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Mikaela B. von Bonsdorff

# Physical Activity as a Predictor of Disability and Social and Health Service Use in Older People

JYVÄSKYLÄN YLIOPISTO

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UNIVERSITY OF JYVÄSKYLÄ

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# ABSTRACT

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The purpose of the study was to investigate whether functional status and physical activity history predict all-cause hospital and long-term care use among older community-dwelling people. In addition, the effects of physical activity counseling on instrumental activities of daily living (IADL) disability and home care service use in an older sedentary population were studied.

Data from three larger studies were used. The Evergreen project cohorts born in 1910 and 1914 consisted of 617 persons. From the Evergreen project interview data on individuals born in 1908-1923, a decedent population was investigated (n=846). Screening and Counseling for Physical Activity and Mobility among Older People, SCAMOB, was a 2-year physical activity counseling randomized controlled trial with a 1.5 year follow-up (n=632). Data on physical activity, walking speed, cognitive capacity, disability and health status were obtained in face-to-face interviews in the participants' homes or at research centre examinations. Register-based data were collected on home care use for 3.5 years and for hospital and long-term care use for up to 16 years.

The risk of long-term care was higher for older people with co-occurring mobility limitation and cognitive deficits compared to people with no limitations. Among men, hospital care in the last year of life decreased with higher levels of physical activity from midlife onwards. Among women, end-of-life long-term care increased with lower physical activity levels. The physical activity counseling intervention had no effect on IADL disability. However, subgroup analyses showed that the incidence of IADL disability for those with no IADL disability at baseline was lower in the intervention group. In addition, the secondary analyses suggested that home care use was lower in the intervention group.

The study stresses the beneficial effect of midlife and old age physical activity in compressing end-of-life disability and related service use. The effectiveness of an easily implemented physical activity counseling intervention which decreases disability and related service use should be studied more closely in different target groups.

Keywords: disability, home care, hospital care, long-term care, physical activity, primary care, older people

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*Mikaela von Bonsdorff*

## LIST OF ORIGINAL PUBLICATIONS

The thesis is based on the following papers, which will be referred to by their Roman numerals.

I von Bonsdorff M, Rantanen T, Laukkanen P, Suutama T, Heikkinen E. 2006. Mobility limitations and cognitive decline as predictors of institutionalization among community-dwelling older people. Gerontology 52, 359-365.

II von Bonsdorff MB, Rantanen T, Leinonen R, Kujala UM, Törmäkangas T, Mänty M, Heikkinen E. 2009. Physical activity history and end-of-life hospital and long-term care. Journals of Gerontology Series A: Biological Sciences and Medical Sciences 64, 778-784.

III von Bonsdorff MB, Leinonen R, Kujala UM, Heikkinen E, Törmäkangas T, Hirvensalo M, Rasinaho M, Karhula S, Mänty M, Rantanen T. 2008. Effect of physical activity counseling on disability among older people: a 2-year RCT. The Journal of the American Geriatrics Society 56, 2188-2194.

IV von Bonsdorff MB, Leinonen R, Kujala UM, Heikkinen E, Törmäkangas T, Hirvensalo M, Rasinaho M, Karhula S, Mänty M, Rantanen T. 2009. Effect of physical activity counseling on home care use among older people. The Journal of the American Geriatrics Society 57, 571-573.

## ABBREVIATIONS

| | |
|---|---|
| ADL | Activities of daily living |
| ANOVA | Analysis of variance |
| BMI | Body Mass Index |
| CES-D | Center for Epidemiologic Studies Depression Scale |
| 95% CI | 95% confidence interval |
| HR | Hazard ratio |
| IADL | Instrumental activities of daily living |
| ICD-10 | International Classification of Diseases, tenth revision |
| ICIHD | International Classification of Impairments, Disabilities, and Handicaps |
| MMSE | Mini-Mental State Examination |
| n | Number |
| OR | Odds ratio |
| RCT | Randomized controlled trial |
| RR | Risk ratio |
| SCAMOB | Screening and counseling for physical activity among older people |
| SD | Standard deviation |
| WHO | World Health Organization |

# CONTENTS

# 1 INTRODUCTION

Most older people would prefer to live a long life and die at an old age without extended suffering prior to death. This description of successful active aging is in line with the theory of compression of morbidity put forward by Fries (1980, 1983). The theory posits that a healthy lifestyle could potentially delay the onset of chronic illnesses and thus help to compress the period of disability and dependence in late life (Fries 1980, 1996).

According to Verbrugge & Jette (1994), in the disablement process the main pathway leads from pathology (disease, injury) to impairments (dysfunctions in specific body systems), which in turn lead to functional limitations (restriction in basic physical and mental actions), and disability (difficulty in performing activities of daily life). Impaired cognition (Agüero-Torres et al. 1998, Spiers et al. 2005), comorbidity (Fried et al. 1999, Dunlop et al. 2002, Song et al. 2006), functional limitations (Gill et al. 1995, Guralnik et al. 1995, Tinetti et al. 1995, Fried & Guralnik 1997, Rantanen et al. 1999a, Shinkai et al. 2000), and physical inactivity (Hirvensalo et al. 2000a, Nusselder et al. 2005, Boyle et al. 2007, Landi et al. 2007a) have been identified as significant risk factors for subsequent disability in several well-conducted longitudinal studies. Disability in activities of daily living (ADL) such as dressing, grooming, and getting in and out of bed (Katz et al. 1963) and in instrumental activities of daily living (IADL) such as cooking, shopping, and cleaning (Lawton & Brody 1969) will increase the risk for dependency and need for health and social services among older community-dwelling individuals (Fried & Guralnik 1997, Miller & Weissert 2000, Kadushin 2004). Old people often tend to suffer from multiple impairments and limitations simultaneously. However, the combined effects of co-occurring impairments and limitations on related service use is not known.

The main services provided for older people are home care, long-term care in a health centre hospital ward, in service housing with 24-hour assistance, or in a nursing home, inpatient specialized health care, and outpatient primary care. In terms of service need, every sixth of those aged 65 years and older, every third of those aged 75 years and older, and every other of those aged 85 years and older are in need of health and social services on a daily basis (Vaarama 2004). Impairments in cognitive and physical functioning as well as

disability in ADL and IADL tasks are likely to increase the need for both home care (Branch et al. 1988, Kemper 1992, Liu et al. 2000, LaPlante et al. 2002) and long-term care (Guralnik et al. 1994, Laukkanen et al. 2000, Agüero-Torres et al. 2001, Angel et al. 2004, Bharucha et al. 2004, Friedman et al. 2005, Gaugler et al. 2007) among community-living older people. The presence of diseases such as heart disease and diabetes (Freedman et al. 1996) as well as problems in physical functioning, prior hospitalization, and having an informal caregiver (Miller & Weissert 2000) predict subsequent hospital care. In general, the need for overall social and health care services increases with age and closeness to death (Busse et al. 2002, Yang et al. 2003, Dixon et al. 2004), mainly because of increased need for nursing home care among very old persons (McGrail et al. 2000, Spillman & Lubitz 2000, Yang et al. 2003).

It has been suggested that health behavior, such as physical activity, might delay the onset of morbidity (Hakim et al. 1998, Wannamethee et al. 1998, Friedenreich et al. 2001, Bean et al. 2004) and thus help to compress the period of disability and high health care costs near the end of life (Fries 1980). Functional limitations have been shown to mediate the effect of physical activity on disability (Miller et al. 2000) along the main pathway of the disablement process (Verbrugge & Jette 1994). With respect to the disablement process, there is a growing body of evidence for the beneficial effects of physical activity on functional limitation (Pahor et al. 2006, Morey et al. 2008, Hughes et al. 2009, Mänty et al. 2009). Several well-conducted longitudinal studies have shown that physical activity is beneficial in reducing or postponing disability in older age (Leveille et al. 1999, Hirvensalo et al. 2000a, Nusselder et al. 2005, Boyle et al. 2007, Landi et al. 2007a). However, the results of randomized controlled trials (RCT) on the effect of physical activity on disability for older people have been inconsistent (van Haastregt et al. 2000, Elkan et al. 2001, Keysor & Jette 2001, Stuck et al. 2002, Bean et al. 2004, Latham et al. 2004, Daniels et al. 2008). Existing research on the effect of physical activity on health and social service use is very inadequate, partially with regards to the early predictors of need for care prior to death among people who die in old age.

Interventions for reducing or postponing disability are needed within primary care (Ferrucci et al. 2004, Gill et al. 2004). So far, among older sedentary community-dwelling people, RCTs on physical activity counseling have shown positive results in increasing the amount and intensity of physical activity (Halbert et al. 2000, Stewart et al. 2001, Dubbert et al. 2002, Elley et al. 2003, Kerse et al. 2005, Pinto et al. 2005, Wilcox et al. 2006, Kolt et al. 2007). Trials have shown that physical activity counseling among older persons has prevented deterioration in physical functioning scores (Morey et al. 2008) and decreased limitation in advanced mobility (Mänty et al. 2009). Furthermore, Kerse et al. (2005) showed in their primary-care based physical activity counseling program that brief activity counseling by a nurse or a doctor followed by telephone support decreased hospitalization among sedentary older persons. However, the effect of physical activity counseling on disability

and home care use among community-dwelling sedentary older people is not known.

This study explored the association of functional status and physical activity on hospital and long-term care use. In addition, the effects of a physical activity counseling intervention on the instrumental activities of daily living disability and home care need was studied in an older sedentary community-dwelling population.

# 2 REVIEW OF THE LITERATURE

## 2.1 Compression of morbidity in old age

Life expectancy has improved among older people over the past half century. The remaining life expectancy in Finland for a 70-year-old man is currently 13.4 years and for a woman 16.8 years (Statistics of Finland 2007). Ideally, people live a long and healthy life and die at an advanced age without long periods of dependence caused by illness or disability at the end of life. However, the phenomenon of ill health at the end of life, partly due to the decrease in acute illnesses and increase in chronic disabling illnesses (Fries 1996), poses a threat to this scenario. Thus, it has been argued that active life expectancy, and the amount of time remaining without disability in the activities of daily living among older persons (Katz et al. 1983), will not increase accordingly (Guralnik et al. 1993).

The three theories which describe the trends in the health of older people are compression of morbidity, expansion of morbidity, and dynamic equilibrium. Compression of morbidity occurs if the age of onset of chronic diseases increases at a faster rate than life expectancy (Fries 1980, 1983). The compression of morbidity does not mean that the age of death increases dramatically but that the onset of morbidity takes place at an older age (Fries 1980, 1996). The theory posits that a healthy lifestyle could delay the onset of chronic illnesses and thus help compress the period of disability and dependence in late life (Fries 1996). The expansion of morbidity theory postulates that advances in medical care have increased both the time that a person suffers from chronic diseases and life expectancy (Gruenberg 1977). This could potentially lead to an increase in the number of persons who are chronically ill and disabled for long periods at the end of life and who thus cannot lead an independent life with normal activities and social participation. The third theory by Manton (1982), known as the dynamic equilibrium theory, incorporates elements from both the compression and expansion of morbidity theories. According to the theory the proportion of life spent with a serious

disabling disease will decrease, while the proportion of life spent with less severe disease will increase.

Currently, morbidity is concentrated mostly in the last two decades of life with onset at about 55 years and increase with age (Fries 1996). Lubitz et al. (2003) estimated that in the U.S. a 70-year-old person with no limitations has a total remaining life expectancy of 14.3 years on average of which 0.7 years will be spent in an institution, and 4.9 years with at least one limitation in the activities of daily living (ADL). On the other hand, a 70-year-old person with an ADL limitation is expected to live approximately 12 years of which 0.7 years would be spent in an institution and about 6.5 years with at least one ADL limitation. Jagger et al. (2007) showed that, among persons aged 65 or over without diabetes, men lived 4.4 years and women 5.6 years longer and spent 4.1 and 5.1 years, respectively, free from disability. In the Established Populations for Epidemiologic Studies of the Elderly, people who lived a long life and died without prior disability were more likely to be physically active earlier in their life (Leveille et al. 1999).

## 2.2 Disability in old age

### 2.2.1 Disablement process

Disability is defined as difficulty in or inability to perform everyday activities due to a health or physical problem (Nagi 1976, Verbrugge & Jette 1994). It has also been defined as the gap between the person's abilities and the environmental demand (Verbrugge & Jette 1994). The sociomedical model of disability, called the disablement process (Verbrugge & Jette 1994), builds on the previous disablement frameworks of Nagi (1976) and the International Classification of Impairments, Disabilities, and Handicaps (ICIHD) (World Health Organization 1980). Recently, the WHO model has been revised and introduced as the International System of Functioning, Disability, and Health (ICF) (World Health Organization 2002). In the ICF model, functioning and disability are considered to be the result of a complex interaction between a person's health and both contextual environmental and individual factors.

In the disablement process model by Verbrugge & Jette (1994), the main pathway leads from pathology (disease, injury) to impairments (dysfunctions in specific body systems), which in turn lead to functional limitations (restriction in basic physical and mental actions), and disability (difficulty in performing activities of daily life), see Figure 1. The pathway is modified by risk factors (predisposing characteristics), intra-individual factors (e.g. lifestyle and behavior changes), and extra-individual factors (e.g. external support).

Disability is typically reported as difficulties in or an inability to perform activities of daily living (ADL) and instrumental activities of daily living (IADL) tasks. ADL tasks include basic self-care tasks such as eating, bathing, dressing,

toileting, getting in and out of bed and getting around indoors (Katz 1963). These tasks are important for maintaining independency in older age (Dunlop et al. 1997, Jagger et al. 2001).

Disability in ADL tasks is an indication of serious disability and a strong indicator for nursing home admission (Laukkanen et al. 2000, Angel et al. 2004, Friedman et al. 2005, Gaugler et al. 2007). Dunlop et al. (1997) showed in a longitudinal setting using data from the Longitudinal Study of Aging that restrictions appeared in ADL tasks first in walking, then in bathing, toileting, dressing, transfers from bed, and feeding. Jagger et al. (2001) found the order to be the same except that bathing was the first ADL task to be affected. The discrepancy between these studies may partly be caused by the greater number of proxies interviewed in the first study, as these individuals often report more ADL disabilities (Jagger et al. 2001).

IADL tasks include more complex tasks such as preparing food, shopping, washing clothes, doing light and heavy household work, using public transportation, administering and taking medication, and handling finances (Lawton & Brody 1969). Difficulties in IADL tasks often precede difficulties in ADL tasks (Judge et al. 1996). Cognitive decline influences IADL tasks at an earlier stage than ADL tasks, which are well-learned and depend on cognition to a lesser extent (Njegovan et al. 2001). IADL disability is closely related to the ability to live independently (Spillman 2004) and to social participation (Rejeski et al. 2008).

In the research literature, exist, several overlapping terms for disability such as functional limitation, functional status, functional dependence, physical decline, and frailty (Tinetti et al. 1995, Gill et al. 1996, Rockwood et al. 1999, Stuck et al. 1999). Functional limitation is usually defined with either self-reported or measured ability to perform functional tasks such as walking 500 meters, climbing stairs, and lifting objects from the floor to a table (Guralnik et al. 1994). Some researchers (e.g. Guralnik et al. 1995, Rantanen et al. 1999b, Leveille et al. 2001) use physical performance measures such as walking speed, standing balance, and rising from a chair, in addition to ADL tasks, in measuring disability. Disability is usually measured by self-reported difficulty or inability in performing ADL and IADL tasks (Ferrucci et al. 1996, Gill & Kurland 2003, Phelan et al. 2004, Hardy et al. 2005, Wolinsky et al. 2007). Debate continues on whether difficulties in ADL and IADL tasks should be included in the definition of disability or whether disability should be defined as dependence, i.e. need of help from another person (Gill et al. 1998, Jagger et al. 2001). In the present study, disability is self-reported and defined as having difficulty or being unable to perform one or more ADL or IADL tasks without help from another person (Verbrugge & Jette 1994).

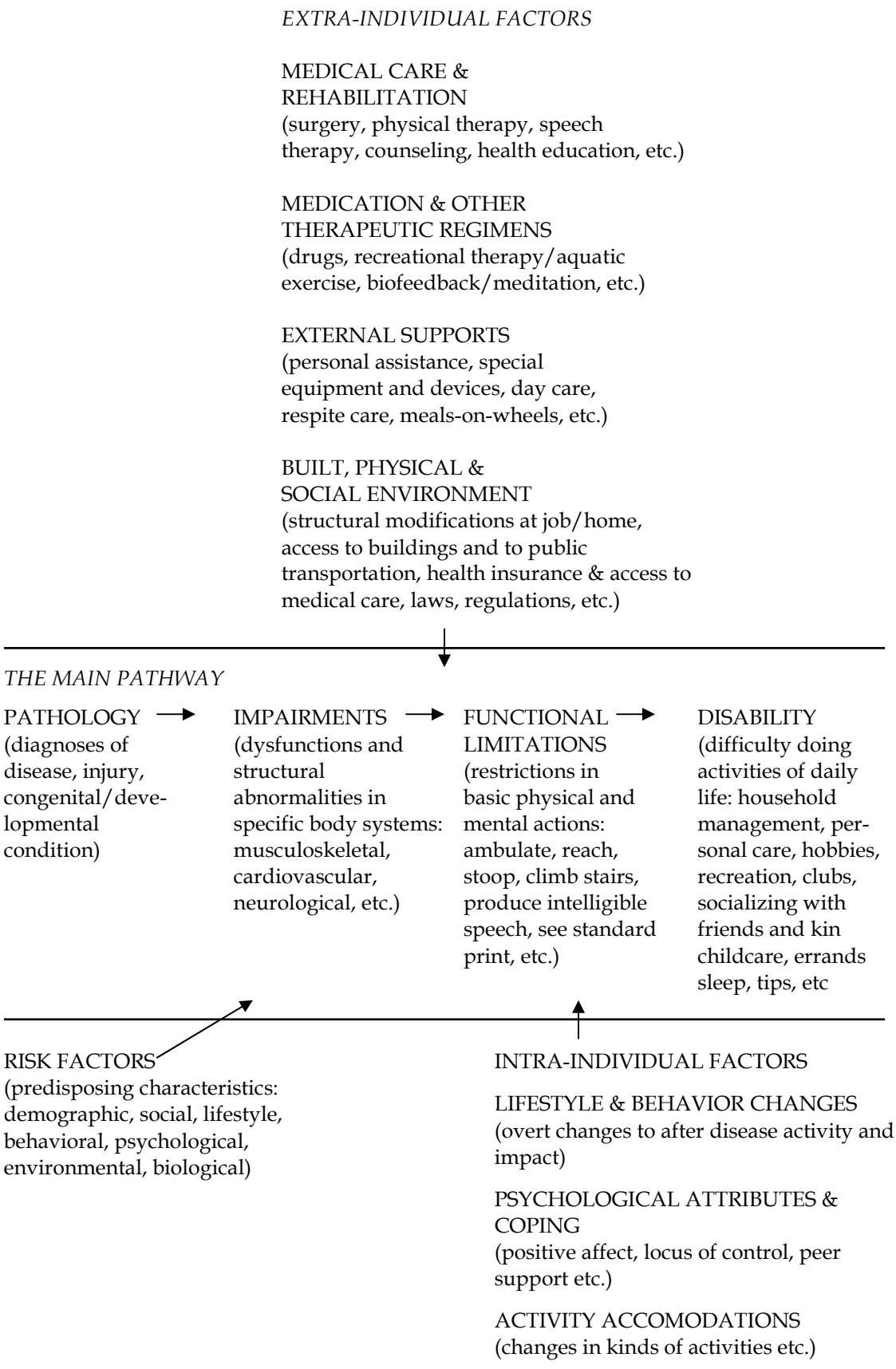


FIGURE 1 The disablement process (Verbrugge & Jette 1994).

### 2.2.2 Prevalence of disability

Disability in populations is typically measured as prevalence and incidence. Prevalence is defined as individuals belonging to a specific group of people who are disabled at a given point in time, e.g. at the beginning of a follow-up period. Incidence is defined as the number of new cases of disability occurring in a population free from disability during a given time interval. Disability can develop suddenly as a result of an accident or an illness, such as a stroke, that lead to hospitalization and restricted activity, or it can be chronic and develop gradually with time (Ferrucci et al. 1996, Gill et al. 2004). Earlier, disability was often considered to be progressive, resulting in a permanent state of dependence (Ferrucci et al. 1996). However, disability has been shown to be a dynamic process with transitions between the onset of disability and recovery from it (Verbrugge & Jette 1994, Leveille et al. 1998, Gill & Kurland 2003, Hardy et al. 2005). Individuals who become disabled may recover from their disability, and possibly later on become disabled again. Hardy & Gill (2004) showed that newly disabled persons were more likely to recover independent ADL function than persons who had a longer history of disability. However, recovery was often found to be short-lasting. Factors that have been linked to recovery from disability include younger age, intact cognitive functioning, and good mobility (Gill et al. 1997).

The prevalence of disability increases with older age (LaCroix et al. 1993, Agüero-Torres et al. 1998, Winblad et al. 2001, Berlau et al. 2009). Women are more often disabled than men (Verbrugge et al. 1989, Winblad et al. 2001, Dunlop et al. 2002, Hardy et al. 2008) and are also expected to have longer durations of dependence than men (Katz et al. 1983). On average, persons with lower education and income suffer more from disability than those with higher education and income (Katz et al. 1983, Nusselder et al. 2005).

In the past decade, the disability rate has been falling in the United States, and several measures of disability have shown improvements (Freedman et al. 2002, Manton 2008, Schoeni et al. 2008). The rate of nondisabled persons older than 65 years increased from 73.5% in the year 1982 to 81.0% in the years 2004/2005 (Manton et al. 2006). Mainly, this is due to the fact that younger cohorts of older people are living longer in better health (Manton et al. 2008). Freedman et al. (2008) showed that for people aged 75 years and older, there was a decline in the rate of ADL limitations from 30.2% in the year 1995 to 26.0% in the year 2004, but no reduction in the rate of IADL limitations was observed. However, the rate of decline in disability has been small for those aged 85 or older (Spillman 2004). In fact, Berlau et al. (2009) reported that ADL dependency was present in 44% of 90-94 year olds and in 66% of the 95-99 years olds.

In Europe, the downward trend in disability has been less evident in the last decade. Within the Nordic countries, Finland's disability rates among the 'young old' have declined; however, the rates among the oldest old have not declined but even increased during the past decade (Laukkanen et al. 1997, Martelin et al. 2002). Winblad et al. (2001) compared cohorts aged 75 or over in

1979, 1989 and 1999 and found that the prevalence of disability did not differ over the 20-year time span. In Spain, overall disability decreased among persons aged 75 years or older from 1986 through 1999, although for women there was a sharp rise in self-care disability (Sagardui-Villamor et al. 2005). Another study from Spain by Zunzunegui et al. (2006), conducted in Leganés between 1993 and 1999, found significant declines in ADL disability for community-dwelling persons aged 65 and over. However, the study found an emerging group of very old and disabled people over 90 years of age. Additionally, a study conducted by Pérès et al. (2005) compared two cohorts aged 75 to 84 years in south-west France in 1988 and 1998. In this cross-sectional analysis there was no change in the prevalence of IADL disability in men, whereas the prevalence of IADL disability decreased in women, a finding which can partly be explained by an increase in women's cognitive performance. For ADL disability, a statistically non-significant downward trend from 1988 to 1998, possibly due to the very low prevalence of severe disability in community-dwellers, was observed.

Healthier living habits, such as increased physical activity, have most likely resulted in the compression of morbidity (Fries 1980, 1996) and in decreased disability at the end of life (Vita et al. 1998, Leveille et al. 1999). However, in spite of decreasing overall disability, the actual number of people with chronic disability has increased among older people (Gulranik et al. 1997, Spillman 2004) as a result of the growth in this segment of the population.

### 2.2.3 Predictors of disability

There are several risk factors for disability in old age (Stuck et al. 1999); these are presented in Table 1. In the 1980s, disability emerged as an important public health outcome alongside morbidity (Guralnik et al. 1996, Fried & Guralnik 1997). Along the disability pathway lie pathology and impairment, which are more distal, and functional limitation which is proximal to disability (Verbrugge & Jette 1994). From the pathology standpoint, comorbidity is a well established risk factor for disability (Verbrugge et al. 1989, Fried et al. 1999, Dunlop et al. 2002, Song et al. 2006). Impairments such as decreased muscle strength have been identified as risk factors for disability (Rantanen et al. 1999a), along with coimpairments, e.g. decreased knee-extension strength and poor standing balance (Rantanen et al. 2001). Cognitive impairment is also a strong predictor of disability (Agüero-Torres et al. 1998, Stuck et al. 1999, Dodge et al. 2005, Spiers et al. 2005). The simultaneous occurrence of co-limitations in cognitive performance and physical functioning add significantly to the risk for disability in comparison to those with no limitation or only one limitation (Gill et al. 1995). Gill et al. (1996) demonstrated that persons with the worst physical and cognitive performance were more than five times more likely to develop ADL disability compared to those with the best performance. Functional limitations, namely upper or lower extremity limitations, have been found to predict subsequent disability (Guralnik et al. 1995, Tinetti et al. 1995, Judge et al. 1996, Fried & Guralnik 1997, Shinkai et al. 2000). Mobility ability (Guralnik et al.

TABLE 1 Main risk factors, measures, and effects of selected prospective studies for ADL and IADL disability in community-dwelling older people according to the Disablement process (Verbrugge & Jette 1994).

| **Pathology** | | | | | |
|---|---|---|---|---|---|
| Risk factor | n | Age | Measure | RR/OR (95% CI) | Reference |
| Affect | | | | | |
| Depression | 1189 | 70-79 | Hopkins Symptom Checklist, 1=no depression, 4=depression | M 3.6 (1.1-11.7)<br>W 5.5 (1.8-16.9) | Bruce et al. 1994 |
| Morbidity | | | | | |
| Arthritis | 7758 | 65+ | Self-reported (yes/no) | 1.5 (1.2-1.8) | Song et al. 2006 |
| Dementia | 1745 | 70+ | Clinical examination, DSM-III-R criteria | 0.7 (0.6-0.8) | Agüero-Torres et al. 1998 |
| Diabetes mellitus | 8344 | 65+ | Self-report & physical examination | 2.5 (2.1-3.0) | Gregg et al. 2002 |
| Coronary heart disease | 2576 | 55-88 | Examinations and hospital records on angina pectoris (yes/no) | M 2.6 (1.3-5.0)<br>W 2.3 (1.4-3.7) | Pinsky et al. 1990 |
| Stroke | 1769 | 73.7± 6.3 | Verified by physician (yes/no) | 3.0 (1.6-5.5) | Guccione et al. 1994 |
| **Impairment** | | | | | |
| Risk factor | n | Age | Measure | RR/OR (95% CI) | Reference |
| Physical impairment | | | | | |
| Decreased muscle strength | 2493 | 65+ | Maximal isometric hand grip strength | Lowest quart. vs. highest quart.<br>M 1.9 (1.1-3.2)<br>W 2.3 (1.6-3.3) | Al Snih et al. 2004 |
| Vision | 5143 | | Visual acuity | 3-fold risk | Salive et al. 1994 |
| Nutrition | | | | | |
| Weight gain | 2037 | 65+ | Weight measured on scale | 5%≥ vs. <5% weigh gain<br>1.4 (1.0-1.9) | Al Snih et al. 2005 |
| Weight loss | 2037 | 65+ | Weight measured on scale | 5%≥ vs. <5% weigh loss<br>1.4 (1.1-2.0) | Al Snih et al. 2005 |

(continues)

TABLE 1 (continues)

| **Functional limitation** | | | | | |
|---|---|---|---|---|---|
| Risk factor | n | Age | Measure | RR/OR (95% CI) | Reference |
| Physical functioning | | | | | |
| Lower extremity functioning | 1122 | 71+ | Short Physical Performance Battery 0-10 | 10-12 vs. 4-6<br>4.2 (2.3-7.7 | Guralnik et al. 1995 |
| Walking speed | 2032 | 70+ | Walking speed (sec) | 1.1 (1.1-1.14) | Woo et al. 1999 |
| Cognitive decline | 1856 | 65+ | Clinical examination, SPMSQ | M 2.7 (1.4-5.4)<br>W 2.6 (1.5-4.4) | Moritz et al. 1995 |
| **Predisposing risk factors** | | | | | |
| Socio-demographic | | | | | |
| Age | 7527 | 70-79 | | 80+ vs. <80<br>3.4 (2.3-4.8) | Mor et al. 1994 |
| Gender | 1453 | 63-94 | | Male vs female<br>1.5 (1.0-2.3) | |
| Education | 1791 | 80+ | | 13> vs. 0-6 years<br>2.4 (1.2-4.7) | Harris et al. 1989 |
| Lifestyle | | | | | |
| Low physical activity | 787 | 81±7.1 | Hours per week participating in physical activity | 0.9 (0.9-1.0) | Boyle et al. 2007 |
| Behavioral | | | | | |
| Falls | 325 | 65+ | Fall frequency, number of falls | no falls vs. more falls<br>3.5 (1.4-8.6) | Laird et al. 2001 |
| Low self-rated health | 7527 | 70+ | Global health status, Likert scale | excellent vs. poor<br>1.56 (1.2-2.0) | Lee 2000 |

DSM-III-R= Diagnostic and Statistical Manual of Mental Disorders, revised third edition. SPMSQ= Short Portable Mental Status Questionnaire.

1994, Judge et al. 1996, Woo et al. 1999) and cognitive functioning (St John et al. 2002, Angel et al. 2004) have been recognized as vital prerequisites for independent community-dwelling.

In longitudinal studies behavioral factors such as sedentary behavior in midlife (Vita et al. 1998, Hillsdon et al. 2005, Chakravarty et al. 2008) and old age (Hirvensalo et al. 2000a, Nusselder et al. 2005, Boyle et al. 2007, Landi et al. 2007a) have been associated with increased risk for disability in old age. On the other hand, results from randomized controlled trials on the effect of physical activity on old-age disability have been inconsistent (Penninx et al. 2001, Binder et al. 2002, Luukinen et al. 2006, Timonen et al. 2006). High body mass index in midlife (Peeters et al. 2004, Alley & Chang 2007, Stenholm et al. 2007) and in old age (Reynolds et al. 2005) are known risk factors for mobility limitation and subsequent disability in old age. Launer et al. (1994) showed that old women who experienced more than 5% weight loss had a twofold risk for disability compared to those whose weight remained stable during the follow-up.

## 2.3 Social and health care services for older people

### 2.3.1 Finnish health care system for older people

The Finnish health care system covers the whole population. Several laws govern the provision of health and social services (e.g. Social Welfare Act 710/1982, the Primary Health Care Act 66/1972, and the Act on Specialised Medical Care 1062/1989). The social and health care services that municipalities are required to provide for their residents are mainly provided by the public sector and financed with tax money (Hermanson et al. 1994, Häkkinen 2005, Häkkinen et al. 2008). Voluntary private services such as private doctors' fees are partly subsidized by the Finnish National Health Insurance and costs of private domestic services are tax deductible (Official Statistics of Finland 2003). The reforms that have taken place during the last decades in the Finnish health care system along with the severe economic recession at the beginning of 1990s have affected the development of health and social services for older people. Institutional care has been partially dismantled over the years and there has been a very small increase in the supply of home care services (Lehto & Blomster 2000).

The services that are targeted at older people are intended to support them in daily activities and ensure appropriate nursing and care (Official Statistics of Finland 2003). Women need services more frequently than men (Vaarama 2004). The main services provided for older people are home care, support for informal care, ordinary service housing, long-term care, inpatient specialized health care, and outpatient primary and specialized health care (Noro 1998). Services for older people are provided in both social and health care. Home care includes home help, which is provided by social services, and home nursing,

which is provided by the health care services (Official Statistics of Finland 2003). Most of the specialized services are provided by university, central; and regional hospitals (Häkkinen et al. 2008). Long-term care is provided in health centre in-patient wards, in service housing with 24-hour assistance, and in nursing homes (Official Statistics of Finland 2003). The present study discusses home care, hospital in-patient care and long-term care.

In terms of service need in Finland, it has been estimated that one in six of those aged 65 years and older, one in three of those aged 75 years and older, and half of those aged 85 years and older need health and social services on a daily basis (Vaarama 2004). In the year 1995, 14% (approximately 102 000 clients) of persons aged 65 years and over used services regularly. At the end of year 2005, 12.9% (approximately 110 000 clients) regularly used health and social services (Voutilainen 2007).

### 2.3.2 Home care, hospital care and long-term care for older people

Social and health care systems vary across countries, making comparison between them difficult. In the Finnish social and health care system service provision is a public sector responsibility and paid for through general taxation (Häkkinen 2005).

*Home care*

One of the main goals of elderly care today is to promote community-dwelling. This is often also the desire of older people themselves. In order to help them remain community-dwelling, older people often first receive informal home care given by their spouse, relatives and friends, when available, and also later on, formal care offered by the municipality. Formal care did not vary according to gender. However, disabled women received about one third of the hours of informal care given their male counterparts (Katz et al. 2000). In the United States, Liu et al. (2000) showed that between 1982 and 1994 the proportion of elderly disabled persons receiving formal care at home increased from one quarter to more than one third. This was due to factors such as higher incomes, worse health, less availability of informal caregivers, and policy changes in publicly financed home services. In Sweden, almost all elderly home-dwelling persons aged 75 or over with high risk for subsequent nursing home placement received informal or formal home care (Davey et al. 2005).

In Finland in 2005, the average age of regular home care recipients was 81.3 years (Voutilainen 2007). There were approximately 4-8 visits made to home care clients per month with a median of 8 visits per month (Vaarama et al. 2000). Home help included help with daily living tasks such as dressing, cooking, and shopping. Home nursing included tasks such as administering medication, taking blood samples, wound care, and giving advice to clients and their next of kin. Home care services can be given for shorter periods of time or on a regular basis. Care is considered to be regular if a person has received continuous care for over three months and is still in need of care (Official

Statistics of Finland 2003). Home care visits by home help and/or home nursing can range from once a month to several times a day depending on the client's needs. In 1996, 13.4% of those aged 75 years and over received regular home care; in 2001 this number had fallen to 12.0% (Ministry of Social Affairs and Health 2003) and in 2005 it had fallen to 11.5% (Vuotilainen 2007). In the last decade, home care has been targeted at a smaller group of elderly people who are severely disabled, and thus have an urgent need for care (Vaarama et al. 2000, Voutilainen 2007).

*Long-term care*

The need for long-term care increases, especially in individuals aged 85 years or older (Spillman & Lubitz 2000, Menec et al. 2007). Yang et al. (2003) showed that expenditure on nursing home care at the end of life for those over 85 was about three times higher than for those aged 65-74. In British Columbia, Canada Sheps et al. (2000) found that 'young old' persons shifted from part-time facility use to no care service use during 1986 to 1993, while those who were 90 years and older shifted towards more facility based use. Rising longevity within the next 20 years will increase the risk for a 65-year-old entering a nursing home to 46% (Spillman & Lubitz 2002).

In Finland, in the year 1996, 6.3% of persons aged 75 years or older resided in a nursing home while 4.2% were in a health centre long-term care ward (Ministry of Social Affairs and Health 2003). Whereas in the year 2005 the corresponding proportion were 4.3% and 2.5% (Voutilainen 2007). Traditional institutional care has declined significantly during the last decade while service housing has increased (Vaarama et al. 2000). The share of service housing has increased over the last 10 years from 3.4% to 5.4%. Service housing with 24-hour help, i.e. institutional care doubled between 2000 and 2005 (Voutilainen 2007). Residents in long-term care institutions are older than before, and with a rise in the prevalence of diseases which cause dementia, the residents of long-term care institutions also tend to be in worse physical and mental condition than before (Ministry of Social Affairs and Health 2003).

*Hospital care*

The number of hospital in-patient days increases with proximity to death (Busse et al. 2002, Yang et al. 2003, Dixon et al. 2004). The use of in-patient hospital care does not increase with age per se; rather there is a higher proportion of people who are in the final stages of their lives (Himsworth & Goldacre 1999, Dixon et al. 2004). In Germany, the average number of in-patient care days in the last year of life was highest for 55- to 64–year-olds (40.6 days) and lowest for the 85-years and above category (23.2 days) (Busse et al. 2002). In the United States, Medicare expenditures for hospital care during the last years of life decreased with age, especially in those aged 85 years and over (Spillman & Lubitz 2000), mainly because the aggressiveness of the medical care given decreases with age (Levinsky et al. 2001). However, the use of long-term care among persons aged 85 years or older is increasing significantly and in part

explains the decrease in hospital care among the oldest old in the last years of life (McGrail et al. 2000, Spillman & Lubitz 2000, Yang et al. 2003).

In Finland, the provision of hospital in-patient care has changed in the recent decade so that long-term care within specialized care is non-existent (Official Statistics of Finland 2003). Acute care is primarily given in a specialized hospital facility with possible rehabilitation given in the primary care wards for older people (Goebeler et al 2004). In the year 2000, approximately 24% of individuals aged 65 years or over had been in hospital care during the last 12 months (Häkkinen et al. 2004).

### 2.3.3 Predictors for health and social service use in old age

According to the Andersen behavioral model, the predictors of health and social service use can be divided into predisposing, enabling, and need factors (Andersen & Newman 1973, Aday & Andersen 1974, Andersen 1995). In addition, there are factors such as prior hospitalization and use of formal care that can predict the need for care (Wolinsky et al. 1995). Miller & Weissert (2000) employed the Andersen model for the purpose of describing the determinants of medical care use in their extensive review of the factors predicting nursing home use, hospitalization, functional impairment, and mortality. According to the model, predisposing characteristics include demographics, social support, health belief indicators, enabling factors (including familial and community related indicators), and need factors, which are related to the person's health status. Predisposing characteristics are the most distal and need factors the most proximal cause for health care use, while enabling factors have a more moderate effect on service use.

Older persons often first depend on informal help from their spouse, children, relatives or friends and turning to formal care when their care needs increase. Home care use varies according to determinants such as difficulties or inability to cope with daily tasks. With respect to home care, persons often receive both informal and formal care simultaneously (Liu et al. 2000). When home care services are not able to meet the care needs of the person, institutional care with help available around the clock is needed.

*Home care*

In a two-year follow-up study, Branch et al. (1988) showed that the most important predictors of formal home care use for community-dwelling persons aged 65 or over who did not use home care at baseline were substantial limitations in physical function, cognition, and social function. Other prospective studies have concluded that ADL and IADL disability are also strong predictors of formal home care need, and that the need for care grows as the number of disabilities in activities of daily living tasks increases (Kemper 1992, Liu et al. 2000, LaPlante et al. 2002). Demographic factors such as gender, age, living arrangements, and marital status do not seem to be related to formal home care use (Branch et al. 1988, Kemper 1992, Katz et al. 2000). The need for

care varies dynamically according to determinants such as disability status and the availability of informal caregivers (Freedman et al. 2004).

*Long-term care*
Previous prospective research has identified several predictors of long-term care for community-dwelling older persons. A recent meta-analysis found that the three strongest predictors of long-term care were worse ADL disability, cognitive impairment, and prior nursing home use (Gaugler et al. 2007). Some of the most frequently reported predictors of nursing home use in prospective studies are older age (Wolinsky et al. 1992, Woo et al. 2000, Freidman et al. 2005, Andel et al. 2007), female gender (Rockwood et al. 1996, Jagger et al. 2001), not being married or living alone (Wolinsky et al. 1992, Rockwood et al. 1996, Hays et al. 2003), lower cognitive functioning and related diseases such as Alzheimer's disease (Agüero-Torres et al. 2001, St John et al. 2002, Banaszak-Holl et al. 2004, Bharucha et al. 2004), ADL or IADL disability, lower physical functioning (Guralnik et al. 1994, Laukkanen et al. 2000, Angel et al. 2004, Friedman et al. 2005), absence of an informal caregiver or the use of formal care (Boaz & Muller 1994, Tsuji et al. 1995, Andel et al. 2007), and a higher number of illnesses and injuries (Tinetti & Williams 1997, Tomiak et al. 2000, Fransen et al. 2002). In addition, evidence from prospective studies is accumulating for midlife lifestyle factors such as obesity, smoking, and inactivity as well as lifestyle-related diseases such as diabetes as predictors of admission to an old age nursing home (Elkins et al. 2006, Valiyeva et al. 2006).

*Hospital care*
Different factors predict nursing home use and hospitalization (Miller & Weissert 2000). In a longitudinal study by Freedman et al. (1996) the presence of diseases such as heart disease and diabetes predicted subsequent hospital care. In addition, Miller & Weissert (2000) found that problems in physical functioning, prior hospitalization, number of physician contacts, and having an informal caregiver increased the risk for hospital admission. Further, from an exhaustive list of predictors, only informal care, lower physical capacity, number or severity of diseases, and prior hospital use increased the risk for both nursing home use and hospitalization.

## 2.4 The role of physical activity in preventing decline in physical functioning in old age

### 2.4.1 Physical activity in old age

Physical activity has been defined as bodily movement resulting from the contraction of skeletal muscle that increases energy expenditure above the basal level (Caspersen 1989). Physical exercise, on the other hand, as a subcategory of

physical activity, has been defined as physical activity that is planned, structured, and repetitive in nature (Marcus & Forsyth 2003). In this study the term physical activity is used, as opposed to the term exercise, on account of its broader meaning.

The American College of Sports Medicine and the American Heart Association have issued recommendations for physical activity, emphasizing the importance of moderate-intensity aerobic activity, muscle-strengthening activity, reducing sedentary behavior, and managing activity-related risks among persons aged 65 years or over (Nelson et al. 2007). The most popular form of physical activity among older people is walking (Bijnen et al. 1998, Hirvensalo 2002, Ashe et al. 2009). Some of the other activities favored by the older Finnish population have been home calisthenics, swimming, skiing, cycling, and dancing (Pohjolainen & Heikkinen 1989). Physical activity can include various everyday activities such as household chores, leisure-time activities such as gardening, and activities such walking to the store. Physical activity can be a home-based or centre-based activity; for example, in the latter individuals attend organized group exercise classes. Home-based exercise can be more attractive for disabled people, who have difficulties in accessing sport facilities (King et al. 1992). On the other hand, low adherence to physical activity has been found to be a problem in home-based exercise (Jette et al. 1996). In absolute terms physical activity among older people usually involves light or moderate physical exercise; however, among older people are a minority of master athletes who train vigorously and participate in top-level competitions.

Physical activity declines with older age (Beckett et al. 1996, Bennett 1998, Bijnen et al. 1998). This is partly due to the aging process, the deterioration of muscle tissue, and an increase in the disease and disability burden (Bijnen et al. 1998, Rantanen et al. 1999b, Taylor et al. 2004). Currently, in western countries approximately 30-60% of the older population is physically inactive (Kruger et al. 2008, Ashe et al. 2009). King et al. (1992) identified some of the factors that are related to physical activity behavior among older people, including personal characteristics, program-based factors, and environmental factors. Personal characteristics include various factors such as demographic and health variables, individuals' physical activity-related attitudes and beliefs, and psychological and behavioral factors that are associated with physical activity (King et al. 1992). Older men have been more physically active than older women (Wolinsky et al. 1995, Kruger et al. 2008), which may partly be due to different socialization into physical activity among older men and women, it being more natural for older men than older women to be physically active (Wolinsky et al. 1995). People with higher educational levels have been found to be more physically active than those with lower educational levels (Wister 1996, Stuart et al. 2002, Ashe et al. 2009). Deteriorating health has been frequently associated with sedentary behavior (Wolinsky et al. 1995, Cohen-Mansfield et al. 2003). The level of physical activity earlier in life has been found to be a strong determinant of physical activity behavior in older age (Hirvensalo et al.

2000b). Self-efficacy, the belief in one's ability to successfully perform a certain behavior (Bandura 1977), is one of the most important determinants of physical activity behavior (Oman & King 1998, McAuley et al. 2003).

The most frequently reported barriers to physical activity include health problems and pain, unsuitable environment, physician advice, ignorance concerning the benefits of exercise, and earlier negative experiences related to exercise (Cohen-Mansfield et al. 2003, Schutzer & Graves 2004, Rasinaho et al. 2006). High self-efficacy, positive feelings, heatlh maintenance, physical activity counseling, social factors (such as support from peers), and environmental factors (such as conveniently located facilities) are some of the most important motivators for physical activity (McAuley et al. 2003, Schutzer & Graves 2004, Rasinaho et al. 2006).

Evidence is accumulating on the beneficial effect of midlife physical activity on well-being in old age. Physical activity has a favorable effect on mood (Tsutsumi et al. 1997) and has been found to decrease depressive symptoms among healthy older people (Wilcox et al. 2006) and people suffering from depression (Penninx et al. 2002, Sjösten & Kivelä 2006, Frederick et al. 2007, Pakkala et al. 2008). With respect to midlife physical activity, those who had been more active in midlife had better mobility in old age compared to the inactive individuals (Patel et al. 2006). Further, physical activity earlier in life (Rovio et al. 2005, Landi et al. 2007b) and in old age (Laurin et al. 2001, Weuve et al. 2004) has been associated with a decreased risk for or delayed onset of Alzheimer's disease.

Miller et al. (2000) introduced the pathway from physical activity to disability via functional limitations and showed in their prospective population-based study that functional limitations mediated the effect of physical activity on disability. Physical inactivity has been associated with increased morbidity (Fries 1996, Wannamethee et al. 1998, Friedenreich et al. 2001, Bean et al. 2004), which is an important risk factor for subsequent disability (Fried & Guralnik 1997, Dunlop et al. 2002, Song et al. 2006). Earlier, the finding by Lakka et al. (1994) that higher levels of leisure-time physical activity reduced the risk of acute myocardial infarction was supported by the recent review by Heckman & McKelvie (2008) who found that regular exercise prevents cardiovascular disease among older people. Physical activity has also been reported to be effective in decreasing the risk for type II diabetes (Ivy 1997, Solomon et al. 2008), which is an important risk factor for old age disability (Gregg et al. 2000).

With respect to the disablement process, there is a growing body of evidence on the beneficial effects of physical activity on pathology, impairments, and functional limitation. The results for older people on the effects of physical activity on disability are inconsistent and the research conducted so far on the effects of physical activity for health and social service use is very limited. However, longitudinal studies have shown strong evidence that increased physical activity in midlife (Vita et al. 1998) and old age (Leveille et al. 1999, Hirvensalo et al. 2000a, Nusselder et al. 2005, Boyle et al. 2007, Landi

et al. 2007a) can reduce the risk of disability in old age. Some longitudinal evidence also exists on the association of physical activity and decreased nursing home care in old age (Wolinsky et al. 1995, Valiyeva et al. 2006).

### 2.4.2 Physical activity promotion among older people

The awareness of healthy living habits such as physical activity has increased physical activity promotion during the last decades in western countries (Marcus et al. 1998). The recommendations of the American College of Sports Medicine and the American Heart Association, targeted towards older people (Nelson et al. 2007), are examples of nationwide physical activity promotion in the U.S. Several large scale physical activity programs targeted at sedentary older people such as the PACE (Long et al. 1996), the LIFE study (Rejeski et al. 2005, Katula et al. 2007) and, the PAL (Pinto et al. 1998) have been launched in the past two decades. Randomized controlled trials conducted on these programs and similar programs have shown that physical activity interventions can increase physical activity among older people in the short term (King et al. 1998, van der Bij et al. 2002, Elley et al. 2003, Taylor et al. 2004, Jancey et al. 2008) but the level seldom meets the accepted behavior standards set to achieve positive health outcomes (Conn et al. 2003, Taylor et al. 2004). The long-term effect of physical activity with respect to adherence towards physical activity is less clear (van der Bij et al. 2002, Green et al. 2002, Taylor et al. 2004).

Factors associated with physical activity adherence are complex and likely to involve both individual and environmental factors (Rhodes et al. 1999, Satariano 2003). The use of behavioral strategies such as the Social Cognitive Theory has proved to be more effective than applying health education and advice alone (King et al. 1998). According to the Social Cognitive Theory, interactions between the environment, personal factors, and behavioral factors affect behavior change (Bandura 1977). Interventions based on the Social Cognitive Theory emphasize the importance of control over one's own behavior and on how changes in both the individual and the environment induce behavior change. The most commonly used techniques for promoting physical activity include goal setting, stimulus control strategies, and social support (Stewart et al. 2001, McAuley et al. 2003). The Transtheoretical Model involves five stages of motivational readiness to change an individual's physical activity behavior (Prochaska & DiClemente 1983). In the Transtheoretical Model, the main idea is to match interventions with the level of motivational readiness for change and to recognize that a person may not yet be ready for behavior change but might be ready to consider it. In addition, physical activity promotion interventions combined with additional supervision such as telephone support have been found to be more effective than programs without additional surveillance (Dubbert et al. 2002, Pinto et al. 2005). Considering the amount of physical activity promotion given, it is important to ensure that the environment and its infrastructure, such as recreational facilities, parks, sidewalks, and transportation, are safe and appropriate to meet the needs of older people (King 2001). In a review by Humpel et al. (2002) on physical

activity behavior and physical environmental attributes, the physical environment (such as accessibility and opportunities) was found to be significantly associated with physical activity behavior.

So far, several types of interventions for community-dwelling and institutionalized older people have been introduced to promote health, well-being, and independent living among persons initially healthy, frail, disabled or chronically ill. These interventions have mainly comprised specific exercise programs (Binder et al. 2002, Luukinen et al. 2006, Timonen et al. 2006), counseling by health care workers on topics such as physical activity, nutrition, and disability prevention (Payette et al. 2002, Elley et al. 2003, Pinto et al. 2005, Bouman et al. 2008a, Melis et al. 2008), programs incorporating both clinical training programs and advice from health care professionals (Leveille et al. 1998, Chin A Paw et al. 2001, Gill et al. 2002), in-home geriatric assessments (Stuck et al. 2000, Shapiro & Taylor 2002, Bouman et al. 2008a), and programs tackling psychological problems such as loneliness in old age (Pitkälä et al. 2009). However, well-conducted systematic reviews have shown that all these different types of RCT interventions have yielded inconsistent results in term of health-related outcomes (van Haastregt et al. 2000, Elkan et al. 2001, Keysor & Jette 2001, Spirduso & Cronin 2001, Stuck et al. 2002, Bean et al. 2004, Latham et al. 2004, Daniels et al. 2008, Huss et al. 2008). The present study includes public health-related interventions designed for community-dwelling healthy, chronically ill, frail or disabled persons; however, trials aimed at treating specific diseases are not discussed in detail.

*Efficacy and effectiveness of physical activity interventions*

The efficacy of interventions for promoting physical activity which include specific exercise training programs, are organized under controlled circumstances and can be evaluated. Efficacy trials are carried out in optimized conditions and reveal the upper limit of the intervention effect. Intervention effectiveness, on the other hand, refers to the benefits of the treatment in 'real life' conditions as opposed to optimal conditions. The effectiveness of physical activity interventions among older people is usually based on the level of adherence to community-based programs operating in natural settings. Thus, while studies on specific exercise programs have yielded results on the efficacy of exercise training, they do not offer an insight into the feasibility and effectiveness of programs which promote physical activity in general among older people (Jette et al. 1999).

Efficacy trials have been found positively to affect the age-related loss in physical capacities such as muscle strength, aerobic capacity, and endurance (Judge et al. 1994, Sipilä et al. 1996, Chandler et al. 1998, Cress et al. 1999, Jette et al. 1999) have favorable psychological effects (Tsutsumi et al. 1997, Penninx et al. 2002). However, the results of specific exercise training on functional limitations and on disability have been less clear (Keysor & Jette 2001, Latham et al. 2004). A program with aerobic or resistance exercise for older individuals with osteoarthritis reduced the incidence of ADL disability during a 1.5-year intervention (Penninx et al. 2001). Binder et al. (2002) reported in their

randomized controlled trial that intensive exercise therapy improved physical functioning and preclinical disability in older persons with impairments in physical performance at baseline. On the other hand, in a strength-training trial Timonen et al. (2006) found improvements in strength, balance, and walking speed but no effect on ADL or IADL disability among women aged 75 and older who had been discharged from a hospital and had mobility impairments. Another randomized controlled trial by Luukinen et al. (2006) showed no effect for an exercise program on disability for home-dwelling persons aged 85 years or older. Further, Chin A Paw (2001) found no effect on disability scores for an intervention that incorporated a nutritional intervention (food enriched with vitamins and minerals) and a 17-week group exercise program where the intervention group participated twice a week in supervised training designed to maintain or improve mobility and performance in daily activities. Some efficacy trials have investigated the effect of specific exercise training on health care service use. A RCT by Buchner et al. (1997) showed that their 24- to 26–week exercise intervention with strength and endurance training reduced outpatient clinic visits and hospital costs for the intervention group of 68- to 85-year-old people.

Community-based physical activity programs have been shown to reduce functional limitations (Hughes et al. 2009). A randomized controlled trial by Gill et al. (2002) on a home-based physical therapy intervention among older people was able to prevent functional decline and decline in IADL disability over time for moderately frail persons. The 6-month program consisted of up to 16 home visits and monthly supportive phone calls over a six-month period carried out by a physical therapist. Leveille et al. (1998) found in their 1-year senior centre-based RCT that a geriatric nurse practitioner lead intervention consisting of disease self-management and multi-component disability prevention with a voluntary physical activity program reduced disability and hospitalization among chronically ill persons aged 70 or over. Additionally, positive results on reducing disability were found among persons who were disabled at baseline (Phelan et al. 2004). An intervention using psychosocial group rehabilitation with group exercise as one of the activities found that the need for health care services and health care costs were significantly lower for the intervention than for the control group (Pitkälä et al. 2009). Selected community-based multicomponent randomized controlled interventions with physical activity for reducing disability among older home-dwelling people are listed in Table 2.

Randomized controlled trials on physical activity counseling for older people with interventions lasting from 3 to 12 months have increased physical activity (Halbert et al. 2000, Stewart et al. 2001, Dubbert et al. 2002, Elley et al. 2003, Kerse et al. 2005, Pinto et al. 2005, Wilcox et al. 2006, Kolt et al. 2007). Physical activity counseling over the phone and through mailed material was successful in preventing deterioration in physical functioning scores among older persons aged 65-94 years (Morey et al. 2008). Mänty et al. (2009) showed

TABLE 2 Selected community-based multicomponent randomized controlled trials with physical activity for reducing disability and related service use among older home-dwelling people.

| Reference | Mean age, years | Participants | Intervention | Duration | Effect on disability & social and health care service |
|---|---|---|---|---|---|
| Leveille et al. 1998<br>Phelan et al. 2004 | 77 | IG: 101<br>CG: 100<br>chronically ill | IG: senior centre based GNP led chronic illness self-management + disability prevention program, encouragement to enroll to Lifetime Fitness Program<br>CG: tour at senior centre | IG: 12-month (1 session with GNP + median of 3 visits and phone contacts) | ADL disability +<br>Total hospital days + |
| Jette et al. 1999 | 75 | IG: 107<br>CG: 108<br>disabled | IG: Strong for Life home-based videotaped resistance exercise program 35 min/3 times per week, cognitive & behavioral strategies, exercise calendar + incentives for adherence to program<br>CG: placed on a waiting list, no intervention | IG: 6-month (2 visits by PT + phone surveillance) | ADL disability + |
| Gill et al. 2002<br>Gill et al. 2004 | 83 | IG: 94<br>CG: 94<br>frail | IG: PT assessment + home-based individual training program for specific ADL/IADL impairments with PT supervision + exercise calendar<br>CG: visits by health educator containing individually designed health promotion | IG: 6-month including up to 16 visits by PT + monthly phone surveillance for 6 months<br>CG: 6 monthly visits + phone surveillance for 6-months | ADL disability +<br>Nursing home admission-<br>IADL disability + |
| Gitlin et al. 2006 | 79 | IG: 160<br>CG: 159<br>at least 1 ADL difficulty | IG: OT+PT sessions on home modification, safety, and balance and muscle strength training based on clinical at-home interview<br>CG: no treatment | IG: during 6-months 5 OT contacts & 1 PT session + 3 phone calls by OT | 6-months: ADL & IADL disability +<br>12-months: ADL & IADL disability - |
| Pitkälä et al. 2009 | 80 | IG:117<br>CG: 118<br>lonely | IG: psychosocial group rehabilitation, with physical activity<br>CG: meetings with study nurses | IG: during 3-months 12 times at the research centre for 5-6 hours<br>CG: 3 meeting for 2 hours | Total health care costs+ |

IG=intervention group, CG=control group, GNP=general nurse practitioner, PT=physical therapist, OT=occupational therapist
+ statistically significant improvement for intervention group compared to control group
- no statistically significant differences between the study groups

that a 2-year physical activity counseling trial managed to decrease advanced mobility limitation. The results of physical activity counseling on quality of life have been inconsistent in RCTs, with trials reporting positive effects (Elley et al. 2003, Kerse et al. 2005) and non-significant effects (Halbert et al. 2000, Kolt et al. 2007). Kerse et al. (2005) showed that a primary care-based Green Prescription followed by telephone support over the next three months by exercise specialists decreased hospitalization for sedentary persons aged 65 year or over.

At the beginning of the physical activity counseling project called 'Screening and Counseling for physical activity and mobility among older people' in spring 2003 no studies had been conducted on the effect of physical activity counseling on disability or home care use among older community-dwelling people. The hypothetical associations between physical activity, limitations, disability and health and social service use are presented in Figure 2.

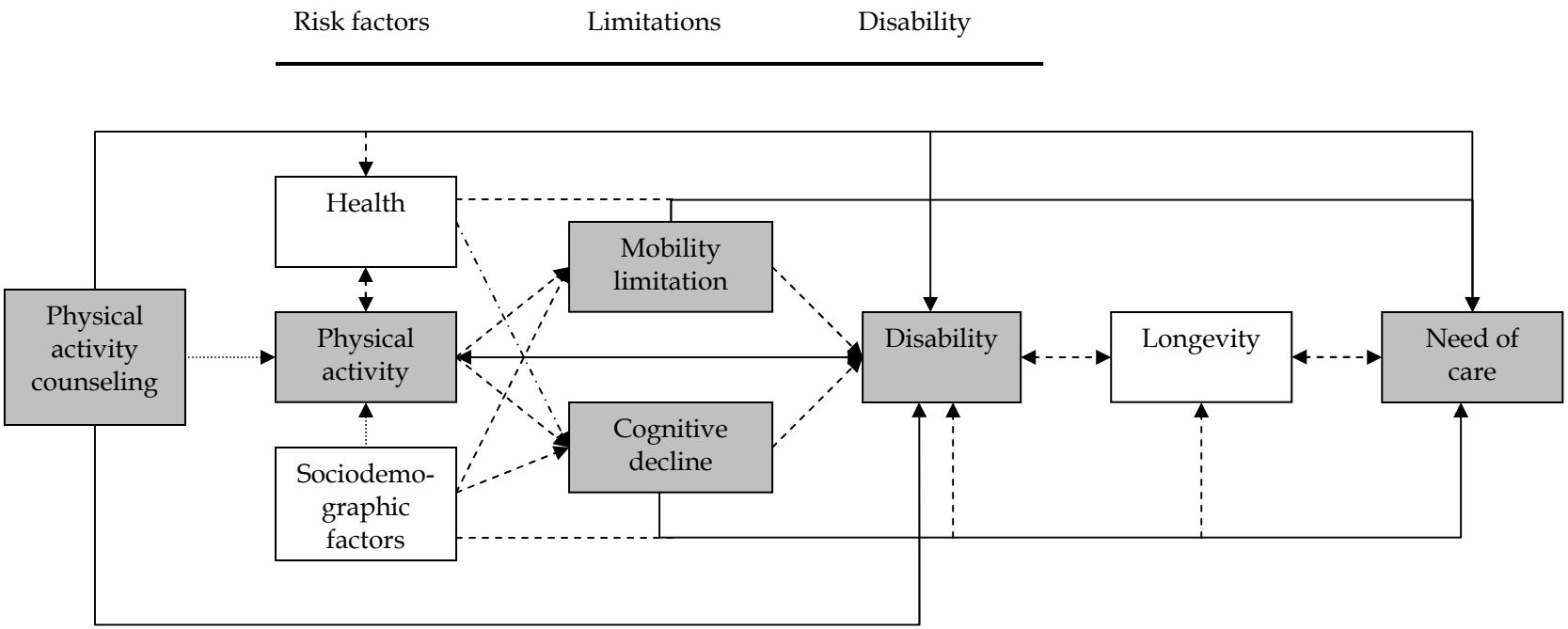


FIGURE 2 A hypothetical model on associations of physical activity, functional limitations, disability, and social and health care service use in old age
Notes: The dotted lines refer to earlier research findings and the solid lines to the associations examined in the present study.

# 3 PURPOSE OF STUDY

The purpose of the study was to investigate whether functional status and physical activity history predict all-cause hospital and long-term care use among older community-dwelling people. In addition, the effects of physical activity counseling on instrumental activities of daily living disability and home care service use in an older sedentary population were studied.

The specific research questions were:

1. Does physical and/or cognitive status decline predict the onset of long-term care among older community-dwelling people? (I)
2. Does hospital and long-term care in the last year of life differ according to physical activity behavior lasting from midlife to old age in an old decedent population? (II)
3. Does counseling for physical activity have an effect on instrumental activities of daily living disability among sedentary community-dwelling older people? (III)
4. Does counseling for physical activity have an effect on the use of home care services among sedentary older people? (IV)

# 4 METHODS

## 4.1 Study design and participants

The analyses included in this thesis are based on prospective observational population studies and a randomized controlled trial. The Evergreen project, which was launched in 1988, is a multidisciplinary longitudinal research program on the health and functional capacity of older residents in the City of Jyväskylä, Finland. Three separate study samples with follow-up times extending up to 16 years for the present study. Screening and Counseling for Physical Activity and Mobility among Older People, SCAMOB, is a randomized controlled trial on physical activity counseling. The study was conducted in the City of Jyväskylä between April 2003 and April 2005 and follow-up lasted until November 2006. Both the Evergreen project and SCAMOB trial have been conducted in close co-operation with the City of Jyväskylä. The studies used are summarized in Table 3.

### 4.1.1 Evergreen project cohorts born in 1910 and 1914 (I)

The target population comprised 617 residents of the City of Jyväskylä, Finland who belonged to two whole birth-year cohorts (1914 and 1910) and who at baseline were 75 and 80 years old, respectively. In 1989 baseline interviews (n=388) and research centre examinations (n=295) were conducted for the 75-year-old cohort. In the year 1990, baseline interviews (n=291) and research centre examinations (n=206) were conducted for the 80-year-old cohort. Follow-up data were gathered for the 1914-born cohort in 1994, 1999, and 2004 and for the 1910-born cohort in 1995 and 2000. The data consist of face-to-face interviews on health, functioning, and living habits as well as clinical examinations on health and functional status such walking speed, muscle strength, and psychometric tests conducted at the research centre. Register-based data is available on hospital in-patient days and long-term care for the study population from baseline until 2004. The dates of death were obtained

TABLE 3 Summary on study designs, populations and outcomes.

| Paper | Study | Design | Population | Age (mean ± SD) | Outcomes |
|---|---|---|---|---|---|
| I | Evergreen | Observational<br>Longitudinal 10-year follow-up | 476 community-dwellers<br>Men n=155<br>Women=312 | 75-year-olds n=285<br>Men n=98<br>Women n=187<br>80-year-olds n=191<br>Men n=57<br>Women n=134 | Permanent institutionalization |
| II | Evergreen | Observational<br>Longitudinal 16-year follow-up | 846 decedent population<br>Men n=308<br>Women n=538 | 65-84 (74.5 ± 5.17) | Hospital care in the last year of life<br>Long-term care in the last year of life |
| III | SCAMOB | RCT<br>2-year intervention | 632 community-dwellers<br>Intervention group n=318<br>Control group n=314 | 75-81 (77.6 ± 1.94) | IADL disability |
| IV | SCAMOB | RCT<br>2-year intervention and<br>1.5-year follow-up | 564 community-dwellers<br>Intervention group n=290<br>Control group n=274 | 75-81 (77.6 ± 1.95) | Home care |

SD= Standard deviation, IADL= Instrumental Activities of Daily Living, RCT=randomized controlled trial

from the Finnish Population register for the entire follow-up time. The study protocol has been described in detail by Heikkinen (1997, 1998).

The study population in paper I, which investigated whether mobility limitation and cognitive functioning predicted long-term care, consisted of 476 community-dwelling members of the 1914- and 1910-born cohorts who participated in the research centre examinations at baseline, and did not have a diagnosis of dementia. The 203 persons not included in the study population were either already institutionalized (n=21), did not come to the research centre (n=180), or had a diagnosis of dementia (n=2). These individuals belonged more frequently to the older age cohort (50% vs. 40%, p=0.031) and had more long-term diseases (3.2, SD 1.5 vs. 2.5, SD 1.6, p=0.003) compared to the study population.

### 4.1.2 Evergreen interview data on persons born in 1908-1923 (II)

The Evergreen interview study is a prospective observational study with a 16-year follow-up. A random sample of 1600 community-dwelling residents of the City of Jyväskylä in central Finland aged 65-84 years was drawn from the national Population Register in the year 1988. Of the random sample, 1224 (76.5%) persons were interviewed face-to-face at baseline in 1988. 33 individuals were living in an institution and were therefore excluded from the study. The reasons for non-participation were refusal (n=275), not located (n=27), died before the interview (n=36), and relocated (n=5). Follow-up interviews were conducted in 1996 (n=663) and 2004 (n=259). The interviews consisted of questions regarding the participants' health, functional capacity, and living habits. In addition, data on hospital and long-term care use was available from baseline to the year 2004. The study design and flow has been described in detail by Heikkinen (1997, 1998).

The study flow of paper II, investigating whether physical activity from midlife onwards predicted end-of-life hospital and long-term care, is illustrated in Figure 3. In 1988, 1224 people in the target group took part in the first interview. From that population, for paper II, a nested case study was conducted. The cases consisted of 846 persons who had died during 1989-2004. Those who had died in 1988 and those who were alive at the end of the follow-up in January 2005 were excluded, to allow for a one-year follow-up of service use before death. In order to shorten the distance from interview to the last year of life, the interview more proximal to the last year of life was used. Data collected in 1988 was used for people who died during 1989-1997 and data collected in 1996 for those who died during 1998-2004, except for persons who had died during 1998-2004 but who had not participated in the 1996 interview (6%) or were institutionalized by 1996 (3%). For these individuals the 1988 interview data were used. The length of time from interview to death ranged between 1-9 years for 91% and 10-16 years for 9% of the participants, with an average time from interview to death being 5.8 years.

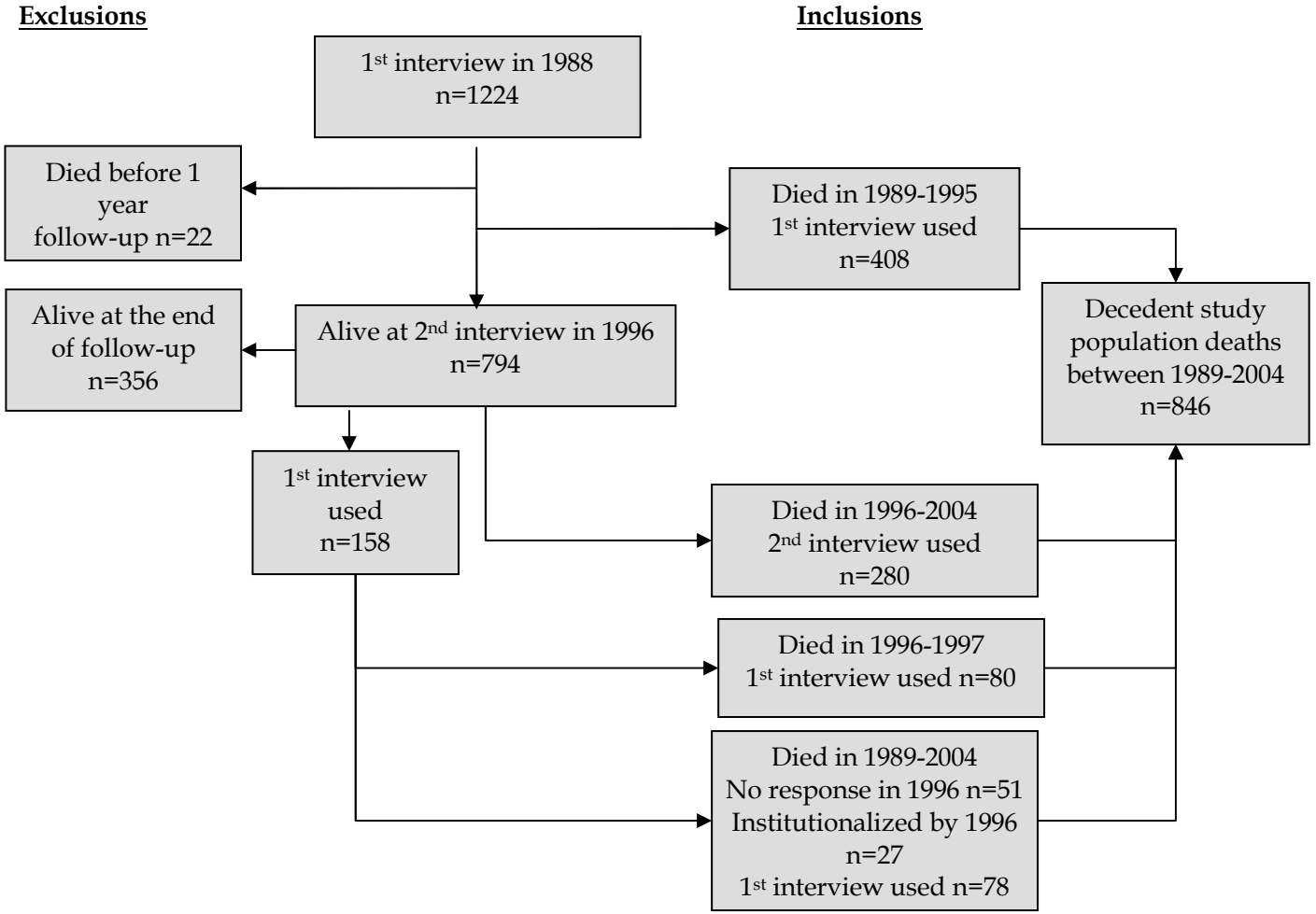


FIGURE 3 Paper II study flow from Evergreen project interview data indicating the formation of the decedent population.

### 4.1.3 Screening and Counseling for Physical Activity and Mobility among Older People (SCAMOB III, IV)

SCAMOB is a 2-year single-blinded randomized controlled trial on the effects of individualized physical activity counseling on older sedentary people. The target population consisted of all 75- to 81-year-old registered residents of the City of Jyväskylä, Finland living in the city centre area in March 2003 (N=1310). At the time of the study there were about 85000 persons living in the City of Jyväskylä of whom 6.1% were aged 75 years or older. The contact information on the target population was obtained from the Finnish population register.

Based on a pilot sample, it was estimated that about 60% of the target population was suffering from or were at an increased risk for mobility limitation. The significance level was set at 5% and power at 80%. A within-person correlation of 0.4 was assumed. To allow for 10% attrition, the total sample size needed was about 630.

After a four-phased screening and data collection process 632 persons (75% women) were found to be eligible for the study. For individuals to be eligible for randomization, they had to be able to walk 500 meters without assistance, be only moderately physically active or sedentary (at most 4 hours of walking or 2 hours of other exercise weekly), have a Mini-Mental State Examination score >21, have no severe medical contraindications for physical activity (assessed by the study nurse and, when necessary, ascertained by a physician), and sign an informed consent to participate in a RCT. Participants were randomly assigned to a physical activity counseling intervention group (n=318) or a control group (n=314). Each week after the completion of the baseline assessments, participants were allocated to groups in blocks of 40-50 persons, using a randomization ratio of 1:1, by drawing lots. The randomization allocation was undertaken by a trial administrator. Allocation concealment was achieved by drawing names from opaque envelopes for 40-50 persons at the same time. The study nurses and interviewers who collected the data, as well as the assistants who recorded the data, were blinded to the group allocations. ISRCTN is 07330512.

The data consist of face-to-face at-home interviews conducted by trained university undergraduates on topics such as health, functional capacity, cognitive functioning, and physical activity and research centre physical assessments and a performance test battery conducted by the nurse examiner at baseline in 2003 and follow-up in 2005. All participants were followed-up by telephone biannually on their health, physical activity, and mobility during the 2-year intervention time and 1.5-year follow-up. In addition, data on home care use was collected at the intervention and follow-up times, over the 3.5-year period, from the City of Jyväskylä's health and social service register for the 567 (intervention n=290 and control group n=274) participants who gave written consent for data collection from the register. The design and methodology of the Screening and Counseling for Physical Activity and Mobility (SCAMOB) project has been reported in detail by Leinonen et al. (2007).

In 2005, at the 2-year follow-up, 295/318 (93%) participants in the intervention group and 283/314 (90%) in the control group completed the IADL questionnaire in at-home interviews. After the randomization at baseline, 16 participants died (intervention group n=8 and control group n=8) and 9 withdrew from the study (intervention group n=5 and control group n=4). On the IADL disability outcome, data were missing for 10 persons (poor health 4 and declined 6) in the intervention group and for 19 (poor health 7, declined 11 and moved 1) for the control group. The study flow of paper III, examining the effect of physical activity counseling on IADL disability, is presented in Figure 4.

Paper IV, on the effect of physical activity counseling on home care use, included the 567 participants with data on home care use collected for the 2-year intervention and the subsequent 1.5-year surveillance time. Three persons who were already using home care at baseline were excluded from the study.

## 4.2 Ethics

The Evergreen project and SCAMOB study were approved by the Ethical Committee of the Central Finland Health Care District. The studies were conducted according to the principles of good scientific and clinical practice laid down by the Declaration of Helsinki. The measurements and physical activity counseling in the SCAMOB trial were conducted according to the American College of Sports Medicine (2000) guidelines. All data were recorded blinded, handled and registered according to the Finnish Personal Data Act.

The Evergreen project was granted a license by the Ministry of Social Affair and Health to obtain data on inpatient care provided in health centers and hospitals from the register held by the National Institute for Health and Welfare.

## 4.3 Register-based data

### 4.3.1 Home care

For the SCAMOB trial home care data were collected from the City of Jyväskylä health and social service register between March 2003 and September 2007 (IV). Home care was defined as using publicly subsidized home help and/or home nursing for various activities at least once a month for at least three months. Examples of home care activities included help in IADL and self-care tasks such as bathing, shopping, and preparing food, and home nursing tasks such as wound care, administering medication, and counseling clients and their next of kin.

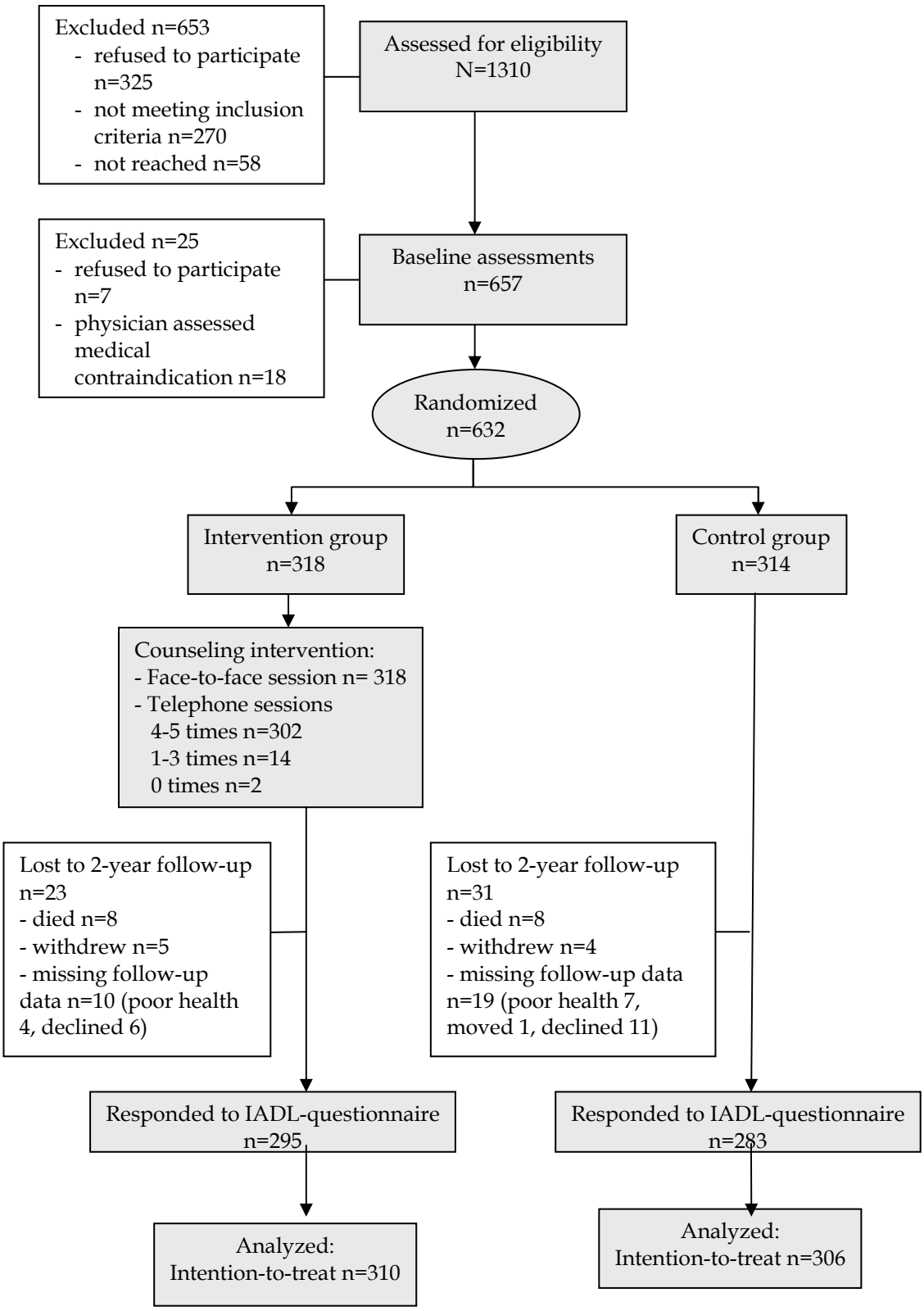


FIGURE 4 Paper III study flow from SCAMOB data.

### 4.3.2 Long-term care

In the Evergreen project, nursing home and health centre ward care data were collected from the local nursing home registers and from the hospital records of the Central Finland Health Care District between January 1, 1989, and December 31, 2000. Permanent institutionalization was defined according to the date when care in a hospital, health centre ward, or nursing home which was staffed around the clock had exceeded 90 days and the subject was considered to be in need of continuous care. In addition, for the Evergreen project, data on health centre ward care were also drawn from the register of the National Institute for Health and Welfare, (HILMO). Records include exact dates of admissions and discharges from health centre ward stays in Finland for the entire study period spanning from January 1, 1988 to December 31, 2004.

### 4.3.3 Hospital care

In the Evergreen project, data on university hospital, central and district hospital inpatient ward care were drawn from the register of the National Institute of Health and Welfare (HILMO). The information consisted of dates on all-cause in-patient admissions and discharges and the specific public or private institution in which care took place in Finland between 1998 and 2004.

### 4.3.4 Dates of deaths

Dates of deaths for participants in the Evergreen project and SCAMOB trial who died during the follow-up were obtained from the Finnish Population Register Center.

## 4.4 Measurements

A summary of the measurements and variables used in the original papers (I-IV) and the reliability of the measures is given in Table 4.

### 4.4.1 Activities of daily living

In the Evergreen project, self-reported information on disability in eight activities of daily living (ADL) were collected: eating, transferring from bed, dressing, bathing, getting around indoors and outdoors, cutting toenails, and toileting (Katz 1963, Laukkanen 1998). Information on instrumental activities of daily living (IADL) disability was collected with regard to ten IADL tasks: preparing meals, washing clothes, shopping, coping with light and heavy housework, administering and taking medications, using the telephone, using

TABLE 4 Variables and measurements used in the study as well as methods, references, and reliability of the measures.

| Variables/measurements | Paper | Method | References | Reliability |
|---|---|---|---|---|
| **Home care (date)** | IV | Health and social service register, City of Jyväskylä | | |
| **Hospital care (date)** | II | National register on health and social services, National Institute for Health and Welfare | | |
| **Long-term care (date)** | | | | |
| Permanent institutionalization (date) | I | Local nursing home and health centre registers | | |
| Nursing home and health centre ward (days) | II | National register on health and social services, National Institute for Health and Welfare<br>Local nursing home registers | | |
| **Disability** | | | | |
| ADL disability (cont.) | II | At-home interview, self-report | Katz 1963, Laukkanen 1998 | |
| IADL disability (cont.) | II | At-home interview, self-report | Lawton & Brody 1969, Laukkanen 1998 | |
| IADL disability (cont.) | III | At-home interview, self-report | Lawton & Brody 1969 | Kendall's tau-b=1.00-0.292 (Leinonen et al. 2007) |
| **Mobility limitation** | | | | |
| 10 m maximal walking speed | I | Research centre, stopwatch | Aniasson et al. 1980 | |
| Difficulty in walking 2 km | III | At-home interview, self-report | | Kendall's tau-b=1.00 (Leinonen et al. 2007) |
| Difficulty in walking 500 m | III | At-home interview, self-report | | Kendall's tau-b=1.00 (Leinonen et al. 2007) |
| **Cognitive capacity** | | | | |
| Digit span (cont.) | I | Research centre, psychologist | Wechsler 1945 | |
| Digit symbol (cont.) | I | Research centre, psychologist | Wechsler 1955 | |
| Word Fluency (cont.) | I | Research centre, psychologist | Schaie 1985 | |
| Mini-D (score 0-43) | II | At- home interview | Erkinjuntti et al. 1986 | |
| MMSE (score 0-31) | III | At- home interview | Folstein et al. 1975 | |

(continues)

TABLE 4 (continues)

| Variables/measurements | Paper | Method | References | Reliability |
|---|---|---|---|---|
| **Depressive symptoms** | | | | |
| CES-D (cont.) | III | At-home interview | Radloff 1977, Heikkinen et al. 1995 | Chronbach's alpha 0.88 (Heikkinen et al. 1995) |
| **Physical activity** | | | | |
| Habitual physical activity (cont.) | II | At-home interview, self-report | Ruuskanen & Ruoppila 1995, Hirvensalo et al. 1998 Hirvensalo et al. 2000b | |
| Physical activity history (yes/no) | II | At-home interview, self-report | | |
| Habitual physical activity (cont.) | III | At-home interview, self-report | Grimby 1986 | Kendall's tau-b=0.874, (Leinonen et al. 2007) |
| **Time of death (date)** | II | Finnish Population Register Center | | |
| **Anthropometry** | | | | |
| Body height (cm) | I | Scale stadiometer | | |
| Body weight (kg) | I | Beam scale | | |
| **Health status** | | | | |
| Long-term diseases (no.) | I | At-home interview, self-report, confirmed by physician at research centre | | |
| Long-term diseases (no.) | II | At-home interview, self-report | | |
| Primary causes of death | II | Population Register Centre, ICD-9 | | WHO 1977 |
| Long-term diseases (no.) | III | At-home interview, self-report, double-checked by a nurse at research centre | | r=0.89, (Leinonen et al. 2007) |
| **Demographics** | | | | |
| Marital status (cat.) | II, III | At-home interview | | |
| Household composition (cat.) | I,III, | At-home interview | | |
| Informal care (yes/no) | IV | At-home interview | | |
| Formal care (yes/no) | III | At-home interview | | |
| Full-time education (cat.) | II | At-home interview | | |
| Full-time education (cont.) | I,II,III | At-home interview | | Kendall's tau-b=0.955 |
| Smoking (yes/no) | I,II,III | At-home interview | | |

IADL= Instrumental Activities of Daily Living, MMSE= Mini-Mental State Examination, ICD-9= International Classification of Diseases, ninth version, CES-D=Centre for Epidemiologic Studies Depression Scale, cont=continuous scale, cat=categorized scale, no.=number

public transport, and handling finances (Lawton & Brody 1969, Laukkanen 1998). The participants were asked whether they 1) had no difficulty, 2) had some difficulty, 3) had a lot of difficulties in performing a task, 4) were not able to perform a task without someone's help, or 5) were not able to perform the task even with help. Participants were interviewed face-to-face in their homes.

In the SCAMOB trial, self-reported information was collected in face-to-face interviews with regard to eight IADL tasks: preparing meals, washing clothes, shopping, coping with heavy housework, administering and taking medications, using the telephone, using public transport, and handling finances (Lawton & Brody 1969). For the statistical analyses, for each individual IADL task, people were categorized into the following two categories: those with no disability (independent without difficulty) and those with disability (task difficulty, need of assistance or unable to perform the task). A summary score for the eight IADL tasks, ranging from 0 (no disability in any of the IADL tasks) to 8 (disability in all eight IADL tasks) was calculated. Thus, IADL disability included persons with IADL difficulties or the inability to perform IADL tasks.

### 4.4.2 Mobility limitation

Mobility limitation was assessed by maximal walking speed over a 10-meter distance timed with a stop-watch (I). At the research centre, participants were allowed 2-3 meters for acceleration before the start line (Aniasson et al. 1980). They were encouraged to walk as fast as possible without risking their health and were allowed to use normal walking aids when necessary. For the statistical analysis, walking speed (m/s) was calculated by dividing the 10-meter distance by the time that it took the participant to walk it.

In the SCAMOB trial, self-perceived difficulties in walking 2 kilometers and 500 meters were elicited in the at-home interviews by the question: "Do you have difficulty in walking 2km/500 meters?" The five response options were: 1) without difficulty, 2) with some difficulty, 3) with a great deal of difficulty, 4) only with help from another person, and 5) unable to manage even with help. Individuals were also asked about task modification in walking 2 km and 500 meters such as tiredness, reduced pace, longer duration, using walking aids, or cutting back on walking distance.

### 4.4.3 Cognitive decline

In the Evergreen cohort study, cognitive capacity was evaluated with the following battery of psychometric tests 1) Digit Span from the Wechsler Memory Scale (Wechsler 1945) for testing short-term memory, 2) Digit Symbol from the Wechsler Adult Intelligence Scale (WAIS) (Wechsler 1955) for testing psychomotor speed affected by visual perception and learning, and 3) a modified oral version of Word Fluency from the Schaie-Thurstone Adult Mental Abilities Test (Schaie 1985) for testing verbal fluency and flexibility (I). Psychometric tests were performed at the research centre by trained

psychologists. For the statistical analysis, a principal component, indicating cognitive capacity, was formed from the above-mentioned three tests.

In the Evergreen project interview study, cognitive functioning was measured with the Mini-D test (Erkinjuntti et al. 1986), developed from the neuropsychological test of Luria (1973). Scores range from 0-43, with a higher score indicating better cognitive functioning. The Mini-D tests were carried out by trained university undergraduates at the homes of the participants.

In the SCAMOB trial cognitive capacity was measured with the Mini-Mental State Examination (MMSE) (Folstein et al. 1975). In the test, scores ranged between 0-30, with higher scores indicating better cognitive functioning. The MMSE score was used as one of the eligibility criteria, and persons with a MMSE score under 21 being excluded from the randomized trial.

### 4.4.4 Depressive symptoms

Depression was measured with the Centre for Epidemiologic Studies Depression Scale (CES-D) (Radloff 1977) (III). The cut-off was set at 16 points, with a higher score indicating depressive symptoms (Radloff 1977, Heikkinen et al. 1995).

### 4.4.5 Physical activity

In the Evergreen project, physical activity level and intensity at the time of the interview was measured using the following seven-point scale: moving about only minimally to carry out everyday chores; light physical activity 1-2 times/week; light physical activity several times/week; exercise causing breathlessness and sweating 1-2 times/week; exercise causing breathlessness and sweating several times/week; exercise causing breathlessness and heavy sweating several times/week; and engaging in competitive sports several times/week (Ruuskanen & Ruoppila 1995, Hirvensalo et al. 1998). Physical activity earlier in life was determined with a retrospective question on participation in recreational or competitive sports at the ages of 10-19, 20-39, 40-64, 65-74 years, and 75 years and over (Hirvensalo et al. 2000b). The participants were asked: "During your life, have you been engaged in regular recreational or competitive sports during your life?" The disciplines typically included skiing, track and field sports, and gymnastics. The reliability for the retrospective question was indicated by the fact that over 90% of the individuals who reported being sedentary throughout their lives answered similarly at baseline and 8-year follow-up interview (Hirvensalo 2002). For the analyses, physical activity was categorized according to the data from midlife to old age and physical activity at the time of the interview, as physical activity from age 40 years onwards has been found to predict activity in old age (Hirvensalo et al. 2000b), and because midlife physical activity has been observed to be more closely related to health and functional capacity in old age than more distal physical activity behavior (Rovio et al. 2005, Patel et al. 2006). Three exclusive groups were formed according to physical activity at 40-64 years, 65-74 years,

75 years and over, and present physical activity. The groups were 1) consistently physically active from midlife onwards (consistent participation in recreational or competitive sports from age 40 years onwards and, at the time of the interview, at least light physical activity several times/week), 2) occasionally physically active from midlife onwards (participation in sports at some point, but not consistently, from age 40 years onwards and, at the time of the interview, either active or sedentary), and 3) consistently sedentary from midlife onwards (no engagement in sports from age 40 years onwards and, at the time of the interview, light physical activity 1-2 times/week at most).

In the SCAMOB trial (III and IV), physical activity was assessed with the previously validated seven-point scale by Grimby (1986). The scale was used as one of the eligibility criteria in the trial to determine the baseline level of physical activity. Persons belonging to the five first categories were eligible for the trial: mainly resting; most activities performed sitting down; light physical activity 1-2 hours/week; moderate physical activity or housework 3 hours/week; and moderate physical activity at least 4 hours/week. Persons belonging to the two highest activity categories, who reported doing physical exercise or competitive sports several times a week, were excluded from the study before randomization as they would not have benefited from our physical activity counseling intervention. To study the changes in habitual physical activity from baseline to the 2-year follow-up we categorized individuals into 1) those whose activity level remained moderate or above or who increased their activity level from sedentary (light physical activity 1-2 hours/week at the most) to at least moderate, and 2) those who remained sedentary or reduced their activity level from at least moderately physically active to sedentary.

### 4.4.6 Health status

In the Evergreen project cohort study, morbidity was indicated by the number of long-term diseases at baseline. Information was collected in face-to-face interviews by trained university undergraduates at the participants' homes. At the research centre participants underwent a half-hour consultation with a physician where self-reported long-term diseases and medication were confirmed according to the International Classification of Diseases ninth version (ICD-9) (World Health Organization 1977) and a physical examination was performed (Laukkanen 1998). For the analyses, a comorbidity index and the sum total of all diagnoses of long-term conditions which had lasted over three months, were calculated and dichotomized (2 or less vs. 3 or more).

In the Evergreen project interview study, morbidity was assessed according to self-reported physician-diagnosed chronic diseases lasting over three months. The information was collected in at-home interviews by trained university undergraduates. In addition, primary causes of death were used to indicate the morbidity of the decedent population. Causes of death, which were obtained from the Population Register Centre, were classified as diseases of the heart and circulatory, nervous, respiratory, digestive, and genitourinary

systems, cancer at any site, acute infections, accidents and all other causes of death according to the International Classification of Diseases, ninth version (WHO 1977).

In the SCAMOB trial, morbidity was measured as the number of self-reported physician-diagnosed chronic conditions lasting over three months. The number of chronic diseases was first elicited at the face-to-face interview by trained university undergraduates and later double-checked by the nurse at the clinical examination at the research centre.

### 4.4.7 Background information

Demographic, socioeconomic, and living habit information along with information on anthropometry was collected at baseline and in the follow-up face-to-face interviews and clinical examinations.

Marital status (married or cohabiting/single, widowed, divorced) and household composition (living alone/with spouse, children, relatives, someone else) was elicited in the interviews (I,III,IV). Participants were asked about the use of informal care given by a spouse, relatives or friends (III) and about formal home care received during the previous year (II). Full-time education was measured as total formal education in years and dichotomized for the analyses to 6 years or less vs. more than 6 years (I,II,III). Participants were also asked about their current smoking habits (II).

Body weight and height were measured at the research centre during the clinical examination (I). In the SCAMOB trial, adverse events which might have resulted from the physical activity counseling intervention were assessed by asking the participants whether they had had injuries in the previous year and, if so, whether the injuries required medical treatment (III).

## 4.5 Physical activity counseling intervention

### 4.5.1 Screening for participants

The SCAMOB trial was implemented in co-operation with the University of Jyväskylä, the Centre for Health and Social Services of the City of Jyväskylä, and the Department of Sports and Physical Activity Services of the City of Jyväskylä.

The physical counseling intervention targeted people who were cognitively intact and sedentary, but able to move outdoors on their own. These individuals were considered to be the group most likely to benefit from physical activity counseling. The target population consisted of 1310 community-dwelling, 75- to 81-year-old people living in the city centre area of the City of Jyväskylä. The screening process began with a letter mailed to the whole target group informing them about the intervention. Soon after the letter,

participants who met the inclusion criteria received a telephone call (n=1100) to determine their willingness of to partake in the intervention. On the basis of the telephone conversation, 17% were excluded because of mobility impairment, cognitive problems or because they were physically too active. In addition, a further 16% refused to participate. This resulted in 727 participants who took part in the face-to-face at-home interviews conducted by trained university undergraduates. After the interview, 36 participants were excluded for the above-mentioned reasons and 34 refused to participate in the examinations held at the research centre. Overall, 657 took part in the examination by the nurse at the research centre of whom 127 underwent a physician's examination. Of the latter 18 were excluded due to health problems and an additional 7 refused to participate. Thus, the final study group included 632 persons who were randomized into an intervention (n=318) or a control (n=314) group. The screening process has been described in detail by Leinonen et al. (2007).

### 4.5.2 Physical activity counseling

The intervention consisted of one physical activity counseling session with a physiotherapist, followed by telephone contacts every four months for two years by the same physiotherapist to support compliance and behavior change. In addition, the intervention group was invited to participate in two voluntary lectures on topics such as home calisthenics and disability prevention. They were also informed about the exercise groups organized for older people by the Centre for Social and Health Services, Department of Sports and Physical Activity Services. The no-intervention control group continued to receive advice on healthy living habits as usual when visiting health and social service providers and had access to all exercise facilities.

The counseling approach was based on the Social Cognitive Theory (Bandura 1977, 1997). The theory suggests that interactions between the environment, personal factors, and behavioral factors affect behavior change. Self-efficacy, i.e. confidence in one's own ability to successfully perform a particular behavior in specific situations, is a central concept in the Social Cognitive Theory (Bandura 2000). The theory identifies self-efficacy as the most important mediator in behavior change. Unless one believes that he or she can produce the wanted effects with their actions, they have very little incentive to continue if difficulties or setbacks are encountered (Bandura 2000).

During the intervention, in the physical activity counseling, the motivational interviewing technique was used (Rollnick et al. 1999). The technique emphasizes the partnership between the professional and the client and is implemented through negotiation rather than confrontation with the client. In the intervention the physiotherapist also helped participants to use problem solving methods, for example to negotiate possible barriers to physical activity. The physiotherapist who counseled the participants underwent comprehensive training in behavior change and motivational interviewing techniques before the start of the intervention.

Approximately two weeks after randomization, the intervention group received a single one-hour individual motivational face-to-face physical activity counseling session by the same physiotherapist who would subsequently delivered the whole counseling intervention. The topics covered during the session included present level of physical activity, the persons' interest in maintaining or increasing physical exercise, performing everyday activities such as walking to the grocery store, and participating in inexpensive exercise classes organized by the municipality. Possible barriers to physical activity were also addressed. The physiotherapist and the participant together designed a personal physical activity plan based on the participant's interests and signed an agreement on how to increase the participants' physical activity level.

The physiotherapist telephoned the participants every four months for two years to inquire about the participant's progress and to support compliance and behavior change. Telephone calls were planned to take place every three months, but for practical reasons, such as not being able to reach the participant, they took place every four months the two-year period.

## 4.6 Statistical methods

Baseline comparisons of discrete characteristics of the study groups were performed using Pearson's $\chi$2-tests. For continuous variables, independent sample Student's t-test and one-way analysis of variance (ANOVA) were used. All tests were performed as two-tailed with SPSS software with significance level set at $p<.05$. Rates were calculated for institutionalization and home care use by dividing the number of outcomes by the sum of persons-years of follow-up (I,IV). Cumulative incidence was calculated by summing the number of new events and dividing it by the number of persons (IV).

*The Cox proportional hazards model*

The Cox proportional hazards regression model (Cox 1984) was used to estimate whether mobility limitation and/or cognitive functioning predicted permanent institutionalization (I). In the analyses, the outcome was the date when the permanent institutionalization decision was made. Persons who were non-institutionalized were included in the analyses until the date of their death or the end of the surveillance period, whichever occurred first. Age- and gender-specific distribution-based cut-off values were used to categorize participants into groups with impaired or normal mobility and cognitive function. The lowest third of each distribution was classified as having mobility limitations or cognitive deficits. As a result, four exclusive study groups were formed: 1) no limitation (reference group), 2) mobility limitation, 3) cognitive deficits, and 4) mobility limitation and cognitive deficits. The model was adjusted for confounding factors (living alone, comorbidity, and full-time education).

The Cox regression model was also used to estimate the hazard of home care use for the intervention group and control group (reference group) in the physical activity counseling trial (IV). In the analyses, the outcome was the date when home care lasting for over three months started. Persons who did not use home care services for three months or more were included in the analyses until the date of their death or the end of the surveillance period, whichever occurred first. Because the randomization effect was uncertain due to the fact that data on home care were available for 567 of 632 people, the model was adjusted for age, sex, and living alone. Hazard ratios and 95% confidence intervals were estimated for each variable and entered into the Cox regression models with $p<0.10$. The modeling was performed with SPSS software and the statistical significance was set at $p<0.05$.

*Negative binomial regression model*

The associations between physical activity from midlife onwards and ADL and IADL disability in old age, and hospital and long-term care in the last year of life were studied using negative binomial regression models. In the models, the strength of an association is measured as an Incidence Rate Ratio (IRR). Negative binomial regression modeling takes into consideration that hospital and long-term care are non-independent observations, since care tends to be recurrent and subsequent care is more likely. IRRs are interpreted as relative risk estimates and represent the risk for persons in the predictor variable groups relative to those in the reference group. The model allows for varying time of follow-up of the participants. Hospital and long-term care outcomes were continuous variables with one day as a unit, and ranged from 0 to 365 days. The risk values and their 95% confidence intervals were estimated by comparing those who had been sedentary from midlife onwards and those who had been occasionally physically active from midlife onwards with those who had been consistently physically active from midlife onwards (reference group). Based on the earlier literature and knowledge of the factors that affect service need, the models were adjusted for age at death, time from interview to death, marital status, education, smoking, formal home care, cognitive functioning, and selected chronic diseases and causes of death. IRRs for risk for hospital and long-term care in the last year of life were calculated for men and women separately. Modeling was performed with STATA 9 software (Stata Corporation 2003) with significance level set at $p<0.05$ for all effects.

*Generalized estimating equations model*

A generalized estimating equation (GEE) model (Liang & Zeger 1986) was constructed to test the group*time interaction in the intervention and control groups on the IADL variable. A statistically significant interaction term indicates that the change observed in the intervention group differs from the change in the control group. In addition, subgroup analyses were performed according to baseline IADL disability, mobility limitation, and cognitive status. The analyses were carried out according to the intention-to-treat principle. The explanatory variables used in the model included a measurement time indicator

variable and an intervention group status variable. The analyses were carried out using SAS software, version 9.1 (GENMOD procedure) (SAS Institute Inc., Cary, NC). All significances were set at $p<0.05$ level and were two-tailed.

*Data imputation*

In the SCAMOB trial, at the two-year follow-up, 38 persons (6%) had missing values in one or more of the eight IADL questions. For these cases, data were imputed with the multiple imputation procedure implemented in SAS by using information on the other IADL questions and baseline information such as number of chronic diseases, physical activity level, and MMSE and CES-D scores. Values were not imputed for persons who died during the follow-up (n=16). Sensitivity analyses performed suggested no significant differences in effects due to imputation.

# 5 RESULTS

## 5.1 Sample characteristics

Table 5 summarizes the baseline characteristics of the participants in the Evergreen project data sets and SCAMOB trial.

TABLE 5 Characteristics of participants in all studies: Evergreen project cohorts born in 1910 and 1914 (Evergreen cohorts), the decedent population from the Evergreen project interview data on persons born in 1908-1923 (Evergreen interview), and Screening and Counseling for Physical Activity and Mobility among Older People (SCAMOB) randomized controlled trial.

| | Evergreen cohorts n=476 | Evergreen interview n=846† | SCAMOB n=632 |
|---|---|---|---|
| | Mean±SD | Mean±SD | Mean±SD |
| Age (years) | 75, 80* | 77.1 ± 6.1 | 77.6 ± 1.9 |
| Comorbidity (number) | 2.5 ± 1.6 | 2.1 ± 1.6 | 3.0 ± 2.0 |
| Education (years) | 6.0 ± 3.5 | 6.3 ± 3.3 | 9.2 ± 4.2 |
| | % | % | % |
| Women | 67.4 | 63.6 | 74.8 |
| Living alone | 52.1 | - | 57.3 |
| Married | 41.4 | 40.8 | 42.6 |

* Of the participants 85 persons were 75 years old and 191 persons were 80 years old
† The interview proximal to death used, either in the year 1988 or 1996

In this thesis, the total study population consisted of 1 954 persons who were approximately 77 years of age, with a range of 65-92 at baseline. The majority of the participants were women and about 40% were married. The participants had 2 to 3 chronic diseases on average. The Evergreen project participants were less educated (6 years) than the SCAMOB participants (9 years). However, this might be due to the fact that the SCAMOB participants were interviewed in the years 2003, whereas the Evergreen project participants had been interviewed about 20 years earlier.

## 5.2 Mobility limitation and cognitive deficit as predictors of long-term care (I)

The participants of the Evergreen cohort study were divided into three subgroups according to their status at the end of the surveillance period: community-dwelling, institutionalized or died without prior institutionalization. Women accounted for almost 80% of the institutionalized persons, 70% of those who remained community-dwelling and 60% of those who died without prior institutionalization. At baseline, about 60% of those men and women who remained community-dwelling throughout the surveillance period had three or more long-term diseases whereas the corresponding number was about 70% for those who were institutionalized and more than 80% for those who died. Those who remained community-dwelling had the highest average walking speed, and those who died during the surveillance period had the slowest, while those who were admitted to an institution were in between. For cognitive capacity, the lowest baseline scores were observed among those who were later institutionalized and highest for those who survived and were still community-dwelling at the end of the follow-up.

The mean duration of the follow-up on the community-dwelling 75- and 80-year-olds was 2728 days with a range of 58 to 4017 days. At the end of the 10-year surveillance period, of the 476 participants, 52 were institutionalized, 209 remained community-dwelling and 215 had died without prior institutionalization.

The institutionalization rate was 24.4/1000 person-years among those in the lowest tertile of walking speed and 10.1/1000 persons-years for those in the middle and highest tertiles. For the cognitive capacity score, the corresponding figures were 21.0/1000 and 11.0/1000 person-years, respectively. To study the combined effects of mobility limitations and cognitive deficits, four exclusive study groups were formed. Institutionalization rates among those with both mobility limitations and cognitive deficits was 35.1/1000 person-years, whereas the rate among those with solely mobility limitation was 15.6/1000 and solely cognitive deficits 10.0/1000 person-years. The number of institutionalization cases and rates are presented in Figure 5.

The crude risk for institutionalization was 2.55 (95% confidence interval [CI] 1.45-4.49) times higher for those in the lowest tertile of the dichotomized walking speed variable and 1.94 (95% CI 1.11-4.00) times higher for those in the lowest tertile of the cognitive capacity variable compared to those in the middle and highest tertiles, respectively (Table 6). Significant interaction between the variables ($p<0.001$) was observed. Secondly, the combined effects of mobility and cognitive capacity were tested. The unadjusted relative risk of institutionalization was 3.80 times greater (95% CI 1.85-7.77) among people with co-occurring mobility limitation and cognitive deficits compared to people with no limitations. Adjusting the model for education, living alone and

comorbidity increased the risk to 4.89 (95% CI 2.14-11.17). In the combined effects model, having solely mobility limitations or solely cognitive deficits increased the risk of institutionalization slightly but not statistically significantly due to the small number of cases in the respective groups.

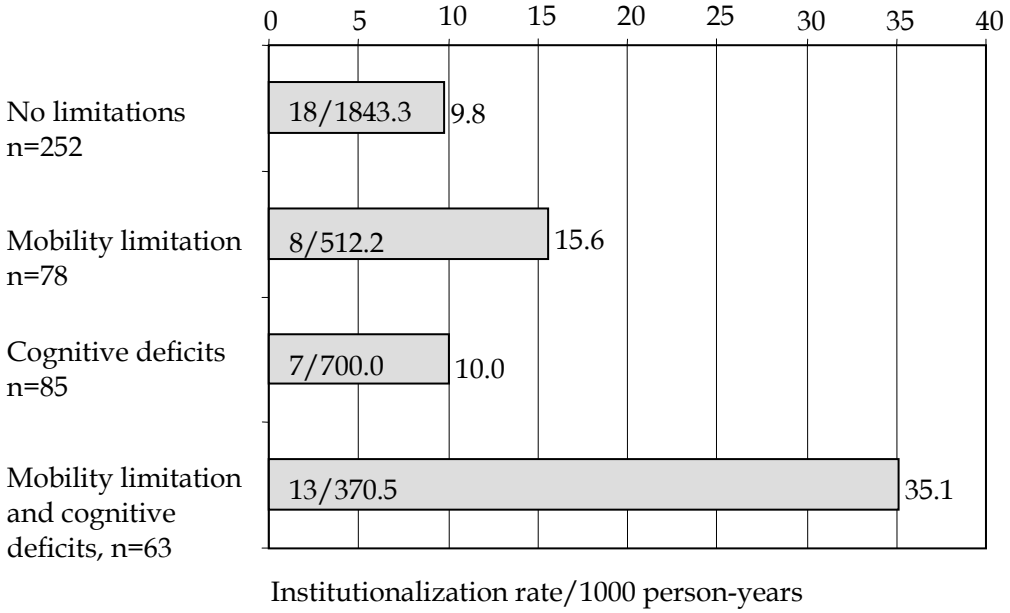


FIGURE 5 Institutionalization rates per 1000 person-years, long-term care cases and person-years according to study groups during the 10-year surveillance period. Groups were formed based on walking speed and cognitive capacity test dichotomized according to distribution based cut-offs at the lowest third vs. middle and highest third.

TABLE 6 Relative risks (RR) and 95% (CI) confidence intervals for long-term care according to baseline mobility and cognitive capacity.

| | Model 1. Walking speed | | Model 2. Cognitive capacity | | Model 3. Walking speed and cognitive capacity unadjusted | | Model 4. Walking speed and cognitive capacity adjusted* | |
|---|---|---|---|---|---|---|---|---|
| | RR | 95% CI | RR | 95% CI | RR | 95% CI | RR | 95% CI |
| Mobility limitation† | 2.55 | 1.45-4.49 | | | | | | |
| Cognitive deficits ‡ | | | 1.94 | 1.11-4.00 | | | | |
| No limitation§ | | | | | 1 | | 1 | |
| Mobility limitation§ | | | | | 1.69 | 0.73-3.90 | 1.93 | 0.82-4.57 |
| Cognitive deficits § | | | | | 1.02 | 0.43-2.45 | 1.25 | 0.50-3.13 |
| Mobility limitation and cognitive deficits § | | | | | 3.80 | 1.85-7.77 | 4.89 | 2.14-11.17 |

*Adjusted for education, living alone and co-morbidity.
†Lowest third of walking speed vs. middle and highest third.
‡ Lowest third of cognitive capacity principal component score vs. middle and highest third.
§Groups formed based on walking speed and cognitive capacity tests dichotomized according to distribution based cut-offs at the lowest third vs. middle and highest third.

## 5.3 Physical activity history in relation to disability and need for care at the end of life

### 5.3.1 Physical activity history and hospital and long-term care at the end of life (II)

A decedent population was identified from the data obtained for the Evergreen interview study on persons born in 1908-1923. Of the 846 deaths that occurred during 1989-2004, 26% occurred at the ages of 66-79, 53% at 80-88, and 21% at the ages of 89-98. The mean age of death was 82 (SD 6.2) years for men and 84 (SD 6.1) years for women. 67% of the participants were women. The most common causes of death were diseases of the heart and circulatory system (54%), cancer at any site (19%), diseases of the nervous system, e.g., dementia (8%), and acute infections e.g. septicemia (4%). Thirty-eight percent of men and 23 percent of women were categorized as physically active from midlife onwards. The consistently active persons suffered less from IADL disability, used less formal home care, and more frequently had higher education than those categorized in the sedentary or occasionally physically active groups.

There was a statistically significant gender interaction for hospital ($p=0.027$) and long-term care ($p=0.001$), and thus the analyses of care were performed separately for men and women.

For men and women, hospital care decreased and long-term care increased in the last year of life with older age at death (Figure 6). For men, hospital care decreased with higher level of physical activity from midlife onwards (p for trend 0.026), but there were no differences in long-term care use according to physical activity behavior. For women with a lower physical activity level, there was an increase in long-term care (p for trend 0.021), but there were no differences in hospital care use according to physical activity behavior from midlife onwards (Figure 7).

For men, with the active group as the reference group, the adjusted risk for all-cause hospital care in the last year of life was higher for those who had been sedentary (risk ratio [IRR] 1.98, 95% confidence interval [CI] 1.14-3.42). The long-term care risk did not differ according to physical activity (Table 7). For women, the risk for hospital care did not differ according to physical activity. The risk for long-term care in the last year of life was higher for the women who had been sedentary (IRR 2.03, 95% CI 1.28-3.21) or occasionally physically active (IRR 1.60, 95% CI 1.06-2.43) from midlife onwards, with the consistently physically active as the reference group (Table 8). The results remained the same when the data were based solely on earlier physical activity as a predictor of need for care was used.

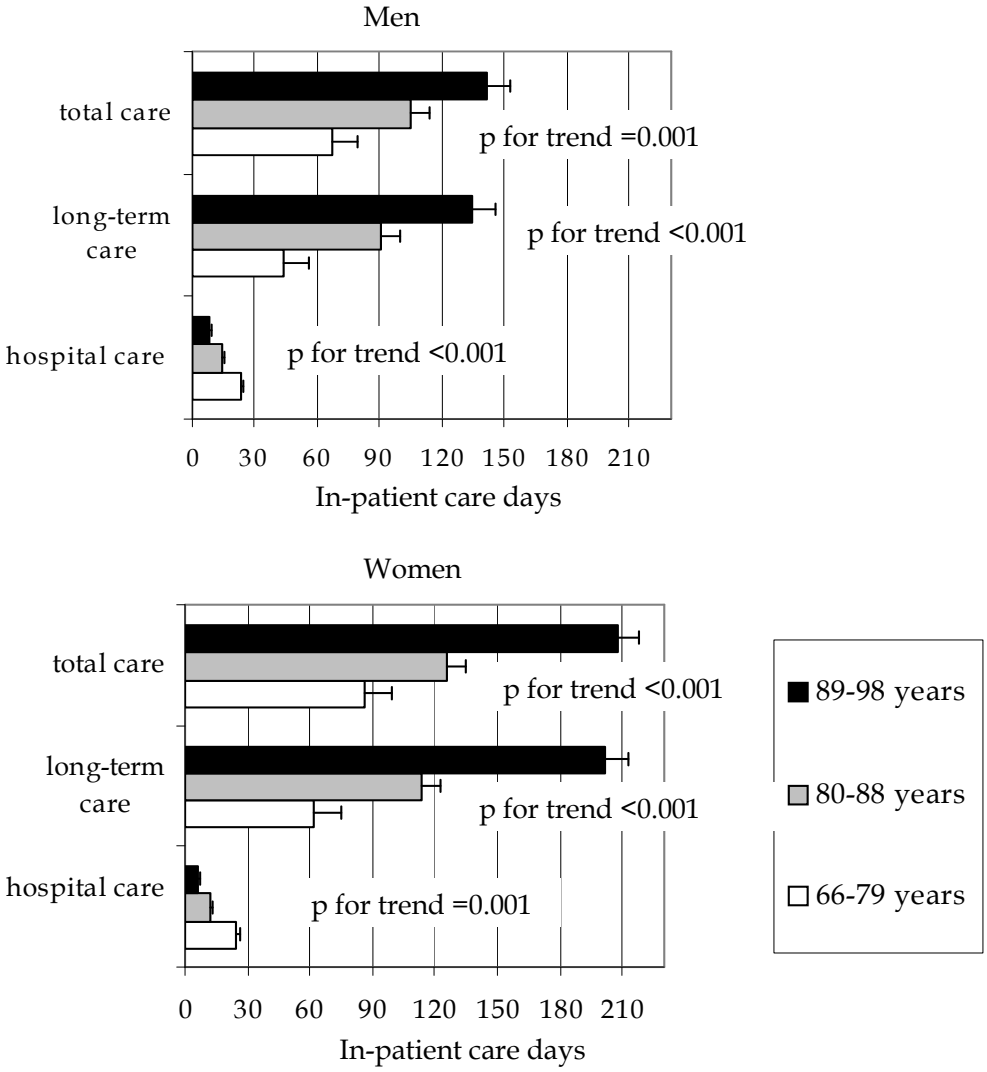


FIGURE 6 All-cause hospital, long-term and total care in-patient days in the last year of life according to age at death for men and women.

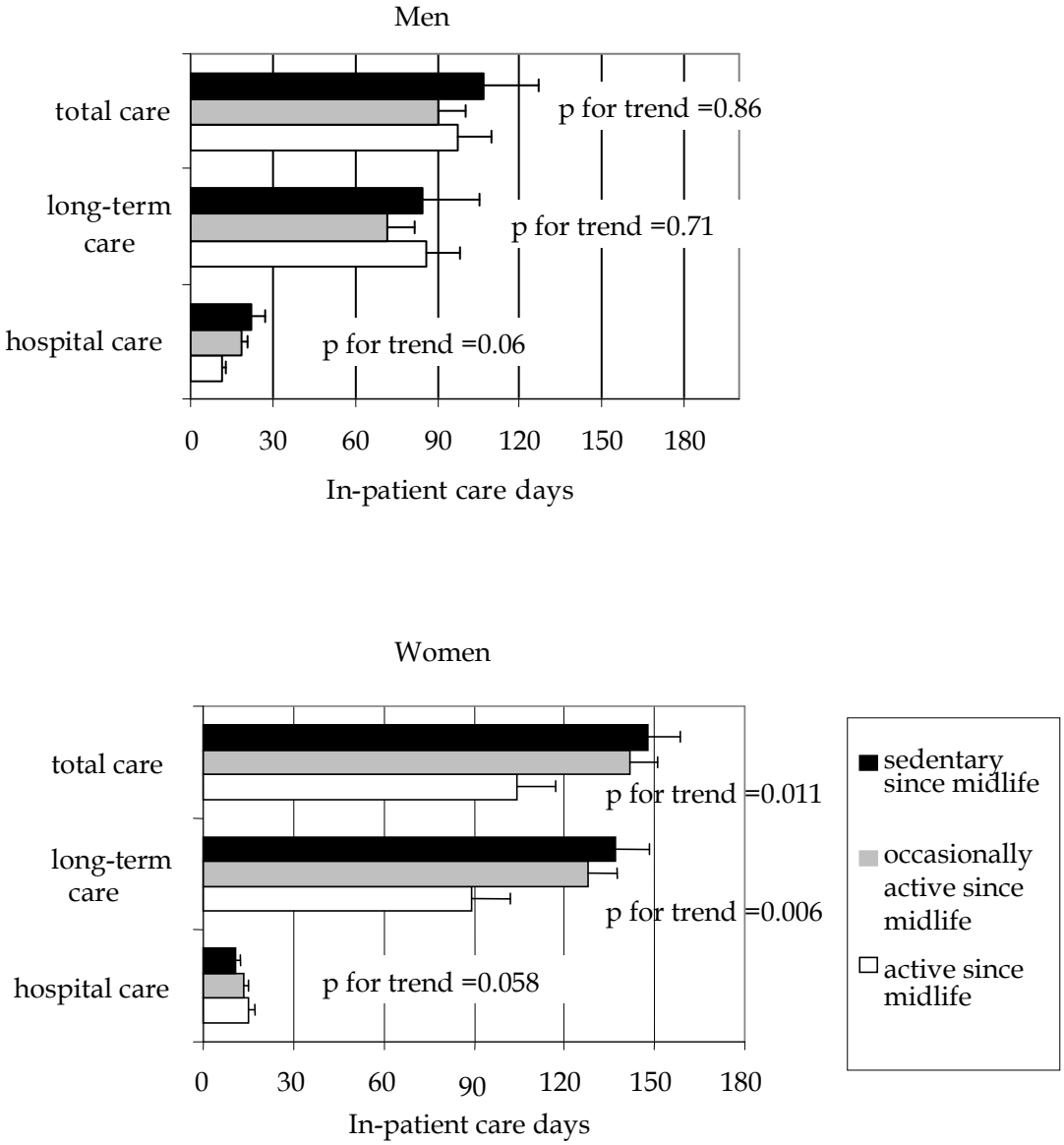


FIGURE 7 All-cause hospital, long-term and total in-patient care in the last year of life according to physical activity behavior for men and women.

The study groups were stratified according to age at death (66-79, 80-88, and 89-98 years). For men, the results for the risk of hospital and long-term care were similar for all the age strata. For women who had died at the age of 66-79 or 80-88 years, the risk for long-term care in the last year of life was lower among the consistently active women compared to others. However, for women who died at the age of 89-98 years, the statistical significance of physical activity behavior on the need for long-term care was lower.

In addition, the proximity of the interview and death was investigated by excluding persons who had died 1-2 years after the interview, but this did not change the results.

TABLE 7 Risk ratios (IRR) and 95% confidence intervals (CI) from negative binomial regression models for the risk for hospital and long-term care in the last year of life for men with consistently physically active from midlife onwards as the reference group.

| | **Model 1** | | **Model 2** | |
|---|---|---|---|---|
| | *Hospital care* | *Long-term care* | *Hospital care* | *Long-term care* |
| | IRR (95% CI) | IRR (95% CI) | IRR (95% CI) | IRR (95% CI) |
| Physical activity from midlife onwards | | | | |
| Consistently active | 1 | 1 | 1 | 1 |
| Occasionally active | 1.46 (0.98-2.17) | 0.84 (0.48-1.46) | 1.35 (0.91-2.00) | 1.29 (0.68-2.43) |
| Consistently sedentary | 1.79 (1.03-3.12) | 0.82 (0.37-1.82) | 1.98 (1.14-3.42) | 1.23 (0.52-2.94) |
| Age at death, IRR/year | 0.95 (0.92-0.98) | 1.09 (1.04-1.14) | 0.97 (0.94-1.00) | 1.07 (1.00-1.14) |

Model 1=adjusted for age at death, Model 2=Model 1 + adjusted for time from interview to death, marital status, education, smoking, formal home care, cognitive functioning, selected chronic diseases and causes of death.

TABLE 8 Risk ratios (IRR) and 95% confidence intervals (CI) from negative binomial regression models for the risk for hospital and long-term care in the last year of life for women with consistently physically active from midlife onwards as the reference group.

| | **Model 1** | | **Model 2** | |
|---|---|---|---|---|
| | *Hospital care* | *Long-term care* | *Hospital care* | *Long-term care* |
| | IRR (95% CI) | IRR (95% CI) | IRR (95% CI) | IRR (95% CI) |
| Physical activity from midlife onwards | | | | |
| Consistently active | 1 | 1 | 1 | 1 |
| Occasionally active | 0.90 (0.63-1.30) | 1.78 (1.22-2.59) | 0.70 (0.48-1.03) | 1.60 (1.06-2.43) |
| Consistently sedentary | 0.68 (0.45-1.02) | 1.79 (1.18-2.71) | 0.72 (0.47-1.10) | 2.03 (1.28-3.21) |
| Age at death, IRR/year | 0.93 (0.91-0.95) | 1.08 (1.06-1.11) | 0.97 (0.94-0.99) | 1.04 (1.01-1.07) |

Model 1=adjusted for age at death, Model 2=Model 1 + adjusted for time from interview to death, marital status, education, smoking, formal home care, cognitive functioning, selected chronic diseases and causes of death.

### 5.3.2 Association of physical activity history and disability in old age

In the ancillary analyses, for men, with the consistently active group as the reference group, the adjusted risk for ADL disability was higher for those who had been occasionally active (risk ratio [IRR] 1.99, 95% confidence interval [CI] 1.33-2.97) or sedentary (IRR 2.48, 95% CI 1.50-4.10) from midlife onwards. The risk for IADL disability in old age was higher for the sedentary men (IRR 1.92, 95% CI 1.31-2.81) and the occasionally active men (IRR 1.52, 95% CI 1.12-2.07) compared with those who had been active from midlife onwards.

For women, with the consistently active group as the reference, the adjusted risk for ADL disability was higher for those who had been occasionally active (IRR 1.58, 95% CI 1.20-2.07) or sedentary (IRR 2.30, 95% CI 1.73-3.07) from midlife onwards. The risk for IADL disability in old age was higher for the sedentary women (IRR 1.82, 95% CI 1.46-2.27) and the occasionally active women (IRR 1.30, 95% CI 1.05-1.60) compared with those who had been active from midlife onwards.

## 5.4 The effect of the physical activity counseling intervention

### 5.4.1 IADL disability (III)

In the SCAMOB randomized controlled trial, the baseline characteristics of the intervention and control groups were comparable. In both trial groups the majority of participants were women (approximately 76%) with a mean age of 77.6 ± 1.95 years, and they suffered on average from three chronic diseases. Difficulties or the inability to perform one or more IADL tasks were found in 45.0% of the intervention group and 52.5% of the control group. However, 66.2% of the intervention and 68.1% of the control group reported being able to walk 2 km without difficulties.

At baseline, 143 persons in the intervention group and 165 in the control group had IADL disability and at follow-up these numbers were 160 and 200, respectively. The IADL disability score was 0.83 (SD 1.16) for the intervention and 1.04 (SD 1.39) for the control group (Table 9). At follow-up IADL disability had increased in both groups ($p<0.001$) but was lower in the intervention group (1.30 (SD 1.84) vs. 1.81 (SD 2.01) $p=0.002$). However, the group by time interaction effect did not reach statistical significance (risk ratio [RR] = 1.07, 95% CI 0.87-1.32). After this, subgroup analyses were performed according to baseline IADL status. The incidence of IADL disability for those with no IADL disability at baseline was 36.4% for the intervention group and 46.2% for the control group ($p=0.077$). Among those with IADL disability at baseline, 73.0% in the intervention group and 82.6% in the control group ($p=0.045$) had IADL disability at the 2-year follow-up. Among those with no IADL disability at baseline, the intervention prevented IADL disability over time (RR = 0.68, 95% CI 0.47-0.97). For those with IADL disability at baseline, there were no statistically significant differences in recovery from IADL disability at follow-up. There were no statistically significant differences in the treatment effect over time according to presence of mobility limitations or cognitive status at baseline. When individual IADL tasks were investigated separately the results were similar.

At baseline, approximately 30% of those in the intervention group and 28% of those in the control group reported having had an injury of some kind during the previous year. There were no statistically significant changes in the number of injuries sustained during the 2-year intervention period.

### 5.4.2 Home care (IV)

Home care use was investigated for 564/632 (intervention n=290 and control group n=274) persons of whom, approximately 59% managed self-care tasks such as bathing, getting in and out of bed, and toileting without difficulty, whereas out of the RCT participants who were not investigated (n=68) approximately 42% managed self-care tasks without difficulty ($p=0.01$). Of those investigated for home care use, the intervention and in the control groups

were comparable at baseline, except that in the intervention group 61.4% and control group 50.7% lived alone (p=0.01). In the intervention group 14.5% and in the control group 18.2% received informal care from a spouse, child or relative.

In the intervention group 15 persons and in the control group 26 persons commenced using home care during the 2-year intervention. The cumulative incidence of home care use was 2.6/100 person-years in the intervention and 5.0/100 person-years in the control group (Figure 8). During the 3.5-year intervention and follow-up period 27 persons (2.8/100 person-years) in the intervention group and 52 persons (6.0/100 person-years) in the control group commenced using home care.

The treatment effect was significant at the end of the 2-year intervention (HR=0.51, 95% CI 0.27-0.97) and remained significant 1.5-years after the end of the intervention (HR=0.51, 95% CI 0.27-0.97). Models were adjusted for gender, age, and living alone.

TABLE 9 IADL disability, mean score, standard deviations, and effects in the GEE model for the intervention and control groups for all participants and subgroups according to IADL disability, mobility limitation and cognitive status at baseline.

| **Study groups** | **IADL disability** | | **Effect in the GEE Model** | | | | |
|---|---|---|---|---|---|---|---|
| | Baseline Mean (±SD) | Follow-up Mean (±SD) | Group effect p-value | Group x time effect p-value | Time effect p-value | 95% CI | RR |
| All participants n=632 | | | | | | | |
| Intervention group | 0.83 (1.16) | 1.30 (1.84) | 0.002 | 0.504 | <0.001 | 0.87-1.32 | 1.07 |
| Control group | 1.04 (1.39) | 1.81 (2.01) | | | | | |
| No IADL disability n=324 | | | | | | | |
| Intervention group | - | 0.75 (1.35) | **0.036** | - | - | **0.47-0.97** | **0.68** |
| Control group | - | 1.07 (1.66) | | | | | |
| IADL disability n=308 | | | | | | | |
| Intervention group | 1.84 (1.05) | 2.00 (2.12) | 0.103 | - | - | 0.68-1.04 | 0.84 |
| Control group | 1.99 (1.34) | 2.48 (2.07) | | | | | |
| No mobility limitations n=347 | | | | | | | |
| Intervention group | 0.44 (0.77) | 0.83 (1.46) | 0.135 | 0.937 | <0.001 | 0.68-1.51 | 1.02 |
| Control group | 0.55 (0.86) | 1.19 (1.74) | | | | | |
| Mobility limitations n=285 | | | | | | | |
| Intervention group | 1.34 (1.36) | 1.93 (2.09) | 0.013 | 0.358 | <0.001 | 0.88-1.42 | 1.12 |
| Control group | 1.59 (1.64) | 2.52 (2.07) | | | | | |
| Intact cognition n=299 (MMSE score 28-30) | | | 0.084 | 0.161 | <0.001 | 0.91-1.79 | 1.28 |
| Intervention group | 0.78 (1.15) | 0.99 (1.41) | | | | | |
| Control group | 0.80 (1.11) | 1.33 (1.76) | | | | | |
| Mild cognitive problems n=332 (MMSE score 22-27) | | | 0.014 | 0.689 | <0.001 | 0.73-1.23 | 0.95 |
| Intervention group | 0.88 (1.17) | 1.60 (2.14) | | | | | |
| Control group | 1.26 (1.57) | 2.24 (2.13) | | | | | |

Notes. IADL=Instrumental Activities of Daily Living; GEE model=generalized estimating equation model; MMSE=Mini-Mental State Examination

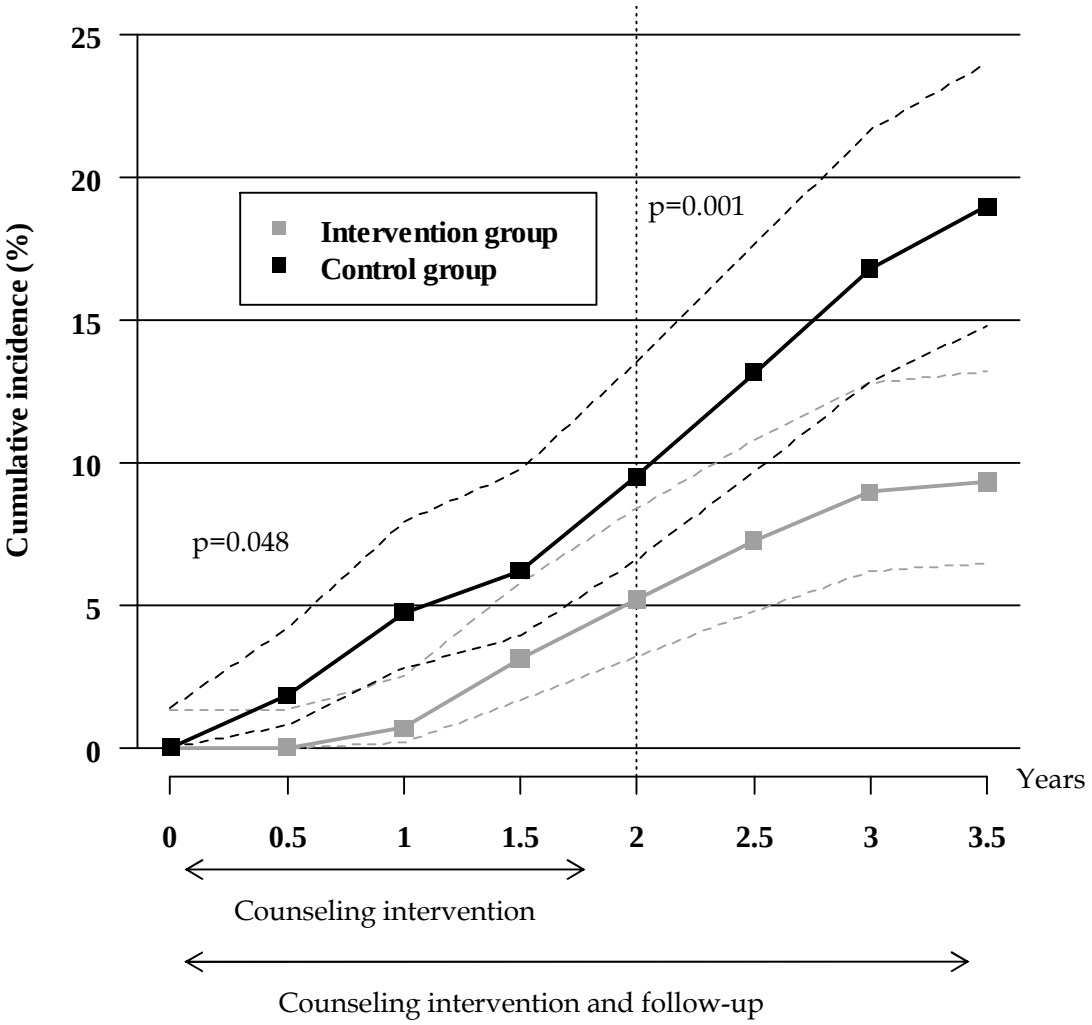


FIGURE 8 Cumulative incidences and 95% confidence intervals for home care use during the 2-year intervention and 2-year intervention and 1.5-year follow-up time among the intervention and control group. Comparisons made with chi-square test.

# 6 DISCUSSION

This study investigated whether functional status and physical activity history predicted all-cause hospital and long-term care use among older community-dwelling people. Additionally, the effects of physical activity counseling on instrumental activities of daily living disability and home care service use in an older sedentary population were studied.

In this study, the presence of co-existing mobility limitations and cognitive deficits placed older community-dwelling persons at a significantly higher risk for long-term care compared to persons with no limitations or only a single limitation. At the end of life, long-term care increased and hospital care decreased among older people. Men who reported consistent physical activity from midlife onwards needed fewer days of hospital care in their last year of life than those who reported less physical activity. Similarly, consistently active women spent fewer days in long-term care at the end of life. In addition, the present study found that IADL disability increased during a physical activity counseling trial for older community-dwelling persons and that the changes did not differ between the intervention and control groups. However, subgroup analyses revealed that physical activity counseling prevented new disability among those without IADL disability at baseline, but had no effect on recovery from disability among those with baseline disability. Similarly, no differences were observed for IADL disability between the trial groups in subgroup analyses according to mobility limitation or cognitive capacity. Finally, the study demonstrated that physical activity counseling could help reduce the need for home care among community-dwelling sedentary persons in the long term.

## 6.1 Hospital and long-term care at the end of life

The ideal scenario in old age for most people is to live a long life without suffering from poor health for extended periods of time at the end of life. This scenario of 'successful aging and dying' is the wish of many older people as well as ideal for the national social and health care system. However, morbidity (Fries 1996) and disability (Guralnik et al. 1991) pose a threat to this scenario, since they are concentrated into the last years of life.

In accordance with previous research findings, hospital care with aggressive forms of care was found to decrease (Spillman & Lubitz 2000, Levinsky et al. 2001, Menec et al. 2007, Forma et al. 2009) and long-term care increase (McGrail et al. 2000, Yang et al. 2003, Forma et al. 2009) in the last year of life with older age at death. The need for health care has been found to increase with age and closeness to death (Scitovsky 1994, Spillman & Lubitz 2002, Yang et al. 2003, Menec et al. 2007), mainly because of increased need for long-term care among very old persons (Roos et al. 1987, McGrail et al. 2000, Spillman & Lubitz 2000). This was corroborated in the present study. Men and women aged 66-79 years at death spent on average 23 and 25 days, respectively, in hospital care during the last year of life, whereas the corresponding numbers were 8 and 6 days for those who died at the age of 89 or over. On the other hand, men and women who died at the age of 66-79 spent on average 44 and 62 days, respectively, in long-term care in the last year of life whereas those who died very old spent on average 134 and 201 days in long-term care. Thus, in terms of investigating the total number of days of in-patient care at the end of life, it is important to consider care given in both hospital and long-term care settings. This is something that most of the earlier research has failed to do, with the result that total care needs at the end of life have been underestimated (Roos et al. 1987, Lubitz et al. 1995).

Previous prospective studies have identified cognitive decline (Agüero-Torres et al. 2001, Banaszak-Holl et al. 2004, Bharucha et al. 2004) and physical impairments (Guralnik et al. 1994, Laukkanen et al. 2000) as independent risk factors for long-term care in older, cognitively intact community-dwelling persons. The results on simultaneously occurring co-limitations in cognitive performance and physical functioning and their associations with disability are inconsistent (Gill et al. 1995, Kempen & Ormel 1998). However, in a prospective study by Gill et al. (1996) persons with the worst physical and cognitive performance were more than five times more likely to develop ADL disability compared to those with the best performance. Disability has been identified as a strong predictor for long-term care (Stuck et al. 1999, Fried et al. 2001, Angel et al. 2004, Friedman et al. 2005), thus supporting the potential pathway leading from functional limitations through disability to long-term care use. However, no previous studies have addressed existing impairments and limitations simultaneously as predictors of long-term care in older community-dwelling populations. The present study is the first to suggest that the co-occurrence of

both cognitive impairment and functional limitation increases the risk for long-term care in a community-dwelling population without diagnosed dementia.

Mobility ability (Guralnik et al. 1994, Judge et al. 1996, Woo et al. 1999) and cognitive functioning (St John et al. 2002, Angel et al. 2004) are vital prerequisites for independent community-dwelling. Performing self-care and IADL tasks as well as moving about at home and in its immediate surroundings and engaging in meaningful social interaction is essential for maintaining an independent and socially active lifestyle (Fried et al. 2004, Andel et al. 2007). Additionally, physiologic (Fried et al. 2004) and cognitive reserves (Richards & Deary 2005) help older individuals withstand the deterioration in functional abilities, which, if unchecked, may result in adverse health outcomes such as increased need for care (Branch et al. 1988, Wolinsky et al. 1992, Stuck et al. 1999, Friedman et al. 2005). In the present study, people who had better mobility ability and cognitive functioning had a potentially greater reserve capacity than those with lower functioning. Thus, individuals with greater physical reserve capacity could not only be less vulnerable to acute events such as infections but also able to compensate for potential losses by drawing on that reserve, and thus avoid loss of independence (Tinetti et al. 1995, Fried et al. 2004).

Mounting evidence linking physical and cognitive decline (Binder et al. 1999, Tabbarah et al. 2002, Atkinson et al. 2005, Rosano et al. 2005), suggests that they may share the same etiology or be causally related to each other. Decline in cognitive performance has been associated with decline in physical tasks such as walking at normal speed (Atkinson et al. 2007) and performance in the Physical Performance Test (Binder et al. 1999). These results indicate that patterns of change in cognitive and physical performance are interrelated and that cognition plays a significant role in the execution of physical tasks (Tabbarah et al. 2002). On the other hand, the inability to maintain a socially active lifestyle due to physical disability may accelerate cognitive decline (Bassuk et al. 1999). However, the causal relations of mobility limitations and cognitive decline cannot be determined on the basis of this study.

Little is known about the factors which underlie co-occurring cognitive and physical decline. Smoking, which is a lifestyle related factor, has been associated with combined physical and cognitive decline (Atkinson et al. 2005). Another potential underlying lifestyle-related factor for cognitive and physical decline is physical activity. Prospective studies have shown that physical activity is an important determinant for physical functioning (Leveille et al. 1999, Hirvensalo et al. 2000a, Nusselder et al. 2005, Boyle et al. 2007, Landi et al. 2007a). Evidence is accumulating on the positive effects of physical activity on cognitive functioning in older people (Laurin et al. 2001, Weuve et al. 2004, Rovio et al. 2005, Angevaren et al. 2008).

## 6.2 Effect of physical activity on disability and related service use among older community-dwellers

The compression of morbidity theory suggests that a healthy life-style, including physical activity, may delay the onset of morbidity and thus help compress the period of disability and high health care costs to near the end of life (Fries 1980). However, the debate on the compression of morbidity continues. On the one hand, longevity increases the probability that new and costly diseases will occur. On the other hand, higher life expectancy postpones the expensive last year of life which becomes less expensive with older age (Gandjour 2009), partly due to the administration of less aggressive forms of treatment. Many studies have shown that physical activity reduces mortality among older people (Hakim et al. 1998, Kujala et al. 1998, Wannamethee et al. 1998), thus postponing the last year of life to an older age.

Little research has been conducted on the association between physical activity and health and social service use in old age. Previous research has indicated that physical activity is related to a decreased need for self-reported hospital care in older people (Martin et al. 2006). Kujala et al. (1996) compared former elite athletes with age-matched controls and discovered that the former athletes needed less hospital care during later life. With respect to long-term care, Wolinsky et al. (1995) found that persons who were physically active had a decreased risk for subsequent nursing home care. Valiyeva et al. (2006) more recently found in their nationally representative study that physical inactivity, especially for middle aged people, was a risk factor for future nursing home admission. However, previous studies have not investigated the association of physical activity with both hospital and long-term care at the end of a long life.

The present study is the first observational study to report on the association between physical activity from midlife onwards and the need for both hospital and long-term care in the last year of life. The main pathway of the disablement process leads from pathology to disability through impairment and functional limitations (Nagi 1976, Verbrugge & Jette 1994). Physical activity, especially when started earlier in life, can potentially decrease the risk of disease (Fries 1980, Wannamethee et al. 1998, Friedenreich et al. 2001) and functional limitations (Hirvensalo et al. 2000a, Miller et al. 2000, Pahor et al. 2006, Patel et al. 2006). According to current prospective studies, physical activity might further postpone or prevent the development of disability (Keysor 2003, Spirduso & Cronin 2001, Wolinsky et al. 2007) which could be reflected in decreased need for assistance and care in activities of daily living (Katz et al. 1983, Stuck et al. 1999). Furthermore, reducing old age dependence (Vita et al. 1998, Hillsdon et al. 2005, Chakravarty et al. 2008) and long-term care (Valiyeva et al. 2006) through lifestyle-related prevention, such as increasing physical activity, has been shown to be more effective when started in midlife than in old age. In the present study, physical activity from midlife to old age correlated with a lower level of ADL and IADL disability at old age, thus

supporting earlier findings (Vita et al. 1998, Hillsdon et al. 2005, Chakravarty et al. 2008). In the present study, the risk for disability in old age was higher for those who had been sedentary or only occasionally active from midlife onwards compared to the consistently active. The findings suggest that physical activity might help decrease the development and progression of disability, which in turn could mean that physical activity may be a mediator for reduced need of care. Consistent with the theory on the compression of morbidity, put forward by Fries, the reduced need for care at the end of life found in the more physically active group in the present study could have resulted both from compression of morbidity (Fries 1980) and from higher active life expectancy (Leveille et al. 1999).

So far, longitudinal studies have produced evidence that increased physical activity in old age (Leveille et al. 1999, Hirvensalo et al. 2000a, Nusselder et al. 2005, Boyle et al. 2007, Landi et al. 2007a) reduces the risk for subsequent disability. Further, randomized controlled trials have reported positive effects from various types of physical activity interventions on functional limitations such as walking (Nelson et al. 2004, Pahor et al. 2006, Morey et al. 2008, Hughes et al. 2009, Mänty et al. 2009). Some programs with specific exercise trials (Penninx et al. 2001, Worm et al. 2001, Binder et al. 2002) and community-based programs (Leveille et al. 1998, Phelan et al. 2004, Pitkälä et al. 2009) have reduced the incidence of disability in old age. However, non-significant findings have also been reported (Chin A Paw et al. 2001, Luukinen et al. 2006, Timonen et al. 2006). Overall, these findings indicate that increased physical activity may not only decrease mobility difficulties, but also decrease or postpone disability and related service use, albeit the results from randomized trials on the effect of physical activity on disability have been inconsistent.

In the present randomized controlled trial, IADL disability increased during the 2-year period of physical activity counseling, although the changes did not differ between the intervention and control groups. However, subgroup analyses revealed that while physical activity counseling had no effect on the recovery from disability among those with baseline disability, it prevented incident disability among those without IADL disability at baseline. The secondary analyses in the present study showed that the need for home care decreased in the intervention group during the 3.5-year intervention and follow-up time. This trial was the first randomized controlled trial, to the best of our knowledge, to investigate the long-term effect of primary care-based physical activity counseling on IADL disability and home care use among community-dwelling sedentary older people.

Earlier programs targeting disability and related service use have included preventive home visits with multidimensional geriatric assessments (Fabacher et al. 1994, Stuck et al. 2000, Bouman et al. 2008a, Melis et al. 2008), the case-management approach (Shapiro & Taylor 2002, Onder et al. 2007), educational interventions with counseling on healthy living habits such as nutrition (Burton et al. 1995, Payette et al. 2002), and physical activity promotion interventions

with specific exercise trials (Ettinger et al. 1997, Jette et al. 1999, Chin A Paw et al. 2001, Penninx et al. 2001, Gill et al. 2002, 2004, Timonen et al. 2006), and community-based physical activity programs (Leveille et al. 1998, Phelan et al. 2004, Pitkälä et al. 2009). However, well-conducted systematic reviews have shown that the different types of randomized health and physical activity promotion interventions have yielded inconsistent results on disability prevention and related service use among older community-dwelling people (van Haastregt et al. 2000, Elkan et al. 2001, Keysor & Jette 2001, Stuck et al. 2002, Bean et al. 2004, Latham et al. 2004, Bouman et al. 2008b, Daniels et al. 2008, Huss et al. 2008).

Recent reviews on interventions designed for disability prevention have indicated that older people with an increased risk for disability might benefit from high-intensity interventions with multidimensional relatively long-lasting programs that target specific problems (Bouman et al. 2008b, Daniels et al. 2008). For example, a randomized controlled trial by Gill et al. (2002) on a home-based physical therapy intervention among older people was able to prevent functional decline and decline in IADL disability over time for moderately frail persons. The 6-month program consisted of up to 16 visits and monthly supportive phone calls carried out by a physical therapist. Another community-based program, found to be effective, especially for older disabled people, included an initial assessment by a gerontologic nurse practitioner, who then developed a 12-month health action program including 3 surveillance visits and an average of 9 telephone contacts (Phelan et al. 2004). In addition, a similar type of multi-component trial was found to decrease disability and hospital care in frail older persons (Leveille et al. 1998).

In the present study, subgroup analyses showed that the 2-year physical activity counseling program consisting of a single face-to-face counseling session and telephone contact every 4 months prevented incident disability among those with no disability at baseline. Additionally, the secondary analyses showed that home care use was significantly reduced in the intervention group. These results suggest that this type of feasible, fairly easily implemented physical activity counseling may be effective among high functioning older people in preventing more complex disability and thus home care use in the long term. The mechanisms underlying the association between physical activity and IADL disability are likely to be complex (Boyle et al. 2007), indicating that an increase in physical fitness alone may not be enough to improve functional dependence (Bean et al. 2004). Factors other than physical fitness, such as the individual's background, beliefs, and personal behavior, along with the physical and social contexts that are not related to activity interventions, may determine whether a person becomes disabled (Humpel et al. 2002, Satariano 2003, Bean et al. 2004). For example, environmental factors such as the lack of an elevator can prevent outdoor mobility and lead to increased disability despite the fact that the individual's level of physical fitness would have increased as a result of a physical activity counseling intervention. In addition, physical activity is a complex behavior in itself with many barriers

and motivational factors that can be hard to tap into (Rhodes et al. 1999, DiPietro 2001, King 2001,McAuley et al. 2003). Having said that, preventing IADL disability may not only require physical exercise but also other measures such as geriatric assessments and health-related counseling to support behavior change, especially for disabled persons who are most likely to experience greater barriers to motivation and adherence to physical activity (Cohen-Mansfield et al. 2003, Schutzer & Graves 2004, Rasinaho et al. 2006).

Interventions to prevent the onset and progression of disability are urgently needed (Ferrucci et al. 2004, Gill et al. 2004). However, the inconsistent findings of various trials aimed at decreasing disability indicate the size of the challenge of developing programs and suitable measures to evaluate the effect of interventions in a heterogeneous population of older people with chronic illnesses and various needs for services (Leveille et al. 1998). Further, it has been argued that the discrepancy in the results of studies on the effect of physical activity on disability is due to factors such as poor methodological quality of studies, problems in targeting the right subgroups of older persons who will benefit from physical activity interventions, different duration of intervention and follow-up, and differences in measuring physical activity and disability (Keysor & Jette 2001, Spirduso & Cronin 2001, Eden et al. 2002, Ferrucci et al. 2004, Latham et al. 2004).

## 6.3 Methodological considerations

This study is based on two Evergreen project prospective observational studies and the SCAMOB trial, which was a 2-year randomized controlled trial with 1.5-year follow-up. The two Evergreen projects had long data surveillance periods ranging from 10-16 years. The participation rates were high both for the interviews (80-93%) and the clinical examinations (72-77%). Recruiting participants using the population register database ensured that individuals with diverse socioeconomic backgrounds and health status were included in the studies. In the Evergreen project interview study, the long surveillance period allowed for the use of a relatively large decedent population with varying times of death for studying hospital and long-term care use in the last year of life. In order to obtain reliable results, a representative sample of the target population must be used. In the Evergreen project cohort study on persons born in the year 1910 and 1914, all the people born in those years and who resided in the city of Jyväskylä were included in the study sample. In the Evergreen project interview study, a sample of 1600 persons, consisting of 21.1% of people aged 65 years or over residing in the City of Jyväskylä in the beginning of the year 1988, was obtained from the Population register. From the standpoint of generalizability, it has to be acknowledged that the study samples were all derived from one urban community in Finland. However, the register-based

recruiting, the long follow-up, and the prospective analyses add to the reliability of the study.

The at-home interviews were quite wide-ranging and conducted face-to-face by trained university undergraduates. Some of the interview questions and measurements used in the studies have been validated while others are well-known and widely used tests and methods. In the Evergreen project interview study, the physical activity data were collected by retrospective interviews and were based on self-report. Potential recall bias and possible subclinical cognitive impairments of the participants at the time of the interview could have influenced the results. In the clinical examination conducted as part of the Evergreen project cohort study, walking speed was measured at the research centre with a standardized test (Aniasson et al. 1980) and cognitive capacity with well-known psychometric tests (Wechsler 1945, Wechsler 1955, Schaie 1985) which were performed by trained psychologists. Although disability was self-reported, standardized questions were used in face-to-face interviews (Katz et al. 1963, Lawton & Brody 1969). The reliability of the interview data was assessed in the SCAMOB trial. It was found to be high for chronic conditions (r=0.89), and habitual physical activity (Kendall's tau-b=0.874), and ranged between 0.491 and 1.00 for questions on ADL, IADL and mobility ability.

In the present study, data on care given in university hospitals, central and district hospitals and in health centre wards were drawn from the registers of the National Institute for Health and Welfare. The information consists of dates on all-cause admissions and discharges and the name of public or private institution in which care took place. Data on nursing home care were collected from the local registers of nursing homes in the area. The use of national and local registers rather than self-report data contributed to the validity of the study. The register-based data on hospital, long-term care, and home care were linked to the interview data. However, when investigating the use of health and social services, it should be noted that other factors besides health status, such as changing practices of health care, can affect the use of services (Goebeler et al. 2004).

Reduced cognitive capacity may decrease the reliability of the results, given that individuals with cognitive problems may not be able to provide accurate answers in the interviews. In the Evergreen project cohort study, persons who were community-dwelling, did not have a diagnosis of dementia, and were able to come to the research centre for an entire day to participate in the multiple physical and psychometric tests were included in the study sample. Persons with poor performance are more likely to drop out from such a study than persons with better performance. This might result in underestimation of the risk of institutionalization at the population level, a possibility which should be considered when interpreting the results. In the SCAMOB trial, persons with a Mini-Mental State Examination score of 21 or less were excluded from the study group. While this strengthened the reliability of the data, it should be taken into account when generalizing the results and counseling older people with possible cognitive decline on physical activity.

In the SCAMOB trial, the sample of 632 persons was screened from all of the 75- to 81-year–old residents registered as living in the Jyväskylä city centre area in the year 2003. The randomization process was successful and the baseline characteristics of the intervention and control groups were comparable. The intervention was single blinded, i.e. the study nurses and assistants who performed the baseline and follow-up examinations and interviews were unaware of the study group assignment. The participants were randomly assigned to the study groups in blocks of 40 to 50 persons by drawing lots each week after the completion of baseline assessments with a randomization ratio of 1:1. The randomization allocation was performed by the trial administrator and allocation concealment was achieved by drawing names from opaque envelopes for 40 to 50 persons at the same time.

The intervention time was long when compared to other previous physical activity counseling programs. In addition, adherence to the physical activity counseling program was high. In the trial, the intervention group was advised to participate in the exercise groups organized by the City of Jyväskylä. The municipality organizes various exercise groups for older people and offer older people good overall possibilities for physical activity. This is another factor which must be considered when generalizing the results of the trial. Further more, in the SCAMOB trial the results of the subgroup analyses need to be considered with caution, since the effect of randomization is uncertain. In addition, the power of the data might not have been sufficient for conducting the IADL subgroup analyses. Home care data were available for 90% of the RCT participants, which is why the effect of randomization is uncertain.

## 6.4 Future directions

Disability rates have been falling in some western countries during the past few decades. However, the trend is less evident among the oldest old, who are the main users of long-term care. Also, in spite of decreasing overall disability, the actual number of persons with chronic disability has increased among older people as a result of the growth in numbers of this population segment. To study hospital and long-term care use at the end of a long life, observational longitudinal data must be used even if an experimental design would allow for evaluation of the effect of physical activity. However, interventions to study end-of-life care are very hard to implement, because individuals die at different ages and it would be impossible to schedule the intervention optimally. Further, ideally, interview data should be prospective and not retrospective when studying the association of midlife health habits with old age service use. In the future, existing prospective data with follow-up from midlife onwards should be linked to register-based hospital and long-term care data.

Evidence on the beneficial effect of healthier living habits, such as increased physical activity, is accumulating. Prospective studies have shown

that physical activity, especially when started earlier in life, has resulted in the compression of morbidity and in decreased disability at the end of life (Fries 1980, Vita et al. 1998). However, the evidence obtained from experimental trials has been inconsistent (Keysor 2003). The present study indicates that physical activity, even when started at an old age, is associated with decreased disability and related service use. These findings suggest that there is a growing need for interventions aiming at increasing physical activity among older people together with follow-up on the need of health and social services. Studies on the effect of physical activity on disability and related service use continue to be needed because physical activity is a lifestyle-related factor that individuals can change themselves. The subgroup findings on IADL disability can be used for hypothesis building and should be further tested and verified in experimental studies.

In future studies, physical activity interventions for older people should be carefully designed to avoid the above-mentioned methodological pitfalls when planning and implementing physical activity programs designed to decrease disability. First, it is important to target individuals who stand to gain from these interventions (Ferrucci et al. 2004). For example, newly disabled persons are more likely to recover independent ADL functioning than persons with chronic disability (Hardy & Gill 2004). In addition, 'over exclusion' should be avoided when screening participants for trials, as clinically relevant groups of persons might be excluded from the study sample and, further, enrolling a small group of the reference population will seriously affect the generalizability of the findings. Second, physical activity interventions should be designed to include measures that help reduce injuries such as falls which might result from increased physical activity. In future physical activity interventions designed for older people, the safety of the programs should be monitored and reported on more carefully. Third, physical activity interventions for decreasing disability should include multidimensional programs with a relatively long surveillance period. The fact that disabilities are socially constructed should be considered when planning interventions that are designed to decrease disability (Heikkinen 2006). Moreover, future research data on the costs of these multidimensional programs is urgently needed. In connection with multidimensional programs, concerns have been raised on whether it is possible to pinpoint which components of the program are truly effective. On the other hand, there is an ongoing debate about whether it is in fact necessary to investigate the individual components of such programs, as it is the overall effectiveness of the program that ultimately matters. Finally, the mechanisms through which physical activity effects functional limitations and disability, and consequently social and health care service use, should be further investigated. However, combining research on disability and physical activity is challenging, partly because of conceptual differences (Stewart 2003).

# 7 MAIN FINDINGS AND CONCLUSIONS

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

1. Among community-dwelling older people, co-existing decline in physical and cognitive status significantly increased the risk for institutionalization.

2. Hospital care decreased and long-term care increased with older age at death among older men and women during the last year of life.

3. Among people who died after 66 years of age, consistent long-term physical activity decreased the need for end-of-life hospital care for men and long-term care for women.

4. A physical activity counseling program with one face-to-face counseling session follow-up by telephone surveillance every 4 months for 2 years did not decrease IADL disability. However, subgroup analyses showed that for those with no IADL disability at baseline the IADL incidence was lower for the intervention group than for the control group. The intervention had no effect on recovery from IADL disability.

5. The secondary analyses of the physical activity counseling program indicated that the intervention group needed significantly less home care during the 2-year intervention and 1.5-year follow-up than the control group.

In conclusion, the results of the present study indicate that physical activity, even when started in old age, is associated with decreased disability and related health and social service use in old age. The findings suggest that physical activity might help to compress the disabled and dependent period at the end of life. The present findings, however, need to be further investigated and the results corroborated with prospective and experimental study designs.

# YHTEENVETO

## Fyysinen aktiivisuus toiminnanvajauden ja sosiaali- ja terveyspalvelujen käytön ennustajana iäkkäillä henkilöillä

Suurin osa iäkkäistä henkilöistä toivoo elävänsä pitkän elämän ilman pitkittynyttä toiminnanvajautta ja palvelujen tarvetta elämän loppuvaiheessa. Ajatus on samansuuntainen Friesin (1980) teorian mukaan, jossa sairaudet ja toiminnanvajaus tiivistyvät lyhyeen jaksoon elämän loppuvaiheessa. Sosiaali- ja terveyspalvelujen tarve kasvaa kuitenkin iän ja kuoleman läheisyyden vuoksi. Tähän osaltaan on syynä sairastuvuuden ja toiminnanvajauksien lisääntyminen vanhana. Hoidontarpeen kasvu on merkittävää paitsi iäkkään henkilön myös julkisen terveydenhuollon kannalta. Varsinkin yli 80-vuotiaiden, pitkäaikaishoitoa eniten tarvitsevien henkilöiden määrä tulee seuraavina vuosikymmeninä lisääntymään suhteellisen voimakkaasti. Terveellisten elintapojen, kuten keski-iässä tai vanhana aloitetun säännöllisen liikunnan, on todettu pidentävän elinikää ja siirtävän kroonisten sairauksien ilmaantumista korkeampaan ikään. Keski-iästä vanhuuteen ulottuneen säännöllisen liikunnan vaikutusta viimeisen elinvuoden sairaala- ja laitoshoidon käyttöön ei ole aiemmin tutkittu.

Pitkittäistutkimuksissa fyysisen aktiivisuuden on todettu vaikuttavan positiivisesti toiminnanvajauden syntyprosessin eri vaiheisiin kuten suorituskyvyn rajoituksiin ja toiminnanvajauksiin. Satunnaistetut kontrolloidut kokeet ovat osoittaneet liikuntainterventioiden lisänneen fyysistä aktiivisuutta aiemmin liikuntaa harrastamattomilla iäkkäillä henkilöillä. Näiden interventioiden vaikutukset suorituskyvyn rajoituksiin ja toiminnanvajauksiin ovat kuitenkin olleet ristiriitaisia. Liikuntaneuvonnan on todettu lisäävän fyysistä aktiivisuutta ja vähentävän suorituskyvyn rajoituksia iäkkäillä henkilöillä. Liikuntaneuvonnan vaikutusta toiminnanvajauteen tai kotipalvelun tarpeeseen kotona asuvilla liikuntaa harrastamattomilla iäkkäillä henkilöillä ei ole tutkittu aiemmin.

Tutkimuksen tarkoituksena oli tarkastella ennustavatko toimintakyky ja fyysinen aktiivisuus sairaala- ja laitoshoitoa iäkkäillä kotona asuvilla henkilöillä. Lisäksi tarkoituksena oli tutkia liikuntaneuvontaintervention vaikutusta asioiden hoitamiseen, Instrumental activities of daily living (IADL), liittyvään toiminnanvajauteen ja kotihoidon käyttöön kotona asuvilla liikuntaa harrastamattomilla iäkkäillä henkilöillä.

Tutkimuksessa käytettiin kolmea aiemmin kerättyä tutkimusaineistoa. Ikivihreät-projektin kohorttitutkimusaineiston kohdejoukkona olivat kaikki vuosina 1910 ja 1914 Jyväskylän kaupungin alueella asuneet henkilöt. Tutkimusjoukkoon kuului 617 kotona asuvaa henkilöä, jotka osallistuivat seurantahaastatteluihin ja tutkimuskeskuksella tehtyihin mittauksiin. Ikivihreät-projektin seurantahaastatteluihin osallistui 1224 vuosina 1908–1923 syntynyttä Jyväskylän kaupungin asukasta. Tutkimusjoukosta valittiin tutkimukseen 846 henkilöä, jotka olivat kuolleet 66–89 vuoden ikäisenä. Ikivihreät aineistojen seuruuaika on 10–16 vuotta. Tutkimukseen osallistujista on olemassa rekisteritiedot heidän

sairaala- ja laitoshoidon käytöstä vastaavalta ajalta. Tutkimuksessa käytettiin lisäksi 'Screening and Counseling for Physical Activity and Mobility among Older People' (SCAMOB) intervention aineistoa, johon osallistui 632 Jyväskylän kaupungin keskustassa asuvaa henkilöä. SCAMOB oli 2-vuotinen satunnaistettu kontrolloitu liikuntaneuvonta interventio, johon kuului yksi fysioterapeutin liikuntaneuvontasessio, jonka jälkeen sama fysioterapeutti soitti osallistujille neljän kuukauden välein kahden vuoden ajan. Lisäksi osallistujia seurattiin 1.5 vuotta intervention jälkeen ja heidän kotihoitotietonsa kerättiin koko tutkimuksen ajalta Jyväskylän kaupungin rekisteristä.

Laitoshoidon riski oli merkitsevästi suurempi niillä kotona asuvilla henkilöillä, joilla oli vaikeuksia kävelyssä ja kognitiivisessa toiminnassa verrattuna henkilöihin, joilla oli vain yksi vaikeus tai ei ollenkaan vaikeuksia kävelyssä tai kognitiossa. Tämä tutkimus oli ensimmäinen jossa tutkittiin iäkkäiden henkilöiden keski-iästä vanhuuteen ulottuneen säännöllisen liikunnan yhteyttä viimeisen elinvuoden sairaala- ja laitoshoitoon iäkkäillä henkilöillä. Tutkimuksen tulokset osoittivat, että sairaalahoito väheni ja laitoshoito lisääntyi iäkkäillä henkilöillä elämän loppuvaiheessa. Keski-iästä lähtien säännöllistä liikuntaa harrastaneilla miehillä oli merkitsevästi pienempi riski sairaalahoitoon viimeisenä elinvuotena verrattuna miehiin, jotka olivat harrastaneet liikuntaa satunnaisesti tai eivät olleenkaan. Keski-iästä lähtien liikuntaa säännöllisesti harrastaneilla naisilla oli merkitsevästi pienempi riski laitoshoitoon kuin satunnaisesti tai ei olleenkaan liikuntaa harrastaneilla.

Tutkimus osoitti, että liikuntaneuvontainterventiolla ei ollut vaikutusta IADL toiminnanvajauteen. Sen sijaan alaryhmäanalyysit osoittivat, että niillä koeryhmään kuuluvilla henkilöillä, joilla ei ollut IADL toiminnanvajautta tutkimuksen alussa, oli merkitsevästi pienempi riski toiminnanvajauksien ilmaantumiseen intervention lopussa. IADL toiminnanvajauksista toipumiseen ei liikuntaneuvontainterventiolla ollut vaikusta. Tulokset osoittivat liikuntaneuvontaintervention vähentäneen kotihoidon käyttöä 2 vuoden intervention ja 1.5 vuoden seuruun aikana.

Tutkimuksessa todettiin, että vanhanakin aloitettu fyysinen aktiivisuus on yhteydessä toiminnanvajavuuden ilmaantumisen sekä sairaala- ja laitoshoidon käytön vähenemiseen vanhana. Tulokset viittaavat siihen, että fyysisen aktiivisuuden lisääntyminen mahdollisesti lykkäisi toiminnanvajavuuksien ilmaantumista sekä sairaala-, laitos- ja kotihoidon tarvetta myöhempään ikään. Liikuntaneuvonnan vaikutusta toiminnanvajavuuteen ja kotihoidon käyttöön on tutkittua vähän. Satunnaistettujen kontrolloitujen tutkimusten tulokset fyysisen aktiivisuuden vaikutuksesta toiminnanvajavuuteen ovat ristiriitaiset. Tehdyt interventiot viittaavat kuitenkin siihen, että toiminnanvajauden vähenemiseen suunnattujen interventioiden tulisi olla monitasoisia, suhteellisen pitkiä ja ne tulisi suunnata kohdennetulle joukolle, joka hyötyy interventiosta eniten.

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