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LEENA TIMONEN

# Group-Based Exercise Training in Mobility Impaired Older Women

Effects of an Outpatient Multi-Component Training  
Program on Physical Performance, Mood, Functional  
Abilities, and Social Welfare and Healthcare Costs  
After Acute Hospitalization

Doctoral dissertation

To be presented by permission of the Faculty of Medicine of the University of Kuopio  
for public examination in Auditorium L3, Canthia building, University of Kuopio,  
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## ABSTRACT

The present study assessed the effects of a group-based multi-component exercise program on physical performance, mood, functional abilities and municipal costs among older women after acute hospitalization in a primary health care setting. A total of 68 women (mean age 83.0, SD 3.9 years) who were admitted to a primary-care hospital due to an acute illness and were mobility impaired at admission were randomized into either group-based (N=34) or home exercise (N=34) groups. The 10-week group-based intervention, which included progressive strength training, functional exercises and guided imagery relaxation, was started after discharge from the hospital. The participants were provided with transportation and a lunch at each training session. The home exercise group only received instructions on how to perform functional exercises. The measurements included maximal isometric strength, maximal walking speed, dynamic balance (the Berg Balance Scale), mood (the Zung Self-Rating Depression Scale), and expert-assessed functional abilities (the Joensuu Classification). The measurements were performed before the start and 1 week, 3 and 9 months after the intervention. Medical records and billing files were examined for recording service use, falls and costs during the follow-up period. After the interventions, significant improvements were observed in the group-based exercise group compared to the home exercise group with respect to the isometric knee extension strength (20.8, SD 25.9% vs. 5.1, SD 16.0 %,  $p=0.009$ ), balance score (+4.4, SD 7.2 points vs. -1.3, SD 5.5 points,  $p=0.001$ ), walking speed (+0.12, SD 0.32 m/s vs. -0.05, SD 0.23 m/s,  $p=0.035$ ) and depression score (-3.1, SD 9.0 points vs. +1.3, SD 7.6 points,  $p=0.048$ ). Positive effects on muscle strength and walking speed were still apparent nine months after the intervention. The group-based intervention did not improve the level of independence in functional abilities, neither did it reduce falls or the social welfare and healthcare costs compared to the home-based intervention.

This study demonstrated that exercise classes after hospitalization can improve physical performance and mood in older women. The intervention, however, did not reduce the need for municipal services or decrease the number of falls, and thus produced no economic savings.

National Library of Medicine Classification: W 74, WA 288, WE 103, WT 141, WY 145

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*To Tero and Kristina*



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Ylämylly, April 2007

Leena Timonen

## ABBREVIATIONS

|        |  |
|--------|--|
| ACSM   | American College of Sports Medicine                                  |
| ADL    | Activities of Daily Living   |
| ANCOVA | Analysis of Covariance   |
| ANOVA  | Analysis of Variance   |
| BADL   | Basic Activities of Daily Living                                     |
| BDI    | Beck Depression Inventory  |
| BMD    | Bone Mineral Density   |
| CI     | Confidence Interval  |
| FICSIT | Frailty and Injuries: Cooperative Studies of Intervention Techniques |
| EPESE  | Established Populations for Epidemiologic Studies of the Elderly     |
| GBMC   | Group-Based Multi-Component  |
| GDS    | Geriatric Depression Scale   |
| GEE    | Generalized Estimating Equation                                      |
| HE     | Home Exercise  |
| HRSD   | Hamilton Rating Scale of Depression                                  |
| IADL   | Instrumental Activities of Daily Living                              |
| IQR    | Inter-Quartile Range   |
| IR     | Incidence Rate ratio   |
| MMSE   | Mini-Mental State Examination  |
| OR     | Odds Ratio   |
| POMA   | Performance Orientated Mobility Assessment                           |
| 1RM    | One-Repetition Maximum   |
| ROM    | Range of Motion  |
| RR     | Relative Risk  |
| SD     | Standard Deviation   |
| WMD    | Weighted Mean Difference   |
| ZSDS   | Zung Self-Rating Depression Scale                                    |



## LIST OF ORIGINAL PUBLICATIONS

- I** Timonen L, Rantanen T, Ryyänänen O-P, Taimela S, Timonen TE, Sulkava R. A randomized controlled trial of rehabilitation after hospitalization in frail older women: effects on strength, balance and mobility. *Scand J Med Sci Sports* 2002; 12: 178-92.
- II** Timonen L, Rantanen T, Timonen TE, Sulkava R. Effects of group-based exercise program on mood state of frail older women after discharge from hospital. *Int J Geriatr Psychiatry* 2002; 17: 1106-11.
- III** Timonen L, Rantanen T, Mäkinen E, Timonen TE, Törmäkangas T, Sulkava R. Effects of a group-based exercise program on functional abilities in frail older women after hospital discharge. *Aging Clin Exp Res* 2006; 18:50-6.
- IV** Timonen L, Rantanen T, Mäkinen E, Timonen TE, Törmäkangas T, Sulkava R. Economic evaluation of an exercise program for frail older women with respect to municipal social welfare and health care costs and on fall-related costs. (submitted)



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## 1. INTRODUCTION

In the next few years, the population ageing will gather pace faster, and this process will occur more quickly in Finland than in most other countries (Parjanne 2004). This changing age pyramid is a major challenge for the sustainability of public finances, since in the future a smaller working-age population will have to carry the responsibility for an increasing number of economically non-active individuals (Parjanne 2004). It is necessary for different healthcare and social welfare sectors to prepare now for the steep growth, which will occur in the older population. New strategies are needed if we are to prevent the decline in functional abilities and to postpone institutionalization of our older citizens.

Frail, home-dwelling elderly people are at increased risk of functional deterioration, institutionalization and even death following physical stress such as an acute illness (Applegate et al. 1983, Gill et al. 2004a), and preventive interventions are therefore important for this patient group. The main features of frailty are sarcopenia (loss of muscle mass) and muscular weakness, weight loss, fatigue, slowed gait speed, and low physical activity (Fried et al. 2001). The natural course of frailty is progressive, and with time it increases the risk of comorbidity and disabilities (Fried et al. 2001).

Sarcopenia is a common feature of older age, and it is associated with functional limitations such as slow walking speed and balance problems (Young 1986, Rantanen et al. 1997a), as well as falls (Luukinen et al. 1997) and disability in activities of daily living (ADL) (Hyatt et al. 1990). Women have 30 to 40% less muscle mass than men of the same age (Skelton et al. 1994, Lindle et al. 1997) placing older women at increased risk for suffering a functional decline.

Among elderly persons, the reserve in performance capacity may be so slight, that even a marginal additional decline in strength, such as immobilization during an acute illness, subsequently may render some everyday activities impossible (Young 1986, Gill et al. 2004a). However, previous studies have shown that sarcopenia can be reversed and slowed with strength training programs in healthy older adults (Sipilä and Suominen 1995, Skelton et al. 1995) and in frail nursing-home residents (Rydwik et al. 2004). Addition of other components like balance and functional exercises into the training program improves physical performance (Binder et al. 2002) and ADL and IADL (instrumental activities of daily living) functions (Gill et al. 2002), and has reduced the incidence of falls (Robertson et al. 2001a). Some studies have shown even reduced healthcare costs attributable to these programs (Robertson et al. 2001a, Rizzo et al. 1996). In the recent years, several studies have emphasized the importance of nutrition on muscle growth and strength increase after strength training interventions (Esmarck et al. 2001, Holm et al. 2005).

Depression is another major problem in old age and it is associated with somatic illnesses and disabilities (Kivelä 1994, Penninx et al. 1998), social isolation (Simonsick et al. 1998) and increased mortality (Pulska et al. 1999). Though the standard treatment for depression is antidepressant medication, the adverse side effects of antidepressant pharmacotherapy in older adults (Oslin et al. 2003), and the low compliance with such treatment (Mittman et al. 1997) reduce its usefulness in late life depression. Furthermore, even minor depressive symptoms not meeting the diagnostic criteria

for depression are associated with increased use of health services (Johnson et al. 1992, Unützer et al. 1997) and mortality (Whooley and Browner 1998, Penninx et al. 1999, Takeida et al. 1999). Since there are large numbers of older people with depression or depressive symptoms, it is important to develop also non-pharmacological treatment strategies. Several trials have indicated that both aerobic and resistance training programs can alleviate depression in clinically depressed older adults (Blumenthal et al. 1999, Singh et al. 1997, Singh et al. 2005, Sjösten and Kivelä 2006). Exercising in a group setting may provide social interactions and thus further decrease depressive symptoms (Andersson 1985, McNeil et al. 1991, Hassmén and Koivula 1997, McAuley et al. 2000b).

Rehabilitative interventions after hospitalizations are important in frail old individuals, since an acute illness and hospitalization can lead to a further decline in health and impaired functioning (Gill et al. 2004a, Boyd et al. 2005, Creditor 1993, Covinsky et al. 2003, Covertino et al. 1997). There are only a few randomized controlled exercise trials after hospitalizations among older people (Hauer et al. 2001, Morgan et al. 2004, Siebens et al. 2000, Latham et al. 2003b), although resistance training has been found to be safe, even in frail hospitalized patients during the recuperative phases of acute illnesses (Mallery et al. 2003).

Group-based exercise classes among older people have become increasingly popular during the last 10 to 15 years. However, the feasibility and effects of group-based multi-component training in a frail old population have not been studied earlier in the Finnish primary healthcare setting.

This study explores the effects of an outpatient rehabilitation program on muscle strength, walking speed, balance and mood in mobility impaired older women after hospitalization as well as attempting to assess its effects on functional abilities, falls and healthcare and social welfare costs. The rehabilitation program included multi-component exercise training, transportation to and from the session and provision of a meal.

## **2. REVIEW OF LITERATURE**

### **2.1. Concepts of frailty, comorbidity and disability**

Frailty, comorbidity (co-occurrence of apparently unrelated diseases), and disability are used to identify vulnerable older adults. These are distinct clinical entities, but they are causally related and overlapping (Fried et al. 2001).

Physical frailty is an abnormal physiological state that can extend from mild to severe stages. Frailty is thought to result from a generalized decline in multiple physiological systems with exhaustion of functional reserves and vulnerability to a range of adverse outcomes including disability (Bortz 2002). It is hypothesized that a rapid decline in the functional status may follow even minor perturbations in the physiological homeostasis of frail individuals. The definition of frailty includes the following domains: mobility problems, such as lower-extremity performance and gait abnormalities; muscle weakness; poor exercise tolerance; unstable balance; and factors related to body composition, such as weight loss, undernutrition, and sarcopenia (Ferrucci et al. 2004). Frailty is independently predictive of incident falls, worsening mobility or ADL disability, hospitalization, and death (Fried et al. 2001).

The extent of comorbidity increases progressively with age (Guralnik et al. 1989, van den Akker et al. 1998). In the Women's Health and Aging Study, there was a high frequency of chronic diseases among the study population of 3841 community-dwelling women who were 65 to 101 years of age. In that study, there was an average of three diseases per woman, only 5 % of the sample reported having none of the 14 conditions assessed, whereas many as 81% reported two to more chronic conditions (Fried et al. 1999). Comorbidity can exist alone without frailty or disability, but it increases the risk of disability (Guralnik et al. 1989, Ettinger et al. 1994, Fried et al. 1999, Wolff et al. 2005), functional limitations (Boult et al. 1994, Cuccione et al. 1994, Stuck et al. 1999) and frailty (Woods et al. 2005).

Disability has been defined by Nagi (1976) as the inability to perform socially defined activities for independent living, such as shopping, cooking and personal care. There is a causal chain in the disablement process: pathology (disease, injury) leads to impairments of organ systems (e.g. sarcopenia), which will cause functional limitations in the capacity to perform activities leading to disability in ADL/IADL functions. Examples of functional limitations include difficulty in ambulating, climbing stairs, or crouching. Disabilities, on the other hand, describe functional limitations placed in a social context. These can be difficulties in basic ADLs such as getting into and out of bed or a chair, or difficulties performing IADLs such as doing housework or shopping. Disability is associated with increased mortality (Manton 1988, Hirvensalo et al. 2000), and it leads to additional adverse outcomes, such as nursing home placement (Guralnik et al. 1994) and greater use of formal and informal home services (Kemper 1992). There are several factors which can alter the course of the disablement process either by delaying or accelerating the process.

Thus, frailty, comorbidity, functional limitations and disability are intertwined. They may appear independently, but the syndromes often overlap (Fried et al. 2001). They are also risk factors for one

another, and with time they increase the risk of progressive deterioration of functioning and health (Stuck et al. 1999). In addition, they increase the need for help, institutional care and even mortality (Kemper 1992, Guralnik et al. 1994, Hirvensalo et al. 2000). It has been claimed that interventions targeted against the dimensions related to frailty, comorbidity and functional limitations might open a gateway to reverse this progressive deterioration of functioning (Ferrucci et al. 2004).

The ability to move unassisted is one of the most important requirements for independent living at home. Loss of muscle mass and consequent weakness in the lower limb muscles represent a common cause for mobility problems (Young 1986, Rantanen et al. 2001), and are associated with a poor score in the Barthel Index (Hyatt et al. 1990) and a tendency to fall (Luukinen et al. 1997). With increasing age, the joint effects of multiple impairments, such as poor muscle strength and balance, increase further the risk of walking problems (Rantanen et al. 1999). Women have less muscle mass than men of the same age (Lindle et al. 1997) placing older women at increased risk for losing independence in daily functioning. Men are significantly better than women in most measurements of physical performance (Schroll Bjornsbo et al. 2002, Ostchega et al. 2000).

In a critical review assessing the effects of late-life physical activity on the disablement process (Keysor 2003), physical activity and exercise had a beneficial effect on minimizing functional limitations, though their benefits against disability were controversial. Although several prospective studies have revealed a protective effect of physical activity on functional limitations (LaCroix et al. 1993, Stewart et al. 1994, Berkman et al. 1993, Leveille et al. 1999, Miller et al. 2000), the majority of experimental studies that have examined disability as an outcome have not demonstrated improvements in disability (Latham et al. 2003a, Keysor and Jette 2001). However, these studies do show, that the dimensions of frailty such as muscle weakness, and slowed gait speed may be reversed (Latham et al. 2003a)

### **2.1.1 Measurements of functional limitations and disabilities**

Functional limitations and disabilities can be assessed either by using instruments based on self-report, or by using performance tests. The self-report instruments usually assess either activities of daily living (ADL or BADL) or instrumental activities of daily living (IADL). The use of an ADL/IADL scale has several advantages, e.g. no special equipment is needed, and a proxy's interview is possible when the person is not co-operative. There are also disadvantages, e.g. cognitive functions, motivation and depression can influence self-assessments and thus there may be a conflict between apparent capacity and actual talents (Bootsma-van der Wiel et al. 2001, Hoeymans et al. 1997). In addition, the ADL and IADL scales are usually coarsely graded, and thus they are often insensitive to subtle but potentially important clinical changes (Seeman et al. 1994). The ADL/IADL scales have been designed for different purposes, and according to a review, there are 113 published basic ADL or extended ADL scales (Lindeboom et al. 2003). The great number of scales reflects the fact that the most feasible measurement of functional abilities is dependent on the target group and the purpose of the evaluation. A performance measure of physical functioning may be defined as an assessment instrument in which an individual is asked to perform a specific task, and is evaluated in

an objective, standardized manner using predetermined criteria (Guralnik et al. 1989). Performance-based tests may be more accurate at identifying minor functional limitations in well functioning older people than self-report measures (Brach et al. 2002). Performance measures have been shown to be predictors of outcomes such as falls (Tinetti et al. 1988), subsequent disability (Guralnik et al. 1995), nursing home admissions and mortality (Guralnik et al. 1994). Using graded tests of performance and timing of a subject's performance may be more sensitive at detecting changes in functional abilities than ADL/IADL scales. They are, however, limited by their dependence upon the subject's motivation to perform the task. In addition, these instruments reflect performance only at a single point in time, and a subject's level of function as measured in the laboratory or office may not reflect his or her actual performance in daily life (Tinetti 1986). Cognitive capacity and depressive symptoms can influence both self-report and performance measures (Cress et al. 1995, Sinoff et al. 1997).

The relationship between self-report scales and performance-based measures of physical function is weak to moderate suggesting that these instruments are not measuring the same construct (Reuben et al. 1995, Brach et al. 2002, Simonsick et al. 2001). Combining self-reported and performance-based measures may give more accurate information on functional abilities than can be obtained with just one assessment tool (Simonsick et al. 2001, Lin et al. 2001).

### **2.1.2 Deterioration of muscle strength with increasing age**

Cross-sectional studies have shown that muscle strength usually remains unchanged until the age of 50 to 60 years (Metter et al. 1997). Instead, information from longitudinal studies indicates that maximal strength declines on average 1% annually (Rantanen et al. 1998), but a steeper decline of maximal strength does seem to be associated with increased age (Rantanen et al. 1998, Hughes et al. 2001), weight loss, depression (Rantanen et al. 2000), immobility (Rantanen et al. 1997b), and chronic conditions like stroke, diabetes, arthritis, coronary heart disease, and chronic obstructive pulmonary disease (Rantanen et al. 1998).

Loss of muscle mass is the most important factor underlying this phenomenon. Changes in muscle fibres, e.g. selective atrophy of fast-twitch (type II) fibres (Deschenes 2004, Klitgaard et al. 1990, Fiatarone Singh et al. 1999), myofibre necrosis and myofibre type grouping, as well as increased amounts of adipose and connective tissues within muscles (Lexell 1995) account for the age-related decline in muscle function. In addition to the age-related biological factors such as altered hormonal status (Iannuzzi-Sucich et al. 2002, Kamel et al. 2002, Doherty 2003) and inflammatory mediators (Cesari et al. 2004, Hämmäläinen et al. 2004), there are also life-style changes, such as decreased physical activity and decreased total caloric and protein intake, which contribute to the development of sarcopenia (Doherty 2003). Immobility is one of the most important factors in strength and muscle mass loss. Decreased occupational and leisure time activities with periods of enforced bed rest due to acute or chronic illnesses increase the risk of disuse atrophy of skeletal muscles (Bortz 1982). Atrophy of muscles accompanied with loss of strength increases the risk of falls and fractures (Rubenstein and Josephson 2002) leading to further loss of mobility and muscle mass.

Although muscle atrophy is typical in aging, the degree of atrophy varies greatly between individuals (Baumgartner et al. 1998, Iannuzzi-Sucich et al. 2002) and between different muscle groups (Lynch et al. 1999). In both sexes, the strength per muscle cross-sectional area deteriorates with increasing age (Lynch et al. 1999). In women, this deterioration may be faster in leg muscles compared to arm muscles (Lynch et al. 1999). Since women are weaker than men of the same age (Lindle et al. 1997, Frontera et al. 2000), they are at increased risk of suffering from walking problems, falling and losing functional independence (Guralnik and Simonsick 1993).

## **2.2 Possibilities of exercise training in reversing frailty, comorbidity and functional limitations**

### **2.2.1 Definitions of various types of exercise training**

Aerobic (or endurance) exercise is activity that results in increased heart rate for an extended period of time (Christmas and Andersen 2000). Aerobic exercise involves repetitive motions and uses large muscle groups, which increase core body temperature. Examples of aerobic exercise are walking, dancing, swimming and cycling (McDermott and Mernitz 2006). Aerobic training can help maintain and improve various aspects of cardiovascular function (Mazzeo et al. 1998). Resistance (or strength) training requires muscles to generate force to move or to resist a weight (McDermott and Mernitz 2006). Progressive resistance training with slow to moderate velocities of movement maintains or improves muscle mass, strength, and endurance (Kraemer et al. 2002). Power training differs from traditional resistance training by using fast-velocity movements with light to moderate loads. More power is produced when the same amount of work is completed in a shorter period of time (Kraemer et al. 2002). Leg power is associated with functional status (Foldvari et al. 2000), physical performance (Bean et al. 2002) and the incidence of falls (Chu et al. 2005). Power training is recommended for incorporation as a part of resistance training programs (Kraemer et al. 2002). Some exercise programs are aimed to improve postural stability. These programs are usually combinations of several interventions, such as balance/coordination training, aerobic exercise, and strength training, and it is not always possible to discern which component of the exercise program led to the observed changes in balance (Mazzeo et al. 1998). Typical “balance exercises” are Tai Chi exercises, stepping practices, change of direction, dance steps, catching/throwing a ball, and one-leg balancing (e.g. Barnett et al. 2003, Faber et al. 2006, Ballard et al. 2004, Campbell et al. 1997, Lord et al. 1995, Hauer et al. 2001, Wolf et al. 1996). The concept of multi-component training refers to an exercise program, which includes two or more of the above described exercise types.

### **2.2.2 Muscle hypertrophy as a response to strength training and detraining**

Skeletal muscle retains a remarkable plasticity even in nonagenarians to increase strength after resistance training exercises (Fiatarone et al. 1990, Fiatarone Singh et al. 1999). Resistance training in older men and women has been found to be associated with an increase in muscular strength

(Charette et al. 1991, Fiatarone et al. 1994, Skelton et al. 1995, Sipilä and Suominen 1995, Taaffe et al. 1999, Fatouros et al. 2005), increases in type II fiber area (Charette et al. 1991), muscle cross-sectional area (Sipilä and Suominen 1995, Wieser and Harper 2007) and reduced intramuscular fat (Sipilä and Suominen 1995, Wieser and Haber 2007).

The maintenance of the gained strength requires a continuation of the training. A return to sedentary lifestyle decreases strength and muscle mass rapidly (Trappe et al. 2002, Lemmer et al. 2000, Fatouros et al. 2005). In a small study (N= 10) by Trappe et al. (2002), resistance training at 80 % of one-repetition-maximum (1RM) three times a week for 12 weeks increased knee extension strength (45 to 53 % of 1RM,  $p < 0.05$ ) and whole quadriceps muscle size (7%,  $p < 0.05$ ) in older men (age 70, SD 4 years). In the six- month detraining period, there was a reduction of 5% in muscle size and 11% fall in muscle strength in those who resumed their normal lifestyle, but no changes in men who continued to train once a week. Fatouros et al. (2005) found that high intensity strength training (82% of 1RM) maintained strength gains for a longer period after training of 24 weeks compared to lower training intensity (55% of 1RM) training of 52 healthy but inactive men (mean age 71.2, SD 4.1).

### **2.2.2.1 Impact of nutrition in strength training**

Undernutrition is a risk factor for frailty (Woods et al. 2005) and disability (Stuck et al. 1999). Malnutrition, or “nutritional frailty” refers to the disability that occurs in old age owing to rapid, unintentional loss of body weight and a decline in lean body mass (Bales and Richie 2002). Since muscle mass represents the protein reserve of the body, sarcopenia diminishes the capacity to meet the extra demand for protein synthesis such as that needed in response to disease and injury in old age (Bozzetti 2003). An “empty refrigerator” is a good predictor for future hospitalization of a geriatric patient (Boumendjel et al. 2000).

Strength training stimulates muscle protein synthesis, which is required for muscle hypertrophy, and an intake of protein after exercising has a synergistic effect (Dorrens and Rennie 2003). The increase of protein synthesis after strength training becomes reduced with time elapsing between the protein supplementation and the exercise session (Phillips et al. 1997). It seems therefore preferable to have an early intake of protein soon after training. Interventions with combinations of strength training and a protein-energy supplement soon after training have been successful in increasing strength and muscle mass in healthy older men (Esmarck et al. 2001) and post-menopausal women (Holm et al. 2005). In the study of Rosendahl et al. (2006) among older ADL-dependent people in residential care, immediate intake of protein-enriched energy supplement did not, however, augment the gains in walking speed, balance, and lower-limb strength achieved after an exercise program of 13 weeks. This program included individually tailored functional exercises of postural stability, leg strength and gait ability. In two earlier studies (Fiatarone et al. 1994, Bonnefoy et al. 2003) in frail older people living in retirement and nursing homes, the combination of strength training and protein-energy supplement also did not show any interaction effects on physical function. In these studies, the supplement was not taken directly in connection with the exercise session.

### 2.2.3 Benefits of strength training on prevention and treatment of chronic diseases

In older persons, most functional tasks used in normal day-to-day activities are of relatively short duration and therefore are not related to aerobic capacity, but are related to muscular strength or power (Rantanen and Avela 1997a, Rantanen et al. 1996). Earlier studies have also shown that increases in strength after resistance training are related to increased time to exhaustion in endurance activities, even though little or no increase in aerobic capacity had been detected after the training periods (Frontera et al. 1990, Parker et al. 1996). One explanation for the relationship between strength and endurance is that less muscle activation would be needed to perform a task when a muscle is stronger, hence delaying fatigue (Frontera et al. 1990). In addition, if myofibres are larger and therefore capable of greater tension development on activation, more work can be accomplished by low-threshold, efficient fatigue-resistant type I motor units, decreasing the need to activate the less efficient fatigable type II motor units (Hunter et al. 2001). Mild- to moderate strength training can provide an effective method for improving muscular strength and endurance and thus decreasing myocardial demands during daily activities even in patients with cardiovascular disease (Pollock et al. 2000). The age-related decrease in muscle mass and physical activity level decrease total energy expenditure (Hunter et al. 2001). The reduction in overall energy expenditure results in an increased prevalence of obesity and abdominal fat accumulation increasing the risk for insulin resistance (Taniguchi et al. 2002, Poirier et al. 2005). Insulin resistance contributes to the development of type 2 diabetes, hyperlipidemia, and hypertension in a genetically susceptible population (Fujiwara et al. 2005, Fonseca 2005). The combined effect of these metabolic abnormalities increases the risk of cardiovascular death and other morbidities (Nair 2005). A number of studies have shown that strength training increases resting energy expenditure, at least if the training is intense enough to induce a measurable increase in fat-free mass (Campbell et al. 1994, Treuth et al. 1995b). Strength training can improve glucose tolerance and insulin sensitivity in non-diabetic (Ryan et al. 1996) and diabetic subjects (Ibañez et al. 2005, Dunstan et al. 2002) and reduces the amount of intra-abdominal adipose tissue (Treuth et al. 1995a). Exercise interventions aimed at high-intensity progressive strength training have found increases in hip and spine bone mineral density (BMD) (Kerr et al. 2001, Cussler et al. 2003). Moderate-intensity strength training has not been found to generate the same increases in hip BMD as high-intensity training (Kerr et al. 2001, Kerr et al. 1996). Low BMD, reduced physical activity, poor muscle strength and balance increase the risk for fractures in old age (Cummings et al. 1995). Strength training has been proposed as potentially one of the most effective means of reducing falls and fracture incidence because of its beneficial effects of multiple risk factors for fracture (Nelson et al. 1994). Strength training has been found to reduce pain and improve function in older patients with knee osteoarthritis (Baker et al. 2001, Ettinger et al. 1997) and alleviate depression in depressed elders (Singh et al. 2005). Strength training has been claimed to yield larger improvements in health-related quality of life measures than endurance training in patients with chronic obstructive pulmonary diseases (Puhan et al. 2005).

#### **2.2.4. Benefits of strength training on reversing frailty and functional limitations**

Sarcopenia is one of the main features of physical frailty (Mühlberg and Sieber 2004, Ferrucci et al. 2004) increasing the risk of mobility problems (Young 1986, Rantanen et al. 1994) and ADL disabilities (Hyatt et al. 1990). Sarcopenia can be reversed with progressive strength training exercise, and several studies have indicated that strength training alone or in combination with aerobic or balance exercises can improve general physical performance and functioning, and decrease the risk of falls (Table 1).

##### **2.2.4.1 Differences between group-based and home-based training programs**

Most of the multi-component or strength-only exercise interventions among home-dwelling older adults have used either home-based (Campbell et al. 1997, Campbell et al. 2005, Chandler et al. 1998, Clemson et al. 2004, Gill et al. 2002, Jette et al. 1999, Latham et al. 2003b, Nelson et al. 2004, Robertson et al. 2001a, Robertson et al. 2001c, Siebens et al. 2000, Tinetti et al. 1994, Tinetti et al. 1999) or group-based (Buchner et al. 1997) programs with usual care/information/waiting list control groups (Table 1). There are two group-based intervention studies with a control group receiving group-based placebo/stretching activities (Hauer et al. 2001, Liu-Ambrose et al. 2004), and two studies with home exercise control groups (Binder et al. 2002, Binder et al. 2004). Six studies combined group- and home-based training in their intervention programs (Barnett et al. 2003, Day et al. 2002, King et al. 2002, Skelton et al. 1995, Helbostad et al. 2004a, the LIFE Study Investigators 2006).

In the study of Binder et al. (2002), the motivation towards the training was better in the home exercise group compared to the class-based intervention group: the home exercise participants completed the required amount of exercise sessions significantly earlier than the participants in the group-based intervention ( $350 \pm 65$  days vs.  $422 \pm 80$  days,  $p = 0.001$ ). A similar trend was observed in another study by Binder et al. (2004), and furthermore, those home exercise subjects who completed the study, performed the exercises more often than required in the research protocol. In both studies, the group-based interventions were, however, superior at improving strength, balance, walking speed and functional performance.

In a Cochrane database review comparing home-based to center-based training programs in older adults with peripheral vascular disease, chronic obstructive pulmonary disease and osteoarthritis, center-based programs were better in physiological measures in the short-term, but home-based programs appeared to be superior to center-based programs in terms of adherence to the exercise regime, especially in the long-term (Ashworth et al. 2005).

In many exercise programs, however, the exercise classes are more akin to unorganized aggregates than to true groups, and no or only minimal attempts have been made to increase group cohesion and social support, which are positively associated with attendance in exercise programs (Estabrooks and Carron 1999, Fraser and Spink 2002). The use of group meetings has been successful in alleviating feelings of loneliness and lack of purpose and enhancing social contacts and self-

esteem among older women (Andersson 1985). Social relations in exercise groups are also related to increases in satisfaction with life and a reduction in loneliness (McAuley 2000b). Attention to psychological aspects such as self-efficacy may be motivating for older adults to adherence to exercise by creating a more meaningful physical activity experience for these individuals (Katula et al. 2006).

Class-based high-intensity strength training interventions have usually shorter durations than home-based interventions, probably because the improvements in strength can be achieved after only 8 to 12 weeks of training (Latham et al. 2004). Home exercise interventions are usually long-lasting; eight of the home exercise programs listed in Table 1 have durations of at least 6 months and only three of the programs last 10 weeks or less. Long-term maintenance in an exercise program may be useful especially in reducing the incidence of falls (Campbell et al. 1999).

Most home-based exercise programs have used free weights or resistive tubes for strength exercises (e.g. Campbell et al. 1997, Jette et al. 1999, Nelson et al. 2004). However, the use of weight machines allows for a greater intensity of training (Kraemer et al. 2002), which ensures greater increases in strength (Seynnes et al. 2004, Kalapotharakos et al. 2004) and muscle hypertrophy (Fry 2004), and may even alleviate depression (Singh et al. 2005).

#### **2.2.4.2 Differences between strength-only and multi-component training**

Several studies have demonstrated the benefits from both multi-component and strength-only interventions on strength and physical performance in older adults (Table 1). These studies have included both healthy older subjects (e.g. Day et al. 2002, Skelton et al. 1995) and frail people with multiple diseases and functional limitations (e.g. Hauer et al. 2001, Binder et al. 2002, Brochu et al. 2002, Barnett et al. 2003).

The magnitude of strength improvements are similar after either multi-component or strength-only interventions if the training intensity is similar, e.g. improvements in maximal isometric knee extension strength after multi-component or strength-only interventions have varied from 12 to 27 % (de Vreede et al. 2005, Skelton et al. 1995, Sipilä et al. 1996, Buchner et al. 1997, Lord et al. 1995, Day et al. 2002).

Multi-component interventions including both strength and balance exercises produce improvements in balance (Barnett et al. 2003, Binder et al. 2002, Day et al. 2002, Hauer et al. 2001, Lord et al. 1995, Nelson et al. 2004, Binder et al. 2004, Campbell et al. 1997, King et al. 2002), while those programs with strength-only exercises usually fail to improve balance (Brochu et al. 2002, Buchner et al. 1997, Skelton et al. 1995). Some studies including measurements of walking speed in the protocols have demonstrated significant improvements in gait speed (Binder et al. 2004, Hauer et al. 2001 Sipilä et al. 1996), while in other studies no significant improvements could be detected (Barnett et al. 2003, Buchner et al. 1997, Nelson et al. 2004, Singh et al. 1997).

The programs designed to concentrate on just one component of physical fitness have usually been successful in improving that narrow sector (de Vreede et al. 2005, Skelton et al. 1995, Taaffe et al. 1999). The magnitude of improvements in multi-component programs are less distinct, but those

programs produce benefits in several domains of physical fitness (Hauer et al. 2001, Lord et al. 1995, Binder et al. 2002), some of them even improve functional abilities (King et al. 2002, Nelson et al. 2004, Penninx et al. 2001, Siebens et al. 2000, the LIFE Study Investigators 2006) or reduce the numbers of falls (Barnett et al. 2003, Buchner et al. 1997, Campbell et al. 1997, Tinetti et al. 1994). Since muscle strength improvements can be achieved after 10 to 12 weeks of intensive strength training, interventions using strength-only programs are relatively short-lasting. In the review by Latham et al. (2004), the average duration of strength-only intervention among adults aged 75 or more was 12 weeks (range 2 to 26 weeks). The average duration of multi-component interventions listed in Table 1 is 8 months (range 7 weeks to 18 months).

### **2.2.5 Studies of the effects of strength-only and multi-component interventions on functional limitations and ADL/IADL skills**

Several exercise interventions have included an assessment of functional limitations or ADL/IADL skills as one of the outcome measures (Table 1). Functional limitations have been assessed using performance-based tests (de Vreede et al. 2005, Taaffe et al. 1999, Skelton et al. 1995, Nelson et al. 2004, the LIFE Study Investigators 2006) and ADL/IADL skills have been assessed using scales based on self-reporting of disabilities (Gill et al. 2002, Buchner et al. 1997, Tinetti et al. 1999, Jette et al. 1999, Latham et al. 2003b, Penninx et al. 2001). Some studies have used both performance tests and self-assessment of ADL/IADL disabilities (Barnett et al. 2002, Binder et al. 2004, Binder et al. 2002, Brochu et al. 2002, Gill et al. 2004b, Hauer et al. 2001, King et al. 2002, Siebens et al. 2000).

Performance tests seem to be more sensitive than ADL/IADL scales at detecting improvements even in healthy high-functioning individuals after exercise interventions (e.g. Taaffe et al. 1999, Skelton et al. 1995). Questionnaires of disability based on self-report seem to be less sensitive at finding changes, even when performance tests have detected significant changes in functional status (e.g. Brochu et al. 2002, King et al. 2002, Hauer et al. 2001). This contradictory result may reflect the fact that these tests measure different aspects of functional abilities. Another explanation may be that exercise interventions may not be comprehensive in terms of disability rehabilitation, or that the exercise studies are not powered at detecting changes in categorical variables.

The exercise trials which have been successful in improving ADL/IADL skills (Binder et al. 2002, Binder et al. 2004, Gill et al. 2002, Gill et al. 2004b, Jette et al. 1999, Penninx et al. 2001, the LIFE Study Investigators 2006) are long-lasting (6 to 18 months) and with an intensity of training sufficient to improve strength and physical performance (Binder et al. 2002, Binder et al. 2004, Jette et al. 1999, Gill et al. 2004b, the LIFE Study Investigators 2006).

The LIFE-P study (the LIFE Study Investigators 2006) was a multi-center trial of a physical activity intervention compared to a successful aging intervention in sedentary older adults. The mean age of the 424 participants was 76.8 (SD 4.2) years. The physical activity intervention consisted of a combination of aerobic, strength, balance, and flexibility exercises. For the first 2 months, three center-based exercise sessions per week were conducted in a supervised setting. During the next

4 months, the number of center-based session was reduced to 2/week and home-based endurance/strengthening/ flexibility exercises were started. The subsequent maintenance phase consisted of the home intervention, optional once-to-twice-per week center-based sessions, and monthly telephone contacts. For the first 10 weeks, the intervention included weekly group-based behavioral counseling sessions that focused on the benefits of participations in physical activity and disability prevention. The intervention focused on walking as the primary mode for exercise. The physical activity intervention improved physical performance as measured with the Short Physical Performance Battery (Guralnik et al. 1994). The intervention group had also a lower incidence of major mobility disability as defined as the inability to complete a 400-meter walk.

Gill et al. (2002 and 2004b) conducted a multi-factorial intervention among 188 physical frail persons (mean age 83 years). The home-based intervention included physical therapy and focused on improving underlying impairments in physical abilities, including balance, strength, ability to transfer, and mobility. The intervention included 16 home visits over a six-month period. After the intervention, the participants in the intervention group suffered a less extensive decline in ADL and IADL over time than participants in the educational control group.

Some exercise intervention studies after hospitalizations in older adults have included an assessment of functional status as an outcome measure. Hauer et al. (2001) conducted a study among older women (aged 82, SD 4.8 years) who were admitted to acute care or inpatient rehabilitation with a history of recurrent or injurious falls. The 3-month multi-component program started after discharge from the hospital and included progressive strength training, balance, and basic function exercises. The patients in the intervention group achieved improved balance, strength and functional motor performance as measured with chair rise, maximal step height, stair flight, gait speed and the Performance Orientated Mobility Assessment (POMA, Tinetti 1986). The training program did not, however, improve functional abilities measured with ADL and IADL scales. Improved physical performance does not necessarily lead to increased independence in daily activities. Other factors, such as housing circumstances or motivations, influence the extent to which the improved physical abilities are used in everyday life.

Siebens et al. (2000) conducted an intervention study among older (mean age 78.2, SD 5.6 years) acutely hospitalized adults. The intervention group started an exercise program while still hospitalized and continued it at home for one month after discharge. The exercise program included 12 exercises for flexibility and strengthening, and a walking program. The program did not shorten the length of stay, but it did improve IADL skills at one month after discharge.

Tinetti et al. (1999) used a home-based intervention program, which included both instructions for safer gait and environmental modifications together with balance and strength exercises. The research subjects were old (mean age 80.5, SD 7.0 years) hip fracture patients. The 12-month intervention program did not result in any improvements in the basic ADL skills. The authors hypothesized that the reasons for the negative outcome could have been the reluctance of many participants to engage in home management due to concerns about safety of doing housekeeping tasks, and even worry that they might lose their home helps if they became more independent.

Binder et al. (2004) conducted a study among 90 community-dwelling hip fracture patients aged 65 or more who had undergone surgical repair of a proximal femur fracture no more than 16 weeks previously and had completed standard physical therapy. The first 3 months of the intervention included flexibility, balance and, to some extent, strength exercises. After the initial phase, progressive high-intensity strength training was added for an additional 3 months. After 6 months of exercise training, the intervention group exhibited greater increases than the home exercise controls in performance-based and self-report measures of functional abilities.

### **2.2.6 Contraindications and risks of strength training**

In general, frailty or extreme age is not a contraindication to exercise. Acute illnesses, particularly febrile illnesses, unstable chest pain, uncontrolled diabetes and hypertension and congestive heart failure may warrant investigation before a new regimen is initiated. A small number of untreatable or serious conditions, including inoperable enlarging aortic aneurysm, malignant ventricular arrhythmia related to exertion, severe stenotic or regurgitant valvular disease, hypertrophic cardiomyopathy end stage congestive heart failure, and severe behavioral agitation, are absolute contra-indications to vigorous exercise (Mazzeo et al. 1998, Pollock et al. 2000). The information about adverse events in exercise studies is probably poorly collected and underreported (Latham et al. 2004). In a systematic review of the effects of strength training interventions, only 30 of the 64 studies made any comment about adverse events (Latham et al. 2004). Most adverse events were musculoskeletal problems; there were no reports of cardiac events or death associated with strength training. However, a study by Kallinen et al. (2002) indicated that severe cardio- or cerebrovascular health problems can occur during an exercise period in spite of medical screening of heart conditions and supervised training. Muscle soreness lasting up to a few days and slight fatigue are normal after strength training exercises. For patients who have joint pain or discomfort or have a limited range of motion (ROM), weight machines can be double pinned to restrict their ROM. This allows patients to exercise through a pain-free part of their ROM and still attain a significant training effect (Mazzeo et al. 1998).

### **2.2.7 Current recommendations for a strength training program intended for older people**

Evidence that strength training is of benefit to older people has accumulated over the last few years (Latham et al. 2004, Rydwick et al. 2004). Individual variations, such as genetic predisposition, fitness level, age and gender, may influence the optimal training design (Hunter et al. 2004). Based on research findings, there are general guidelines for prescription of strength exercises for older people (Hunter et al. 2004). The loading intensity to promote hypertrophy should be 60 to 80 % of 1RM with a volume of 2 to 4 sets of 8 to 15 repetitions per exercise. Each muscle group should be exercised 2 to 3 days per week for 8 to 12 weeks (Frontera et al. 1988, Charette et al. 1991, Fiatarone et al. 1994, Trappe et al. 2002). For muscle power production, low to moderate intensity (20 to 50% of 1RM), high velocity contractions are recommended (de Vos et al. 2005, Earles et al. 2001).

Although most of the strength training programs have used three weekly training sessions, there is evidence that exercise programs with fewer than three sessions per week are sufficient to increase muscle strength in older people (Taaffe et al. 1999, Difrancisco-Donoghue 2006, Galvao and Taaffe 2005, Harris et al. 2004, Wieser et al. 2007).

Training on weight machines has advantages compared with training with free weights or tubes. Weight machines have been regarded as safe to use and easy to learn, and allow the performance of some exercises that may be difficult with free weights, e.g. leg extension (Kraemer et al. 2002). Machines help stabilize the body and limit movements around specific joints, e.g. patients with osteoarthritis can use training equipment and workloads can be increased easier allowing greater intensity of training (Kraemer et al. 2002). To achieve a training effect, it is necessary to expose the individual to an overload and increase the intensity of training (McArdle et al. 1996), and especially among healthier adults, it may be difficult to achieve sufficiently high resistance with free weights.

The American College of Sports Medicine (ACSM) has issued recommendations for resistance training in healthy older adults (Kraemer et al. 2002, Mazzeo et al. 1998). These recommendations suggest that training programs should include variations, gradual progressive overload, specificity, and careful attentions to recovery. The ACSM recommends both multiple- and single-joint exercises with slow to moderate lifting velocity including all six muscle groups (chest, shoulders, arms, back, abdomen and legs) in each exercise session (Mazzeo et al. 1998). There are also safety factors why machines are recommended over free weights (Kraemer et al. 2002). Balance training should be incorporated as a part of strength training or as a separate modality to decrease the risk for falls (Mazzeo et al. 1998). Aerobic training should follow strength and balance training whenever possible. A program including six muscle groups and balance exercises may, however, be too strenuous for the oldest and frailest individuals. Since poor leg muscle strength is associated with mobility impairments (Rantanen et al. 2001), it would seem advisable to concentrate on lower limb exercises if whole body training seems to be too exhausting.

There is already an abundance of evidence of safety and benefits of strength training even among older individuals with chronic diseases, and several recommendations have included strength training as a part of well-rounded exercise programs. The American Heart Association recommends strength training for low-risk cardiac patients (Pollock et al. 2000) and the ACSM recommends strength training for persons with type 2 diabetes (Albright et al. 2000) and for preventing osteoporosis and fractures in the aged population (Kohrt et al. 2004).

### **2.3 Depression and physical activity in old age**

Depression is a major health problem in the elderly. The estimates of the prevalence of depression vary widely in elderly populations. In the EURODEP-study with nine European centers, the prevalence of depression among people aged 65 years and over varied from 8.8% (Iceland) to 23.6 % (Munich) (Copeland et al. 2004). In a study of the Finnish non-demented population aged 85 years and older, the prevalence of major depression was 8.1 % in men and 4.9% in women, and that

of minor depression was 18.9 % in men and 18.5 % in women (Päivärinta et al. 1999). In another Finnish study among a community-dwelling 80-year old population, the prevalence of noteworthy depressive symptoms was 37.1 % for men and 44.1 % for women (Laukkanen et al. 1994).

Poor physical health and especially functional disabilities increase the risk of late-life depression (Braam et al. 2005, Päivärinta et al. 1999, Lampinen and Heikkinen 2003) and, on the other hand, depressive mood has been shown to be an independent risk factor for functional and physiological decline predisposing an individual to disability (Penninx et al. 1999, Rantanen et al. 2000, Kivelä and Pahkala 2001). Depressive mood is often considered as a normal reaction to physical illnesses and social and economical problems, and depression often remains undetected and untreated (Jackson and Baldwin 1993, Laukkanen et al. 1992). Particularly in older mobility impaired people, social isolation may lead to a depressed mood (Simonsick et al. 1998) as well as feelings of loneliness (Green et al. 1992). Several cross-sectional (Kivelä and Pahkala 2001, Ruuskanen and Ruoppila 1995, Kritz-Silverstein et al. 2001, Galper et al. 2006) and longitudinal studies (Strawbidge et al. 2002, Lampinen et al. 2006) have clearly established the association of physical exercise with mood and quality of life even in an older population. In fact, the association of exercise with emotional well-being may be greater in the elderly compared to younger people (Ransford and Palisi 1996).

Exercise is claimed to improve mood through multiple biological mechanisms, such as increased brain norepinephrine turnover (Chaouloff 1989, Dishman et al. 1997) and activation of central and peripheral opioid systems (Thoren et al. 1990). There are also several psychological hypotheses to explain the mechanism of improved mood after physical exercise. One postulated mechanism is the distraction hypothesis, which suggests that diversion from unpleasant stimuli or painful somatic complaints leads to improved affect following exercise sessions (Morgan et al. 1985). Another possible mechanism is the self-efficacy theory (Bandura 1977): confidence in one's ability to exercise is strongly related to one's actual ability to perform the behavior. Since exercise represents a challenging task for sedentary individuals, successfully adopting regular physical activity may produce improved mood, increased self-confidence and enhanced ability to handle events that challenge the individual's mental health (Gauvin and Spence 1996, McAuley et al. 1995a, Motl et al. 2005). Improved self-efficacy increases the probability of long-term commitment to an exercise program (McAuley et al. 1993). Finally, social interactions during exercise sessions are related to increases with satisfaction with life and a reduction in loneliness (McAuley et al. 2000b).

### **2.3.1 Guided imagery and relaxation techniques**

Guided imagery, a mind-body relaxation technique, is a cognitive, behavioral technique that allows individuals to exert active control over their focus of attention (Watanabe et al. 2005). Guided imagery may be achieved through prompting by a live practitioner, via an audiotape, or simply by self-prompting. Guided imagery has been used to alleviate anxiety in patients with cancer (Sloman 2002), cardiac disease (Tsai 2004), and multiple sclerosis (Maguire 1996). There is evidence that guided imagery is useful in managing stress (Watanabe et al. 2005), and depression (McKinney et al. 1997, Gruzelier 2002), as well as reducing pain (Fors et al. 2002, Syrjala et al. 1995) and the

side effects of chemotherapy (Roffe et al. 2005). The studies of the effects of guided imagery and relaxation have included only young or middle aged adults. There seems to be only one exercise study among older adults that has used guided imagery and relaxation as a part of the training program (Lord et al. 1995). In that study, the 5 to 10- minute cool down period consisted of muscle relaxation, controlled breathing and guided imagery. In most studies using strength-only or multi-component training programs, the cool-down period has included only stretching exercises (e.g. Sipilä and Suominen 1995, Taaffe et al. 1999, Hauer et al. 2001, Barnett et al. 2003, de Vreede et al. 2005, Singh et al. 2005).

### **2.3.2 Strength-only and multi-component interventions in improving mood in older adults.**

Experimental studies about the effects of various forms of exercise on mood among older people have mainly focused on aerobic interventions or “young-old” populations (Blumenthal et al. 1999, Babyak et al. 2000, McNeil et al. 1991, Chou et al. 2004, Emery and Gatz 1990, McMurdo and Burnett 1992, Penninx et al. 2002), and there are only a few strength-only or multi-component interventions among older population aged 70 or more (Table 2). Meta-analyses of the benefits of physical exercise have indicated that both aerobic and resistance training are associated with elevation of mood state, particularly in clinical samples (Arent et al. 2000, Scully et al. 1998, Paluska and Schwenk 2000, Sjösten and Kivelä 2006, Salmon 2001, Lawlor and Hopker 2001, Rejeski and Mihalko 2001).

Singh et al. (1997) conducted a study of the effects of high-intensity progressive strength training on the mood of older adults (mean age 71.3, SD 1.2 years) with unipolar major or minor depression or dysthymia. After 10 weeks of training three days per week, the intervention subjects had significantly decreased scores in the Beck Depression Inventory (BDI, Beck 1961) and Hamilton rating scale of depression (HRSD, Hamilton 1967). Intensity of training was a significant independent predictor of a decrease in the depression scores. In a later study by Singh et al. (2005), the intensity of training and strength gain after 8 weeks of resistance training were directly associated with a reduction in depressive symptoms. Progressive high-intensity training (80% of 1RM) with 8 repetitions in 3 sets improved mood more than non-progressive low intensity (20% of 1RM) training with the same number of repetitions and sets, or usual care by a general practitioner.

In a meta-analysis evaluating 32 studies (Arent et al. 2000) of the effects of exercise on mood in older adults, the global mood improvement in experimental-versus-control studies was 0.34 of the standard deviation. The greatest improvements in mood were observed in those trials which used resistance training procedures (0.80 of a SD) when compared to endurance training (0.26) or mixed type (resistance + endurance) training (0.37). Contrary to the studies of Singh et al. (1997 and 2005), in this meta-analysis, the greatest improvements in mood were associated with the low- to medium intensity of exercise, fewer than 3 days per week, exercise done more than 45 minutes or based on the participant’s needs.

Tsutsumi et al. (1997) conducted a study to explore the effects of high- and low-intensity resistance training on physical fitness and mood. This study was included to the previously

mentioned meta-analysis by Arent et al. (2000). The research subjects, 9 men and 36 women, were recruited through advertisements. The mean age was 68.8, SD 5.7 years (range 61 to 86), and they were medically healthy but physically sedentary. The subjects were randomized to high intensity strength training (n=14), low intensity strength training (n=14) and no-exercise control (n=14) groups. The subjects in the training groups attended 3 supervised strength training sessions each week for 12 weeks using dynamic variable resistance weight machines on major muscle groups of upper and lower limbs and trunk. The high intensity group performed 75 to 80 % of 1RM with 8 to 12 repetitions and the low intensity group did 55 to 65% of 1RM with 12 to 16 repetitions in 2 sets. The loads were increased every 4 to 6 sessions to maintain the appropriate training load. Arm and leg dynamic muscle strength improved significantly in both training groups compared to the controls. Training resulted in a significant reduction in tension and vigor in the self-reported mood state. Physical self-efficacy improved in the training groups. In this trial, improvement in mood was not associated with the intensity of the training program. In addition to mood improvement, the training regimens were similar in improving strength and physical performance, too. Contrary to the trial of Singh et al. (2005), in this trial, the training intensity in the low-intensity group was higher, the training loads were increased progressively, and that the number of repetitions was adjusted to the training loads.

In a study by Perrig-Chiello et al. (1998) with 46 older (mean age 73 years) adults, once a week resistance training intervention for eight weeks significantly increased maximum dynamic strength, which was associated with a significant decrease in self-attentiveness and anxiety. A more detailed training program of this intervention has not been published. Chin A Paw et al. (2004) did not detect any improvements in the quality of life, vitality or depression of older people living in long-term care facilities after 6 months of strength training or all-round functional training compared to educational control group. In fact, the group with combination of strength and functional training had lower scores for quality of life and vitality than they had had at baseline.

In an intervention study using strength-only exercises among elderly women (mean age 70.5) with coronary heart disease, improvement of mood, as assessed with the Geriatric Depression Scale (GDS, Yesavage et al. 1983), was found in both strength training and control group with stretching and calisthenics program, but there were no differences between the two groups (Brochu et al. 2002).

There are three multi-component exercise studies, which have included mood assessments to their measurement protocols. Nelson et al. (2004) found no differences between the home-based exercise and control groups in mood measured with the GDS (Yesavage et al. 1983). It is possible, that the low intensity of training and lack of social interactions with other trainees were the reasons for the unimproved mood. In the study of Hauer et al. (2001), no differences were found between the intervention and control groups in mood measured with the GDS (Yesavage et al. 1983), but the subjects in the intervention group had significantly reduced scores compared to the control group in Falls Handicap Inventory (FHI), a scale which measures post-traumatic fall-related emotional instability and behavioral changes (Rai et al. 1995). Helbostad et al. (2004b) compared two exercise regimens on health-related quality of life among frail community-dwelling people (N=77) aged 75

years or more. The home exercise (HE) intervention consisted of twice daily functional balance and strength exercises and three group meetings in the 12 weeks intervention period. The combined training (CT) intervention included group training twice weekly and the same home exercises. The CT group had an improved mental index in the SF-36 health survey (Ware 1993) after the training, and there was a significant difference between the groups after 6 months. The authors postulated that participating in a training program outside of the home offered the CT group subjects social contacts and a sense of belonging, which may have improved their mood.

The exercise studies aimed at improving mood of home-dwelling older adults have usually included somatically healthy “young-old” people aged less than 75 years. There is only one earlier study after hospitalizations in frail old people (Hauer et al. 2001). Acute illnesses and hospitalizations have been reported to increase the risk of depression (Jackson et al. 1993, Livingston et al. 2000, Aben et al. 2003), and interventions aimed at improving the mood state after acute illnesses are therefore important.

#### **2.4 Muscle strength and falls in old age**

Around 30 to 40 % of community-dwelling adults older than 70 years will fall each year (Tinetti et al. 1988, Campbell et al. 1989), and about one fourth of those who fall suffer serious injuries (Tinetti et al. 1988). The incidence of falls goes up with increasing age (Campbell et al. 1989), and especially institutionalized people are at increased risk of falling (Rubenstein et al. 1988). Environmental hazards are the leading cause of falls in community-dwelling older adults, accounting for about one third of cases in most studies. Gait and balance disorders or muscular weakness are the second leading cause, accounting for about 20 % of the cases (Rubenstein and Josephson 2002). Other common causes for falls are past history of stroke and falls, postural hypotension, leg weakness, visual disorders, use of sedatives, and daily use of more than four drugs (Tinetti et al. 1988, Campbell et al. 1989, Nevitt et al. 1989, Rubenstein and Josephson 2002, Swift 2006). Among a cohort of community-dwelling older adults, the risk of falling increased from 8 % for persons with no risk factors to 78 % for those with four or more risk factors (Tinetti et al. 1988). Although lower extremity strength is associated with impaired gait function and poor balance (Wolfson et al. 1995), it is also an independent risk factor for falls (Campbell et al. 1989). In a meta-analysis of studies of accidental falls (Moreland et al. 2004), lower extremity muscle weakness was found to be a significant risk factor for any fall (OR 1.76, 95% CI 1.31-2.37) and for recurrent falls (OR 3.06, 95% CI 1.86-5.04). The impact of muscular weakness on the risk of falls has been shown to be especially distinct in nursing home residents (Wolfson et al. 1995, Sieri and Beretta 2004). In the study of Wolfson et al. (1995), nursing home residents with a history of falls had less than half of the knee and ankle strength of the non-falling subjects residing in the same home. In community-dwelling older adults, additional factors other than muscular weakness seem to be more important (Luukinen et al. 1997, Tinetti et al. 1988).

#### 2.4.1 Exercise interventions for decreasing falls in home-dwelling older persons

The randomized trials designed to reduce falls have used several interventions: home hazard assessment and reduction (Salkeld et al. 2000, Stevens et al. 2001, Nikolaus and Bach 2003), different exercise training methods, such as strength training combined with vitamin D treatment (Latham et al. 2003b), balance training (Steadman et al. 2003, Wolf et al. 1996), or combination of balance, endurance and strength training (Rubenstein et al. 2000, Barnett et al. 2003, Hauer et al. 2001, Lord et al. 1995, Buchner et al. 1997, Campbell et al. 1997, Robertson et al. 2001a, Robertson et al. 2001c), and multi-factorial interventions including actions such as exercise training, home hazard reduction, medication and behavioral modifications, and vision improvement (Steinberg et al. 2000, Close et al. 1999, Tinetti et al. 1994, Clemson et al. 2004, Day et al. 2002, Gill et al. 2002, Campbell et al. 2005). Some of the studies are listed in Table 1.

Some studies, which have been successful in improving physical performance, have not reduced the risk of falls (Lord et al. 1995, Province et al. 1995, Ballard et al. 2004). It is possible, that improved physical performance alone is not enough to prevent falls in physically frail patients. A preplanned meta-analysis of the seven exercise trials among old people (FICSIT) assessed the intervention efficacy in reducing falls (Province et al. 1995). In 3 of the 7 trials, the risk of falls was non-significantly increased in spite of beneficial effects on strength and physical performance (Buchner et al. 1993, Mulrow et al. 1994, Fiatarone et al. 1994). These trials included a combination of strength, balance, flexibility and endurance training (Mulrow et al. 1994, Buchner et al. 1993) or progressive resistance training with or without nutritional supplements (Fiatarone et al. 1994). Commonly used exercise intervention programs may not be effective in certain population groups, such as those with dementia (Shaw et al. 2003), severe visual impairment (Campbell et al. 2005), too frail (Latham et al. 2003b, Faber et al. 2006), or too fit (Lord et al. 1995). In a frail population, exercise interventions may even increase the risk of falls (Faber et al. 2006) and musculoskeletal injury (Latham et al. 2003b). According to a Cochrane review (Gillespie et al. 2003) of interventions for preventing falls in elderly people, the interventions likely to be beneficial are multidisciplinary, multifactorial, health/environmental risk factor screening/intervention programs in the community both for unselected populations of older people (pooled RR 0.73, 95% CI 0.63 to 0.85), and for older people with a history of falling or selected because of known risk factors (pooled RR 0.86, 95% CI 0.76 to 0.98) or those living in residential care facilities (cluster-adjusted incidence rate ratio 0.60, 95% CI 0.50 to 0.73). Other interventions that are beneficial in preventing falls include programs of muscle strengthening and balance retraining, individually prescribed at home by a trained health professional (pooled RR 0.80, 95% CI 0.66 to 0.98), home hazard assessment and modification for older people with a history of falling (pooled RR 0.66, 95% CI 0.54 to 0.81), withdrawal of psychotropic medication (relative hazard 0.34, 95% CI 0.16 to 0.74), cardiac pacing for individuals falling because of cardio-inhibitory carotid sinus hypersensitivity (WMD -5.20, 95% CI -9.40 to -1.00), and a 15-week Tai Chi group exercise intervention (risk ratio 0.51, 95% CI 0.36 to 0.73). In another meta-analysis of 40 intervention trials for the prevention of falls in older adults, multi-factorial fall risk assessment and management programs (RR 0.82, 95% CI 0.72 to

0.94) and exercise interventions (RR 0.86, 95% CI 0.75 to 0.99) had a beneficial effect on the risk of falling, whereas no clear evidence was found for the independent effectiveness of environmental modifications (RR 0.90, 95% CI 0.77 to 1.05), or educational (1.28 95% CI 0.95 to 1.72) interventions (Chang et al. 2004).

The first successful multi-factorial community trial (Tinetti et al. 1994) used a combination of adjustments of medication, behavioral instructions, and individually tailored exercise programs assessed by a physiotherapist. This combination of interventions reduced the incidence of falls: the adjusted incidence rate for falling was 0.69 (95% CI 0.52 to 0.90). It also reduced the percentage of people with a particular risk factor at baseline.

The Stepping One program using cognitive-behavioral learning in seven small-group sessions was a successful multi-faceted program in reducing falls (RR 0.69 95% CI 0.50 to 0.95) among older adults aged 70 or more with earlier falls or who were concerned about falling (Clemson et al. 2004). The key aspects of the program were improving lower-limb balance and strength with the Otago home exercise program (Campbell et al. 1997), improving home and community environmental and behavioral safety, and encouraging regular visual screening and medication review.

Two multi-factorial studies have been conducted assessing which parts of the multi-factorial interventions are most effective. Day et al. (2002) conducted a multi-factorial intervention study among 1090 community-dwelling men and women (mean age 76.1, SD 5.0 years). They had several combinations of three interventions: group-based exercise, home hazard management, and vision improvement. Exercise intervention included weekly exercise classes for 15 weeks, supplemented by daily home exercises designed to improve balance, leg strength and flexibility. The fall rate decreased only in the intervention groups, which included exercise training (0.82, 95% CI 0.70 to 0.97), in contrast neither home hazard management nor treatment of poor vision reduced the fall rate. The strongest effect, however, was observed for the combination of all interventions (0.67, 95% CI 0.51 to 0.88).

Campbell et al. (2005) included 391 men and women aged 75 or more with severe visual impairment in a multi-factorial intervention trial. The participants received a home safety program, the Otago exercise program (Campbell et al. 1997) plus vitamin D supplementation, both interventions, or social visits. In this population, the exercise intervention with vitamin D supplementation was not successful in reducing falls, probably due to the low adherence level to the exercise program. Home hazard program reduced falls significantly (IR 0.59, 95% CI 0.42 to 0.83) and was more cost effective than the exercise program. Delivering the home safety program cost 344 € per fall prevented.

Several trials that have used exercise-only interventions have been successful in reducing the incidence of falls, including both group-based (Buchner et al. 1997, Barnett et al. 2003, Wolf et al. 1996) and home exercise interventions (Robertson et al. 2001a, Robertson et al. 2001c, Campbell et al. 1997).

## **2.5 Economic evaluation of exercise interventions among community-dwelling older people**

Most of the economic evaluation studies with exercise interventions have focused on cost-effectiveness of prevention for falls and fall-related injuries (Rizzo et al. 1996, Robertson et al. 2001a, Robertson et al. 2001b, Robertson et al. 2001c, Campbell et al. 2005). There are some economic evaluation studies of specific strategies such as rehabilitation of knee osteoarthritis (Sevick et al. 2000, McCarthy et al. 2004), or after a hip fracture (Ruchlin et al. 2001) or cost-benefits of a geriatric day hospital (Tousignant et al. 2003). Most of the studies have provided data only on the incremental costs of the intervention, and only a few have included any assessment of total healthcare costs (Rizzo et al. 1996, Ruchlin et al. 2001, Robertson et al. 2001c). There is only one study with an evaluation of total healthcare costs after a group-based outpatient exercise program (Bucher et al. 1997). This study was designed to assess the effects of strength and endurance training on physical performance, fall risk and healthcare services. The intervention did not improve gait, balance or physical health status, but it had a protective effect on the risk of falling. Between 7 and 18 months after randomization, the control subjects had more outpatient clinic visits and were more likely to sustain hospital costs over 5000 US dollars than the intervention subjects.

**Table 1. List of randomized controlled multi-component and strength-only\* interventions among older (mean age  $\geq 75$  years) home-dwelling adults. Effects on strength, physical performance, functional abilities, falls, and healthcare costs.**

| Study   | Subjects  | Recruitment strategy                                     | Intervention(s)   | Duration Follow-up (FU)                                   | Results  |
|---|---|--|---|---|--|
| Barnett et al. 2003   | 163 increased fall risk, mean age 75                | general practice clinics (GP), physiotherapy departments | balance, ST class+ home, or information   | 12 mo<br>1/wk<br>classes                                  | Falls↓, gait-, balance+, FSc- strength-, PT -                        |
| Binder et al. 2002  | 115 frail mean age 83                               | mass media mailings                                      | balance, flexibility, endurance, ST class or home exercise                                  | 9 mo<br>3/wk classes                                      | PT+, FSc+, balance+, strength+ ADL-                                  |
| Binder et al. 2004  | 90 hip fracture patients mean age 81                | hospital+ home care                                      | balance, flexibility endurance, ST class or home exercise                                   | 6 mo<br>3/wk classes                                      | PT+, FSc+, strength+ balance+, gait+ ADL/IADL-                       |
| Buchner * et al. 1997   | 105, frail mean age 75                              | health maintenance organization (HMO)                    | 1. ST<br>2. endurance<br>3. ST+ endurance or usual care                                     | 24-26 wk<br>3/wk<br>classes<br>18 mo FU<br>(costs, falls) | strength+, gait- balance-, IADL- Fsc-, Falls↓ healthcare (HC) costs↓ |
| Campbell et al. 1997<br>Robertson et al. 2001b<br>Campbell et al 1999 | 233 women mean age 84 (economic evaluation) (falls) | GP clinics   | home-based ST+ balance (Otago) + walking plan or social visits                              | 12 mo<br>3/wk<br>2 yr FU<br>(falls)                       | Falls↓, balance+ chair rise+, strength-, gait- HC costs-             |
| Campbell et al. 2005  | 391, visual impaired, age 83                        | hospital register  | 1. home safety<br>2. exercise (Otago) +vit D<br>3. exercise+ vit D+ safety or social visits | 1 year<br>3/wk  | safety: falls↓<br>exercise: falls-                                   |

|  |   |  |  |  |   |
|--|---|--|--|--|---|
| Chandler *<br>et al. 1998                              | 100 functionally<br>impaired age 78                 | outpatient clinics                       | home-based ST<br>or usual care   | 10 wk<br>3/wk  | strength+   |
| Clemson<br>et al. 2004                                 | 310 frail<br>mean age 78                            | media<br>advertisements                  | home exercise<br>safety instructions in<br>small groups<br>or social visits                              | 7 wk<br>1/wk<br>session<br>14 mo FU  | falls↓  |
| Day<br>et al. 2002                                     | 1107 healthy<br>mean age 76                         | invitation letters<br>to 11 120 people   | 1. group+ home exercise<br>2. home safety<br>3. vision improvement<br>4-8. combinations<br>or usual care | 15 wk<br>1/wk<br>18 mo FU  | exercise: falls↓<br>other interventions:<br>falls-                          |
| Gill<br>et al. 2002<br>Gill<br>et al. 2004b            | 188 frail<br>mean age 83                            | GP clinics                               | individually tailored<br>home exercise<br>program+ home safety<br>or health education                    | 6 mo<br>16 visits<br>6 mo FU   | ADL decline↓<br>IADL decline↓<br>PT+, mobility+                             |
| Hauer<br>et al. 2001<br>Hauer<br>et al. 2003 (2 yr FU) | 57 females frail<br>history of falls<br>mean age 82 | acute care or<br>inpatient rehab         | ST, balance, function<br>group-based classes<br>or flexibility, games etc.                               | 3 mo 3/wk+<br>3 mo FU  | strength +, balance+<br>PT+,ADL/IADL-,<br>falls(↓)                          |
| Helbostad<br>et al. 2004a                              | 77 frail<br>mean age 81                             | newspapers<br>HC workers                 | 1. balance + ST home<br>2. balance+ ST home+<br>balance+ ST group  | 1. 2/daily+<br>3 group<br>meetings<br>2. 2/day home+<br>2/wk group<br>12 wk+ 9 mo FU | both groups: gait+<br>balance-<br>strength-, falls-<br>no group differences |
| Jette *<br>et al. 1999                                 | 215 frail<br>mean age 75                            | mailings<br>self/ physician<br>referrals | home ST video-<br>taped instructions<br>+ 2 home visits<br>or waiting list                               | 6 mo<br>3/wk   | strength +<br>FSct+, gait+, balance-  |

|                                   |   |                                   |   |  |  |
|-----------------------------------|---|-----------------------------------|---|--|--|
| King et al. 2002                  | 155 frail mean age 77                                     | invitation cards to 16 579 people | group-based ST endurance, balance flexibility classes/home or educational sessions        | 3/wk class 6 mo<br>1/wk class+<br>2/wk home 6 mo<br>3/wk home 6 mo                                   | PT+, gait-, FSc-                             |
| Latham* et al. 2003b              | 243 frail mean age 79                                     | 5 hospitals after discharge       | 1. home ST quadriceps or social visits<br>2. vitamin D single dose or placebo single dose | 10 wk<br>3/wk<br>3mo FU  | falls-, FSc-, ADL- strength-, gait- balance- |
| the LIFE Study Investigators 2006 | 424 sedentary mean age 77                                 | mass mailings advertisements      | aerobic, ST, balance flexibility class+ home or health education                          | 3/wk class 2mo<br>2/wk class+ home exercise 4 mo<br>home exercise+ group behavioral sessions 6-12 mo | PT+, gait+ mobility disability↓              |
| Liu-Ambrose* et al. 2004          | 104 women with decreased bone mineral density mean age 79 | invitation letters advertisements | 1. group-based ST<br>2. group-based agility or group-based stretching                     | 25 wk<br>2/wk  | 1. and 2: fall risk↓, strength-, balance +   |
| Nelson et al. 2004                | 72 functionally impaired mean age 78                      | media advertisements              | home-based ST balance, activity or educational sessions                                   | 6 mo<br>11 home visits   | PT+, balance + tandem walk+, strength- gait- |
| Robertson et al. 2001a            | 240 mean age 81   | GP clinics                        | home-based ST + balance (Otago) +walking plan or usual care                               | 12 mo<br>3/wk  | Falls↓ and fall-related hospital costs↓      |
| Robertson et al. 2001c            | 450 mean age 83   | GP clinics                        | home-based ST +balance (Otago) + walking plan or usual care                               | 12 mo<br>3/wk  | Falls↓, fall-related hospital costs-         |

|  |   |                             |  |  |   |
|--|---|-----------------------------|--|--|---|
| Siebens<br>et al. 2000                         | 300 non-frail<br>mean age 78                                | acute care hospital         | flexibility, ST and<br>walking in hospital<br>and home<br>or usual hospital care<br>1. group-based ST<br>2. group-based<br>walking +step aerobics<br>or usual care | 1 mo<br>post-<br>discharge<br>3/wk<br>18 wk<br>3/wk ST<br>2/wk walking<br>+1/wk aerobics | length of stay-<br>IADL+, physical<br>activity-, PT-<br><br>strength + both groups<br>gait+ both groups |
| Sipilä*<br>et al. 1996                         | 42 non-frail<br>women aged<br>76 to 78                      | population<br>register      |  |  |   |
| Skelton*<br>et al. 1995                        | 52 healthy<br>mean age 80                                   | newspaper<br>advertisements | group-based ST with<br>rice bags and tubings<br>+ home exercises<br>or usual care  | 12 wk<br>1/wk group<br>2/wk home   | strength +<br>step up height+   |
| Tinetti<br>et al. 1994<br>Rizzo<br>et al. 1996 | 301 increased<br>fall risk, age 78<br>(economic evaluation) | HMO                         | adjustment of medication<br>behavioral instructions<br>home balance+ ST<br>or social visits  | 3 mo<br>2/day home<br>training<br>9 mo FU  | falls↓<br>fall risks↓<br>HC costs↓  |
| Tinetti<br>et al. 1999                         | 304 with hip<br>fracture, mean<br>age 80                    | hospitals                   | home-based safety<br>instruction, balance, ST<br>occupational therapy<br>or usual care   | 12 mo<br>1/day   | ADL-, balance-<br>triceps strength+<br>knee strength -  |

Abbreviations: FU= follow-up, GP= general practice/practitioner, ST= strength training, ↓= reduction, (↓)= non-significant reduction, += significantly improved performance, - = no significant effect in performance, PT= performance test of functional abilities, FSe= self-report scale of functional abilities, ADL= activities of daily living, IADL= instrumental activities of daily living, HMO= health maintenance organization, HC= healthcare, Otago= home-based exercise program including 3 /wk home ST and balance exercises and 2/wk walking program (Campbell et al. 1997). \* Strength-only interventions.

**Table 2. List of randomized controlled multi-component and strength-only\* interventions among older (mean age  $\geq 70$  years) home-dwelling and institutionalized  $\circ$  adults. Effects on psychological health.**

| Study                                  | Subjects                                      | Recruitment strategy                             | Intervention(s)  | Duration Follow-up (FU)   | Tests and results   |
|--|---|--|--|---|---|
| Brochu *<br>et al. 2002                | 30 females frail with CHD mean age 71         | hospital   | ST group-based or stretching, calisthenics relaxation group-based                          | 6 mo<br>3/wk  | GDS –   |
| Chin A Paw* $\circ$<br>et al. 2004     | 173 in long-term facilities mean age 82       | informative meetings in 6 residential facilities | 1. ST group-based<br>2. all-round functional<br>3. combination of 1&2 or educational group | 6 mo<br>2/wk each<br>intervention   | 1. and 2. DQoL–, GDS–<br>VPS–<br>3. DQoL $\downarrow$ VPS $\downarrow$            |
| Hauer<br>et al. 2001                   | 57 females frail history of falls mean age 82 | acute care or inpatient rehab                    | ST, balance, function group-based classes or flexibility, games                            | 3 mo+<br>3 mo FU  | GDS –, PGMS –<br>FHI+   |
| Helbostad<br>et al. 2004b              | 77 frail mean age 81                          | newspapers<br>HC workers                         | 1. balance + ST home<br>2. balance+ ST home+<br>balance+ ST group                          | 1. 2/day+ 3<br>group meetings<br>2. 2/day +2/wk<br>group<br>12 wk + 9 mo FU | 2. SF-36 Mental Index +   |
| Nelson<br>et al. 2004                  | 72 frail mean age 77                          | media<br>advertisements                          | home-based ST<br>balance, activity<br>or nutrition education                               | 6 mo<br>11 home<br>visits   | GDS –<br>SF-36 –  |
| Perrig-<br>*<br>Chiello et<br>al. 1998 | 46 mean age 73                                | sample of 442<br>people in the<br>IDA project    | ST group-based<br>or waiting list  | 8 wk<br>1/wk  | well-being–<br>self-forgetfulness +<br>lack of complaining–<br>subjective health– |
| Singh*<br>et al. 1997                  | 32 subjects<br>BDI > 12<br>mean age 71        | 2 volunteer<br>databases of<br>2953 people       | ST group-based<br>or educational<br>group- meetings  | 10 wk,<br>3/ wk ST<br>2/wk  | BDI +, HRSD +<br>GDS+, DSM-IV+<br>PGMS–, SF-36+<br>ESSE–                          |

|                          |   |   |  |               |  |
|--------------------------|---|---|--|---------------|--|
| Singh*<br>et al. 2005    | 60 subjects<br>with depression<br>mean age 69-70    | 42 GP clinics<br>sample of<br>13 341 people | 1. ST (80% IRM) group<br>2. ST (20% IRM) group<br>3. GP standard care      | 8wk<br>3/wk   | HRS-D+, GDS+, SF-36+<br>positive correlation<br>to intensity of training   |
| Tsutsumi*<br>et al. 1997 | 45 subjects<br>healthy, sedentary<br>mean age 68-70 | advertisements                              | 1. ST (80% IRM) group<br>2. ST (60% IRM) group<br>or non-exercise controls | 12 wk<br>3/wk | POMS: tension+, vigor+,<br>TMD-, STAI+, Physical<br>Self-Efficacy Scale+<br>no correlation to<br>intensity of training |

Abbreviations: GP= general practice/practitioner, ↓ = reduction, + = significantly improved performance, - = no significant effect in performance, CHD = coronary heart disease, GDS= Geriatric Depression Scale (Yesavage 1983), IDA= Interdisciplinary Ageing Project (Perrig-Chiello et al. 1996), PGMS= Philadelphia Geriatric Morale Scale (Powell-Lawton 1975), FHI= Falls Handicap Inventory (Rai et al. 1995), DQoL= Dementia Quality of Life (Brod et al. 1999), VPS= Vitality Plus Scale (Myers et al. 1999), SF-36= SF-36 Health survey (Ware 1993), BDI= Beck Depression Inventory (Beck 1961), HRS-D= Hamilton Rating Scale of Depression (Hamilton 1967), ESSE = Ewart's Scale of Self-Efficacy (Ewart et al. 1998), POMS= Profile of Mood States (McNair et al. 1981), TMD= Total Mood Disturbance (McNair et al. 1981), STAI= State-Trait Anxiety Inventory (Spielberger et al. 1970), ST= strength training, \* Strength-only interventions ° intervention among institutionalized subjects.

### **3. AIMS OF PRESENT THE STUDY**

The aim of the present study was to compare the effects of a group-based multi-component exercise program to a home exercise program in mobility-impaired older women discharged after an acute illness from a geriatric ward. The interventions were compared with respect to their effects on maximal voluntary isometric strength, maximal walking speed, balance, mood, functional abilities, fall-related healthcare costs and total social welfare and healthcare costs.

## **4. SUBJECTS AND METHODS**

### **4.1 Subjects**

Participants were recruited from an acute geriatric ward of a primary-care health-center hospital in the city of Joensuu. The ward, with approximately 500 admissions annually is only intended for short-term hospitalization. The subjects were selected from successive female patients who were admitted for an acute illness, lived in the center of Joensuu, a city of 50 000 inhabitants (at the time of the study) in Eastern Finland. The total number of women aged 75 or more was 830 in that area of the city. Initially, we planned to include both men and women in the trial, but after 6 months we had recruited only three men into the study. To make the statistical analyses easier, we decided to continue with only female subjects. The reason for the small number of males was that the proportion of men was less than 30 percent of the total population in the oldest age groups. Furthermore, those men who do survive to old age have usually less mobility limitations than women of the same age, and therefore they rarely fulfilled the selection criteria of the study. The inclusion criteria were age 75 years or older and difficulties in mobility and balance, such as complaints of dizziness, tendency to fall when walking unassisted, or difficulty to walk independently during the acute disease. Exclusion criteria included severe heart or circulatory disease, severe dementia, acute bone fracture, terminal disease, or the inability to walk even with assistance. More detailed information of the reasons of admission, chronic diseases and medications is presented in Table 3.

### **4.2 Randomization**

After the recruitment period of 20 months, there was a total of 79 eligible candidates, of whom 11 refused to participate before randomization (Figure 1). Before the consent was asked, all patients were offered the opportunity to familiarize themselves with the training equipment, since none of them had any prior experience of fitness centers. In all, 68 women provided a written informed consent, and were randomized after the baseline measurements into multi-component (N=34) and home exercise (N=34) groups using closed envelopes in blocks of four.

### **4.3 Measurements**

Before the start of the study, the staff involved with the tests performed several measurements together to ensure they were capable of performing and interpreting the tests in the same way. Since the measurements could not be done blinded to the grouping, all efforts were made to avoid biases in performing the measurements. The strength, walking speed, balance, and mood measurements were performed before noon with rests to avoid fatigue. However, subjects were verbally encouraged to try to give their best performance. Two physiotherapists, a physician and a psychology student

**Table 3. Reasons for admission, diseases and medications in the group-based multi-component (GBMC) and home exercise (HE) groups. Frequencies and percentages.**

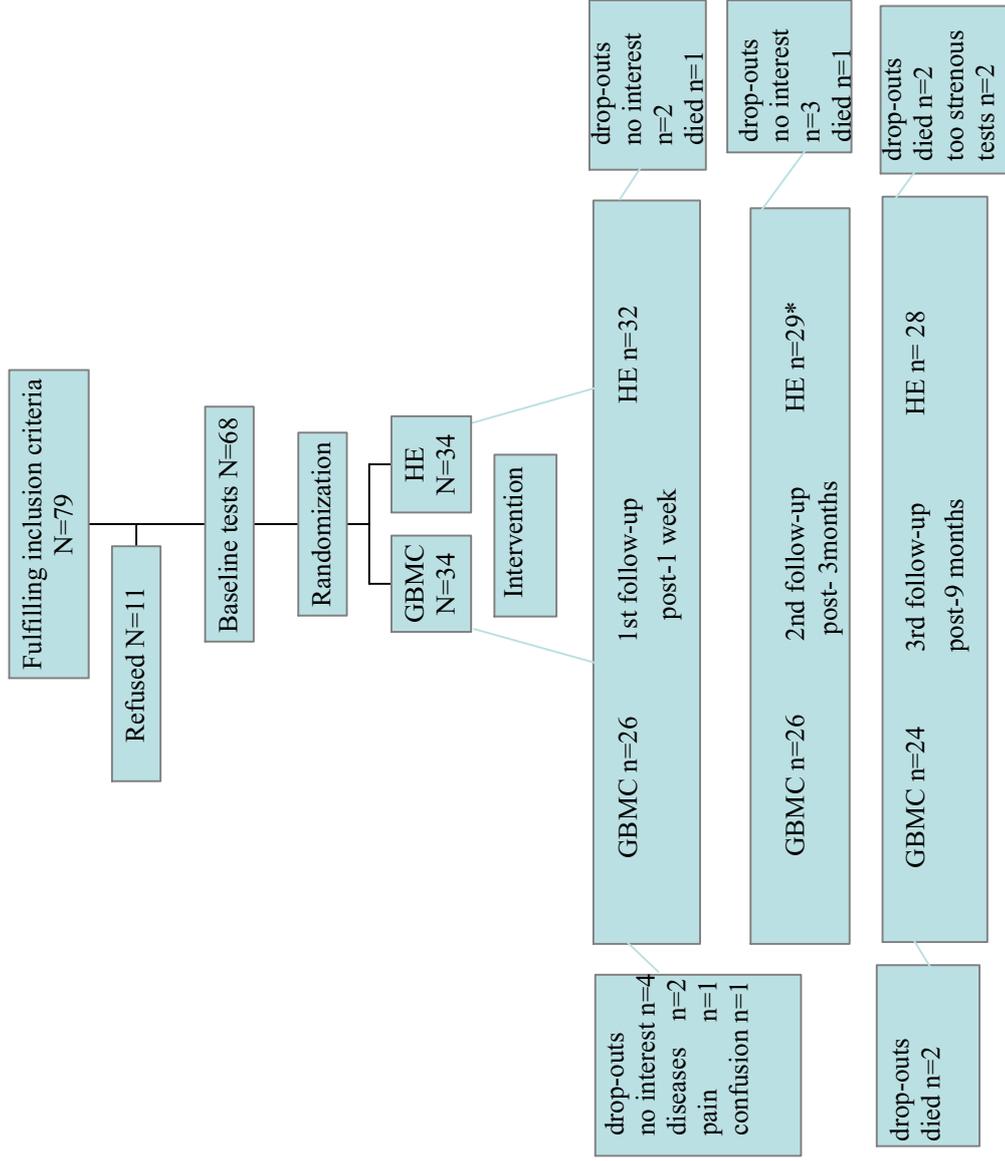
|                             | GBMC N=34 |    | HE group N=34 |    | P      |
|-----------------------------|-----------|----|---------------|----|--------|
|                             | F         | %  | F             | %  |        |
| <b>Reason for Admission</b> |           |    |               |    |        |
| Musculoskeletal             | 13        | 38 | 14            | 41 | 0.810. |
| Infections                  | 10        | 29 | 8             | 24 | 0.597  |
| Cardiovascular              | 7         | 21 | 6             | 18 | >0.999 |
| Gastrointestinal            | 2         | 6  | 5             | 15 | 0.428. |
| Diabetes                    | 2         | 6  | 1             | 3  | 0.619  |
| <b>Chronic conditions</b>   |           |    |               |    |        |
| Cardiovascular              | 30        | 88 | 31            | 91 | 0.714  |
| angina pectoris             | 17        |    | 18            |    |        |
| heart failure               | 10        |    | 11            |    |        |
| high blood pressure         | 12        |    | 8             |    |        |
| arrhythmia                  | 8         |    | 7             |    |        |
| cerebrovascular             | 3         |    | 4             |    |        |
| Arthritis                   | 16        | 47 | 12            | 35 | 0.339  |
| Diabetes                    | 7         | 21 | 6             | 18 | >0.999 |
| Pulmonary disease           | 4         | 12 | 8             | 24 | 0.341. |
| Diseases of spine           | 4         | 12 | 7             | 21 | 0.349  |
| Depression                  | 8         | 24 | 3             | 9  | 0.115  |
| <b>Medication in use:</b>   |           |    |               |    |        |
| Cardiovascular medication   | 32        | 94 | 31            | 91 | 0.678  |
| Analgesics                  | 16        | 47 | 19            | 56 | 0.480  |
| Sleeping pills              | 18        | 53 | 15            | 44 | 0.628  |
| Antidepressants             | 7         | 21 | 3             | 9  | 0.305. |

Difference between the groups was calculated using the Fisher's exact (2-sided) test.

performed the baseline measurements during the last days of hospitalization in the Health Center Hospital. Follow-up tests were performed in the same place at one week, 3 and 9 months after the ten-week intervention (Study I).

Information on baseline characteristics (medication, diseases, physical activities) and secondary outcomes (functional abilities, service utilization, falls) was obtained from medical records, and interviews of the subjects and home service personnel, as appropriate. At every follow-up site, the subjects were interviewed and medical records and home nursing staff reports were examined to record falls, and the use of in- and outpatient services (Studies III and IV). A questionnaire about the frequency and quality of home services was sent to the home service personnel, if the research subject was utilizing such services. During the hospital stay, nurses monitored ADL skills by filling in a specially designed form. The assessment of mood and cognitive capacity was performed by the physician or by a final year psychology student, who was blinded to the grouping (Study II).

Figure 1. Participants and drop-outs in the group-based multi-component (GBMC) and home exercise (HE) group



\*one subject who refused to participate in the one week test, subsequently did participate in the 3- and 9-month tests

#### **4.3.1 Muscle strength**

The maximal voluntary isometric strength of knee extension was measured in a sitting position with the knee flexed at an angle of 60 degrees from full extension using an adjustable dynamometer chair constructed in the Department of Health Sciences, University of Jyväskylä (Viitasalo et al. 1985). The measurement was done separately for the left and right knee extension, and the best result of three trials was recorded. For the analyses, the average of the maximum left and right knee extension strength was calculated. The maximal isometric hip abduction strength was measured bilaterally using the training equipment with an attached measurement device (David Rehab System, David 330, Vantaa Finland). For each test, three trials were conducted, with one-minute intervals. The best measurement was accepted as the final result. Subjects were encouraged to achieve their best performance. At the baseline, we measured also maximal isometric handgrip and elbow flexion in both sides with the dynamometry and maximal isometric knee extension and flexion strength in both knees separately and together using the measurement device attached to the training machines (David Rehab System 200, 300, Vantaa Finland). The strengths in the lower limbs were highly correlated with each other (e.g. the correlation between measurements of the right knee extension strength with the dynamometer and the training equipment was 0.90,  $p < 0.001$ ). To avoid fatigue and to maximize reliability of the strength measurements, we decided to perform only knee extension, hip abduction and right handgrip strength measurement in the follow-up tests.

#### **4.3.2 Walking speed**

Maximal walking speed over 10 meters (Aniansson et al. 1980) was tested in the hospital corridor. Subjects were asked to walk as fast as possible and were given 1-2 meters to accelerate their speed before timing with a stop-watch was started. The better of two trials was taken for analyses. Participants were allowed to use their walking aids.

#### **4.3.3 Dynamic balance**

The 14-item Berg Balance Scale was used for balance measurements (Berg et al. 1992). The scale was translated from English, and before using it we undertook several dummy runs to be sure that the performance and interpretation of the test were uniform. The scale includes both static and dynamic tasks, such as standing, turning, and picking up object (Appendix).

#### **4.3.4 Timed up-and-go**

Modified Timed up-and-go test (Mathias et al. 1986) was performed using a wooden chair, 42 cm high from the floor without arm rests. The subject was asked to rise from the chair and walk 2 meters at their maximal speed. The better of two trials was recorded. Later, we found that the correlation between changes in the maximal walking speed and the modified Timed up-and-go test after the

intervention were strongly related ( $r= 0.932$ ,  $p<0.001$ ), and therefore it is not sure whether this test measured walking speed rather than chair rise. The results of this test have not been published.

#### **4.3.5. Stair climbing ability**

Stair climbing test was carried out using three boxes of 10, 20 and 30 cm height, and when combining these boxes, it was possible to form steps with heights of 40, 50 and 60 cm (Aniansson et al. 1980). The subject was asked to step up and down to each step and the highest step managed was recorded. They were allowed to obtain support from a handrail, but not to pull themselves up with the handrail when stepping up. There were significant correlations between the stair climbing ability and balance ( $r=0.767$ ,  $p<0.001$ ), walking speed ( $r=0.758$ ,  $p<0.001$ ), and knee extension strength ( $r=0.545$ ,  $p<0.001$ ). The results of this test have not been published.

#### **4.3.6 Assessment of mood and cognitive function**

For the mood assessment, the Zung Self-Rating Depression Scale (ZSDS) (Zung 1965) was used. The ZSDS was designed as a short simple way of quantifying the severity of depression among patients. The ZSDS contains 20 items concerned with symptoms of depression, such as lowered mood state, hopelessness, sleep and appetite disturbances. Items are rated on a four-point scale so that total raw score can range from 20 to 80, and converted scores from 25 to 100. Half of the 20 items are positively worded and half are negatively worded. Zung self classified depressive symptoms into four content areas of symptoms: affective, somatic, psychomotor, and psychological. The primary use of the ZSDS has been in clinical research to monitor treatment effectiveness, but it has also been used in general medical practice as a screening test (Zung 1990). The ZSDS test has been widely used in geriatric research, and it can be applied in both written or oral forms. Especially among low functioning patients, it is more feasible to present the test by interviewing the subject (Griffin and Kogut 1988). In the present study, only 19 items of the test were used. Item 6 of the original test “ I still enjoy sex” has been criticized as being unclear, even irrelevant, to older people (Steuer et al. 1980), and it was omitted from the test. The ZSDS was completed through interviewing the subjects, and the raw score was multiplied by 1.3 to obtain a score range from 26 to 99.

The cognitive function was assessed using the Mini-Mental State Examination test (MMSE, Folstein et al. 1975).

#### **4.3.7 Assessment of functional abilities**

ADL/IADL skills were assessed using the Joensuu classification (Mäkinen 1991), which is a scale validated for clients in Finnish home nursing care, and it is designed to be used by home nursing professionals (Mäkinen 1991). The scale includes a total of eleven domains of ADL and IADL: care of medication, shopping, food preparation and feeding, mobility, ability to handle finances, housekeeping, ability to use telephone, bathing, dressing, laundry, and toileting. In addition to ADL/

IADL items, the scale contains a suggestive assessment of memory impairment and an evaluation about the need for nursing services. The Joensuu classification contains up to seven categories of functional status ranging from A: no or minimal care needed to G: severely disabled, needs continuous care and supervision. The ratings from the ADL/IADL measures at each measurement time point were used to group the participants into three groups: AB, CD, and EF groups. Those in the AB-group were independent in all ADL skills and needed only minimal or occasional help in heavy or complex shopping or housekeeping tasks. The subjects in the CD-group needed help in some of the ADL components, for example bathing or tying shoes, and at least some help in all the IADL components: taking care of their own medication, shopping, food preparation, moving outdoors, housekeeping, and handling money. Those in the EF group were unable to manage any IADL tasks even if assisted, and needed help in dressing, toileting and moving in and out of bed or a chair.

The reliability of the scale was tested in home nursing care and nursing home settings with 500 patients. The domains were originally chosen based on their ability to predict both professional and informal care load. The repeatability of the scale was studied in a material of 172 paired ratings showing an inter-rater reproducibility correlation of 0.91.

In the current study, the evaluations were performed by healthcare professionals. At the baseline, the Joensuu classification was performed in the hospital after the patient was accepted into the study. The classification form was filled in by a hospital nurse who interviewed the patient and observed the patient's ADL skills, and, when necessary, used information available in the home care and home service files.

In the follow-up examinations, the Joensuu classification form was sent to the patient's home nurses or home helpers if the patient was utilizing home services (46 patients). Eleven subjects were receiving no home help or home nurse visits, and the information was collected simply by interviewing these patients. Four participants who did not attend the nine-month follow-up investigation were interviewed by telephone. In addition to the Joensuu classification, more detailed information about physical activities and walking abilities was obtained during the hospital period and follow-up interviews.

#### **4.3.8 Methods of economic evaluation**

All the prices originally in Finnish marks were converted to 2004 euros using the Nordea bank conversion tables. The costs of implementing the intervention program included working time of two physiotherapists, transportation provided by a private transportation company and meals. The costs of the exercise classes and meals included overhead costs (such as administration, cleaning and rent of location) and were estimated from the annual report of the financial department of the Health Center. A private company arranged transportations between the Health Center and participants' homes and charges from the company were used as the cost of transportation services. The cost of the home exercise program consisted of one physiotherapist's home visit.

The costs of the social welfare services included home help services and nursing home stays. In Finland, the municipalities are responsible for providing home help services. The amount of home help is allocated according to need criteria assessed by care managers along with the elderly and proxies. Home help personnel assist with personal activities of daily living and to some extent with home management and shopping. At the baseline, we contacted the home help agency and asked about the frequency and average time spent on the home visits during the past month before hospitalization for each participant. The total annual amount of visits during the one year follow-up after the hospitalization was obtained from the billing files of the home help agency. The number of days in nursing homes was obtained from the medical records. The costs of the healthcare services included home nurse visits, outpatient clinic consultations, and the use of the geriatric day hospital, the primary care hospital, and the North Karelia Central Hospital. All of this information was available from the medical records. The costs of the municipal services were obtained from the annual reports of the financial department of the Health Center. Medical records were analyzed for falling events, and direct healthcare costs for falls were recorded.

The costs for a home visit were 23.8 €/h, for a home nurse visit 28.9 €/h, and for an outpatient doctor consultation 34.2 €/visit. The costs per day in a nursing home were 89.3 €, in the geriatric day hospital 60.6 €, and in the primary health care hospital 88.2 €. These prices included overhead costs and excluded the persons' own average share of expenses. The costs of the Central Hospital in- and outpatient consultations were obtained from the monthly hospital charges and were dependent on the length of stay as well as special medical procedures and treatments.

#### **4.3.9 Data of falls**

Falls defined as unintentionally coming to rest on the ground, floor, or other lower level, were monitored using the participants' self-reports when they attended the follow-up tests and questionnaires completed by home helpers and home nurses. Falls resulting in medical contacts were obtained from the medical records. Both primary healthcare and Central Hospital records were available. Medical records were analyzed retrospectively for the one year period before the subject was accepted into the study, during the hospital stay, and prospectively during the one year follow-up after the discharge from the hospital. When the person was accepted into the study, a questionnaire about falls was sent to the home nursing and home help personnel, if the subject was utilizing such services. The personnel were asked to record every fall of which they were aware.

#### **4.3.10 Data of physical activity**

Data about physical activities was obtained by interviewing the subjects and using a structured questionnaire. Subjects were asked to estimate how much time they had spent on leisure time physical activities, shopping, calisthenics at home, and moderate to heavy household activities in the previous week before the baseline and the follow-up sites. The total time per week spent on these activities was recorded.

#### 4.3.11 Primary and secondary outcome measures

The primary outcome measures included maximal voluntary isometric strength tests using the dynamometer chair (Viitasalo et al. 1985) and the measurement device of the training equipment, the Berg Balance test (Berg et al. 1992), 10 meters walk at maximal speed (Aniansson et al. 1980), modified Timed up-and-go test (Mathias et al. 1986), stair climbing test (Aniansson et al. 1980) and the Zung Self-Rating Depression Scale (Zung 1965). The secondary outcome measures were the Joensuu classification (Mäkinen et al. 1991), the structured questionnaires about physical activities, need for help and falls and information from medical records and billing files. The list of the tests is presented in Table 4.

**Table 4. The baseline and follow-up tests**

##### **Baseline measurements in the hospital before randomization:**

###### **Primary outcomes:**

1. Strength and physical performance tests during 1-2 last days of hospitalization performed by two physiotherapists:
  - 1.1 Maximal voluntary isometric strength of handgrip, elbow flexion and knee extension in both sides separately using the dynamometer chair (Viitasalo et al. 1985). Maximal voluntary isometric knee extension and flexion both sides separately and together and bilateral hip abduction strength with the David Rehab System measurement device. Best of three trials recorded (I).
  - 1.2 Performance tests: Berg Balance Scale test (Berg et al. 1992), timed 10 meters walk at maximal speed (Aniansson et al. 1980), timed up-and-go (Mathias et al. 1986), stair climbing height (0-60 cm boxes) (I) (Aniansson et al. 1980)
2. The ZSRDS (Zung 1965) test performed by psychology student (II)

###### **Secondary outcomes:**

3. Questionnaires about social and health conditions and need for help in daily activities including the Joensuu classification (Mäkinen 1991), time spent on different physical activities (III, IV), cognitive capacity with the MMSE test (Folstein et al. 1975) (I)
4. Daily follow-up of ADL skills (IV)
5. Information from medical records on falls during the previous year (IV)

##### **Follow-up tests (1 week, 3 months and 9 months after the end of the intervention)**

###### **Primary outcomes:**

1. Strength and performance tests performed by two physiotherapists and a physician:
  - 1.1 Isometric strength of right handgrip, right and left knee extension strength with the dynamometer and hip abduction strength with the David Rehab System measurement device, best of three trials (I)
  - 1.2 Performance tests: Berg balance scale, timed 10 meters walk at maximal speed, timed chair rise with 2 meters walk at maximal speed, stair climbing height (0-60 cm boxes) (II)
2. ZSRDS test by physician or psychology student (II)

###### **Secondary outcomes:**

3. Structured interview by a physician: changes in health, physical activity, need for help, use of social and health care services, number of falls (IV)
4. The Joensuu classification, performed by home nurse or physician (III)
5. Primary healthcare medical records and monthly hospital charges from the North Karelia Central Hospital: the use and costs of healthcare services for falls and other reasons (IV).
6. The billing files of the home help agency for social welfare services, and home nurses' reports of falls (IV).

## 4.4. Interventions

### 4.4.1 Group-based multi-component intervention

Subjects assigned to the training group started training within 1 to 2 weeks after discharge. Training classes were given twice a week, for a 10-week period (20 sessions, 90 minutes each), and the training sessions were supervised by two physiotherapists. Subjects were provided with transportation, and lunch was served after each training session. The participants were brought together to the Health Center in a mini-van. Since the sessions ended at lunchtime, the participants were served a meal after each session. The lunch was the normal hospital food, and it was served in a hospital ward in the same building. Social interactions were encouraged during meals and transportations. We hoped that providing transportation and meal would increase adherence to the intervention and compensate for the caloric expenditure in the training.

There were 3 to 8 trainees in the group at the same time. There was a gradual change in make-up of the group, with 1 to 4 new subjects starting and finishing in the group every month. Each session started with a warm-up period of 15 minutes. Warming-up included also balance and flexibility exercises, such as tandem walking, walking with a pea bag overhead, throwing and catching a ball, toe raises with simultaneous overhead arm reach. Progressive resistance training for knee extension, knee flexion and hip abduction was performed on weight training equipment based on the principle of variable resistance (David 200, 300, 330, David Fitness and Medical Ltd. Vantaa, Finland). The training phase lasted about 30 minutes. During the first four sessions, only low weights were used with 20 to 30 repetitions. Thereafter, the loads were gradually increased to the point where the participant could accomplish only 10 repetitions in two sets with the encouragement of the trainer. To maintain the relative intensity of the stimulus, weight loads were further increased as muscle strength increased. Hip adduction was trained with low weights as a warm-up exercise. The first assessment of 10 RM was done on the fifth training session and the average of 10 RM was 7.8 (SD 3.4) kg for knee extension (range 1 to 15 kg), 11.8 (SD 3.3) kg for knee flexion (5 to 17.5 kg), and 8.3 (SD 2.7) kg for hip abduction (2.5 to 12.5 kg). The training loads were increased on the average of 2.8 (SD 1.5) times for knee extension, 3.4 (SD 1.6) times for knee flexion, and 2.2 (SD 1.4) times for hip abduction (range 0 to 7 times). The average 10 RM in the last assessment was 14.7 (SD 5.5) kg (1 to 25 kg) for knee extension, 21.1 (SD 5.6) kg for knee flexion (10 to 32.5 kg) and 13.7 (SD 2.2) kg (2.5 to 25 kg) for hip abduction. The average individual increase in training loads were 99.3 (SD 79.0)% for knee extension (0 to 300%), 86.3 (SD 55.7) % for knee flexion (14.3 to 266.7 %), and 57.5 (SD 40.9) % for hip abduction (0 to 150%).

In addition to strength training, functional exercises were also incorporated, such as chair rising, supported hip flexion and extension and toe raises and elbow flexion and extension using light (1 to 2 kg) ankle or wrist weights. Two sets of 15 repetitions of each of these exercises were done in each session. The functional exercises took about 30 minutes.

At the end of each session, there was a relaxation period of 15 minutes resting on the floor with guided imagery employing the tension-relaxation method. Relaxation on the floor offered the participants a short resting period to recover from their physical exertion. In addition, lowering

themselves to floor and rising up provided the opportunity to give advice on how they should rise up after a fall. Guided imagery may also have effects on reducing anxiety and depression.

The participants were taught a stretching program to be performed at home later during the same day. The training loads and functional exercises as well as adverse events were recorded in every session for each participant.

#### **4.4.2 Home exercise intervention**

Control subjects received one visit from a physiotherapist within one week after leaving the hospital and returning to their homes. During the visit, a home exercise program was taught including the functional exercises described above. The subjects were advised to perform two sets of 15 repetitions 2-3 times a week. No further encouragement to exercise was given to the control subjects.

#### **4.5 Ethics**

The study was approved by the Ethics committee of the Joensuu Municipal Health Center, and all participants provided written informed consent.

#### **4.6 Statistical methods**

An earlier study (Skelton et al. 1995) indicated that the expected improvements of isometric knee extension strength and walking speed would be about 0.5 to 0.6 of a SD and we calculated that a sample size of 60-90 would be sufficient for our study based on 2-sided significance of  $\alpha=5\%$  and statistical power  $\beta=80\%$ .

For the comparisons between the groups, we used the 2-sided t-test for normally distributed continuous variables, the Mann-Whitney U-test for non-normally distributed continuous variables, and the Fisher's exact (2-sided) test for categorical data.

The strength, physical performance and ZSDS data were analyzed using the Statview 4.01 and SuperANOVA (Abacus Concepts 1989) statistical packages. For the strength measurements, the results from the 1-week, 3-month, and 9-month follow-up tests were compared to those from the baseline tests. A percentage change was calculated for each subject as follows:  $[(\text{follow-up result} - \text{baseline result}) / \text{baseline result}] \times 100$ . For the 10-meter maximal walking speed test, individual changes relative to the baseline results were expressed as meter/second, and changes in the balance scale as points. The differences in average individual change values between the groups were compared with analyses of covariance (ANCOVA) using weight as a covariate (posthoc-analyses Fisher's PLSD), because subjects in the training group were slightly heavier at the baseline (65.3 kg vs. 60.8 kg,  $p=0.126$ ).

For the ZSDS scores, the results of the follow-up tests were compared to baseline results by subtracting the follow-up score from the baseline score. The difference in average individual change values between the groups were compared with the two-way t-test. In order to obtain a more detailed consideration of the confounding factors, the analysis of covariance (1- factor and 2- factor) was used (posthoc-analyses Fisher's PLSD).

For statistical analyses of the ADL/IADL changes we used the GSK method (Grizzle et al. 1969) developed for analysing categorical data using the weighted least-squares estimation. This was later extended to analyses involving incomplete longitudinal data (Woolson and Clarke 1984). We used the latter methodology to fit a weighted least squares categorical regression model to the present data, because of the small sample size and the possibility of including data matrices with missing values. Generalized estimating equation (GEE) modeling (Agresti 2002) for the binomial distribution family with the logit link function was used to test similarities in percentages for the two indicator outcome variables: need for a walker or assistance in walking indoors and need for help in ADL-activities (eating, bathing, dressing or toileting). The models were constructed with the GENMOD procedure in SAS 8.2 (SAS 2002). We also used SAS, version 8.2 (SAS Institute 2001) to perform a general estimating equations analysis of the data.

The economic evaluation data was analyzed using the SPSS and STATA statistical (Statacorp 2003) packages. For cost analyses between the groups, we used negative binominal regression (Gardner et al. 1995) in STATA to make the comparisons as powerful as possible.

The data from physical activities was not normally distributed and therefore the Mann-Whitney U-test was used to compare between the groups. We counted the difference of total time spent on physical activities between the follow-up sites and the baseline for each subject. We used the chi square test to compare the groups with respect to how many of the subjects had increased their physical activities.

## 5 RESULTS

### 5.1 Baseline characteristics

The average age of the participants was 83.5 (SD 4.1) years in the multi-component and 82.6 (SD 3.7) years in the home exercise group ( $p=0.334$ ), Table 5. The multi-component training group had an average of 1.9 (SD 0.9) acute diseases or symptoms, very similar to the home exercise group, where the corresponding value was 1.7 (SD 0.9), ( $p=0.421$ ). The most frequent reasons for acute admissions were musculoskeletal complaints (mainly due to cervical or lumbar spondylosis), infections (urinary tract or respiratory infections) and heart diseases (heart failure), Table 3. Both groups had an average of 3.5 chronic conditions, the most frequent chronic diseases were cardiovascular diseases (88% in the multi-component group vs. 91% in the home exercise group) and arthritis (47% vs. 35%). The number of daily used medications was 6.2 (SD 3.1) in the multi-component group and 6.1 (SD 3.0) in the home exercise group ( $p=0.833$ ). Nearly all of the subjects were taking at least one drug for cardiovascular diseases and about half of the subjects had analgesics and sleeping pills in daily use. The multi-component group had marginally lower scores in the MMSE test compared to the home exercise group: 23.8 (SD 3.7) vs. 25.2 (SD 3.0),  $p=0.092$ . The ZSRDS score was 47.3 (SD 7.8) in the multi-component group and 48.2 (SD 10.2) in the home exercise group,  $p=0.710$ . There were no statistically significant differences in physical performance tests at the baseline (Table 5). Nine subjects in the multi-component group and one in the home exercise group had fallen during the acute disease at home before admission ( $p=0.013$ ). Fifteen subjects in the multi-component group and 14

**Table 5. Baseline characteristics in the Group-Based Multi-Component (GBMC) and home exercise (HE) groups (N=34/34).**

|  | GBMC        | HE          | p     |
|--|-------------|-------------|-------|
| Age, years (SD)                          | 83.5 (4.1)  | 82.6 (3.7)  | 0.334 |
| Number of medications                    | 6.2 (3.1)   | 6.1 (3.0)   | 0.833 |
| Hand grip, kg                            | 16.1 (5.4)  | 16.6 (5.5)  | 0.727 |
| Knee extension, kg                       | 19.7 (5.7)  | 20.7 (6.6)  | 0.536 |
| Gait speed, m/s                          | 0.77 (0.32) | 0.85 (0.43) | 0.406 |
| Balance Scale*, score                    | 38.0 (13.3) | 40.3 (15.4) | 0.525 |
| ZSRDS**, score                           | 47.3 (7.8)  | 48.2 (10.2) | 0.710 |
| MMSE***, score                           | 23.8 (3.7)  | 25.2 (3.0)  | 0.092 |
| Length of hospital stay <sup>1</sup> , d | 13.5 (7.3)  | 13.2 (10.0) | 0.555 |
| Home nursing, h/month <sup>1</sup>       | 0.35 (0.58) | 0.23 (0.52) | 0.293 |
| Home help, h/month <sup>1</sup>          | 8.8 (13.3)  | 11.9 (18.5) | 0.366 |
| Informal help, times/month <sup>1</sup>  | 9.7 (11.4)  | 7.7 (11.8)  | 0.173 |
| Physical activity, min/week <sup>1</sup> | 270 (282)   | 225 (320)   | 0.193 |

The differences between the groups were calculated using the 2-sided t-test or Mann-Whitney U-test<sup>1</sup>. Isometric muscle strengths were measured using a dynamometer chair (Viitasalo et al. 1985). \* Berg Balance Scale (Berg et al. 1992) \*\* Zung Self-Rating Depression Scale (Zung 1965) \*\*\*Mini-Mental State Examination (Folstein et al. 1975).

in the home exercise group complained of dizziness at admission. Most of the patients experienced difficulties in walking even before the acute illness. Forty-seven patients (23 multi-component/24 home exercise) needed help or were unable to manage stairs, 34 (15/19) needed assistance or were not able at all to move outdoors. The multi-component group subjects needed the assistance of a walker more often than the home exercise subjects (17 vs. 8,  $p=0.027$ ). At the baseline, we asked the participants to evaluate how much time they spent on physical activities such as walking outdoors, shopping and calisthenics at home. The total time per week spent on these activities was 270 minutes (SD 282) in the multi-component group and 225 minutes (SD 320) in the home exercise group ( $p=0.193$ ). In the previous month before the hospital admissions, the multi-component group subjects had received home nursing services on an average of 0.35 (SD 0.58) h/month and the home exercisers for 0.23 (0.52) h/month ( $p=0.293$ ), home help services 8.8 (SD 13.3) h/month vs. 11.9 (SD 18.5) h/month ( $p=0.366$ ) and help from relatives 9.7 (SD 11.4) times/month vs. 7.7 (SD 11.8) times/month ( $p=0.173$ ). The average length of stay in the hospital was 13.5 (SD 7.3) days in the multi-component group compared to 13.2 days (SD 10.0) in the control group ( $p=0.555$ ).

## 5.2 Adherence to interventions and adverse events

Eight subjects dropped out from the multi-component group during the intervention (Figure 1). Four subjects withdrew due to a lack of motivation (after between 1 to 12 sessions). One subject was hospitalized because of an eye-disease (1 session) and one because of thoracic spine pain, which already existed before starting in the training group (12 sessions). One subject discontinued because of hip joint pain (8 sessions), and one because of confusion due to dementia (11 sessions). The drop-outs did not differ from those who continued to train in terms of their baseline tests, diagnoses, medication or functional capacity. Those who continued training attended an average of 18 sessions (range 11 to 20). There were no serious adverse events during the sessions. One participant complained of transient joint pain during one session. Three persons complained of tiredness, but they could continue training with lower loads. One person experienced nose bleeding after one training session, and the training loads were lowered in the next sessions, and one person needed to take a nitroglycerine tablet during one session. Two persons in the multi-component group died between the second and last follow-up.

In the home exercise group, there were three drop-outs before the first follow-up measurement, and six more before the last follow-up. One of the drop-outs from the first follow-up tests, participated in the 3-month and 9-month tests. The reasons for not participating in the follow-up measurements were lack of motivation in four subjects, two subjects considered the tests to be too strenuous, one person was admitted to the Central Hospital for a hip operation because of osteoarthritis, one subject died before the first follow-up and another before the second follow-up. The control group drop-outs were significantly more depressed than rest of the control group subjects (57.7, SD 8.4 vs. 46.1, SD 9.4,  $p=0.010$ ) and needed more home nursing services than the others (2.2, SD 2.0 vs. 0.4, SD 0.9 h/month,  $p=0.010$ ). At the first follow-up measurements 22/32 (69%) control group subjects

reported that they had done regular home exercises for an average of 68 minutes a week (median 61, IQR 35).

### 5.3 Effects of the interventions on physical performance (I)

The effects of the interventions on strength, balance and walking speed are presented in Table 6. One week after the interventions, the multi-component group exhibited significantly greater improvements compared to the home exercise group in the knee extension strength: 20.8 (SD 25.9)% vs. 5.1, (SD 16.0) % ( $p=0.009$ ), walking speed: 0.12 (SD 0.32) m/s. vs. -0.05 (SD 0.23) m/s ( $p=0.035$ ) and balance: 4.4 (SD 7.2) points vs. -1.3 (SD 5.5) points ( $p=0.001$ ). The 3-month test showed that the average changes relative to the baseline in all the tests including the hip abduction strength in the multi-component group were significantly greater than in the home exercise group. At the 9-month tests, the average changes in the multi-component group were still significantly better in walking speed and hip abduction strength compared to the home exercise group. There were significantly more subjects in the multi-component group who could demonstrate distinct improvements in at least two of the three tests (isometric knee extension strength, balance and walking speed) compared to those in the home exercise group (14 multi-component/ 3 home exercise,  $p=0.004$ ).

After the intervention, there were no statistically significant differences between the groups in the average change in the right handgrip 11.1 (SD 34.6)% in the multi-component group vs. 2.7 (SD 22.9) % ( $p=0.296$ ) in the home exercise group. The number of participants with an improvement of at least 10 cm in stair climbing ability was 11/7 (multi-component/ home exercise), the numbers of those whose stair-climbing status had not changed was 12/18 and those with at least 10 cm impairment in stair climbing height was 3/7, the difference between the groups remained non-significant ( $p=0.212$ ). Timed up-and-go speed improved in the multi-component group significantly after the intervention compared with the home exercise group: 0.11 (SD 0.20) m/s vs. -0.02 (SD 0.19) m/s,  $p=0.016$ .

### 5.4 Effects of the interventions on mood (II)

At the baseline, the multi-component group had an average ZSDS score of 47.3 (SD 7.8) points and the home exercise group had 48.2 (SD 10.2) points,  $p=0.710$  (Table 7). After the intervention, the multi-component group had an average decrease of 3.1 (SD 9.0) points while there was an average increase of 1.3 (7.6) points in the home exercise group ( $p=0.048$ ). Three months later, the difference was more obvious: the multi-component group had on the average 2.6 (SD 7.7) points less and the home exercise group 3.5 (SD 9.7) points more than at the baseline ( $p=0.015$ ). The four drop-outs in the home exercise group between the 1-week and 9-month tests were significantly more depressed than those who continued with the study (58.6, SD 9.1 vs. 46.4, SD 9.3,  $p=0.012$ ), which may at least partly explain the result. Nine months after the intervention, no statistically significant

**Table 6. Changes in strength and physical performance in the group-based multi-component (GBMC) and Home exercise (HE) groups**

|                                | Knee extension, kg (SD) |              | Hip abduction, N (SD) |               | Gait speed, m/s (SD) |              | Balance score (SD) |             |
|--------------------------------|-------------------------|--------------|-----------------------|---------------|----------------------|--------------|--------------------|-------------|
|                                | GBMC                    | HE           | GBMC                  | HE            | GBMC                 | HE           | GBMC               | HE          |
| <b>Baseline</b><br>(N=34+34) p | 19.7 (5.7)              | 20.7 (6.6)   | 78.4 (33.0)           | 80.3 (29.0)   | 0.77 (0.32)          | 0.85 (0.43)  | 38.0(13.3)         | 40.3 (15.4) |
|                                | 0.536                   |              | 0.795                 |               | 0.406                |              | 0.525              |             |
| <b>1 week</b>                  | 24.0 (5.2)              | 22.0 (7.6)   | 94.4 (31.8)           | 77.7 (31.1)   | 0.91 (0.30)          | 0.79 (0.43)  | 45.1(9.9)          | 39.1(14.5)  |
| <b>change 1w-0</b>             | 20.8 (25.9)%            | 5.1(16.0)%   | 13.2 (28.8)%          | 5.6 (22.4)%   | 0.12 (0.32)          | -0.05 (0.23) | 4.4 (7.2)          | -1.3 (5.5)  |
| <b>95% CI</b>                  | 4.3-27.0                |              | -6.5-21.7             |               | 0.03-0.31            |              | 2.4-9.1            |             |
| (N=26+31) p                    | 0.009                   |              | 0.292                 |               | 0.035                |              | 0.001              |             |
| <b>3 months</b>                | 24.2 (5.0)              | 21.4 (8.3)   | 91.0 (28.1)           | 74.2 (27.2)   | 0.89 (0.29)          | 0.79 (0.44)  | 44.9 (7.4)         | 41.1 (12.2) |
| <b>change 3 m-0</b>            | 21.3(23.9) %            | 6.7 (25.2)%  | 12.0 (19.9) %         | -4.5 (31.7) % | 0.11 (0.25)          | -0.09 (0.28) | 4.2 (6.2)          | -0.3 (7.2)  |
| <b>95% CI</b>                  | 1.1-28.2                |              | 1.0-32.0              |               | 0.05-0.34            |              | 0.8-8.2            |             |
| (N=26+28) p                    | 0.038                   |              | 0.037                 |               | 0.011                |              | 0.018              |             |
| <b>9 months</b>                | 22.0 (5.5)              | 20.1 (7.9)   | 91.3 (30.6)           | 70.0 (30.2)   | 0.86 (0.37)          | 0.77 (0.47)  | 43.4(10.4)         | 40.0 (14.8) |
| <b>change 9 m-0</b>            | 7.9 (22.5) %            | -3.2 (16.3)% | 9.0 (19.7)%           | -11.8 (25.0)% | 0.05 (0.25)          | -0.09 (0.18) | 1.3 (7.6)          | -0.7 (6.0)  |
| <b>95 % CI</b>                 | -0.1-22.4               |              | 7.9-34.4              |               | 0.02-0.26            |              | -1.8-6.0           |             |
| (N=24+26) p                    | 0.078                   |              | 0.004                 |               | 0.028                |              | 0.347              |             |

Values expressed as mean (SD). Mean change values (1 w-0, 3 m-0, 9 m-0) have been calculated by subtracting follow-up values from baseline values and the differences in average individual change values between the groups were compared with analyses of covariance (weight as a covariate). 95% CI = 95% confidence intervals in the difference of change.

difference could be found between the groups, although the multi-component group was still on average of 0.9 (SD 10.8) points beneath the baseline whereas the home control group had 2.0 (SD 9.6) points more than at the initial assessment.

The average improvement of 3.1 points in the multi-component group after the intervention is approximately 0.4 of one standard deviation. The number of persons with an improvement of at least one standard deviation was greater in the multi-component group (9/26) than in the home exercise group (3/32) at the first follow-up measurements ( $p=0.025$ ). To study whether the improvements in mood state were mediated through improved physical fitness, the changes in lower limb muscle strength, walking speed, and balance scores were added to the models one at a time. After adjusting the model for the changes in knee extension and hip abduction strength, the difference between the groups at the first follow-up test became non-significant, but remained significant at the 3 month tests. The changes in balance or walking speed did not affect the result. A more detailed analysis including covariates such as the presence of antidepressant medication, need for external help, number of chronic diseases, number of daily used drugs, or physical activity did not affect the results.

**Table 7. Changes in the Zung Self-Rating Depression Scale scores in the group-based multi-component (GBMC) and home exercise (HE) groups**

|                           | <b>GBMC (SD)</b> | <b>HE (SD)</b> |
|---------------------------|------------------|----------------|
| <b>Baseline</b> (N=34+34) | 47.3 (7.8)       | 48.2 (10.2)    |
| p                         | 0.710            |                |
| <b>1 Week</b> (N=26+32)   | 45.5 (8.4)       | 49.4 (10.6)    |
| change 1w-0               | -3.1 (9.0)       | 1.3 (7.6)      |
| 95% CI                    | 0.04-8.8         |                |
| p                         | 0.048            |                |
| <b>3 Months</b> (N=26+29) | 46.0 (7.5)       | 49.6 (10.9)    |
| change 3 m-0              | -2.6 (7.7)       | 3.5 (9.7)      |
| 95% CI                    | 1.2-10.8         |                |
| p                         | 0.015            |                |
| <b>9 Months</b> (N=24+28) | 47.6 (9.1)       | 47.8 (12.1)    |
| change 9 m-0              | -0.9 (10.8)      | 2.0 (9.6)      |
| 95% CI                    | -2.7- 8.6        |                |
| p                         | 0.299            |                |

Values expressed as mean (SD). Mean change values (1 w-0, 3 m-0, 9 m-0) have been calculated by subtracting follow-up values from baseline values and the differences in average individual change values between the groups were compared with 2-sided t-test. Negative change values indicate improvement in mood. 95 % CI= 95% confidence interval of the difference in the change scores.

### 5.5 Effects of the interventions on the functional abilities (III)

At the baseline, there were no differences in the functional abilities between the groups. The numbers of subjects in multi-component/home exercise groups were 10/9 in the AB group, 17/18 in the CD group, and 6/7 persons in the EF group.

In the analysis of the follow-up measurements, the data consisted of the four measurement points (baseline, 1 week, 3 and 9 months after the intervention) with the three ordinal response categories (AB, CD and EF). The effect of the intervention was modeled for the multi-component and home exercise samples. We considered a model of four measurement times by including four intercept and four slope terms for both groups and for the categories AB and CD, with EF being the reference category. The slope estimates showed that no change over time was observed in either group. Additional custom hypotheses tests were used to test the equality of intercepts and slopes in both samples and to test the null-hypothesis of equality of parameters in the two treatment groups.

**Table 8. The frequencies and percentages of participants needing a walker or assistance when walking indoors, and needing help in self-care activities at the time of hospital admission, discharge, and 1 week, 3 months, and 9 months after the end of the intervention.**

|  | Admission        |            | Discharge        |            | 1 week        |            | 3 months        |            | 9 months        |            |  |
|--|------------------|------------|------------------|------------|---------------|------------|-----------------|------------|-----------------|------------|--|
| N  | 34/34            |            | 34/34            |            | 26/31         |            | 26/30           |            | 31/30           |            |  |
| <b>Need for a walker or assistance in walking indoors</b>      |                  |            |                  |            |               |            |                 |            |                 |            |  |
|  | <b>f</b>         | <b>(%)</b> | <b>f</b>         | <b>(%)</b> | <b>f</b>      | <b>(%)</b> | <b>f</b>        | <b>(%)</b> | <b>f</b>        | <b>(%)</b> |  |
| <b>GBMC</b>  | 18               | (53%)      | 17               | (50%)      | 9             | (35%)      | 11              | (42%)      | 15              | (48%)      |  |
| <b>HE</b>  | 13               | (38%)      | 8                | (24%)      | 6             | (19%)      | 7               | (23%)      | 9               | (30%)      |  |
|  | <b>Admission</b> |            | <b>Discharge</b> |            | <b>1 week</b> |            | <b>3 months</b> |            | <b>9 months</b> |            |  |
| N  | 34/34            |            | 34/34            |            | 26/31         |            | 26/30           |            | 32/32           |            |  |
| <b>Need for help in eating, bathing, dressing or toileting</b> |                  |            |                  |            |               |            |                 |            |                 |            |  |
|  | <b>f</b>         | <b>(%)</b> | <b>f</b>         | <b>(%)</b> | <b>f</b>      | <b>(%)</b> | <b>f</b>        | <b>(%)</b> | <b>f</b>        | <b>(%)</b> |  |
| <b>GBMC</b>  | 23               | (68%)      | 17               | (50%)      | 10            | (38%)      | 14              | (54%)      | 20              | (63%)      |  |
| <b>HE</b>  | 18               | (53%)      | 11               | (32%)      | 13            | (42%)      | 14              | (47%)      | 19              | (59%)      |  |

#### Probabilities for effects in GEE model:

| Indoor mobility: |         | ADL:         |         |
|------------------|---------|--------------|---------|
| Effect           | p-value | Effect       | p-value |
| Group            | 0.167   | Group        | 0.820   |
| Time             | 0.685   | Time         | 0.117   |
| Time × group     | 0.778   | Time × group | 0.832   |

N= Group-based Multi-component (GBMC)/Home exercise (HE)

The non-significant results of these tests indicate that the parameters can be considered as equal in both groups and that the groups have an equal result of no intervention effect. We also performed a general estimating equations analysis on the data. Similar results were obtained showing that the treatment factor did not have a significant main effect ( $p = 0.407$ ) and the interaction between follow-up time and treatment was not significant ( $p = 0.854$ ).

An additional analysis focusing separately on walking and ADL limitations (eating, bathing, dressing, and toileting) detected no statistically significant group, time or group by time effects (Table 8).

## 5.6 Effects of the interventions on falls (IV)

There were altogether 17 participants (11 multi-component /6 home exercise) who had sought medical help for falls during the previous year before the study or who fell during the acute illness at home or in the hospital. A total of 14 of them (10 /4) fell again during the following year.

Twenty subjects (11/9,  $p=0.791$ ) had one fall during the follow-up period of one year, and 25 (12/13,  $p >0.999$ ) had two or more falls. Twenty-three subjects (10/13,  $p= 0.609$ ) did not have any falls. In the follow-up, there were altogether 102 (57/45) incidents of falls, 32 (20/12) of them led to medical consultations ( $p=0.397$ ).

There were four major traumas: 3 hip fractures (all in the multi-component group) and one pelvis fracture (home exercise group). Two of the multi-component group patients with a hip fracture had dropped out of the intervention before falling. One of them participated in the training group three times and the falling accident leading to the fracture happened six weeks after the last session. The other subject attended 12 sessions and her fall occurred six weeks after the last training session. The third patient with a hip fracture fell eight months after the end of the training period. There were two other minor fractures (rib, toe) in the multi-component group and one (finger) in the home exercise group.

## 5.7 Effects of the interventions on social welfare and healthcare costs (IV)

### 5.7.1 Costs of implementing the intervention programs

The costs of the group-based training program and home exercise program are presented in Table 9. The expenses of the training sessions (excluded transportation and meals) for the whole study period of 72 weeks (exercise classes twice per week) were 12 931€. The transportation between the health center and participants' homes was arranged by a private company and charges were 5 197€ for the whole study period. There were altogether 518 visits in the exercise classes and the total expenses for the meals were 1 181 € (2.28 € per meal including overhead costs). The total costs of the intervention program were 19 310 €. For each participant the unit cost of one session was 37.3 €

**Table 9. Costs of implementing the group-based multi-component (GBMC) and home exercise (HE) programs per session/visit and total costs for the groups.**

|                                      | Costs per session | Total costs       |
|--------------------------------------|-------------------|-------------------|
| <b>GBMC program:</b>                 |                   |                   |
| Two physiotherapists' working time € | 89.8              | 12 931            |
| Transportation €                     | 36.1              | 5 197             |
| Meals €                              | 8.2               | 1 181             |
| Total €                              | 134.1             | 19 310            |
| Cost per participant €               | 37.3              | 568               |
| <b>HE program:</b>                   |                   |                   |
| Cost per participant €               | 44.9              | Total costs 1 527 |

and the total costs of the intervention were 568€. There were on the average of 3.6 participants in every session (range 3 to 8). The capacity of the transportation and exercise classes was designed for a group of 8 participants. Due to the recruitment strategy, the resources were under-used. If the maximal capacity for 8 participants could have been used, the price for each session would have been about 13 € per person, excluding transportation costs.

The cost of the home exercise program including one visit of a physiotherapist was 44.9 € and the costs for the whole control group were 1527 €.

### 5.7.2 Individual social welfare and healthcare costs

The total mean individual social welfare and healthcare costs were 7 717 (SD 6 715) € in the multi-component group and 7 612 (SD 7 903) € in the home exercise group ( $p=0.962$ ) (Table 10). There were no statistically significant differences between the groups in the mean healthcare costs: 4 381 (SD 3 829) € in the multi-component group vs. 3 539 (SD 3 967) € in the home exercise group ( $p=0.477$ ). The social service costs were also similar: 3 336 (SD 4 418) € in the multi-component group vs. 4 073 (SD 5 973) € in the home exercise group ( $p=0.770$ ). In both groups, the social costs consisted mostly of home help costs (92% vs. 96.5 %) and healthcare cost were mostly inpatient costs in the Central or the Primary Health Center Hospitals (83% vs. 82%). The distribution of costs is presented in Figure 2. The individual distribution of total social welfare and healthcare costs was highly skewed, with seven subjects accounting for 32 % of total costs. After adding the costs of the exercise classes and home visits, the total individual mean costs were 8 285 (SD 6 632) € in the multi-component group and 7 657 (SD 7 903) € ( $p=0.731$ ) in the home exercise group.

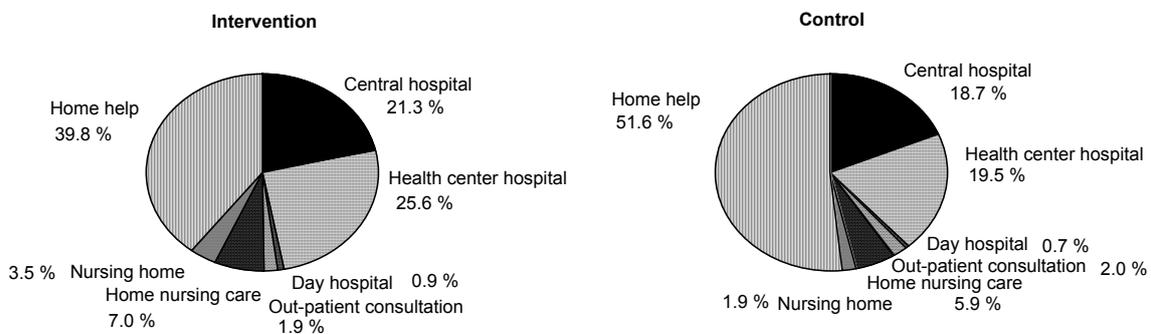
### 5.7.3 Direct healthcare costs for falls

The direct healthcare costs including in- and outpatient treatments for falls was 44 276€, which was 16.4 % of the total healthcare costs (269 262 €). There were five patients whose costs exceeded 3 000 € (4 multi-component/1 home exercise), and their costs were 77.5 % of the total costs for falls.



The total average individual costs were 996 € (SD 2 612) in the multi-component group and 306 € (SD 915) in the home exercise group ( $p=0.314$ ). Those who had no falls, needed an average of 8.4 (SD 13.7) h of home help services per month at the baseline and 8.6 (13.6) h/month during the last 6 months of the follow-up, the increase in their home help utilization was only 2%. Those with at least one fall had had an average of 11.3 (SD 17.2) h of home help assistance per month at the baseline and 16.8 (SD 23.8) h/month during the last part of the follow-up, which represented a 49 % increase in their use of home help services. It was not possible to estimate whether this increase was directly due to the falls or simply a reflection of an accelerated decline in functional abilities.

**Figure 2. The percentage shares of healthcare and social welfare costs in the group-based multi-component (intervention) (N=34) and home exercise (control) (N=34) groups during one year after hospitalization.**



## 5.8 Effect of the interventions on physical activity

At baseline, the total time per week spent on physical activities was 270 (SD 282) min. in the multi-component group compared to 225 (SD 320) min. in the home exercise group ( $p=0.193$ ) in the previous week before hospital admissions. There were 19 (56 %) subjects in the multi-component group and 16 (47 %) in the home exercise group ( $p=0.225$ ) who reported that they had spent at least 150 min. per week on physical activities, which is the minimum amount of moderate physical activity that the ACSM and the Centers for Disease Controls and Prevention recommend for older people (Pate et al. 1995). Six subjects in the multi-component group and 9 in the home exercise group did not practice any physical activities at all. After the intervention, significantly more subjects in the home exercise group compared to the multi-component group reported that they had increased their physical activities: 18/31 vs. 8/26 ( $p=0.039$ ), respectively, and the trend was similar 3 months after the end of the intervention (21/30 vs. 11/25,  $p=0.052$ ), but no longer significant at the last follow-up interview: 8/28 vs. 6/24 ( $p=0.772$ ).

## **6. DISCUSSION**

### **6.1 Effects of physical training on primary and secondary outcome measures**

This study showed that a group-based multi-component training program including strength training, functional exercises and guided imagery relaxation soon after discharge from a geriatric ward was an effective and feasible form of rehabilitation for frail older women with balance and mobility difficulties. The 10-week group-based training program produced improvements in the primary outcomes, i.e. maximal voluntary isometric muscle strength, balance and walking speed, as well as mood compared to the home exercise program. Positive effects on muscle strength and walking speed were still apparent nine months after the intervention. The group-based intervention did not improve secondary outcomes, such as the level of independence in functional abilities, incidence of falls or the annual social welfare and healthcare costs compared to the home-based intervention.

#### **6.1.1 Effects on strength and physical performance**

The percentage gains in muscle strength were comparable to those that have been achieved in other studies using isometric strength measurements as outcomes (Skelton et al. 1995, Lord et al. 1995, Chandler et al. 1998, Brochu et al. 2002, Taaffe et al. 1999, Sipilä et al. 1996). Earlier studies have shown improved balance (Sauvage et al. 1992, Nelson et al. 1994, Campbell et al. 1997, Nelson et al. 2004, Brochu et al. 2002, Hauer et al. 2001, Binder et al. 2004, Lord et al. 1995) and mobility (Sauvage et al. 1992, Fiatarone et al. 1994, Skelton et al. 1995, Ettinger et al. 1997, Taaffe et al. 1999, Brochu et al. 2002) after strength training and multi-component exercise interventions. There are only a few studies with follow-ups over 6 months after the interventions (Hauer et al. 2003, Fatouros et al. 2005) exploring the duration of the positive effects on physical performance in home-dwelling, older people. Hauer et al. (2001) showed that improvements after a 3-month group-based progressive strength training among older women were maintained with only moderate losses 3 months after the training period. After 2 years, physical performance had decreased substantially in both training and control groups, but leg strength and mobility were still significantly better in the intervention group compared to the control group (Hauer et al. 2003). In the study of Fatouros et al. (2005) among older (71.2, SD 4.1 years) healthy but inactive men, a 24-week program of high intensity training (82 % of 1RM) improved strength, aerobic power and mobility better than lower intensity training (55% of 1RM). All of the training induced gains had been lost after four to eight months of training in the lower intensity group, whereas in the high intensity group, strength and mobility gains were maintained throughout detraining. Our study indicated that the positive effects could last between 3 to 9 months after the intervention.

Resistance training programs are based on the application of the overload principle, which states that muscles working close to their force-generating capacity will increase in strength (McArdle et al. 1996). To achieve improvements in muscle strength, it is necessary to expose the individual to an overload and to increase the intensity of training as muscle strength increases. Lexell (2000)

pointed out that the lower the initial level of strength, the higher the magnitude of the percentage increase with respect to the baseline. Although high intensity training (1RM  $\geq$  80 % of 1RM) is superior in improving strength compared to low- to moderate intensity training (20 to 60% of 1RM), strength improvements can be achieved also with lower intensity programs (Fatouros et al. 2005, Kalapotharakos et al. 2004, Hunter et al. 2004, Latham et al. 2004, Seynnes et al. 2004, Harris et al. 2004, Taaffe et al. 1996). The intensity of training in our program was moderate. The training intensity was 10 RM, which equals to 61 ( $\pm$  10) % of the 1 RM (Häkkinen 1990).

Most of the exercise programs listed in Table 1 had training frequencies of 3 times per week. There is evidence that significant improvements in strength can be achieved with programs using only once or twice a week training sessions (Taaffe et al. 1999, Difrancisco-Donoghue 2007, Galvao and Taaffe 2005, Harris et al. 2004, Wieser et al. 2007) if the training intensity is moderate to high. Taaffe et al. (1999) compared training programs with 1, 2, or 3 days per week training sessions in 46 community-dwelling healthy men and women (mean age 69 years) and found that once or twice weekly high-intensity (80% of 1RM) resistance exercises achieved strength gains similar to 3 days per week training (at 80% of 1RM). With our program which had twice weekly sessions, the improvements in strength and performance were similar to those achieved with programs with three training sessions per week (e.g. Binder et al. 2002, Hauer et al. 2001, Brochu et al. 2002, Jette et al. 1999).

Esmarck et al. (2001) showed in their study that early intake of an oral protein supplement (10 g) after a strength training session increased muscle hypertrophy and strength in response to training in older ( $74 \pm 1$  years) men. Our program included a meal after each session. The training sessions ended at lunchtime, and we decided to provide a meal to compensate for the extra energy demands of the exercise training. It is possible that the normal hospital food augmented the response of training. However, the protein content of the served or eaten meal was not measured.

### **6.1.2 Effects on mood**

The reduction of the depression score after the intervention was about 0.40 of a standard deviation of the average baseline ZSDS score, which is of similar magnitude to that earlier reported by Arent et al. (2000).

The mechanisms underlying the association between physical exercise and improvement in mood remain somewhat unclear. In frail and old populations, depressed mood may accompany the age-related loss of functional abilities and fitness. Exercise interventions can, at least to some extent, counteract these losses and improve daily functioning (e.g. see Binder et al. 2002). Psychological improvements may coincide with these physical improvements. In the current study, the group effect on mood decreased after adjusting in the ANCOVA-model for improvement in strength, suggesting that the improved fitness at least partially mediated the exercise-mood state association. Studies by Sing et al. (1997 and 2005) indicate that intensity of training may be important for the improvement of mood. There is evidence that exercise improves mood by enhanced self-efficacy (McAuley et al. 2000a, McAuley et al. 1991) and positive beliefs with respect to health and fitness outcomes

(McAuley et al. 1995b). According to the social-cognitive theory (Bandura 1986), perceptions of enhanced capabilities lead to increases in positive affect and mastery. It is also possible that the social interaction during exercise sessions, meals and transportation was one of the mechanisms through which the positive effects on mood were mediated. Most of our research subjects lived alone and were home confined due to difficulties in outdoor mobility, increasing their risk of social isolation. The importance of a group-effect on mood has been observed in lonely older women (Andersson 1985) and in sedentary (McAuley et al. 2000b) and frail older adults (Helbostad et al. 2004b). Our exercise program included guided imagery and relaxation, which has been found to decrease anxiety (Sloman 2002, Tsai 2004) and to improve mood (McKinney et al. 1997) in younger people.

### **6.1.3 Effects on functional abilities**

In our study, physical training program did not improve functional independence as measured with an expert evaluated ADL/IADL scale. Our results are in agreement with Brochu et al. (2002) and Hauer et al. (2001) who also organized group-based strength training interventions and did observe improvements in several physiological impairments in disabled older women, but found no improvement in self-reported physical function. There are multiple potential explanations underlying the current negative finding.

First, it is possible that the intensity or duration of the physical training program was not enough to increase strength sufficiently to generate improvements in functional independence. Strength differences can be estimated from the baseline ADL/IADL categories. These indicate that the average percentage improvement in knee extension strength required to move from the poorest to the best category is 35% and from the middle to the best category 24%. These are much greater than the average net improvement in knee extension strength attributable to the intervention, which was approximately 15%.

Second, it is possible that the ADL/IADL scales, which increase in rather large steps between the categories, are not sensitive enough to detect modest changes. Assessments of physical performance with a series of graded tests may more accurately detect changes (Seeman et al. 1994). In several studies, multi-component exercise programs have improved results in physical performance tests producing continuous data (King et al. 2002, Hauer et al. 2001, Nelson et al. 2004).

Finally, it is possible that improved physical performance by itself is not sufficient to increase functional independence (e.g. Latham et al. 2003a, Rydwick et al. 2004). Factors other than fitness, such as cognitive capacity, personal strategies, attitudes, traditions, habits as well as social and housing circumstances can determine whether a person is considered as functionally independent or not. In some cases, unsuitable housing conditions may constitute an obstacle. For example, improved walking ability may not translate into better outdoor mobility if the lack of an elevator makes it impossible to reach to the outside door.

#### 6.1.4 Effects on falls and self-reported physical activity

Although the program was targeted to older women with increased risks for falls, it did not manage to reduce falls. The participants were at increased risk of fallings, 25 % of them had sought medical help for falls during the previous year or had fallen at home or in the hospital ward during the inpatient episode. Only three of them did not fall again during the follow-up. Forty-five subjects (68%) fell at least once and 32 of the total 102 incidents of falls (31%) led to medical consultations. In that respect, they were an ideal target group for preventative procedures. The exercise classes produced statistically significant improvements in physical performance, but they did not reduce the numbers of falls or serious injuries compared to the home exercise group. It is possible that better physical performance alone is not enough to prevent falls in physically frail patients (Province et al. 1995). The subjects in the multi-component group were somewhat older, had slower walking speed, and poorer muscle strength, memory and balance than the home exercise subjects at the baseline. Although the differences were not statistically significant, it is possible that the combination of disabilities made them more frail and more vulnerable to falls and other health problems.

Our exercise program included no attempts to reduce the risk of falls by conducting an assessment of hazards in the homes. This strategy has been found to be effective in fall prevention in older community-dwelling adults with histories of falls (Salkeld et al. 2000) and with severe visual impairments (Campbell et al. 2005). Fall reduction (Tinetti et al. 1994, Clemson et al. 2004, Day et al. 2002) and economic benefits (Rizzo et al. 1996, Ruchlin et al. 2001) have been found in multi-factorial intervention trials which have included combinations of exercise, behavioral instruction and medication adjustments. It is also worth noting that the home exercise subjects were provided with an exercise program, which the majority (69 %) of them followed at least once a week. Performance of the home exercises may have reduced fallings in this group. The lack of a non-exercising control group limits our ability to determine the effectiveness of the exercise program compared to the usual care after hospitalization in the Finnish primary healthcare system. In earlier studies, home exercise programs with combinations of balance and strengthening exercises and longer durations, have proved to be effective in fall reduction (Campbell et al. 1997, Campbell et al. 1999, Robertson et al. 2001a, Robertson et al. 2001c). There were more subjects in the home exercise group compared to the multi-component group who reported that they had increased the time they had spent on physical activities in the previous week before the first (18/31 vs. 8/26,  $p=0.039$ ) and second (21/30 vs. 11/25,  $p=0.052$ ) follow-up assessments. The multi-component group participants spent 3 hours every week in the training group, which probably decreased their participation in other physical activities before the first follow-up. It was interesting to note that even this minimally advised and self-administered home exercise program motivated the participants in the home exercise group to increase their physical activity and this lasted at least three months after the intervention. Increased physical activity might have had a protective effect on falls although it did not improve muscle strength or physical performance. In several studies, increased physical activity has found to be associated with fewer falls (Rubenstein et al. 2000, Campbell et al. 1999).

### 6.1.5 Effects on social welfare and healthcare costs

The multi-component training program did not reduce social or healthcare costs. The study sample calculations were based on the expected improvements in primary outcomes like muscle strength, balance and walking speed, and we hoped that at least a trend towards lesser falls and public service use could be observed. The number of research subjects was, however, so small that a few isolated cases requiring costly hospital treatments increased healthcare costs in the multi-component group.

The ten-week exercise program was long enough to improve physical performance, but too short to influence falls, functional abilities, and need for home services. Some multi-component interventions with longer durations have proved to be effective in reducing fall-related (Robertson et al. 2001a) and healthcare costs (Buchner et al. 1997, Rizzo et al. 1996), but even some studies that have been successful in decreasing falls have not produced any financial savings (Robertson et al. 2001b, Robertson et al. 2001c, Campbell et al. 2005). Most exercise studies have not included or reported any economical analyses.

The trend in the cost distribution was slightly different between the groups. The subjects in the intervention group needed more healthcare services and less home help services than the controls. Visits to the exercise classes which were situated in the health center might have increased the use of inpatient services through more careful medical controls and awareness of functional disabilities. The costs for a ten-week exercise period including the sessions, meals and transportation were 568€ for each participant. The price of the training period is equivalent to 6.5 days of hospitalization in the Health Center Hospital. Due to the recruitment strategy and randomization, there were on average two new participants joining the training group every month. The average number of participants was 3.6 in a session. The capacity of the transportation and exercise classes was designed for a group of eight participants, so the resources were underused. Training groups are now an established method of geriatric rehabilitation in the city of Joensuu, and there are eight participants in a group supervised by one physiotherapist and one trained assistant. The costs are now less than half of those in the study. We estimated earlier that 14/24 (58%) participants in the training group but only 3/26 (12%) in the control group improved distinctly in physical performance after the interventions (Study I). The costs for one physically improved participant were 1 379€ in the training group and 508€ in the control group. Theoretically, if the recruitment had been arranged differently with eight women in a group, the maximum amount of participants could have been 56 persons in seven ten-week training groups. In that case the costs of the training period (excluding meals and transportation) would have been 231€ per person, and the cost to achieve an improved person (58% of 56) would have been 404€.

## 6.2 Limitations and strengths of the study

There are several limitations to the study, which need to be taken into account when assessing the advantages of the training program. First, the follow-up measurements could not be performed

blinded. The study staff and the participants were aware of the grouping. The participants with multiple medical conditions had often inpatient stays and outpatient consultations in the Health Center, and it would have been impossible to keep the grouping secret. This problem was recognized before the start of the trial and every effort was made to avoid biases in testing. The testing protocol was defined in detail and was carefully followed. The outcome measurements were selected so that the interpretation of the tests results was unambiguous and clear. The strength and physical performance outcomes of the training were very similar to the results obtained in earlier studies using isometric strength measurements. The power of the study was too weak to detect possible benefits on functional outcomes and economical savings. The number of research subjects needed was estimated from the expected improvements in primary outcome measurements. We hoped to recruit 100 subjects in a one year period, but this estimate was too optimistic. Even continuation of the period to 20 months did not achieve the target. It is probable that the vast majority of the eligible candidates (of a total population of 830 women) were identified during the trial. The number of eligible participants decreased as the recruitment period proceeded. The training period was only 10 weeks. Earlier studies had indicated that this should be sufficiently long to improve strength and physical performance. Studies of longer durations have proved to be more beneficial in improving functional abilities and decreasing fall rates.

The strength of the study was that we obtained our subjects from an unselected primary healthcare population. They were real patients with health problems and limitations in mobility. The follow-up time was also longer than in many other studies, and we applied a broad scale of measurements for both primary and secondary outcomes. Since we arranged several post-intervention visits, it was also possible to estimate the duration of the beneficial effects. The training program proved to be feasible and safe for use in primary healthcare setting, and we were first in Finland to initiate this kind of rehabilitation program in a primary healthcare setting. It is gratifying to note that similar programs are now included in the geriatric rehabilitation strategies in many other municipalities, and even many private fitness centers offer programs for senior citizens.

### **6.3 Recommendations for future studies**

There is already an abundance of evidence of the benefits of multi-component training on muscle strength and mobility in older adults. The effects of exercise interventions on functional abilities (Latham et al. 2003a) and the risk for falls (Gillespie et al. 2003) are still controversial and need further clarification. Ferrucci et al. (2004) have recommended that trials targeting older populations should consider using functional measures and multiple falls as main outcomes, since functional abilities are by far the most important factor affecting the quality of life and healthcare utilization (Ferrucci et al. 2000), and falling many times is a strong predictor of negative health outcomes (Tinetti et al. 1997). Frail individuals who are not yet disabled and those with early disability who are at high risk of progression are those most likely to benefit from an exercise intervention. In eligibility screening, those who are too sick or lacking the required level of cognitive function need

to be excluded (Ferrucci et al. 2004). When determining the sample size, it is wise to be prepared to a considerable drop-out rate. Comorbidity, exhaustion, and respondent burden are the major reasons why frail study participants drop out during follow-up (Ferrucci et al. 2004). It may be essential to adopt a multi-center study to obtain a sufficient sample size. The optimal length and structure of the intervention programs need also further investigation. When trying to improve the functional abilities and reduce the fall rates in older people, multi-factorial interventions with home hazard and medication assessments are probably superior to exercise-only interventions. To achieve long-lasting effects, it would be wise to combine a short-term group-based intervention with a longer home-based exercise program. The benefits from a short-term group-based training program would probably last longer, if the person was motivated to continue with the home training program. The factors which influence motivation to maintain physical activity in old age, are also an important topic worthy of investigation.

## 7. CONCLUSIONS

This study showed that group-based multi-component training is applicable in the outpatient setting, and it can achieve improvements in muscle strength, balance, mobility and mood. The exercise intervention increased muscle strengths within a relatively short time and helped to restore balance and gait that were likely to deteriorate during an acute illness and hospital stay. As a form of rehabilitation, outpatient exercise sessions for groups were relatively inexpensive compared to individual physiotherapy in a hospital ward. The participants of the training group were motivated to exercise and had few negative feelings towards the rehabilitation program of which they had no previous experience. The attendance was satisfactory despite the fact that the participants had multiple diseases; only 8 of the initial 34 (24%) subjects withdrew from training classes.

The psychological and physical resources of old people are often underestimated and ignored in rehabilitation. Our study clearly demonstrated that frail old women can participate in strenuous exercise programs and derive benefits from training. Group-based exercise classes with transportation to and from the training site are a good alternative especially when the subject's out-of-doors activities are limited because of poor mobility. We encourage public service-providers to include exercise classes as a part of geriatric rehabilitation programs after hospitalization.

If one wishes to improve coping with daily activities and to decrease the need for home services, then factors other than improved fitness are probably equally important and need to be addressed. In terms of fall prevention, longer interventions combined with elimination of home hazards are probably more effective.

## 8. SUMMARY IN FINNISH – SUOMENKIELINEN YHTEENVETO

### **Ryhmässä tapahtuvan liikuntaharjoittelun vaikutukset iäkkäiden huonosti liikkuvien naisten kuntoutuksessa: Avohoidossa toteutetun harjoitteluohjelman vaikutus fyysiseen kuntoon, mielialaan, toimintakykyyn ja sosiaali- ja terveydenhuollon kustannuksiin akuutin sairaalahoidon jälkeen.**

Vanhenemiseen liittyvä lihasmassan vähentyminen ja lihasheikkous altistavat iäkkään henkilön liikuntakyvyn ja yleisen toimintakyvyn huonontumiselle. Akuutti sairaus ja sairaalassa oloon liittyvä liikkumattomuus voivat huonontaa lihasvoimia entisestään niin että ongelmia alkaa esiintyä kävelyssä ja tasapainon hallinnassa.

Tässä tutkimuksessa selvitettiin ryhmässä tapahtuvan liikunnallisen kuntoutuksen vaikutuksia iäkkäiden naisten fyysiseen suorituskyykyyn, mielialaan, toimintakykyyn ja sosiaali- ja terveydenhuollon kustannuksiin akuutin sairaalahoidon jälkeen.

Tutkimukseen otettiin 68 peräkkäistä yli 75-vuotiasta naista, jotka olivat joutuneet akuutin sairauden takia Joensuun terveyskeskuksen vuodeosastolle ja joilla oli sairauden aikana kävelyyn tai tasapainoon liittyviä ongelmia. Tutkittavien keski-ikä oli 83.0 vuotta (SD 3.9 vuotta). Heidät arvottiin joko terveyskeskuksen fysioterapia-osastolla kokoontuvaan kuntosaliryhmään (34 naista) tai kotivoimisteluryhmään (34 naista). 10 viikkoa kestävä ryhmäharjoittelu aloitettiin kotiuttamisen jälkeen. Ryhmäharjoittelu sisälsi polven ojennus- ja koukistusharjoituksia sekä lonkan loitonnuksen- ja lähennysharjoituksia kuntosalilaitteilla. Harjoittelupainoja alettiin nostaa viidennestä harjoittelukerrasta lähtien ja vastuksia lisättiin keskimäärin 2-3 kertaa harjoittelujakson aikana. Harjoitteluvastuksia nostettiin niin, että henkilö pystyi kannustettuna tekemään kaksi 10 toiston sarjaa. Lisäksi ohjelma sisälsi toiminnallisia harjoitteita, kuten tuolilta ylösnousua, lonkkien ja yläraajojen koukistuksia pienillä nilkka- ja rannepunnuksilla sekä tasapainoharjoitteita. Harjoittelu sisälsi myös mielikuva-rentoutuksen. Harjoittelukerta kesti 1,5 tuntia ja sen jälkeen tarjottiin lounas sairaalan osastolla. Harjoitteluryhmälle oli järjestetty myös yhteiskuljetus terveyskeskukseen ja takaisin. Kotivoimisteluryhmälle ohjattiin yhden kotikäynnin aikana kotivoimisteluohjelma, joka sisälsi samoja toiminnallisia ja tasapainoharjoituksia, mutta ei voimaharjoittelua. Koehenkilöt testattiin tutkimuksen aikana 4 kertaa: sairaalajakson aikana sekä 1 viikon, 3 ja 9 kuukauden kuluttua interventioon päättymisen jälkeen. Testimittareina oli lihasvoimatestit dynamometrillä ja kuntosalilaitteeseen liitettävällä isometrisen voiman mittarilla, 10 metrin kävelynopeuden testaus, tasapainon testaus Bergin tasapainoasteikolla sekä mielialan testaus Zungin mielialatestillä (ZSDS) ja toimintakyvyn arviointi Joensuu-luokituksella. Lisäksi kerättiin 12 kk kestäneen tutkimuksen aikana tietoja sosiaali- ja terveyspalvelujen käytöstä, kaatumistapauksista sekä sosiaali- ja terveyspalvelujen kustannuksista.

Kuntosaliharjoittelun todettiin parantavan maksimaalista isometristä polvien ojennusvoimaa (20.8, SD 25.9% vs. 5.1, SD 16.0 %,  $p=0.009$ ), tasapainoa (tasapainoasteikolla parannus +4.4, SD 7.2 pistettä vs. -1.3, SD 5.5 pistettä,  $p=0.001$ ) ja kävelynopeutta (+0.12, SD 0.32 m/s vs. -0.05, SD 0.23 m/s,  $p=0.035$ ) merkittävästi verrattuna kotivoimisteluryhmään. Harjoittelu paransi myös mielialaa (ZSDS- pisteiden muutos -3.1, SD 9.0 pistettä vs. +1.3, SD 7.6 pistettä,  $p=0.048$ ). Harjoittelun vaikutukset lihasvoimaan, kävelynopeuteen ja mielialaan olivat yhä todettavissa vielä 9 kk kuluttua harjoittelun päättymisen jälkeen. Kuntosaliharjoittelu ei kuitenkaan parantanut Joensuu-luokituksella mitattua toimintakykyä eikä vähentänyt kaatumisia tai sosiaali- ja terveydenhuollon kustannuksia.

Iäkkäiden kuntosaliharjoittelu todettiin perusterveydenhuoltoon hyvin sopivaksi ja turvalliseksi kuntoutusmuodoksi. Äkillisestä sairaudesta toipumisessa harjoittelu osoittautui nopeaksi menetelmäksi parantaa lihasvoimia, tasapainoa ja kävelynopeutta sekä mielialaa. Harjoitteluohjelma ei kuitenkaan parantanut toimintakykyä tai vähentänyt kaatumisia tai sosiaali- ja terveydenhuollon kustannuksia.

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## 10. APPENDIX

Bergin tasapainoasteikko PVM: \_\_\_\_\_ TESTAAJA: \_\_\_\_\_  
NIMI: \_\_\_\_\_ HETU: \_\_\_\_\_ NRO: \_\_\_\_\_

### 1. Istumasta seisomaan nousu

- Ohjeet: Nouse ylös. Yrittäkää nousta ilman että tuette käsillänne
4. Kykenee nousemaan tukematta käsillä ja saavuttaa tasapainon itsenäisesti
  3. Kykenee nousemaan itsenäisesti käsillä tukien
  2. Kykenee nousemaan käsiä apuna käyttäen useiden yritysten jälkeen
  1. Tarvitsee pientä apua ylösnousussa tai tasapainon saavuttamisessa
  0. Tarvitsee kohtalaisesti tai runsaasti apua ylösnousussa

### 2. Seisominen ilman tukea

- Ohjeet: Seisokaa kaksi minuuttia ilman tukea
4. Kykenee seisomaan turvallisesti 2 min.
  3. Kykenee seisomaan 2 min. valvottuna
  2. Kykenee seisomaan 30 sek. ilman tukea
  1. Tarvitsee useita yrityksiä ennen kuin kykenee seisomaan 30 sek. ilman tukea
  0. Ei kykene seisomaan 30 sekuntia ilman apua

Jos henkilö kykenee seisomaan turvallisesti 2 min. anna täydet pisteet kohdassa 3 ja mene suoraan kohtaan 4.

### 3. Istuminen ilman tukea jalat lattiassa

- Ohjeet: Istukaa kädet sylissä kaksi minuuttia
4. Kykenee istumaan vakaasti kaksi minuuttia
  3. Kykenee istumaan 2 min. valvottuna
  2. Kykenee istumaan 30 sekuntia
  1. Kykenee istumaan 10 sekuntia
  0. Ei kykene istumaan ilman tukea 10 sekuntia

### 4. Seisomasta istuutuminen

- Ohjeet: Istukaa alas
4. Istuutuu turvallisesti vain vähän käsiä apuna käyttäen
  3. Varmistaa istuutumista käsiä apuna käyttäen
  2. Painaa pohkeita tuolia vasten varmistaakseen istuutumisen
  1. Istuu itsenäisesti, mutta istuutuminen hapanoivaa
  0. Tarvitsee apua istumisessa

### 5. Siirtymiset

- Ohjeet: Menkää tuoilta sänkyyn ja takaisin
4. Kykenee siirtymään turvallisesti vähän käsiä apuna käyttäen
  3. Kykenee siirtymään turvallisesti selvästi käsiä apuna käyttäen
  2. Kykenee siirtymään suullisia ohjeita noudattaen ja/tai valvottuna
  1. Tarvitsee yhden henkilön tuen siirtymisessä
  0. Tarvitsee kahden henkilön tuen tai valvonnan siirtymisessä

### 6. Seisominen ilman tukea silmät kiinni

- Ohjeet: Sulkekaa silmät ja seisokaa paikoillanne 10 sekuntia
4. Kykenee seisomaan 10 sekuntia turvallisesti
  3. Kykenee seisomaan 10 sekuntia valvottuna

2. Kykenee seisomaan 3 sekuntia
1. Ei kykene pitämään kiinni silmiä 3 sekuntia, mutta seisoo vakaasti
0. Tarvitsee apua ettei kaadu

7. Seisominen ilman tukea jalat yhdessä

- Ohjeet: Laittakaa jalat yhteen ja seisokaa liikkumatta
4. Kykenee laittamaan jalat yhteen itsenäisesti ja seisomaan minuutin ajan turvallisesti
  3. Kykenee laittamaan jalat yhteen itsenäisesti ja seisomaan minuutin ajan valvottuna
  2. Kykenee laittamaan jalat yhteen itsenäisesti, mutta ei kykene pysymään paikoillaan 30 sekuntia
  1. Tarvitsee apua asennon hakemisessa, mutta kykenee seisomaan paikoillaan 15 sek. jalat yhdessä
  0. Tarvitsee apua asennon hakemisessa eikä kykene seisomaan paikoillaan 15 sek.

8. Seisoma-asennossa eteen kurkottaminen ojennetuin käsivarsin

- Ohjeet: Nostakaa käsivarret 90 astetta. Ojentakaa sormenne ja kurkottakaa eteenpäin niin kauas kuin pystytte
4. Kykenee kurkottamaan eteenpäin vakaasti yli 25 cm
  3. Kykenee kurkottamaan eteenpäin yli 13 cm turvallisesti
  2. Kykenee kurkottamaan eteenpäin yli 5 cm turvallisesti
  1. Kurkottaa eteenpäin, mutta tarvitsee valvontaa
  0. Tarvitsee apua ettei kaadu

9. Esineen nostaminen lattialta seisoen

- Ohjeet: Nostakaa jalkojenne edessä oleva kenkä
4. Kykenee nostamaan kengän turvallisesti ja helposti
  3. Kykenee nostamaan kengän, mutta tarvitsee valvontaa
  2. Ei kykene nostamaan kenkää, mutta ylittää 2-5 cm päähän kengästä ja pysyy pystyssä ilman apua
  1. Ei kykene nostamaan kenkää ja tarvitsee valvontaa yrityksessä
  0. Ei kykene edes yrittämään/tarvitsee apua ettei kaadu

10. Taaksepäin katsominen vasemman ja oikean olkapään yli

- Ohjeet: Katsokaa taakse vasemman olkapään yli. Toistakaa sama oikealle puolelle
4. Katsoo molemmille puolille ja painon siirto onnistuu
  3. Katsoo vain toiselle puolelle, toiselle puolelle siirto onnistuu huonommin
  2. Kääntää pään vain sivuille, mutta säilyttää tasapainon
  1. Tarvitsee ohjausta pään kääntämisessä
  0. Tarvitsee apua ettei kaadu

11. Kääntyminen 360 astetta

- Ohjeet: Kääntykää ympäri koko kierros. Tauko. Kääntykää täysi kierros toiseen suuntaan.
4. Kykenee kääntymään 360 astetta turvallisesti alle 4 sek. kumpaankin suuntaan
  3. Kykenee kääntymään kumpaankin suuntaan 360 astetta, mutta vain toiseen suuntaan alle 4 sekunnissa.
  2. Kykenee kääntymään 360 astetta turvallisesti, mutta hitaasti
  1. Tarvitsee lähivalvontaa tai suullisia ohjeita
  0. Tarvitsee apua kääntymisessä

Dynaaminen painonsiirto ilman tukea seisossa

12. Kuinka monta kertaa jalka koskettaa jalkaraa

- Ohjeet: Laittakaa vuoronperään jalka jalkaralle. Jatkaa kunnes olette koskettanut kummallakin jalalla 4 kertaa.
4. Kykenee seisomaan itsenäisesti ja turvallisesti ja suorittamaan 8 askelmaa 20 sekunnissa
  3. Kykenee seisomaan itsenäisesti ja suorittamaan 8 askelmaa yli 20 sekunnissa

2. Kykenee suorittamaan 4 askelmaa ilman apua ja valvontaa
  1. Kykenee suorittamaan yli 2 askelmaa pienellä avustuksella
  0. Tarvitsee apua ettei kaadu/ ei kykene yrittämään
13. Seisominen ilman tukea toinen jalka toisen edessä
- Ohjeet: (Näytä malli ) Laittakaa jalka heti toisen jalkaterän eteen. Jos tuntuu, ettette pysty laittamaan aivan toisen eteen, yrittäkää laittaa edessä olevan jalan kantapää mahdollisimman lähelle takana olevan jalkaterän varpaita.
4. Kykenee laittamaan jalkaterän aivan toisen eteen ja seisomaan 30 sekuntia
  3. Kykenee laittamaan jalkaterän toisen eteen ja seisomaan 30 sekuntia
  2. Kykenee ottamaan pienen askeleen eteenpäin (mutta ei suoraan toisen jalan eteen) ja seisomaan 30 sekuntia
  1. Tarvitsee apua askeleen ottamisessa, mutta pystyy seisomaan 15 sekuntia
  0. Menettää tasapainon kun ottaa askeleen tai seisoo
14. Yhdellä jalalla seisominen
- Ohjeet: Seisokaa yhdellä jalalla niin kauan kuin pystytte kaatumatta
4. Kykenee nostamaan itsenäisesti jalkaa ja seisomaan yli 10 sek.
  3. Kykenee nostamaan jalan itsenäisesti ja seisomaan 5-10sek.
  2. Kykenee nostamaan jalan itsenäisesti ja seisomaan yli 3 sek.
  1. Yrittää nostaa jalkaa, ei pysty seisomaan 3 sek. mutta seisoo itsenäisesti
  0. Ei kykene yrittämään tai tarvitsee apua ettei kaadu

Bergin tasapainotestin pistelasku:

- |     |                              |       |
|-----|------------------------------|-------|
| 1.  | (istumasta ylösnousu)        | _____ |
| 2.  | (seisominen ilman tukea)     | _____ |
| 3.  | (istuminen ilman tukea)      | _____ |
| 4.  | (seisomasta istuminen)       | _____ |
| 5.  | (siirtyminen)                | _____ |
| 6.  | (silmit kiinni 10 sek.)      | _____ |
| 7.  | (jalat yhdessä)              | _____ |
| 8.  | (eteen kurkottaminen)        | _____ |
| 9.  | (esineen poimiminen)         | _____ |
| 10. | (katsominen olan yli)        | _____ |
| 11. | (kääntyminen 360)            | _____ |
| 12. | (askeltaminen)               | _____ |
| 13. | (tandem 30 sek.)             | _____ |
| 14. | (yhdellä jalalla seisominen) | _____ |

Yhteispisteet: \_\_\_\_\_/56

## 11. ORIGINAL PUBLICATIONS



## Kuopio University Publications D. Medical Sciences

**D 385. Perola, Outi.** Hospital water supply as a source of nosocomial infections. 2006. 99 p. Acad. Diss.

**D 386. Kuittinen, Taru.** Autologous stem cell transplantation in patients with non-Hodgkin's lymphoma: progenitor cell mobilisation, toxicity of high-dose therapy, and progressive disease after transplantation. 2006. 115 p. Acad. Diss.

**D 387. Siloaho, Maritta.** Utilization of quality management systems in Finnish medical laboratories. 2006. 105 p. Acad. Diss.

**D 388. Haara, Mikko.** Osteoarthritis and osteoporosis assessed from hand radiographs: prevalence, determinants, and associations with morbidity and mortality. 2006. 87 p. Acad. Diss.

**D 389. Tenhola, Sirpa.** Cardiovascular risk factors and adrenal function in 12-year-old children born small for gestational age or after a preeclamptic pregnancy. 2006. 85 p. Acad. Diss.

**D 390. Zacharova, Jelena.** Insulin-sensitizing genes and risk of type 2 diabetes: studies on the PGC-1 $\alpha$ , PPAR $\gamma$ , adiponectin, leptin receptor and hepatic lipase genes. 2006. 103 p. Acad. Diss.

**D 391. Rilla, Kirsi.** Hyaluronan synthase: intracellular traffic, activity at plasma membrane, and impact on keratinocyte migration, proliferation and formation of microvilli. 2006. 119 p. Acad. Diss.

**D 392. Pesonen, Tuula.** Trends in Suicidality in Eastern Finland, 1988–1997. 2006. 119 p. Acad. Diss.

**D 393. Tuhkanen, Hanna.** DNA copy number changes in the stromal and epithelial cells of ovarian and breast tumours. 2006. 112 p. Acad. Diss.

**D 394. Koskelo, Reijo.** Säädetävien kalusteiden vaikutukset tuki- ja liikuntaelimestön terveyteen lukiolaisilla. 2006. 96 p. Acad. Diss.

**D 395. Elo, Mika.** Stress-Related Protein Synthesis in Mammalian Cells Exposed to Hydrostatic Pressure. 2006. 74 p. Acad. Diss.

**D 396. Remes-Pakarinen, Terhi.** Influences of genetic factors and regular exercise on bone in middle-aged men. 2006. 95 p. Acad. Diss.

**D 397. Saarela, Tanja.** Susceptibility genes of diabetes and endothelial dysfunction in preeclampsia. 2006. 103 p. Acad. Diss.

**D 398. Piippo-Savolainen, Eija.** Wheezy babies - wheezy adults? Adulthood asthma, bronchial reactivity and lung function after hospitalization for bronchiolitis in early life. 2006. 91 p. Acad. Diss.

**D 399. Kauppinen, Anu.** Lipocalin Allergen-Induced T Cell Response: Prospects for Peptide-Based Immunotherapy. 2006. 81 p. Acad. Diss.