and sickness absence and disability retirement were therefore examined in addition to the SF-36 health functioning. Sickness absence from work indicates temporary work inability and thus lack of health related functioning in occupational settings. Different durations of sickness absence reflect the severity of decline in health related functioning. Disability retirement indicates permanent work inability and thus is a measure of severe loss in health related functioning.

In the present study the SF-36 physical health functioning, sickness absence and disability retirement are used as measures of general health related functioning. The physical component summary score (PCS) of the SF-36 is a composite measure of physical health functioning and is shown to predict subsequent longer sickness absences (Laaksonen et al. 2011) and mortality (Kroenke et al. 2008). Longer medically certified sickness absences predict the onset of work disability and mortality (Marmot et al. 1995) and mortality rates are higher among disability retirees compared with those remaining in employment (Wallman et al. 2006). Detailed descriptions of the measures of health related functioning used in the present study are given in chapter 4.2.

2.3 Physical activity and health related functioning

Physical activity is considered important for preventing many diseases that cause disability and functional problems (Physical Activity Guidelines Advisory Committee 2008). The wide-ranging benefits of physical activity for physical and mental health and fitness are essential for general health related functioning. Among the middle-aged, problems in functioning are often related to chronic diseases and conditions (Aromaa and Koskinen 2004) such as musculoskeletal diseases and mental disorders, which account for two-thirds of disability retirements in Finland (The Social Insurance Institution of Finland 2010). Physical activity is associated with various musculoskeletal diseases such as neck and low back disorders, arthrosis (Vuori 2001) and osteoporosis-related fractures (Kujala et al. 2000) which are major causes of functional limitation and disability. The association of physical activity with musculoskeletal diseases is, however, complex as high strain and injuries may cause e.g. arthrosis. Vigorous physical

activity may also promote the degeneration process and there is some evidence that moderate-intensity physical activity may slow down the degeneration process (Vuori 2001). Regular physical activity is also associated with reduced risk of depression (Strawbridge et al. 2002) and other mental disorders such as anxiety (Ströhle 2009). Some studies have suggested that vigorous physical activity may be important for reducing depression (Lampinen et al. 2000), but a recent review concluded that even low doses of physical activity may protect against depression (Teychenne et al. 2008).

Physical activity may also be important in the treatment of many chronic diseases (Kujala 2009). For example, for common low back and neck disorders physical activity is often recommended (Kujala 2009) and in addition there is some evidence that depression can be treated by physical activity (Ströhle 2009). Physical activity to enhance functioning is in many cases an essential part of rehabilitation.

Physical activity may also have an effect on functioning independently of disease. The importance of physical fitness on functioning is well established among the elderly and there is significant individual variation in functional health decline (DiPietro 2001). Muscle mass, strength and function typically decline with advancing age. In general, peak muscle mass is achieved around 25 years of age after which a gradual decrease that becomes more rapid around the age of 65 is observed (Vandervoort 2002). Other aspects of fitness apart from muscle function also decline with increasing age. Aerobic fitness is important for functioning and it also shows a gradual decrease with age. Maximum oxygen uptake declines approximately at a rate of 1% per year from the age of 25 onward, similarly to muscle strength (Hawkins and Wiswell 2003).

Decline in physical fitness related to ageing is partly owed to decline in physical activity and partly to the inevitable physiological ageing process (Hawkins and Wiswell 2005). Thus physical activity can slow down age-related decline in physical fitness. Physical activity is also important for healthy weight maintenance (Goldberg and King 2007) and as obesity is related to functional problems (Laaksonen et al. 2005) physical activity may also thereby be related to functioning. Maintenance and enhancement of physical fitness to prevent decline in health functioning may, however, be the most important benefit that can be attained from engagement in regular physical activity.

2.4 Previous empirical evidence on the association of physical activity and health related functioning

2.4.1 Physical activity and general measures of physical health functioning

Previous research among the middle-aged has used various physical activity questionnaires and measures of physical health functioning. Most studies have used the SF-36 subscales or component summaries as measures of physical health functioning (Bize et al. 2007, Klavestrand and Vingård 2009). Studies concerning the middle-aged have mostly used cross-sectional designs (Bize et al. 2007, Klavestrand and Vingård 2009, Riise et al. 2003, Vuillemin et al. 2005) or concerned specific occupations (Sörensen 2008). Two recent reviews about physical activity and health related functioning (mostly measured by SF-36) concluded that cross-sectional studies have shown consistently that physical activity is associated with better health functioning but there is limited evidence from prospective studies (Bize et al. 2007, Klavestrand and Vingård 2009). There are few prospective studies that have examined physical activity and subsequent physical functioning among the middle-aged (Hillsdon et al. 2005, Huang et al. 1998, Lang et al. 2007, Leino-Arjas et al. 2004) and one study that examined changes in physical activity and subsequent changes in SF-36 scores (Wolin et al. 2007).

A study from the USA (Huang et al. 1998) showed that physical activity and fitness measured between years 1980 and 1988 were protective against functional limitation in 1990 among middle-aged and older participants. Functioning at the baseline measurement was not, however, taken into account. Another study using data from USA and British cohorts followed 50-69-year-olds for six years and showed that vigorous physical activity protects against functional impairment among normal, overweight and even obese people (Lang et al. 2007). A Finnish study followed up a cohort of employees in the metal industry (Leino-Arjas et al. 2004) and showed that vigorous leisure-time physical activity was inversely associated with poor physical functioning 28 years later. Functioning at the baseline measurement was not taken into account and the age range of participants was wide; 17 to 64 years at the beginning of the study.

The British Whitehall II cohort study used the physical functioning subscale of the SF-36 health questionnaire as an outcome measure and examined the proportion of those with optimal physical functioning (Hillsdon et al. 2005). Participants were

39 to 60 years old at baseline (1991-93). The follow-up survey was conducted in 2001. Baseline physical functioning score and other confounders were adjusted for. Results showed that those with recommended volume of physical activity more often maintained high physical functioning and that the physically active had better functioning among those with and without longstanding illness at baseline. A US study using extensive follow-up data (1986-2000) from women participating in the Nurses' Health Study aged 40 to 67 years at the baseline reported that any increases in physical activity between 1986 and 1996 was associated with significantly higher functioning especially in the physical subscales of the SF-36 in 1996 compared with those with stable physical activity (Wolin et al. 2007). In addition, they reported that increased physical activity was associated with greater increases in subsequent (1996-2000) physical functioning compared with those with stable physical activity.

2.4.2 Physical activity and sickness absence

In general, previous prospective studies on physical activity and sickness absence have shown that those physically active or with better fitness are at reduced risk of sickness absence (Christensen et al. 2007, Eriksen and Bruusgaard 2002, Holtermann et al. 2011, Jacobson and Aldana 2001, Jans et al. 2007, Kivimäki et al. 1997, Kyröläinen et al. 2008, Proper et al. 2006, Strijk et al. 2011, van Amelsvoort et al. 2006, van den Heuvel et al. 2005). In a study of local government employees conducted in a small Finnish municipality an association was found with physical activity and subsequent sickness absence spells of over three days (Kivimäki et al. 1997). When, however, the baseline sickness absence was adjusted for statistically significant differences between physical activity groups were lost (Kivimäki et al. 1997).

In some studies the association between physical activity and sickness absence has been relatively weak (Eriksen and Bruusgaard 2002, van Amelsvoort et al. 2006). Among Norwegian nurses' aides regular leisure-time physical activity reduced the risk of sickness absence (Eriksen and Bruusgaard 2002), but the differences were relatively small during the 15 months of follow-up. A study from the Netherlands (van Amelsvoort et al. 2006) also showed a relatively small difference between active and inactive employees during a follow-up period between 8 and 12 months; however, when only musculoskeletal disorders were considered the association was stronger. A Danish study (Holtermann et al. 2011) showed that those active during leisure time had fewer sickness absence spells

lasting over three weeks during a two-year follow-up. In addition, the results showed that occupational physical activity increased the risk of longer sickness absences. Another Danish study (Christensen et al. 2007) showed that leisure-time physical activity was not associated with more than eight weeks' sickness absence during an 18-month follow-up.

A study from the USA examined the frequency of aerobic activity and annual sickness absence in a large dataset of workers (Jacobson and Aldana 2001). Even one activity session per week was associated with lower sickness absence rates and two sessions reduced the risk even more; however, statistically significant differences were not observed between two and more exercise days per week. A Finnish study (Kyröläinen et al. 2008) examined military personnel and showed that better fitness was associated with less sickness absence. A study from the Netherlands (Strijk et al. 2011) showed similar results; those with good fitness are at lower risk of sickness absence.

One study from the Netherlands examined recommended level of moderate or vigorous physical activity and subsequent sickness absence using two cross-sectional and one prospective datasets (Proper et al. 2006). The results showed that vigorous-intensity physical activity was associated with reduced sickness absence, but those engaging in recommended moderate-intensity physical activity did not have any less sickness absence than those not meeting the recommended level of activity. The vigorously active, however, may have had a higher volume of activity than those meeting the moderate-intensity physical activity recommendation. Two other studies from the Netherlands using the same follow-up data also showed that sports participation was associated with reduced sickness absence (Jans et al. 2007, van den Heuvel et al. 2005). Those who practised sports had on average 20 sick days fewer during the four years of follow-up.

2.4.3 Physical activity and disability retirement

There are only a few previous studies examining physical activity and the risk of subsequent disability retirement. A study following former male elite athletes (n=2402) and their referents (n=1712) examined the risk of disability retirement or death before the age of 65 with an average follow-up of nearly fifty years (Kaprio and Sarna 1994). The results showed that vigorous physical activity may extend the occupationally active lifespan and that the lower risk of disability

retirement among the athletes was mainly due to lower rates of cardiorespiratory diseases and to a lesser extent musculoskeletal diseases. In addition they found that the endurance athletes had a lower risk of disability retirement for mental reasons. A Finnish study conducted among middle-aged men living in Eastern Finland (n=1307) examined whether good cardiorespiratory fitness reduces the risk of subsequent disability retirement (Karpansalo et al. 2003). Even after adjustments for baseline diseases and other confounders a strong inverse association remained between physical fitness and disability retirement over 11 years of follow-up. Disability retirement due to cardiovascular diseases and to a lesser extent to musculoskeletal diseases was more common among those in the lowest quintile compared with the highest quintile of physical fitness, similarly to the athletes study (Kaprio and Sarna 1994). A weaker association was found for mental disorders. Another Finnish study examining municipal employees during the 1980s (Tuomi et al. 1991, Tuomi et al. 1997) showed that vigorous physical exercise maintained work ability and decreased the risk of work disability among those with cardiovascular disease.

Two studies that have examined various determinants of all-cause disability retirement have also included a measure of physical inactivity (Biering-Sorensen et al. 1999, Krokstad et al. 2002). In both studies physical inactivity predicted subsequent disability retirement. In the Norwegian study using a large dataset the association was weak and found only among employees over 50 years of age (Krokstad et al. 2002) whereas the Danish study with a smaller sample (Biering-Sorensen et al. 1999) found a stronger association. In addition, they found that those with better physical condition than those of the same age had significantly lower rates of disability retirement and that those with worse physical condition had an increased risk of disability retirement.

2.4.4 Potential confounding factors

Obesity is associated with many health problems and restricts functioning in everyday life (Laaksonen et al. 2005, Laaksonen et al. 2009, Lang et al. 2007). Obesity is also associated with physical inactivity (Laaksonen et al. 2001). Smoking and heavy alcohol use are also known health risks associated with sickness absence (Laaksonen et al. 2009, Salonsalmi et al. 2009) and with physical inactivity (Laaksonen et al. 2001). Physical inactivity is also associated with lower socioeconomic position (Mäkinen et al. 2009) and may be related to work characteristics (Wu and Porell 2000). Lower socioeconomic position is associated

with poor functioning (Lahelma et al. 2005) and increased sickness absence (Piha et al. 2007). Work characteristics are also associated with health related functioning (Leino-Arjas et al. 2004). Thus, these factors may contribute to the association between leisure-time physical activity and health related functioning.

2.5 Retirement and changes in physical activity

There are life events that may affect engagement in physical activity in general populations. Retirement from work markedly increases free time and thus potentially increases engagement in leisure-time physical activity. The previous prospective studies show diverse results for changes in physical activity after transition to retirement (Berger et al. 2005, Chung et al. 2009, Evenson et al. 2002, Slingerland et al. 2007, Touvier et al. 2010). A study from the USA (Evenson et al. 2002) showed that those not in continuous work during a six-year follow-up period increased their leisure-time physical activity. A four-year follow-up study conducted in Scotland (Berger et al. 2005) showed that the slight increase in leisure-time physical activity found among those not in employment at the follow-up did not compensate for the loss of occupational physical activity among the 699 respondents. A Dutch study with a 13-year follow-up (Slingerland et al. 2007) showed that retirement from work markedly reduced commuting and did not increase leisure-time physical activity, although the physical activity measure changed during the follow-up. Another study from the USA using a measure of vigorous activity during sports or physical labour (Chung et al. 2009) showed that in the total sample retirement did not increase vigorous physical activity but vigorous activity increased with retirement from a sedentary job. A three-year follow-up from France (Touvier et al. 2010) showed that retirement increased moderate-intensity leisure-time physical activity by about two hours per week in a group of highly selected participants of a nutritional intervention study with complete data available only for every fourth subject. None of these previous studies have examined different retirement routes and definition of retirement has been unclear in most studies (Berger et al. 2005, Chung et al. 2009, Evenson et al. 2002).

2.6 Summary of previous research

Previous studies consistently show a positive though varying strength association between physical activity and various measures of health related functioning, suggesting that regular physical activity may protect against functional health

decline and onset of work disability. Many of the prospective studies have not considered the direction of the association adequately: e.g. health differences at the time of physical activity measurement have not been considered. Associations may be different among women and men and most studies have not examined them separately. Furthermore, many of the previous studies have only relied on self-reported measures of health related functioning. Studies examining different intensities of physical activity suggest that vigorous activity may offer more health benefits in terms of health related functioning than moderate-intensity activity. More evidence is needed, however, as the higher intensity may be associated with greater volumes of activity and thereby appear to be more beneficial to functional health outcomes.

Previous studies examining retirement and changes in physical activity suggest that retirement from work is associated with increasing moderate-intensity leisure-time physical activity. The results vary between studies, however, partly because of methodological differences and different study settings. Furthermore, the definition of retirement has been unclear and none of the previous studies have distinguished old-age retirees from disability retirees. Often studies have examined only one or selective occupations. The studies have often used only a few cases, and thus convincing evidence has been lacking.

3. AIMS OF THE STUDY

The general aim of this thesis was to examine the impact of moderate and vigorous intensity leisure-time physical activity on subsequent health related functioning and changes in leisure-time physical activity after transition to retirement. In addition, the potential contribution of sociodemographic, lifestyle, health, and work-related factors to these associations were examined with data from middle-aged female and male employees.

The specific aims were to examine:

1. Whether recommended levels of moderate and vigorous intensity leisure-time physical activity impact on physical health functioning five to seven years later.
2. The impact of the volume and intensity of leisure-time physical activity on subsequent short and long sickness absence spells.
3. Whether leisure-time physical activity has an impact on all-cause disability retirement and the two main medical causes of disability retirement, i.e. musculoskeletal diseases and mental disorders.
4. Whether old-age or disability retirement impacts on leisure-time physical activity of moderate and vigorous intensity.

4. DATA AND METHODS

4.1 Data

This study is part of the ongoing Helsinki Health Study conducted among middle-aged employees of the City of Helsinki. The City of Helsinki is the largest employer in Finland (~40000 employees, 70% women). The mean age of the employees in the early 2000s was around 45 (Lahelma et al. 2005). The prospective data used in these four studies comprise the baseline survey with linkages to sickness absence registers (Study II) and retirement registers (Study III) and a follow-up survey (Studies I and IV).

4.1.1 Survey data

The baseline data were collected by questionnaire surveys in 2000, 2001 and 2002. The questionnaires were sent to employees of the City of Helsinki who reached the ages of 40, 45, 50, 55 and 60 during each survey year (Lahelma et al. 2005). The sample consisted of 13346 people and 8960 returned the questionnaire (67%). Corresponding to the figure in the target population 80% of the respondents were women. According to non-response analysis women, older employees, those in higher socioeconomic position and those with less medically confirmed (over three days) sickness absence were slightly more willing to participate in the baseline survey. The differences between non-respondents and respondents were small, however, and the data satisfactorily represent the target population (Laaksonen et al. 2008). The follow-up survey data were collected in 2007. A similar questionnaire was sent to all respondents of the baseline survey. The response rate for the follow-up was 83% (n=7332, 80% women).

4.1.2 Register data and linkages

The baseline survey data were linked to the employer's sickness absence register and the national retirement registry of the Finnish Centre for Pensions. Of the baseline respondents 78% gave permission for the linkages to the employer's sickness absence register and 74% for the retirement linkages obtained from the Finnish Centre for Pensions. The linkages were made by using the personal identification number given to all residents of Finland. Giving consent to register linkages was associated with background variables similarly to participation in the

baseline survey, although the associations were weaker and men gave their consent more often than women (Laaksonen et al. 2008).

4.2 Measurements

4.2.1 Leisure-time physical activity

Leisure-time physical activity (including commuting) within the previous twelve months was measured identically at the baseline and follow-up surveys. Physical activity was divided into four intensity grades and exemplified with common physical activities that people usually engage in: walking, brisk walking, jogging, and running. The respondents were instructed first to estimate the intensity of each activity they engaged in and then to estimate how many hours per week they spent on average in physical activity corresponding to each grade of intensity. Each intensity grade had five response alternatives: no activity, 0-½ hours/week, ½-1 hours/week, 2-3 hours/week, ≥ 4 hours/week.

Leisure-time physical activity was converted to an approximate metabolic equivalent (MET) index. The MET value is a multiple of the resting rate of oxygen consumption. One MET is defined as the energy expenditure of a person sitting quietly. The total MET-hours per week for leisure-time physical activity were calculated by multiplying the time used (class midpoints) by the estimated MET value of each physical activity grade (Kujala et al. 1998) and adding the four values together (Ainsworth et al. 2000). The respondents were first classified into quintiles (Study II) according to the volume of physical activity (MET-hours per week) which is a common practice in physical activity epidemiology (Lee and Paffenbarger 2009, Kujala et al. 1998). This classification does not distinguish between those engaging in moderate-intensity physical activity and those who engage in vigorous activity, but merely differentiates the volume. For the purpose of this study physical activity groups were formed according to physical activity recommendations (Fogelholm et al. 2005, Haskell et al. 2007, Physical Activity Guidelines Advisory Committee 2008) by taking into account both the intensity (moderate or vigorous) and the weekly volume (MET-hours per week) of physical activity. Owing to the nature of our physical activity measure not all aspects of these recommendations could be considered, such as the frequency of physical activity in a week and the nature of activity, i.e. aerobic or muscle-strengthening activity.

In this classification moderate-intensity physical activity is equal to walking and brisk walking and vigorous to jogging and running. First, the group of those not engaging in physical activity as recommended for health was formed, i.e. the inactive group (0-14 MET-hours per week). The mean MET-hours per week for the inactive group (Table 1) correspond to e.g. 45 minutes of both walking and brisk walking per week so the group was not entirely inactive. Then those engaging only in moderate-intensity activities were separated from those reporting vigorous activity (Table 1). Those engaging in moderate-intensity activity only were classified into two groups: active moderate (14-30 MET-hours/week) and very active moderate (over 30 MET-hours/week). Fifteen MET-hours equal, for example, two hours and 30 minutes of brisk walking per week. Those who engaged in vigorous activity were classified into separate groups with approximately the same volume as the moderate activity groups. As people usually engage in moderate-intensity activity in some form there were only a few participants reporting vigorous activity only. Those reporting vigorous activity only were classified into the same groups with those combining moderate and vigorous intensity activity according to the volume of leisure-time physical activity. For those engaging also in vigorous activity the groups were: active vigorous (14-30 MET-hours/week) and very active vigorous (30-50 MET-hours/week). Finally, the most active group, i.e. conditioning exercise (over 50 MET-hours/week) was left.

For Studies I and II the six physical activity groups were used and for Study III the middle activity groups were collapsed into two groups: active moderate (14-50 MET-hours per week) and active vigorous. For Study IV the inactive group (0-14-MET-hours per week) was used. The total time used in leisure-time physical activity was calculated for each respondent. In addition, the time used in moderate-intensity physical activity (walking, and brisk walking, or their equivalent activities) and vigorous physical activity (jogging, and running, or their equivalent activities) was calculated separately.

Table 1. Leisure-time physical activity classification. Proportion (%) of women and men, range and mean MET-hours per week and engagement in vigorous activity.

	Proportion (%) of women and men		MET-hours/week range	Mean MET-hours/week		Vigorous physical activity
	Women	Men		Women	Men	
1. Inactive	24	25	0-14	7	7	Yes/No
2. Active moderate	29	19	14-30	20	20	No
3. Active vigorous	9	12	14-30	22	22	Yes
4. Very active moderate	17	9	30+	41	42	No
5. Very active vigorous	11	16	30-50	39	39	Yes
6. Conditioning exercise	10	19	50+	74	82	Yes

4.2.2 Physical health functioning

In Study I physical health functioning at the follow-up survey was used as the outcome. For the purpose of this study the physical component summary (PCS) of the Finnish version of the Short-Form 36 (SF-36) health questionnaire (Hagman 1996, Ware et al. 1994) was chosen as it gives a good overall measure for physical health functioning. There are also other advantages of using the component summary score instead of analysing the subscales separately: e.g. fewer statistical comparisons, smaller confidence intervals and most importantly elimination of both floor and ceiling effects (Ware et al. 1994). The component summary score does not, however, distinguish between the dimensions of physical health functioning. The PCS is a generic measure of physical health and health related functioning. The eight subscales of the SF-36 include physical functioning, role limitations due physical problems, bodily pain, general health perceptions, mental health, role limitations due emotional problems, social functioning and vitality. These subscales of the SF-36 can be compressed by means of factor analysis into two component summary scores describing physical and mental health functioning. Each of these subscales positively or negatively contributes to both

physical (PCS) and mental component (MCS) summaries. The physical functioning, role limitations due physical problems, bodily pain and general health perceptions subscales are referred to as physical subscales; however, of the other four subscales vitality and social functioning also have notable correlations with the physical component score. The PCS score is a continuous variable ranging from zero to 100 with a mean of 50 (SD=10) observed in the general US population. Low scores imply poor and high scores good physical health functioning. The SF-36 has good construct validity and high test-retest reliability and internal consistency (Ware et al. 1994).

4.2.3 Sickness absence

Prospective sickness absence information was obtained from the comprehensive personnel registers of the employer (City of Helsinki). The number of sickness absence spells during the follow-up was used as the outcome variable in Study II. Sickness absence spells lasting up to 14 days (short) and those lasting more than 14 days (long) were examined separately. The long spells were medically confirmed whereas the short spells included both medically confirmed (3-14 days) and self-certified (1-3 days) sickness absence. All other absences (e.g. maternity leave) were removed from the follow-up time. Consecutive sickness absence spells were combined. The follow-up started on the day the questionnaire was returned and continued until the work contract ended or until the end of the year 2005. The mean follow-up time was 3.9 years.

4.2.4 Disability retirement

Prospective disability retirement data were obtained from the comprehensive national retirement register of the Finnish Centre for Pensions and used as the outcome in Study III. Disability retirement includes all granted (permanent, temporary and partial) disease-based pensions, i.e. disability pensions and individual early retirement pensions. Eligibility for disability pension requires medically confirmed illness, disease or injury which essentially reduces working capacity in the occupation of the person. The causes of disability retirement were distinguished according to the ICD-10 classification. Main diagnosis in the medical certificate given by the attending physician was used for this classification. Two large groups were distinguished, i.e. diseases of the musculoskeletal system and connective tissue (ICD codes M00-M99) and mental and behavioural disorders (F00-F99). The follow-up began on the day the questionnaire was returned and

continued for a maximum of 6.8 years or ended on the date of other retirement pensions, the age of 63 years (after the age of 63 disability pensions are no longer applicable in Finland) or death, providing a mean follow-up time of 6.0 years.

4.2.5 Transition to retirement

Details of employment status, date of retirement and type of retirement pension were requested at the follow-up survey. Disability retirees (disability and individual early retirement pensioners) were distinguished from old-age retirees (e.g. old-age, early old-age and unemployment pensioners). Those who were on part-time retirement or were working part-time were regarded as employed. The employees were examined in the baseline age groups 40, 45, 50, 55-60 and for the analysis two groups were formed: 40-50-year-olds and 55-60-year-olds.

4.2.6 Covariates

Baseline health

Physical health functioning (PCS) of the Short-Form (SF-36) health questionnaire as an outcome was also used as a covariate in all studies. Mental health functioning (MCS) of the SF-36 was used as a covariate in Study III. Details of limiting longstanding illness (LLI) were requested in two separate questions and classified into two groups: those with LLI and those without LLI. In addition, in study II those participants reporting significantly limiting longstanding illness were excluded. Data on sickness absence benefit periods were obtained from the national registers of The Social Insurance Institution of Finland for the Study III. Those who had a longer benefit period (90 days) between four to one years preceding the baseline were separated from those who did not have such a sickness benefit period. Those who had sickness benefits because of diseases of the musculoskeletal system and connective tissue (ICD codes M00-M99) and mental and behavioural disorders (F00-F99) were separated from those that did not. The Social Insurance Institution of Finland maintains a comprehensive register with information on diagnoses with regard to sickness benefit periods lasting 90 days or over. Data on the shorter periods are also maintained, but diagnoses are not collected comprehensively.

Health behaviours and body mass index

The body mass index (BMI) was calculated as the weight in kilograms divided by the height in metres squared, using baseline questionnaire data, and was used as a continuous variable or categorical variable: normal weight (< 25 kg/m²), overweight (25-30 kg/m²) and obese (> 30 kg/m²). Smoking was classified into smokers and non-smokers (ex-smokers) or into three groups: smokers, ex-smokers and non-smokers. Problem drinking in Study III was measured by the CAGE questionnaire (Schofield 1988). Alcohol use in Study I was classified into three groups: non-drinking, moderate and heavy drinking (> 7 drinks/week for women and > 14 drinks for men).

Socioeconomic position

Occupational social class was used as an indicator of socioeconomic position. Information on occupational social class was taken from the personnel registers of the employer for those who gave permission (78%) and for others the baseline questionnaire data were used. Occupational class was categorized into four hierarchical groups: managers and professionals, semi-professionals, routine non-manual employees, and manual workers (Lahelma et al. 2005). Managers include managerial and administrative work and professionals include occupations such as teachers and doctors. Semi-professionals include occupations such as nurses and foremen. Routine non-manual employees include occupations like child minders and assistant maids. Manual workers' occupations are e.g. in transportation and cleaning work.

Work characteristics

The respondents were asked how strenuous their work is physically with four response alternatives: 'very light', 'fairly light', 'fairly heavy', 'very heavy'. Physical strenuousness of work was dichotomized as heavy or light. The same procedure was repeated for mental strenuousness of work. In Study I potentially harmful physical working conditions were measured using an 18-item question battery developed at the Finnish Institute of Occupational Health (Pirainen et al. 2003). Each item had four alternatives: 'does not exist', 'exists but does not bother', 'exists and bothers somewhat' and 'exists and bothers a lot'. Three factors were identified by using factor analysis: physical work load, computer work and hazardous exposures (Laaksonen et al. 2005). Six items loaded to the physical work load factor: uncomfortable postures, repetitive trunk rotation,

repetitive movements, standing, walking, and heavy physical work. Three items loaded to the factor labelled as computer work: computer work, using the computer mouse, and sedentary work. Nine items loaded to the hazardous exposures factor: exposure to dirt and dust, damp and wetness, mould, noise, vibration, solvents and other irritating substances, dryness of air, and problems with temperature and lighting. Working time was classified into two groups: overtime work (> 40 hours/week) and no overtime work.

4.3 Statistical methods

Statistical analyses were performed with SAS version 8.2 and SPSS version 15.0 programs. The main analyses were done separately for women and men (Studies I-IV). In Study III women and men were combined in the analyses examining musculoskeletal and mental reasons for disability retirement because there were few events among men. Other physical activity groups were compared with the inactive group (Studies II-III).

In study I analysis of covariance (ANCOVA) was used as the main statistical method to calculate adjusted means and 95% confidence intervals (CI) for physical health functioning (PCS) by physical activity groups. In the first model age was adjusted for. In the second model the mean values were further adjusted for baseline PCS and limiting longstanding illness (LLI). In the third model additional adjustments were made for working conditions. In the fourth model alcohol use, smoking and BMI were adjusted for in addition to previous adjustments. A similar procedure was then applied to calculate adjusted proportions for poor physical health functioning (lowest quartile) and good physical health functioning (highest quartile).

In Study II sickness absence rates per 100 person-years were calculated separately for absence spells lasting 14 days (short) or fewer and over 14 days (long). Poisson regression analysis was used to examine the association between leisure-time physical activity and sickness absence spells (short/long) by calculating rate ratios (RRs) with 95% confidence intervals. The RRs were first adjusted for age and smoking status. Further adjustments were made for socioeconomic position, body mass index and physical health functioning at the baseline. In Poisson distribution mean and variance are equal. If the observed variance is greater than the mean the data are overdispersed and this indicates that the model is not appropriate. Overdispersion was corrected by adjusting the

confidence intervals with a scale parameter obtained by dividing the residual deviance by the degrees of freedom. This adjustment increases standard errors and thus widens the confidence intervals but does not affect the point estimates (Gardner et al. 1995).

In study III Cox regression analysis was used to calculate hazard ratios (HR) and 95% confidence intervals (95% CI) for subsequent all-cause disability retirement as well as disability retirement due to musculoskeletal diseases and mental disorders. In the first model, age, smoking status and problem drinking were adjusted for. In the second model, socioeconomic position and physical and mental strenuousness of work were adjusted for in addition to the first model. In models 3 to 6, body mass index, mental health functioning, physical health functioning and prior long sickness absences were adjusted for, respectively. Cox regression also known as proportional hazards regression assumes that the ratio of hazards is not time-dependent and is thus proportional. The proportional hazards assumption was examined using Schoenfeld residuals (Schoenfeld 1982) and confirmed for leisure-time physical activity and all covariates.

In study IV, analysis of covariance (ANCOVA) was used to calculate adjusted means and 95% confidence intervals (CI) for change in total time used in leisure-time physical activity (minutes/week) by employment status. Logistic regression analysis was used to calculate adjusted odds ratios (OR) for physical inactivity at the follow-up to compare old-age retirees with the 55-60-year-old employees. Adjustments were made for smoking and body mass index, physical work, socioeconomic position and limiting longstanding illness.

4.4 Ethical issues

The study protocol of the Helsinki Health Study was approved by the ethics committees of the Department of Public Health, University of Helsinki and the health authorities of the City of Helsinki.

5. RESULTS

5.1 Impact of leisure-time physical activity on health related functioning

The descriptions of common background variables by physical activity are presented in Studies I and II (see Table 1 in Studies I and II). The inactive and those active in moderate-intensity were slightly older than those engaging in vigorous activity. The inactive were also more often smokers and their body mass index was higher than those who were active. Those engaging in vigorous activity tended to smoke less often and had a lower body mass index than the moderate activity groups. Some minor differences were observed in alcohol use among men. Physical activity groups differed in physical health functioning at the baseline. The conditioning exercise group had about five points more on the mean physical health functioning score than did the inactive group. The moderate activity groups had poorer physical health functioning than did the corresponding vigorous activity groups. There were no consistent differences between physical activity groups by occupational social class. No consistent differences between physical activity groups by work characteristics were found among women. Among men some minor differences were found in work characteristics between conditioning exercise and inactive groups. Those vigorously active worked overtime slightly more often than did the other activity groups.

5.1.1 Physical health functioning

Study I focused on leisure-time physical activity and physical health functioning of the SF-36 five to seven years later. There were clear differences between physical activity groups in subsequent physical health functioning (PCS mean scores) among women in the age-adjusted model (Table 2). The inactive women had the poorest physical health functioning and the conditioning exercise group the best. Women in the active moderate group had poorer physical health functioning than did those in the active vigorous group. The active moderate group did not differ from the inactive group. The very active moderate group had better physical health functioning than did the inactive group and the active moderate group. The active and very active vigorous groups, however, had better physical health functioning than did the very active moderate group.

Adjusting for baseline physical health functioning and limiting longstanding illness clearly attenuated differences between physical activity groups. The conditioning

exercise and active vigorous groups still had statistically significantly better physical health functioning than did those in the inactive and active moderate groups, suggesting that the differences partly emerged during the follow-up. Adjusting for work characteristics did not contribute to these differences whereas body mass index, smoking and alcohol use had some effect. After all adjustments the patterns between physical activity groups remained broadly similar, but statistically significant differences were lost.

Table 2. Physical health functioning (PCS) mean scores with 95% confidence intervals at follow-up by baseline physical activity from analysis of covariance among women.

Physical activity	n= 5437	Model 1	Model 2	Model 3	Model 4
Inactive	1292	45.8 (45.3-46.3)	46.9 (46.4-47.3)	46.8 (46.4-47.2)	47.2 (46.8-47.6)
Active moderate	1580	46.3 (45.8-46.7)	46.7 (46.3-47.1)	46.7 (46.3-47.1)	46.8 (46.4-47.2)
Active vigorous	494	49.0 (48.2-49.8)	48.2 (47.5-48.8)	48.1 (47.4-48.8)	47.9 (47.2-48.6)
Very active moderate	915	47.5 (46.9-48.1)	47.6 (47.1-48.1)	47.7 (47.1-48.2)	47.6 (47.1-48.1)
Very active vigorous	597	48.9 (48.1-49.6)	47.6 (47.0-48.3)	47.6 (47.0-48.2)	47.3 (46.6-47.9)
Conditioning exercise	559	50.1 (49.3-50.9)	48.3 (47.7-49.0)	48.4 (47.7-49.0)	47.9 (47.2-48.5)

Model 1 Age adjusted

Model 2 Age and baseline physical health functioning and limiting longstanding illness adjusted

Model 3 Age, baseline physical health functioning and limiting longstanding illness, working conditions and working overtime adjusted

Model 4 Age, baseline physical health functioning and limiting longstanding illness, working conditions, working overtime and BMI, smoking and alcohol adjusted

Among men the age-adjusted differences in physical health functioning between physical activity groups were similar to those for women (Table 3). Among men the inactive clearly had the poorest physical health functioning. The active moderate and very active moderate groups had mean scores two points higher than the inactive group, but the differences were statistically non-significant. The

active vigorous and very active vigorous groups had significantly better physical health functioning than did the inactive group, similarly to women, although, unlike women, the differences from the corresponding moderate groups were non-significant.

Adjusting for baseline physical health functioning and limiting longstanding illness clearly attenuated differences, similarly to women, thus also suggesting that the differences partly emerged during the follow-up, although among men the differences lost statistical significance. Adjusting for work characteristics did not contribute to these differences among men either. Body mass index, smoking and alcohol attenuated the differences, after which the differences between physical activity groups were small.

Table 3. Physical health functioning (PCS) mean scores with 95% confidence intervals at follow-up by baseline physical activity from analysis of covariance among men.

Physical activity	n=1257	Model 1	Model 2	Model 3	Model 4
Inactive	310	47.1 (46.2-48.0)	48.4 (47.7-49.2)	48.4 (47.7-49.2)	48.9 (48.1-49.6)
Active moderate	243	49.0 (47.9-50.0)	49.2 (48.3-50.1)	49.2 (48.3-50.1)	49.3 (48.4-50.2)
Active vigorous	153	50.2 (48.9-51.5)	50.0 (48.9-51.1)	49.9 (48.8-51.0)	49.7 (48.6-50.8)
Very active moderate	119	49.0 (47.5-50.4)	49.1 (47.9-50.4)	49.3 (48.1-50.5)	49.4 (48.2-50.6)
Very active vigorous	195	50.8 (49.7-51.9)	49.9 (48.9-50.9)	49.9 (48.9-50.9)	49.6 (48.7-50.6)
Conditioning exercise	237	51.0 (50.0-52.0)	49.6 (48.7-50.5)	49.6 (48.7-50.5)	49.2 (48.3-50.1)

Model 1 Age adjusted

Model 2 Age and baseline physical health functioning and limiting longstanding illness adjusted

Model 3 Age, baseline physical health functioning and limiting longstanding illness, working conditions and working overtime adjusted

Model 4 Age, baseline physical health functioning and limiting longstanding illness, working conditions, working overtime and BMI, smoking and alcohol adjusted

The age-adjusted differences between physical activity groups were similar to the mean scores of physical health functioning when examining poor (lowest gender-specific quartile in SF-36 PCS) and good (highest gender-specific quartile in SF-36 PCS) physical health functioning among both genders (see Tables 3 and 4 in Study I). However, after all adjustments clearer differences remained in good physical health functioning: The proportion of women with good physical health functioning varied from 24% (95% CI 21-26%) among the inactive to 31% (95% CI 28-34%) among the conditioning exercise group. The corresponding proportions among men were 21% and 29%.

5.1.2 Sickness absence

Study II focused on leisure-time physical activity and sickness absence spells of different length during a mean follow-up period of 3.9 years. The sickness absence rates varied between the physical activity groups (see Table 2 in Study II). Among women, the number of shorter sickness absence spells per 100 person years was lowest in the conditioning exercise group (182 spells) and highest in the very active moderate group (219 spells), similarly to the inactive group (212 spells). Similarly, in the longer absence spells the conditioning exercise group had the lowest number (15 spells) and the very active moderate group the highest (23 spells) and the inactive had 22 spells. Among men, the corresponding figures for shorter absences were 110, 167 and 151 and for longer absences 11, 21 and 22, respectively.

Table 4. Rate ratios (RR) with 95% confidence intervals from Poisson regression analysis for longer (> 14 days) sickness absence spells among women. Physical activity groups compared with the inactive group.

Physical activity	n=	Model 1	Model 2	Model 3	Model 4
Inactive	1200	1.00	1.00	1.00	1.00
Active moderate	1472	1.01 (0.87-1.17)	1.00 (0.87-1.15)	1.07 (0.93-1.24)	1.07 (0.94-1.23)
Active vigorous	477	0.81 (0.64-1.02)	0.86 (0.69-1.07)	0.91 (0.72-1.14)	0.94 (0.76-1.17)
Very active moderate	842	1.07 (0.90-1.27)	1.00 (0.85-1.18)	1.18 (1.00-1.40)	1.17 (1.01-1.37)
Very active vigorous	560	0.74 (0.60-0.92)	0.77 (0.63-0.95)	0.87 (0.70-1.08)	0.88 (0.72-1.08)
Conditioning exercise	539	0.74 (0.59-0.92)	0.73 (0.59-0.91)	0.88 (0.71-1.11)	0.94 (0.77-1.16)

Model 1 Age and smoking adjusted

Model 2 Age, smoking and occupational social class adjusted

Model 3 Age, smoking and body mass index adjusted

Model 4 Age, smoking and physical health functioning adjusted

Among women, the active and very active moderate groups did not differ from the inactive group in subsequent rates of longer sickness absence spells whereas the conditioning exercise and very active vigorous groups had significantly lower risk of sickness absence when age and smoking were adjusted (Table 4). Also, the active vigorous group had a lower risk of sickness absence, but the relative risk did not reach statistical significance. Adjusting for occupational social class did not contribute to the association. Adjusting for body mass index and even more baseline physical health functioning attenuated the differences found between physical activity groups. The differences were no longer statistically significant, except that the very active moderate group had somewhat higher risk of sickness absence after these adjustments.

Table 5. Rate ratios (RR) with 95% confidence intervals from Poisson regression analysis for longer (> 14 days) sickness absence spells among men. Physical activity groups compared with the inactive group.

Physical activity	n=	Model 1	Model 2	Model 3	Model 4
Inactive	340	1.00	1.00	1.00	1.00
Active moderate	268	0.64 (0.39-1.05)	0.66 (0.43-1.01)	0.67 (0.42-1.07)	0.73 (0.45-1.19)
Active vigorous	163	0.58 (0.31-1.10)	0.64 (0.37-1.11)	0.64 (0.36-1.15)	0.65 (0.35-1.20)
Very active moderate	135	0.96 (0.54-1.69)	0.90 (0.55-1.46)	1.00 (0.59-1.69)	1.05 (0.61-1.81)
Very active vigorous	213	0.77 (0.46-1.29)	0.87 (0.55-1.35)	0.88 (0.54-1.42)	0.96 (0.58-1.60)
Conditioning exercise	256	0.53 (0.30-0.93)	0.53 (0.33-0.86)	0.61 (0.36-1.03)	0.67 (0.39-1.17)

Model 1 Age and smoking adjusted

Model 2 Age, smoking and occupational social class adjusted

Model 3 Age, smoking and body mass index adjusted

Model 4 Age, smoking and physical health functioning adjusted

Among men only the conditioning exercise group showed a statistically significantly lower risk of subsequent sickness absence compared with the inactive in the age and smoking adjusted model (Table 5). The very active moderate group did not show any lower risk of sickness absence than the inactive group and the other middle activity groups had lower sickness absence rates, albeit statistically non-significant. Similarly to women the very active vigorous group had a lower risk than did the corresponding moderate group. Adjusting for occupational social class had no effect whereas body mass index and even more baseline physical health functioning attenuated the differences found between physical activity groups, although not to the same extent as among women.

The associations were stronger for these longer sickness absence spells (over 14 days) than for shorter spells (14 days or under) although the patterns between physical activity groups were similar (see Tables 1 and 2 Study II). The

adjustments contributed equally to the differences between physical activity groups in shorter spells as well. Self-certified sickness absence spells (three days or under) were also examined and the differences were similar for the spells of 14 days or under (data not shown).

5.1.3 Disability retirement

Study III focused on leisure-time physical activity and disability retirement during a mean follow-up period of 6.8 years. The subsequent disability retirement events differed between the physical activity groups (See Table 1 Study III). Among women, 9.4% in the inactive group and 8.5% in the active moderate group retired due to disability. In the vigorous group 3.1% and in the conditioning exercise group 2.8% retired due to disability. Among men, the corresponding figures were: 11.1%, 6.6%, 5.8%, and 2.2%, respectively. Disability retirement due to musculoskeletal diseases and mental disorders also showed similar differences between the physical activity groups.

Table 6. Hazard ratios (HR) with 95% confidence intervals from Cox regression analysis for all-cause disability retirement among women. Physical activity groups compared with the inactive group.

Physical activity	n=	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Inactive	4920	1.00	1.00	1.00	1.00	1.00	1.00
Active moderate	2208	0.93 (0.74-1.18)	0.87 (0.69-1.10)	1.02 (0.81-1.29)	1.04 (0.82-1.31)	0.96 (0.76-1.22)	0.97 (0.76-1.23)
Active vigorous	998	0.39 (0.26-0.59)	0.41 (0.28-0.61)	0.47 (0.31-0.70)	0.54 (0.36-0.80)	0.42 (0.28-0.62)	0.43 (0.29-0.64)
Conditioning exercise	534	0.37 (0.22-0.64)	0.35 (0.21-0.60)	0.47 (0.27-0.81)	0.56 (0.33-0.97)	0.40 (0.23-0.69)	0.41 (0.24-0.70)

Model 1 Age, smoking and problem drinking adjusted

Model 2 Age, smoking and problem drinking and occupational social class and physical and mental strenuousness of work

Model 3 Age, smoking and problem drinking and body mass index

Model 4 Age, smoking and problem drinking and physical health functioning

Model 5 Age, smoking and problem drinking and mental health functioning

Model 6 Age, smoking and problem drinking and prior sickness absence

Among women moderate-intensity physical activity did not reduce the risk of subsequent disability retirement compared with the inactive group (Table 6). Active vigorous and conditioning exercise groups had significantly reduced risk of disability retirement when age, smoking and problem drinking were adjusted for. Adjusting for baseline physical health functioning slightly attenuated the differences found between physical activity groups in subsequent all-cause disability retirement although differences remained statistically significant. Other adjustments did not contribute to the differences found between physical activity groups.

Table 7. Hazard ratios (HR) with 95% confidence intervals from Cox regression analysis for all-cause disability retirement among men. Physical activity groups compared with the inactive group.

Physical activity	n=	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Inactive	350	1.00	1.00	1.00	1.00	1.00	1.00
Active moderate	395	0.56 (0.34-0.92)	0.62 (0.38-1.02)	0.59 (0.36-0.98)	0.64 (0.39-1.06)	0.58 (0.35-0.96)	0.56 (0.34-0.92)
Active vigorous	364	0.56 (0.33-0.96)	0.69 (0.40-1.18)	0.63 (0.37-1.10)	0.70 (0.40-1.20)	0.58 (0.34-0.99)	0.59 (0.34-1.01)
Conditioning exercise	246	0.22 (0.09-0.57)	0.22 (0.09-0.57)	0.22 (0.09-0.57)	0.26 (0.10-0.67)	0.22 (0.09-0.58)	0.20 (0.08-0.52)

Model 1 Age, smoking and problem drinking adjusted

Model 2 Age, smoking and problem drinking and occupational social class and physical and mental strenuousness of work

Model 3 Age, smoking and problem drinking and body mass index

Model 4 Age, smoking and problem drinking and physical health functioning

Model 5 Age, smoking and problem drinking and mental health functioning

Model 6 Age, smoking and problem drinking and prior sickness absence

Among men the active moderate and vigorous groups had significantly lower risk of disability retirement compared with the inactive group when age, smoking and problem drinking were adjusted for (Table 7). The conditioning exercise group had a very low risk of subsequent all-cause disability retirement. Similarly to women, only the adjustment for physical health functioning slightly attenuated

the differences. In the middle activity groups the statistical significance was lost whereas the conditioning exercise group remained.

With regard to the two main medical causes for disability retirement, the differences between physical activity groups were broadly similar to all-cause disability retirement (see Table 3 in Study III). Adjusting for mental health functioning slightly attenuated the differences between physical activity groups when mental causes for disability retirement were examined. When musculoskeletal causes were examined adjusting for physical health functioning attenuated the differences even more than for all-cause disability retirement.

5.2 Impact of retirement on leisure-time physical activity

The description of background variables by follow-up employment status is presented in Study IV (see Table 1 in Study IV). Women on disability retirement had a high body mass index but otherwise the differences were small. Disability retirees were also usually smokers at the baseline and old-age retirees were less often smokers than were employees. Physically strenuous work at the baseline was prevalent among those on disability retirement at the follow-up. Among men physically strenuous work was not as prevalent in the group of 55-60-year-old employees as among the old-age retirees. Disability retirees tended to come from lower occupational social classes, especially women. Limiting longstanding illness was prevalent at the baseline among disability retirees and also slightly more prevalent among old-age retirees than among those still employed. The proportion of physically inactive slightly differed between employees and retirees at the baseline. The group of younger employees spent most time in physical activity at the baseline and disability retirees the least. Old-age retirees and 55-60-year-old employees, however, spent on average the same time in physical activity at the baseline.

Study IV focused on changes in leisure-time physical activity during the follow-up of five to seven years among those still employed and those retired. Leisure-time physical activity changed during the follow-up. Of the four activity groups described previously among those classified as physically inactive (25%) at the baseline about half were active at the follow-up, mainly moving to the active moderate group. The proportion of those physically inactive remained about the same during the follow-up, however, as some 15% of those active at the baseline were inactive at the follow-up measurement. For instance, among those classified

as conditioning exercisers about 5% were inactive at the follow-up, whereas about 14% of those in the active vigorous group and slightly more (19%) of those in the active moderate group were inactive at the follow-up. Although there were gender differences in the physical activity classification (Table 1) the changes from one physical activity group to another were similar among women and men.

At the follow-up, 15% of women and 20% of men were retired due to old-age and 3 to 4% were retired due to work disability. Among women, the old-age retirees increased their time for moderate-intensity leisure-time 31 minutes per week whereas in the age groups of employees and disability retirees such changes were not found (Table 8). The time used in moderate-intensity activity at the follow-up was higher among old-age retirees than among the employees, although the time used in moderate-intensity activity tended to increase from 40-year-old to 55-60-year-old employees. In contrast, the time used in vigorous physical activity at the follow-up showed a gradual decrease from 40-year-old to 55-60-year-old employees and further among old-age retirees. The disability retirees were the least active group and showed very low participation in vigorous activity.

Table 8. Mean change from the baseline (min per week) and time used (min per week) with 95% confidence intervals in leisure-time physical activity (total, moderate, vigorous) at the follow-up by employment status and by age groups of those still employed: women.

Employment status	n=	Change total	Time total	Change moderate	Time moderate	Change vigorous	Time vigorous
Employees	5434						
	4745	7 (1-13)	318 (312-324)	2 (-4-7)	278 (273-283)	5 (3-8)	40 (38-43)
40	1095	9 (-4-21)	329 (317-340)	-4 (-16-7)	269 (259-279)	13 (7-19)	59 (53-65)
45	1132	7 (-5-20)	320 (309-332)	1 (-10-13)	276 (266-286)	6 (0-12)	45 (39-50)
50	1171	1 (-12-13)	318 (307-330)	-1 (-12-10)	284 (274-294)	2 (-4-7)	35 (29-40)
55-60	1066	11 (-2-24)	304 (293-316)	11 (-1-22)	281 (271-291)	0 (-5-6)	23 (18-28)
Old-age retirees	802	29 (15-44)	324 (310-338)	31 (18-44)	304 (292-315)	-2 (-8-4)	20 (15-26)
Disability retirees	187	-7 (-37-23)	268 (239-296)	-3 (-30-24)	257 (232-281)	-4 (-17-9)	11 (0-24)

Among men a mean increase in moderate-intensity activity of 42 minutes per week was found in the group of old-age retirees (Table 9). Similarly to women the other groups did not show such changes, although in the group of 55-60-year-old employees moderate-intensity activity increased by 25 min per week and vigorous activity decreased by 17 minutes per week on average. The time used in physical activity at the follow-up by employment status showed a similar pattern to women. The old-age retirees used the most time in moderate-intensity activity. The time used in moderate-intensity activity increased gradually from 40-year-old employees to the older age groups. The time used in vigorous activity was more than double in the group of 40-year-old employees than in the group of 55-60-year-old employees. Among men the disability retirees were the least active group, similarly to women.

Table 9. Mean change from the baseline (min per week) and time used (min per week) with 95% confidence intervals in leisure-time physical activity (total, moderate, vigorous) at the follow-up by employment status and by age groups of those still employed: men.

Employment status	n=	Change total	Time total	Change moderate	Time moderate	Change vigorous	Time vigorous
Employees	954	0 (-15-15)	318 (304-332)	8 (-5-21)	239 (228-251)	-7 (-15-0)	79 (71-88)
40	204	-7 (-39--26)	342 (310-373)	3 (-25-30)	223 (198-248)	-9 (-27-8)	119 (100-137)
45	226	4 (-27-35)	315 (285-345)	-6 (-32-20)	227 (204-250)	10 (-6-27)	88 (70-106)
50	242	-6 (-36-24)	308 (278-337)	6 (-20-31)	245 (222-267)	-11 (-27-5)	63 (47-81)
55-60	282	8 (-20-36)	313 (286-339)	25 (2-48)	256 (235-277)	-17 (-32-(-2))	57 (42-72)
Old-age retirees	255	42 (13-71)	344 (316-371)	42 (18-67)	291 (269-313)	-0 (-15-15)	52 (37-68)
Disability retirees	44	16 (-54-85)	291 (225-357)	19 (-39-78)	264 (211-318)	-4 (-40-33)	27 (0-69)

Analysis of covariance was used to examine whether baseline covariates such as BMI, smoking, physical strenuousness of work, SEP and LLI contributed to the differences found between employees and retirees (see Table 3 in Study IV). Adjustments had no effect on these differences, however. It was also examined whether the effect of old-age retirement on change in leisure-time physical

activity differed by the baseline covariates and statistically significant interactions were not found.

In addition to the mean changes in the time used in physical activity the occurrence of physical inactivity was examined with logistic regression analysis (see Table 4 in Study IV). Among women the occurrence of physical inactivity at the follow-up was significantly lower among old-age retirees (OR 0.78, 95% CI 0.62-0.99) compared with 55-60-year-old employees. Adjustments made for baseline covariates had no effect on these differences. Among men similar differences were observed, although they were statistically non-significant owing to fewer men in the data.

6. DISCUSSION

This thesis used prospective cohort data on middle-aged female and male employees of the City of Helsinki of whom one-fifth retired during the follow-up period. The main aim was to examine the impact of leisure-time physical activity on subsequent health related functioning and changes in leisure-time physical activity after transition to retirement.

6.1 Main findings

The first main finding was that the inactive had the poorest and the conditioning exercisers the best self-reported physical health functioning among both women and men. Engagement in leisure-time physical activity showed, however, relatively small differences in mean scores for physical health functioning emerging in the follow-up period. In good physical health functioning larger differences remained between physical activity groups, however. In addition, engagement in vigorous activity showed more beneficial effects compared with moderate-intensity activity.

Second, both women and men engaging in vigorous physical activity had a reduced risk of both short and long sickness absence spells indicating temporary work disability. Relatively high volumes of moderate-intensity activity showed no reduction in the risk of sickness absence compared with those inactive during their leisure-time, especially among women. Adjusting for physical health functioning at baseline among both genders and body mass index among women explained some of the differences found in subsequent sickness absence rates between the physical activity groups.

Third, those engaging in vigorous physical activity clearly had a reduced risk of subsequent all-cause disability retirement and in addition, among men, those active in moderate-intensity had a reduced risk of disability retirement. Vigorous physical activity showed similar benefits in disability retirement due to musculoskeletal and mental causes. Adjusting for baseline physical health functioning attenuated, but did not abolish, the differences.

Fourth, as regards retired employees those retired due to old age increased their engagement in moderate-intensity leisure-time physical activity on average by more than half an hour per week. Among those who remained employed and disability retirees the time used in physical activity remained fairly stable. In

addition, the occurrence of physical inactivity at the follow-up among old-age retirees was lower compared with the groups of older employees.

6.2 Interpretation of the main results

6.2.1 Impact of leisure-time physical activity on physical health functioning

Differences in physical health functioning mean scores between physical activity groups at the follow-up were relatively small after adjustment for baseline physical health functioning and limiting longstanding illness. The differences emerging over follow-up between physical activity groups were clearer for good physical health functioning, suggesting that physical activity helps in maintaining good physical health functioning. The Whitehall II study of middle-aged British civil servants reported similar results using data that were comparable to the present study (Hillsdon et al. 2005). The authors concluded that high physical activity is critical for maintaining good physical functioning. They used the physical functioning sub-scale of the SF-36, which is highly correlated with the physical component summary scores used in the present study.

In addition, the present study examined change in poor physical health functioning but clear differences did not emerge, suggesting that physical activity did not improve physical health functioning over the follow-up period. In the Nurses' Health Study three measurement points were available for better examination of the relationship between physical activity and functioning among women (Wolin et al. 2007). The findings suggest that increase in physical activity enhances physical functioning.

In the present study, in addition to baseline health functioning, a range of work characteristics were adjusted for. These adjustments, however, did not contribute to the differences in physical health functioning between physical activity groups. Further adjustments for body mass index, smoking and alcohol use slightly attenuated the differences in physical health functioning, suggesting that the emerging differences are only partly confounded by complex relationships between health related behaviours. A previous study (Lang et al. 2007) showed that vigorous activity reduced poor physical functioning also among those with higher body mass index, although the findings also showed that high body weight was a risk for poor physical functioning.

6.2.2 Impact of leisure-time physical activity on sickness absence

The vigorous activity groups consistently had fewer sickness absence spells than did the inactive. These results are similar to a previous study showing that those active in recommended vigorous physical activity had reduced sickness absence whereas those meeting the recommendation for moderate-intensity physical activity did not (Proper et al. 2006). In other studies (Holtermann et al. 2011, van Amelsvoort et al. 2006) physical activity is also associated with reduced sickness absence, but the intensity of activity has not been considered. A few studies have examined whether objectively measured aerobic fitness is associated with sickness absence (Kyröläinen et al. 2008, Strijk et al. 2011) and showed that better fitness reduces the risk of sickness absence, which supports the finding that vigorous activity is important.

In the present study adjusting for physical health functioning at baseline attenuated the differences found in subsequent sickness absence rates between physical activity groups. This suggests that the vigorous activity groups had less sickness absence than did the inactive, partly due to better physical health functioning. Thus there were health differences already at the baseline between physical activity groups. Some of the inactive may have poorer health functioning due to illnesses that also restrict engagement in leisure-time physical activity and cause more sickness absence. They may, however, have poorer physical health functioning owing in part to low physical activity.

A previous study (Strijk et al. 2011) showed that those with good aerobic fitness had less sickness absence and the association was partly mediated by work ability, similarly to the present study. In the present study, those engaging in vigorous physical activity probably have better fitness which contributes to better physical health functioning and less sickness absence than in the less active. Adjusting for body mass index attenuated the differences among women nearly to the same extent as did physical health functioning, which suggests that those vigorously active have less overweight and consequently less sickness absence. Physical activity is important for healthy weight maintenance (Goldberg and King 2007) and this may also contribute to less sickness absence.

6.2.3 Impact of leisure-time physical activity on disability retirement

The results are in line with previous studies suggesting that vigorous activity (Kaprio and Sarna 1994, Tuomi et al. 1991) and good aerobic fitness (Karpansalo

et al. 2003) are associated with the reduced risk of disability retirement. At the time of these previous studies, cardiovascular diseases accounted for the majority of disability retirement events in Finland. Vigorous physical activity and good aerobic fitness are essential for preventing cardiovascular disease (Kohl 2001, Sesso et al. 2000). Currently musculoskeletal and mental causes account for over two-thirds of disability retirements but vigorous physical activity remains important for preventing work disability.

Similarly to the present study, in previous studies vigorous physical activity (Kaprio and Sarna 1994) and fitness (Karpansalo et al. 2003) were also associated with disability retirement due to musculoskeletal diseases. The association of leisure-time physical activity with musculoskeletal diseases is complex as sufficient physical activity is good for musculoskeletal health in general, but with increasing activity and intensity adverse effects such as injuries also become more common (Vuori 2001). The present results suggest that vigorous physical activity is important for preventing disability due to musculoskeletal causes. Some of the inactive may have had existing musculoskeletal problems already at the baseline that led to disability, as adjusting for physical health functioning attenuated the differences between physical activity groups. Adjusting for prior sickness absence due to musculoskeletal causes, however, had no effect on these differences between physical activity groups.

Vigorous physical activity also proved to be important for preventing mental causes of disability retirement. In a study by Kaprio and Sarna (1994) former endurance athletes had a low risk of disability retirement due to mental causes. Some other studies also suggest that vigorous activity may be important for preventing depression (Lampinen et al. 2000). A recent review (Teychenne et al. 2008) showed that avoiding physical inactivity may, however, be more important than engaging in vigorous physical activity. In this study moderate activity showed some, albeit statistically non-significant, reduction in the risk of disability retirement due to mental causes. It could be argued that some of the inactive employees had some mental health problems already at the baseline; we adjusted for mental health functioning and prior sickness absence due to mental causes and only very slight effect was found.

6.2.4 Impact of retirement on leisure-time physical activity

The findings of the present study are in line with previous studies showing that moderate-intensity physical activity increases after transition to retirement (Evenson et al. 2001, Touvier et al. 2010). In the present study it was found that weekly moderate-intensity physical activity increased among those transferred to old-age retirement: about 30 minutes for women and about 40 minutes for men. A French study (Touvier et al. 2010) found even higher increases (2 hour/week) but it consisted of selected nutritional intervention participants, which may explain such a large increase in physical activity after retirement.

Other studies have shown varying results, but nevertheless they indicate that even if leisure-time physical activity increases after transition to retirement it is not enough to compensate for the loss of work-related physical activity, especially among those who have been working in physically strenuous occupations. The present study focused on changes in leisure-time physical activity. We adjusted extensively for potential confounders including physical strenuousness of work, and these adjustments had no effect on the differences found between old-age retirees and employees. The effect of old-age retirement on leisure-time physical activity did not differ by physical strenuousness of work either. It may be that the baseline covariates simply cannot contribute to the differences as old-age retirement is an independent event during the life-course, increasing people's leisure time. Nonetheless, these results suggest that some people and even more importantly some of those previously inactive increase their leisure-time physical activity after transition to retirement.

6.3 Towards an overall picture of leisure-time physical activity and health related functioning among middle-aged women and men

For women the results consistently showed that compared with the inactive those engaging in vigorous leisure-time physical activity had better subsequent health related functioning whether measured by self-reported SF-36 physical health functioning or register data on sickness absence or disability retirement. In addition, among the vigorously active higher volume of physical activity showed further benefits. Those very active in moderate-intensity physical activity had slightly better subsequent physical health functioning, but no fewer sickness absences and disability retirement events than did the inactive.

Among men the picture is principally similar to women's, but some gender differences were found. Whereas the physically inactive men consistently had the poorest health related functioning and the conditioning exercisers the best, moderate-intensity activity was somewhat more beneficial among men than among women. The men active in moderate-intensity for example had a reduced risk of disability retirement similarly to the vigorously active with the same volume of physical activity. It may be that women with underlying health problems are more likely to engage in moderate-intensity physical activity than men. It may also be that women tend to give socially more acceptable responses than men.

These results confirm that among middle-aged women and men physical inactivity during leisure time is a clear risk factor for subsequent problems in health related functioning and work disability. The strongest associations were found when disability retirement, a measure of permanent work disability indicating serious decline in functioning due to disease was used as an outcome. In addition, it was found that those engaging in vigorous activity such as jogging and running had better subsequent health related functioning whereas moderate-intensity physical activity such as walking and brisk walking showed little or no benefit. Previous studies (Lee and Paffenbarger 2000, Proper et al. 2006, Physical Activity Guidelines Advisory Committee 2008, Sesso et al. 2000) also indicate that vigorous activity may provide additional health benefits to moderate-intensity physical activity. Nevertheless, moderate-intensity physical activity is beneficial for health if done regularly and often enough (Physical Activity Guidelines Advisory Committee 2008).

In the present study, about a quarter of both women and men reported physical activity below the minimum recommendations, which is slightly less than among the general population of middle-aged Finns (Fogelholm et al. 2007). This may be because of the different measures and classification of physical activity and the fact that participants in the present study included only those who were healthy enough to work. Furthermore, it should be noted that due to the change in recommended physical activity (Fogelholm et al. 2005, UKK Institute 2009), among middle-aged Finns only 5 to 10% fulfil the current recommendation (Husu et al. 2011). This is because the recommended muscle-strengthening activity is not achieved although many engage in aerobic activity as recommended. Nonetheless, Finns are among the physically active Europeans (Martinez-Gonzalez et al. 2001).

In the present study, women engaged more in moderate-intensity physical activity than men whereas men engaged more in vigorous activity than women. Men engaged in vigorous activity twice as much as women among those still employed and among those retired. In addition, the present study found that women and men spent approximately the same time overall in leisure-time physical activity. Thus there were gender differences in the physical activity groups formed. About one-fifth of men and only 10% of women were conditioning exercisers and the majority of women were in the moderate activity groups whereas the majority of men were in vigorous activity groups. These findings are in line with previous studies showing that men usually engage in more vigorous activity than women (Trost et al. 2002). Age is also related to engagement in physical activity (DiPietro 2001) as was also found in this study. Differences between age groups were best seen in vigorous activity which gradually decreased from younger to older employees and further among old-age retirees, whereas those who had retired on grounds of disability reported only little vigorous activity. The old-age retirees, however, spent even more time in physical activity than the group of younger employees.

Although moderate-intensity physical activity increases fitness among previously inactive individuals (Pollock et al. 1998) and is beneficial for healthy weight maintenance for instance (Goldberg and King 2007), those engaging in vigorous activity are probably fitter than those engaging in the equivalent amount of moderate-intensity physical activity. As fitness is important for functioning (Huang et al. 1998, Brill et al. 2000) it is plausible that vigorous activity is more beneficial for general health related functioning than activity of moderate-intensity. Physical activity and fitness are strongly related but physical activity and fitness may also have independent effects on health (Blair et al. 2001). Those who are vigorously active may also be a selected group as those with health problems may be restricted from engaging in vigorous activity. Those with poorer health may, however, be able to engage in moderate-intensity activities such as walking. It may also be that those engaging in vigorous activity especially may have a healthy lifestyle in other ways as well, although in this study adjustment made for other health behaviours had only minimal effects.

This study considered reverse causality, meaning that the association between physical activity and health related functioning may reflect that those in poor health are less able to engage in physical activity. First, the temporal order was established so that physical activity measurements preceded the measurement of

health related functioning. Second, health and functioning at the baseline were adjusted for. Even after these adjustments some differences between physical activity groups remained, suggesting that physical activity has some impact on subsequent health related functioning. Although the statistical significance was weak or lost when baseline health functioning was adjusted for it does not directly imply that leisure-time physical activity does not affect subsequent health related functioning, since the health differences found at the baseline may also be due to differences in physical activity. Furthermore, the differences between physical activity groups were similar when the self reported SF-36 on functioning or register data on sickness absence and disability retirement were used, which increases the credibility of the results. In addition, the association was stronger with outcomes reflecting more severe lack of health related functioning. For example, long sickness absence spells show stronger association with physical activity than short absences and further disability retirement shows the strongest associations.

In addition to adjustments made for health and functioning at the baseline the contributions of potential confounding factors such as socioeconomic position, work characteristics, smoking, alcohol use and body mass index were examined. Adjusting for socioeconomic position and work characteristics had only minimal effects on the differences found in health related functioning between physical activity groups. Whereas work characteristics (Leino-Arjas et al. 2004, Vahtera et al. 2010) and socioeconomic position (Lahelma et al. 2005, Leinonen et al. 2011, Piha et al. 2007) are related to the measures of health related functioning used in the present study, in these data work characteristics and occupational social class were quite equally distributed between physical activity groups and thus did not markedly contribute to the associations between physical activity and health related functioning.

Adjusting for body mass index explained the association of physical activity with sickness absence, especially among women. This suggests that the physically active have less overweight and consequently less sickness absence. It may be that overweight restricts engagement in physical activity and may thus confound the association between physical activity and physical health functioning. It may also be that high body mass index is a marker of unhealthy behaviours such as poor diet and physical inactivity. Smoking was associated also with physical activity and contributed somewhat to these associations. Alcohol use was weakly

associated with physical activity and did not contribute to the associations examined.

Physical inactivity was a risk factor for subsequent disability retirement and vigorous activity provided more benefits than moderate-intensity physical activity. In addition, those retired due to disability were physically the least active group and their engagement in vigorous physical activity was especially low. About half of those on disability retirement at the follow-up had a limiting longstanding illness already at the baseline, which probably restricts engagement in physical activity. Adjusting for limiting long standing illness did not, however, attenuate the differences found between physical activity groups in subsequent disability retirement. Adjusting for physical health functioning somewhat attenuated the differences suggesting that those retired due to disability had some health problems that also restrict engagement in vigorous physical activity.

Some dimensions of SF-36 health functioning have been shown to improve during intervention studies aiming to produce gains in fitness among the middle-aged (Sillanpää 2011). The results from a structured training programme show that individual planning may be required as gains in fitness varied markedly between individuals (Karavirta 2011). Many physical activity interventions intended to reduce sickness absence rates and work ability have failed to produce such changes (Proper et al. 2002). One randomized controlled trial showed that exercise reduced the frequency of absence compared with the control group (Kerr and Vos 1993). In most intervention studies the follow-up periods have been too short to conclude whether training is effective. If training is not carefully planned and considered with regard to individual level of fitness and previous engagement in physical activity sickness absence rates may even increase, due to injuries, for example. There is promising evidence that multidimensional health interventions in occupational settings aimed at workers at high risk of sickness may reduce sickness absence (Taimela et al. 2008).

Further research would benefit from objective measures of physical activity to provide a more accurate approximation of physical activity engagement in large-scale studies. In addition, lifelong physical activity engagement should be examined for better assessment of causal relationships among factors potentially affecting physical activity engagement at different life stages and to find stronger evidence on the benefits of physical activity for health and functioning. As genetic factors are related to physical activity engagement and fitness (Kujala 2011,

Stubbe et al. 2006) it should be ascertained whether the genetic factors related to physical inactivity also relate to poorer health. This study, among others, highlights the importance of vigorous activity to health related functioning, which suggests that fitness is important for health and functioning. Therefore, interventions aiming at enhanced fitness at individual level may prove useful for functioning, work ability and even for preventing work disability.

6.4 Methodological issues

This prospective cohort study using data from the Helsinki Health Study following middle-aged female and male municipal employees enabled to examine whether leisure-time physical activity contributes to subsequent health related functioning measured with the most commonly used measure of health functioning, the SF-36 health questionnaire. Register data on sickness absence and disability retirement were also available as objective measures of health related functioning. In addition to these relatively rarely studied health outcomes in physical activity studies, the follow-up survey enabled to examine whether those retired during the follow-up changed their leisure-time physical activity engagement compared with those still employed. Women and men were examined separately. The comprehensive baseline survey data also allowed to take into account other health related behaviour and working conditions in the analysis: in particular, health and functioning at the baseline were considered when subsequent differences in health related functioning between physical activity groups were examined. Some methodological issues are discussed in more depth in the following.

6.4.1 Data sources

In this cohort of relatively healthy middle-aged employees, the respondents were a selected group. First, only those who were healthy enough to work and aged 40 to 60 years old were invited to participate in the study, i.e. the healthy worker effect, meaning that those with the poorest health may have left the workforce before the study. Second, due to non-response to the baseline survey selection bias may have occurred. This has been considered in non-response analyses done by the Helsinki Health Study research group (Laaksonen et al. 2008). Those with medically confirmed sickness absence and lower socioeconomic position were slightly less willing to respond. Thus, the respondents of the baseline survey may be in better health than the non-respondents, although the differences between

them were small (Laaksonen et al. 2008). In addition, it should be noted that those who did not respond to the follow-up survey were slightly more often physically inactive at the baseline than the follow-up respondents (Seiluri et al. 2011). Third, the consent for register linkages (74-78%) given by the respondents is a further source of selection bias. Men were slightly more willing to give consent to these register linkages than women. Otherwise the differences among those not giving the consent to the register linkages were smaller than the differences in the non-responding to the baseline survey (Laaksonen et al. 2008). Further selection of healthier respondents was, however, possible. Fourth, although the response to the follow-up survey was quite high (83%), some further selection bias may also have occurred in the two studies using the follow-up data. Due to the non-response to the surveys and that not all respondents gave consent for the register linkages and missing information in some study variables, around 50% of those who were invited to take part in the study (n=13346) were used in the analyses.

Although the differences between follow-up respondents and non-respondents were minor, some further selection of physically active respondents may have occurred among the baseline respondents. This kind of selection is usually thought to cause some attenuation rather than biased strengthening in the estimated associations between physical activity and health outcomes. Nonetheless, the non-response analyses indicate that even though some differences between the non-respondents and respondents occurred they were unlikely to cause biased results. It should, however, be kept in mind that these results cannot be directly generalized to the general population around the same age. In addition, it was found that physical activity changed during the follow-up as over half of those classified as inactive at the baseline measurement were active at the follow-up and some 15% of them changed to inactive during the follow-up. This change in physical activity may cause some weakening in the prospective differences found in health related functioning between physical activity groups. Furthermore, genetic factors are known to contribute to physical fitness and engagement in physical activity and as the same genes may for instance protect against metabolic diseases some bias may occur in observational studies examining physical activity and health (Kujala 2011). For instance, in this study those vigorously active may have genes that contribute to both better fitness and health related functioning.

6.4.2 Measurement of leisure-time physical activity

Leisure-time physical activity was self-reported, which is a common practice in large cohort studies. There are some limitations that need to be acknowledged. The maximum time of leisure-time physical activity in each intensity grade was restricted to four hours or more per week. This could have caused some underestimation, especially of moderate-intensity physical activity, and even more so when changes in physical activity were examined. Commuting physical activity was integrated in the question, which prevents examining the contribution of commuting to the time spent in leisure physical activity; furthermore those retired do not commute. There were no separate questions for muscle-strengthening physical activity, which would have added to this study, considering that muscle strength is important for functioning (Brill et al. 2000). The information on leisure-time physical activity was self-reported and could therefore be prone to overestimation (LaPorte et al. 1985). Although the leisure-time physical activity measure used lacks validation, a comprehensive review concluded that no single physical activity questionnaire has proven superior (van Poppel et al. 2010). Vigorous activity may, however, be more accurately reported than moderate-intensity physical activity. Cross-tabulating the physical activity groups with body mass index and physical health functioning shows that the inactive have higher body mass index and poorer physical health functioning than the other activity groups and that increasing the volume and intensity of physical activity shows a graded association with lower body mass index and better physical health functioning. This supports the use of our physical activity measure and classification. In addition, the results are fairly consistent whether the outcome is self-reported (SF-36) or objectively measured using register data on sickness absence and disability retirement.

6.4.3 Further methodological issues

Information on types of retirement pension received was requested at the follow-up survey and used in Study IV to distinguish old-age and disability retirees from employees. Some of the old-age retirees may have moved from disability to old-age pensions before the follow-up and are thus classified as old-age rather than disability retirees in this study. This could to some extent cause underestimation of the true effect of old-age retirement on leisure-time physical activity.

We used both self-reported and register-based measures of health related functioning. The SF-36 health questionnaire physical component summary was used as the outcome in the Study I. SF-36 is the most widely used measure in previous studies and has been validated thoroughly (Ware 2000). When self-reports are used on both the outcome and exposure, same source bias may occur, but the results were similar when register-based measures of health functioning were used. The sickness absence data for Study II were obtained from the employer's register on which wages are based and are thus as reliable as possible. The data on disability retirements for Study III were obtained from the Finnish Centre for Pensions and are also likely to be reliable. The main diagnosis given by the attending physician was used to distinguish two main diagnostic groups according to ICD-10 classification.

7. CONCLUSIONS

This study provided novel information on leisure-time physical activity and subsequent health related functioning as well as changes in physical activity after transition to retirement. The present study suggests the importance of vigorous activity for health related functioning. For those close to retirement age the importance of physical activity for health and functioning later in life should be emphasized, as the mean increase in leisure-time physical activity found among old-age retirees in this study was relatively low although encouraging from the public health perspective.

There is a massive amount of evidence showing that those who are physically active are at reduced risk of many chronic diseases (Physical Activity Guidelines Advisory Committee 2008). In addition to disease outcomes, the benefits of physical activity for general health related functioning may be useful in motivating people to engage in physical activity during their leisure time. Furthermore, the reduced risk of sickness absence and disability retirement among those with high physical activity may interest employers in encouraging physical activity to enhance productivity and reduce costs related to sickness absence and, even more importantly, to permanent work disability which is very damaging both to individuals and to the economy. Although the benefits of moderate-intensity physical activity for health are well recognized, and the recommendation of moderate-intensity physical activity is justified for previously inactive individuals, some debate is warranted. When moderate-intensity activity is given as much emphasis as it is, it should be kept in mind that at least for the healthy middle-aged engaging in moderate-intensity physical activity some vigorous activity may provide significant health benefits. From a public health perspective vigorous physical activity to enhance fitness should be given more emphasis.

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