

KUOPION YLIOPISTON JULKAISUJA D. LÄÄKETIEDE 406
KUOPIO UNIVERSITY PUBLICATIONS D. MEDICAL SCIENCES 406

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,
on Friday 27th April 2007, at 12 noon

Department of Public Health and General Practice
University of Kuopio



KUOPION YLIOPISTO

KUOPIO 2007

- Distributor:** Kuopio University Library
P.O. Box 1627
FI-70211 KUOPIO
FINLAND
Tel. +358 17 163 430
Fax +358 17 163 410
www.uku.fi/kirjasto/julkaisutoiminta/julkmyyn.html
- Series Editors:** Professor Esko Alhava, M.D., Ph.D.
Institute of Clinical Medicine, Department of Surgery
- Professor Raimo Sulkava, M.D., Ph.D.
School of Public Health and Clinical Nutrition
- Professor Markku Tammi, M.D., Ph.D.
Institute of Biomedicine, Department of Anatomy
- Author's address:** Social and Welfare Health Center of Joensuu
Noljakantie 17
FI-80130 JOENSUU
FINLAND
E-mail: leena.timonen@fimnet.fi
- Supervisors:** Professor Raimo Sulkava, M.D., Ph.D.
School of Public Health and Clinical Nutrition
University of Kuopio
- Professor Taina Rantanen, Ph.D.
Department of Health Sciences
University of Jyväskylä
- Reviewers:** Professor Kaisu Pitkälä, M.D., Ph.D.
Department of General Practice and Public Health
University of Helsinki
- Research Director Sarianna Sipilä, Ph.D.
The Finnish Centre for Interdisciplinary Gerontology
Department of Health Sciences
University of Jyväskylä
- Opponent:** Professor Sirkka-Liisa Kivelä, M.D., Ph.D.
Institute of Clinical Medicine, Family Medicine
University of Turku

ISBN 978-951-27-0666-2
ISBN 978-951-27-0743-0 (PDF)
ISSN 1235-0303

Kopijyvä
Kuopio 2007
Finland

Timonen, Leena. 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. Kuopio University Publications D. Medical Sciences 406. 2007. 91 p.

ISBN 978-951-27-0666-2

ISBN 978-951-27-0743-0 (PDF)

ISSN 1235-0303

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

Medical Subject Headings: Accidental Falls/economics; Activities of Daily Living; Affect; Aged, 80 and over; Female; Frail Elderly; Gait; Health Care Costs; Muscle Strength; Musculoskeletal Equilibrium



To Tero and Kristina



ACKNOWLEDGEMENTS

The present study was carried out in the Division of Geriatrics, Department of Public Health and General Practice in the University of Kuopio and the Department of Health Sciences, University of Jyväskylä with collaboration with the Social Welfare and Healthcare Center of Joensuu.

I express my deepest gratitude to my supervisor Professor Raimo Sulkava in the University of Kuopio. His encouraging support through our long research process made it possible to complete this work.

My other supervisor Professor Taina Rantanen in the University of Jyväskylä was the soul and the inspiration behind this work. I was very lucky that she agreed to be to my supervisor. Her knowledge of the topic was invaluable, especially at the start of the work, when no one else in the research group had any experience of resistance training. Without her contribution, this work would have been impossible. Her advice and constructive criticism during the writing process were of enormous value. Her enthusiasm and belief helped me through difficult times.

I express my warm thanks to physiotherapists Marja Koivula and Katja Raiskio for designing of the rehabilitation program. Marja Koivula's long experience in rehabilitation of older people supplemented with Katja Raiskio's athletic background was a productive combination in developing the program. At the start of the project (1995-1996), the general opinion about geriatric rehabilitation was very different from today. I am delighted that these marvelous ladies had such a clear and uncompromising vision and were able to ignore the prejudices and criticisms.

I want to thank my co-writer Docent Simo Taimela from the David Fitness and Medical Ltd for providing us with the training equipment and sending Mrs. Sirkka Parviainen to teach us how to use the devices.

I express my warm thanks to the other co-writers Erkki Mäkinen, MD, PhD, for his encouragement throughout the project, Timo Törmäkangas, MA, for analysis of the data and Professor Olli-Pekka Ryytänen for his help in planning the research protocol.

I am most grateful to the reviewers of this dissertation, Professor Kaisu Pitkälä and Docent Sarianna Sipilä for their excellent comments during the preparation of the final manuscript.

I am greatly indebted to the personnel of the Siilainen Hospital and Home Healthcare of the City of Joensuu for their help during the research project, and my colleagues in the Health Center for their understanding and flexibility.

I also want to thank Mrs. Päivi Heikura for practical help in collecting the literature and Dr. Ewen MacDonald for revising the language of two of the original papers and this thesis.

I am very grateful to my research patients, who without prejudices and hesitation volunteered to be pioneers to test the novel training program.

I want to thank my husband Tero for his endless support and help in analyzing the data, repairing the computer over and over again, and giving me the opportunity to concentrate on writing. Finally, I want to thank my daughter Kristina, whose empathy and support made it easier to spend my holidays and weekends on research work.

I had the opportunity to participate in the Primary Healthcare Research School of the Kuopio University for three months, which was of the utmost importance for completing the final manuscript. This study was also supported by the Uulo Arhio and Juho Vainio Foundations.

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)



CONTENTS

1. INTRODUCTION	15
2. REVIEW OF LITERATURE	17
2.1. Concepts of frailty, comorbidity and disability	17
2.1.1 Measurements of functional limitations and disabilities	18
2.1.2 Deterioration of muscle strength with increasing age	19
2.2 Possibilities of exercise training in reversing frailty, comorbidity and functional limitations.....	20
2.2.1 Definitions of various types of exercise training	20
2.2.2 Muscle hypertrophy as a response to strength training and detraining	20
2.2.2.1 Impact of nutrition in strength training	21
2.2.3 Benefits of strength training on prevention and treatment of chronic diseases ...	22
2.2.4 Benefits of strength training on reversing frailty and functional limitations.....	23
2.2.4.1 Differences between group-based and home-based training programs ...	23
2.2.4.2 Differences between strength-only and multi-component training	24
2.2.5 Studies of the effects of strength-only and multi-component interventions on functional limitations and ADL/IADL skills	25
2.2.6 Contraindications and risks of strength training.....	27
2.2.7 Current recommendations for a strength training program intended for older people.....	27
2.3 Depression and physical activity in old age	28
2.3.1 Guided imagery and relaxation techniques	29
2.3.2 Strength-only and multi-component interventions in improving mood in older adults.	30
2.4 Muscle strength and falls in old age.....	32
2.4.1 Exercise interventions for decreasing falls in home-dwelling older persons	33
2.5 Economic evaluation of exercise interventions among community-dwelling older people	35
3. AIMS OF PRESENT THE STUDY	42
4. SUBJECTS AND METHODS	43
4.1 Subjects	43
4.2 Randomization	43
4.3 Measurements	43
4.3.1 Muscle strength.....	46
4.3.2 Walking speed.....	46
4.3.3 Dynamic balance	46
4.3.4 Timed up-and-go.....	46
4.3.5 Stair climbing ability	47
4.3.6 Assessment of mood and cognitive function	47
4.3.7 Assessment of functional abilities	47
4.3.8 Methods of economic evaluation.....	48
4.3.9 Data of falls	49
4.3.10 Data of physical activity	49
4.3.11 Primary and secondary outcome measures.....	50
4.4 Interventions.....	51
4.4.1 Group-based multi-component intervention.....	51
4.4.2 Home exercise intervention	52
4.5 Ethics.....	52
4.6 Statistical methods	52

5	RESULTS	54
5.1	Baseline characteristics	54
5.2	Adherence to interventions and adverse events	55
5.3	Effects of the interventions on physical performance (I)	56
5.4	Effects of the interventions on mood (II)	56
5.5	Effects of the interventions on the functional abilities (III)	59
5.6	Effects of the interventions on falls (IV)	60
5.7	Effects of the interventions on social welfare and healthcare costs (IV)	60
5.7.1	Costs of implementing the intervention programs	60
5.7.2	Individual social welfare and healthcare costs	61
5.7.3	Direct healthcare costs for falls	61
5.8	Effect of the interventions on physical activity	63
6.	DISCUSSION	64
6.1	Effects of physical training on primary and secondary outcome measures	64
6.1.1	Effects on strength and physical performance	64
6.1.2	Effects on mood	65
6.1.3	Effects on functional abilities	66
6.1.4	Effects on falls and self-reported physical activity	67
6.1.5	Effects on social welfare and healthcare costs	68
6.2	Limitations and strengths of the study	68
6.3	Recommendations for future studies	69
7.	CONCLUSIONS	71
8.	SUMMARY IN FINNISH – SUOMENKIELINEN YHTEENVETO	72
9.	REFERENCES	73
10.	APPENDIX	
11.	ORIGINAL PUBLICATIONS	

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 ± 65 days vs. 422 ± 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, Difranco-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 1/wk 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 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 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 2. endurance 3. ST+ endurance or usual care	24-26 wk 3/wk classes 18 mo FU (costs, falls)	strength+, gait- balance-, IADL- Fsc-, Falls↓ healthcare (HC) costs↓
Campbell et al. 1997 Robertson et al. 2001b 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 3/wk 2 yr FU (falls)	Falls↓, balance+ chair rise+, strength-, gait- HC costs-
Campbell et al. 2005	391, visual impaired, age 83	hospital register	1. home safety 2. exercise (Otago) +vit D 3. exercise+ vit D+ safety or social visits	1 year 3/wk	safety: falls↓ exercise: falls-

Chandler * et al. 1998	100 functionally impaired age 78	outpatient clinics	home-based ST or usual care	10 wk 3/wk	strength+
Clemson et al. 2004	310 frail mean age 78	media advertisements	home exercise safety instructions in small groups or social visits	7 wk 1/wk session 14 mo FU	falls↓
Day et al. 2002	1107 healthy mean age 76	invitation letters to 11 120 people	1. group+ home exercise 2. home safety 3. vision improvement 4-8. combinations or usual care	15 wk 1/wk 18 mo FU	exercise: falls↓ other interventions: falls-
Gill et al. 2002 Gill et al. 2004b	188 frail mean age 83	GP clinics	individually tailored home exercise program+ home safety or health education	6 mo 16 visits 6 mo FU	ADL decline↓ IADL decline↓ PT+, mobility+
Hauer et al. 2001 Hauer et al. 2003 (2 yr FU)	57 females frail history of falls mean age 82	acute care or inpatient rehab	ST, balance, function group-based classes or flexibility, games etc.	3 mo 3/wk+ 3 mo FU	strength +, balance+ PT+,ADL/IADL-, falls(↓)
Helbostad et al. 2004a	77 frail mean age 81	newspapers HC workers	1. balance + ST home 2. balance+ ST home+ balance+ ST group	1. 2/daily+ 3 group meetings 2. 2/day home+ 2/wk group 12 wk+ 9 mo FU	both groups: gait+ balance- strength-, falls- no group differences
Jette * et al. 1999	215 frail mean age 75	mailings self/ physician referrals	home ST video- taped instructions + 2 home visits or waiting list	6 mo 3/wk	strength + 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 1/wk class+ 2/wk home 6 mo 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 2. vitamin D single dose or placebo single dose	10 wk 3/wk 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 2/wk class+ home exercise 4 mo 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 2. group-based agility or group-based stretching	25 wk 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 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 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 3/wk	Falls↓, fall-related hospital costs-

Siebens et al. 2000	300 non-frail mean age 78	acute care hospital	flexibility, ST and walking in hospital and home or usual hospital care 1. group-based ST 2. group-based walking +step aerobics or usual care	1 mo post- discharge 3/wk 18 wk 3/wk ST 2/wk walking +1/wk aerobics	length of stay- IADL+, physical activity-, PT- strength + both groups gait+ both groups
Sipilä* et al. 1996	42 non-frail women aged 76 to 78	population register			
Skelton* et al. 1995	52 healthy mean age 80	newspaper advertisements	group-based ST with rice bags and tubings + home exercises or usual care	12 wk 1/wk group 2/wk home	strength + step up height+
Tinetti et al. 1994 Rizzo et al. 1996	301 increased fall risk, age 78 (economic evaluation)	HMO	adjustment of medication behavioral instructions home balance+ ST or social visits	3 mo 2/day home training 9 mo FU	falls↓ fall risks↓ HC costs↓
Tinetti et al. 1999	304 with hip fracture, mean age 80	hospitals	home-based safety instruction, balance, ST occupational therapy or usual care	12 mo 1/day	ADL-, balance- triceps strength+ 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 ≥ 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 * et al. 2002	30 females frail with CHD mean age 71	hospital	ST group-based or stretching, calisthenics relaxation group-based	6 mo 3/wk	GDS –
Chin A Paw* \circ et al. 2004	173 in long-term facilities mean age 82	informative meetings in 6 residential facilities	1. ST group-based 2. all-round functional 3. combination of 1&2 or educational group	6 mo 2/wk each intervention	1. and 2. DQoL–, GDS– VPS– 3. DQoL \downarrow VPS \downarrow
Hauer 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+ 3 mo FU	GDS –, PGMS – FHI+
Helbostad et al. 2004b	77 frail mean age 81	newspapers HC workers	1. balance + ST home 2. balance+ ST home+ balance+ ST group	1. 2/day+ 3 group meetings 2. 2/day +2/wk group 12 wk + 9 mo FU	2. SF-36 Mental Index +
Nelson et al. 2004	72 frail mean age 77	media advertisements	home-based ST balance, activity or nutrition education	6 mo 11 home visits	GDS – SF-36 –
Perrig- * Chiello et al. 1998	46 mean age 73	sample of 442 people in the IDA project	ST group-based or waiting list	8 wk 1/wk	well-being– self-forgetfulness + lack of complaining– subjective health–
Singh* et al. 1997	32 subjects BDI > 12 mean age 71	2 volunteer databases of 2953 people	ST group-based or educational group- meetings	10 wk, 3/ wk ST 2/wk	BDI +, HRSD + GDS+, DSM-IV+ PGMS–, SF-36+ ESSE–

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

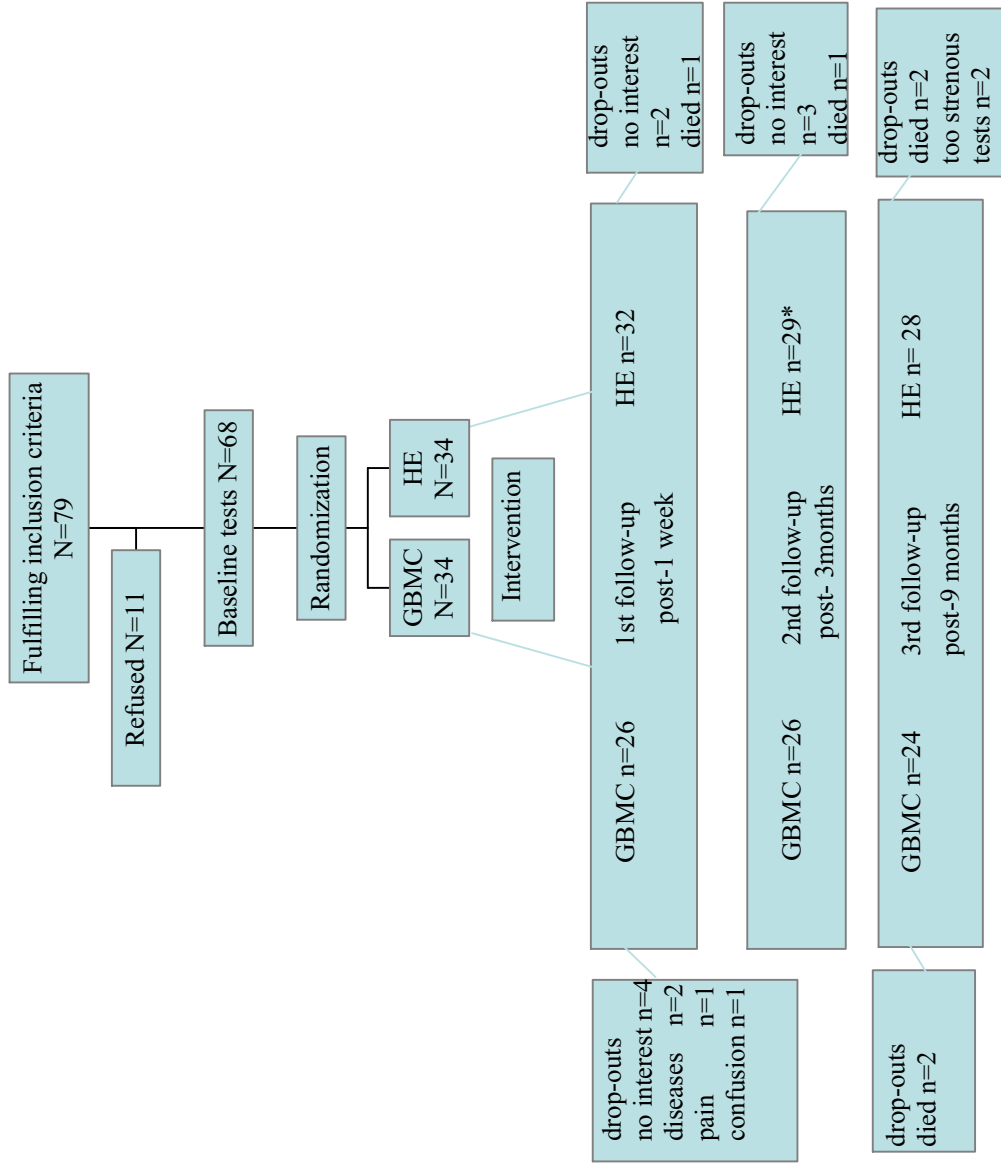
	GBMC N=34		HE group N=34		P
	F	%	F	%	
Reason for Admission					
Musculoskeletal	13	38	14	41	0.810.
Infections	10	29	8	24	0.597
Cardiovascular	7	21	6	18	>0.999
Gastrointestinal	2	6	5	15	0.428.
Diabetes	2	6	1	3	0.619
Chronic conditions					
Cardiovascular	30	88	31	91	0.714
angina pectoris	17		18		
heart 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
Medication in use:					
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 ¹ , d	13.5 (7.3)	13.2 (10.0)	0.555
Home nursing, h/month ¹	0.35 (0.58)	0.23 (0.52)	0.293
Home help, h/month ¹	8.8 (13.3)	11.9 (18.5)	0.366
Informal help, times/month ¹	9.7 (11.4)	7.7 (11.8)	0.173
Physical activity, min/week ¹	270 (282)	225 (320)	0.193

The differences between the groups were calculated using the 2-sided t-test or Mann-Whitney U-test¹. 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
Baseline (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	
1 week	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)
change 1w-0	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)
95% CI	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	
3 months	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)
change 3 m-0	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)
95% CI	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	
9 months	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)
change 9 m-0	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)
95 % CI	-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

	GBMC (SD)	HE (SD)
Baseline (N=34+34)	47.3 (7.8)	48.2 (10.2)
p	0.710	
1 Week (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	
3 Months (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	
9 Months (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		
Need for a walker or assistance in walking indoors											
	f	(%)	f	(%)	f	(%)	f	(%)	f	(%)	
GBMC	18	(53%)	17	(50%)	9	(35%)	11	(42%)	15	(48%)	
HE	13	(38%)	8	(24%)	6	(19%)	7	(23%)	9	(30%)	
	Admission		Discharge		1 week		3 months		9 months		
N	34/34		34/34		26/31		26/30		32/32		
Need for help in eating, bathing, dressing or toileting											
	f	(%)	f	(%)	f	(%)	f	(%)	f	(%)	
GBMC	23	(68%)	17	(50%)	10	(38%)	14	(54%)	20	(63%)	
HE	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
GBMC program:		
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
HE program:		
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

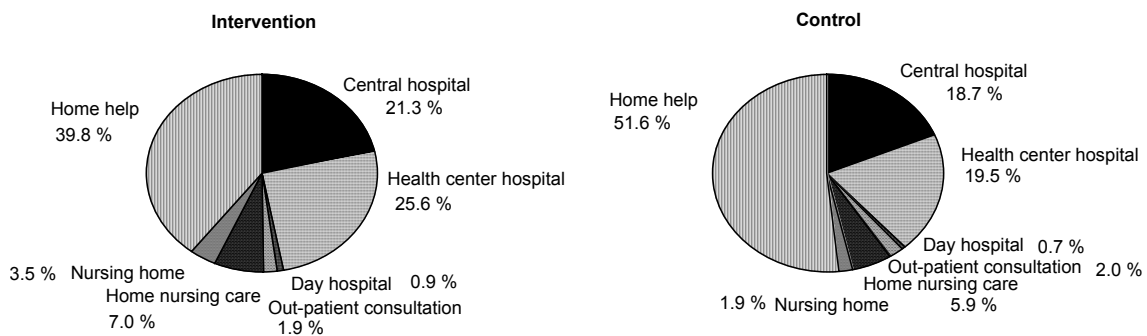
The total mean individual social welfare and healthcare costs were 7 717 (SD 6 715) € in the multi-component group and 7 612 (SD 7 903) € in the home exercise group ($p=0.962$) (Table 10). There were no statistically significant differences between the groups in the mean healthcare costs: 4 381 (SD 3 829) € 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 ± 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 (Slooman 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 liikuntakykyyn ja yleisen toimintakykyyn 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 intervention 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 toimintakykyyn 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.

9. REFERENCES

Abacus Concepts, SuperANOVA. Abacus Concepts, Inc. Berkeley, CA, 1989.

Aben I, Verhey F, Strik J, Lousberg R, Lodder J, Honig A. A comparative study into the one year cumulative incidence of depression after stroke and myocardial infarction. *J Neurol Neurosurg Psychiatry* 2003; 74:581-585.

Agresti A. *Categorical data analysis*. 2nd Ed. New York; Wiley, 2002.

Albright A, Franz M, Hornsby G, Kriska A, Marrero D, Ullrich I, Verity LS. American College of Sports Medicine position stand. Exercise and type 2 diabetes. *Med Sci Sports Exerc* 2000; 32:1345-1360.

Andersson L. Intervention against loneliness in a group of elderly women: an impact evaluation. *Soc Sci Med* 1985; 20:355-364.

Aniansson A, Rundgren A, Sperling L. Evaluation of functional capacity in activities of daily living in 70-year-old men and women. *Scand J Rehabil Med* 1980; 12: 145-154.

Applegate WB, Akins D, Vander Zwaag R, Thoni K, Baker MG. A geriatric rehabilitation and assessment unit in a community hospital. *J Am Geriatr Soc* 1983; 31:206-210.

Arent SM, Landers DM, Etnier JL. The effects of exercise on mood in older adults: a meta-analytic review. *J Aging Phys Act* 2000; 8:407-430.

Ashworth NL, Chad KE, Harrison EL, Reeder BA, Marshall SC. Home versus center based physical activity programs in older adults. *Cochrane Database Syst Rev* 2005;1: CD004017.

Babiyak M, Blumenthal JA, Herman S, Khatri P, Doraiswamy M, Moore K, Craighead WE, Baldewicz TT, Krishnan KR. Exercise treatment for major depression: maintenance of therapeutic benefit at 10 months. *Psychosom Med* 2000; 62:633-638.

Baker KR, Nelson ME, Felson DT, Layne JE, Sarno R, Roubenoff R. The efficacy of home based progressive strength training in older adults with knee osteoarthritis: a randomized controlled trial. *J Rheumatol* 2001; 28:1655-1665.

Bales CW, Ritchie CS. Sarcopenia, weight loss, and nutritional frailty in the elderly. *Annu Rev Nutr* 2002; 22: 309-323.

Ballard JE, McFarland C, Wallace LS, Holiday DB, Roberson G. The effect of 15 weeks of exercise on balance, leg strength, and reduction in falls in 40 women aged 65 to 89 years. *J Am Womens Assoc* 2004; 59: 255-61.

Bandura A. Self-efficacy: toward a unifying theory of behavioral change. *Psychol Rev* 1977; 84: 191-215.

Bandura A. *Social foundations of thought and action: A social cognitive theory*. Englewood Cliffs, NJ: Prentice Hall, 1986

Barnett A, Smith B, Lord SR, Williams M, Baumand A. Community-based group exercise improves balance and reduces falls in at-risk older people: a randomized controlled trial. *Age Ageing* 2003; 32:407-414.

Baumgartner RN, Koehler KM, Gallagher D, Romero L, Heymsfield SB, Ross RR, Garry PJ, Lindeman RD. Epidemiology of sarcopenia among the elderly in New Mexico. *Am J Epidemiol* 1998; 147:755-763.

- Bean JF, Kiely DK, Herman S, Leveille SG, Mizer K, Frontera WR, Fielding RA. The relationship between leg power and physical performance in mobility-limited older people. *J Am Geriatr Soc* 2002; 50: 461-467.
- Beck AT, Ward CH, Mendelson M, Mock J, Erbaugh J. An inventory for measuring depression. *Arch Gen Psychiatry* 1961; 4:561-571.
- Berg KO, Wood-Dauphinee SL, Williams JI, Maki B. Measuring balance in the elderly: validation of an instrument. *Can J Pub Health* 1992;83 suppl 2: S7-11.
- Berkman LF, Seeman TE, Albert M, Blazer D, Kahn R, Mohs R, Finch C, Schneider E, Cotman C, McClearn G, et al. High, usual and impaired functioning in community-dwelling older men and women: findings from the MacArthur Foundation Research Network on Successful Aging. *J Clin Epidemiol* 1993; 46: 1129-1140.
- Binder EF, Brown M, Sinacore DR, Steger-May K, Yarasheski KE, Schechtman KB. Effects of extended outpatient rehabilitation after hip fracture. *JAMA* 2004; 292:837-846.
- Binder EF, Schechtman KB, Ehsani AA, Steger-May K, Brown M, Sinacore DR, Yarasheski KE, Holloszy JO. Effects of exercise training on frailty in community-dwelling older adults: Results of a randomized, controlled trial. *J Am Geriatr Soc* 2002; 50:1921-1928.
- Blumenthal JA, Babyak MA, Moore KA, Craighead WE, Herman S, Khatri P, Waugh R, Napolitano MA, Forman LM, Appelbaum M, Doraiswamy PM, Krishnan KR. Effects of exercise training on older patients with major depression. *Arch Intern Med* 1999; 159:2349-2356.
- Bonnefoy M, Cornu C, Normand S, Boutitie F, Bugnard F, Rahmani A, Lacour JR, Laville M. The effects of exercise and protein-energy supplements on body composition and muscle function in frail elderly individuals: a long-term controlled randomised study. *Br J Nutr* 2003; 89: 731-738.
- Bootsma-van der Wiel A, Gussekloo J, de Craen AJ, van Exel E, Knook DL, Lagaay AM, Westendorp RG. Disability in the oldest old: "can do" or "do do". *J Am Geriatr Soc* 2001; 49:909-914.
- Bortz W 2nd. Disuse and aging. *JAMA* 1982; 248:1203-1208.
- Bortz WM 2nd. A conceptual framework of frailty: a review. *J Gerontol A Biol Sci Med Sci* 2002; 57: M283-288.
- Boult C, Kane RL, Louis TA, Boult L, McCaffrey D. Chronic conditions that lead to functional limitation in the elderly. *J Gerontol* 1994; M28-36.
- Boumendjel N, Herrmann F, Girod V, Sieber C, Rapin CH. Refrigerator content and hospital admission in old people. *Lancet* 2000; 356: 563.
- Boyd CM, Xue Q-L, Guralnik JM, Fried LP. Hospitalization and development of dependence in activities of daily living in a cohort of disabled older women: The Women's Health and Aging Study I. *J Gerontol A Biol Sci Med Sci* 2005; 60: 888-893.
- Bozzetti F. Nutritional issues in the care of the elderly patient. *Crit Rev Oncol Hematol* 2003; 48: 113-121.
- Braam AW, Prince MJ, Beekman ATF, Delespaul P, Dewey ME, Geerlings SW, Kivelä S-L, Lawlor BA, Magnússon H, Meller I, Pérès K, Reischies FM, Roelands M, Schoevers RA, Saz P, Skoog I, Turrina C, Versporten A, Copeland JRM. Physical health and depressive symptoms in older Europeans. Results from EURODEP. *Br J Psychiatry* 2005; 187:35-42.
- Brach JS, VanSwearingen JM, Newman AB, Kriska AM. Identifying early decline of physical function in community-dwelling older women: Performance-based and self-report measures. *Phys Ther* 2002; 82:320-328.

- Brochu M, Savage P, Lee M, Dee J, Cress ME, Poehlman ET, Tischler M, Ades PA. Effects of resistance training on physical function in disabled women with coronary heart disease. *J App Physiol* 2002; 92:672-678.
- Brod M, Stewart AL, Sands L, Walton P. Conceptualization and measurement of quality of life in dementia: The dementia quality of life instrument (DQoL). *Gerontologist* 1999; 39: 25-35.
- Buchner DM, Cress ME, de Lateur BJ, Esselman PC, Margherita AJ, Price R, Wagner EH. The effect of a strength and endurance training on gait, balance, fall risk, and health services use in community-living older adults. *J Gerontol A Biol Sci Med Sci* 1997; 52: M218-224.
- Buchner DM, Cress ME, Wagner EH, de Lateur BJ, Price R, Abrass IB. The Seattle FICSIT/Movelt study: the effects of exercise on gait and balance in older adults. *J Am Geriatr Soc* 1993; 41: 321-325.
- Campbell AJ, Borrie MJ, Spears GF. Risk factors for falls in a community-based prospective study of people 70 years and older. *J Gerontol* 1989; 44:M112-117.
- Campbell WW, Crim MC, Young VR, Evans WJ. Increased energy requirements and changes in body composition with resistance training in older adults. *Am J Clin Nutr* 1994; 60:167-175.
- Campbell AJ, Robertson MC, Gardner MM, Norton RN, Buchner DM. Falls prevention over 2 years: a randomized controlled trial in women 80 years and older. *Age Ageing* 1999; 28: 513-518.
- Campbell AJ, Robertson MC, Gardner MM, Norton RN, Tilyard MW, Buchner DM. Randomized controlled trial of a general practice programme of home based exercise to prevent falls in elderly women. *BMJ* 1997; 315: 1065-1069.
- Campbell AJ, Robertson MC, La Grow SJ, Kerse NM, Sanderson GF, Jacobs RJ, Sharp DM, Hale LA. Randomized controlled trial of prevention of falls in people aged ≥ 75 with severe visual impairment: the VIP trial. *BMJ* 2005; 331:817-821.
- Cesari M, Penninx BW, Pahor M, Lauretani F, Corsi AM, Rhys Williams G, Guralnik JM, Ferrucci L. Inflammatory markers and physical performance in older persons: the inCHIANTI study. *J Gerontol A Biol Sci Med Sci* 2004; 59: 242-248.
- Chandler JM, Duncan PW, Kochersberger G, Studenski S. Is lower extremity strength gain associated with improvement in physical performance and disability in frail, community-dwelling elders? *Arch Phys Med Rehabil* 1998; 79:24-30.
- Chang JT, Morton SC, Rubenstein LZ, Mojica WA, Maglione M, Suttorp MJ, Roth EA, Shekelle PG. Interventions for prevention of falls in older adults: systematic review and meta-analysis of randomised clinical trials. *BMJ* 2004; 328:680-686.
- Charette SL, McEvoy L, Pyka G, Snow-Harter C, Guido D, Wiswell RA, Marcus R. Muscle hypertrophy response to resistance training in older women. *J Appl Physiol* 1991; 70: 1912-1916.
- Chaouloff F. Physical exercise and brain monoamines: a review. *Acta Physiol Scand* 1989; 137:1-13.
- Chin A Paw MJM, van Poppel MNM, Twisk JWR, van Mechelen W. Effects of resistance and all-round functional training on quality of life, vitality and depression of older adults living in long-term care facilities: a 'randomized' controlled trial. *BMC Geriatr* 2004;4:5.
- Chou KL, Lee PWH, Yu ECS, Macfarlane D, Cheng YH, Chan SSC, Chi I. Effect of Tai Chi on depressive symptoms amongst Chinese older patients with depressive disorders: a randomized clinical trial. *Int J Ger Psychiatry* 2004; 19: 1105-1107.

- Chu LW, Chi I, Chiu AYY. Incidence and predictors of falls in the Chinese elderly. *Ann Acad Med Singapore* 2005; 34: 60-72.
- Christmas C, Andersen RA. Exercise and older patients: guidelines for the clinician. *J Am Geriatr Soc* 2000; 48: 318-324.
- Clemson L, Cumming RG, Kendig H, Swann M, Heard R, Taylor K. The effectiveness of a community-based program for reducing the incidence of falls in the elderly: a randomized trial. *J Am Geriatr Soc* 2004; 52:1487-1494.
- Close J, Ellis M, Hooper R, Glucksman E, Jackson S, Swift C. Prevention of falls in the elderly trial (PROFET): a randomized controlled trial. *Lancet* 1999; 353:93-97.
- Copeland JRM, Beekman ATF, Braam AW, Dewey ME, Delespaul P, Fuhrer R, Hooijer C, Lawlor BA, Kivela S-L, Lobo A, Magnusson H, Mann AH, Meller I, Prince MJ, Reischies F, Roelands M, Skoog I, Turrina C, deVreys MW, Wilson KCM. Depression among older people in Europe: the EURODEP studies. *World Psychiatry* 2004;3: 45-49.
- Covertino VA, Bloomfield SA, Greenleaf JE. An overview of the issues: physiological effects of bed rest and restricted physical activity. *Med Sci Sports Exerc* 1997; 29: 187-190.
- Covinsky KE, Palmer RM, Fortinsky RH, Counsell SR, Stewart AL, Kresevic D, Burant CJ, Landefeld CS. Loss of independence in activities of daily living in older adults hospitalized with medical illness: increased vulnerability with age. *J Am Geriatr Soc* 2003; 51:451-458.
- Creditor MC. Hazards of hospitalization of the elderly. *Ann Intern Med.* 1993; 118: 219-223.
- Cress ME, Schechtman KB, Mulrow CD, Fiatarone MA, Gerety MB, Buchner DM. Relationship between physical performance and self-perceived physical function. *J Am Geriatr Soc* 1995; 43:93-101.
- Cummings SR, Nevitt MC, Browner WS, Stone K, Fox KM, Ensrud KE, Gauley J, Black D, Vogt TM for the Study of Osteoporotic Fractures Research Group. Risk factors for hip fracture in white women. *N Engl J Med* 1995; 332: 767-773.
- Cussler EC, Lohman TG, Going SB, Houtkooper LB, Metcalfe LL, Flint-Wagner HG, Harris RB, Teixeira PJ. Weight lifted in strength training predicts bone change in postmenopausal women. *Med Sci Sports Exer* 2003; 35:10-17.
- Day L, Fildes B, Gordon I, Fitzharris M, Flamer H, Lord S. Randomised factorial trial of falls prevention among older people living in their own homes. *BMJ* 2002;325:128-133.
- Deschenes MR. Effects of aging on muscle fibre type and size. *Sports Med* 2004; 34:809-824.
- De Vos NJ, Singh NA, Ross DA, Stavrinou TM, Orr R, Fiatarone Singh MA. Optimal load for increasing muscle power during explosive resistance training in older adults. *J Gerontol A Biol Sci Med Sci* 2005; 60: 638-647.
- De Vreede PL, Samson MM, van Meeteren NLU, Duursma SA, Verhaar HJJ. Functional-task exercise versus resistance strength exercise to improve daily function in older women: A randomized, controlled trial. *J Am Geriatr Soc* 2005; 53:2-10.
- Difranco- Donoghue J, Werner WG, Douris PC. Comparison of once and twice weekly strength training in older adults. *Br J Sports Med* 2007; 41: 19-22.

Dishman RK, Renner KJ, Youngstedt SD, Reigle TG, Bunnell BN, Burke KA, Yoo HS, Mougey EH, Meverhoff JL. Activity wheel running reduces escape latency and alters brain monoamine levels after footshock. *Brain Res Bull* 1997; 42: 399-406.

Doherty TJ. Aging and sarcopenia. *J Appl Physiol* 2003; 95:1717-1727.

Dorrens J, Rennie MJ. Effects of ageing and human whole body and muscle protein turnover. *Scand J Med Sci Sports* 2003; 13: 26-33.

Dunstan DW, Daly RM, Owen N, Jolley D, de Courten M, Shaw J, Zimmet P. High-intensity resistance training improves glycemic control in older patients with type 2 diabetes. *Diabetes Care* 2002; 25:1729-1736.

Earles DR, Judge JO, Gunnarsson OT. Velocity training induces power-specific adaptations in highly functioning older adults. *Arch Phys Med Rehabil* 2001; 82: 872-878.

Emery CF, Gatz M. Psychological and cognitive effects of an exercise program for community-residing older adults. *Gerontologist* 1990; 30:184-188.

Esmarck B, Andersen JL, Olsen S, Richter EA, Mizuno M, Kjaer M. Timing of postexercise protein intake is important for muscle hypertrophy with resistance training in elderly humans. *J Physiol* 2001; 535: 301-311.

Estabrooks PA, Carron AV. Group cohesion in older adult exercisers: prediction and intervention effects. *J Behav Med* 1999; 22: 575-588.

Ettinger WH, Burns R, Messier SP, Applegate W, Rejeski WJ, Morgan T, Shumaker S, Berry MJ, O'Toole M, Monu J, Craven T. A randomized trial comparing aerobic exercise and resistance exercise with a health education program in older adults with knee osteoarthritis. The Fitness Arthritis and Seniors Trial (FAST). *JAMA* 1997; 227:25-31.

Ettinger WH, Davis MA, Neuhaus JM, Mallon KP. Long-term physical functioning in persons with knee osteoarthritis from NHANES-I: Effects of comorbid medical conditions. *J Clin Epidemiol* 1994; 47: 809-815.

Ewart C, Stewart K, Gillian R, Keleman M. Self efficacy mediates strength gains during circuit weight training in men with coronary artery disease. *Med Sci Sports Sci* 1986; 18: 531-540.

Faber MJ, Bosscher RJ, Chin A Paw MJ, van Wieringen PC. Effects of exercise programs on falls and mobility in frail and pre-frail older adults: A multicenter randomized controlled trial. *Arch Phys Med Rehabil* 2006; 87: 885-896.

Fatouros IG, Kambas A, Katrabasas I, Nikolaidis K, Chatziniolaou A, Leontsini D, Taxildaris K. Strength training and detraining effects on muscular strength, anaerobic power, and mobility of inactive older men are intensity dependent. *Br J Sports Med* 2005; 39: 776-780.

Ferrucci L, Baldasseroni S, Bandinelli S, de Alfieri W, Cartei A, Galvani D, Baldini A, Masotti G, Marchionni N. Disease severity and health-related quality of life across different chronic conditions. *J Am Geriatr Soc* 2000; 48: 1490-1495.

Ferrucci L, Guralnik JM, Studenski S, Fried LP, Cutler GB, Walston JD for The Interventions on Frailty Working Group. Designing randomized, controlled trials aimed at preventing or delaying functional decline and disability in frail, older persons: A consensus report. *J Am Geriatr Soc* 2004; 52:625-634.

Fiatarone MA, Marks EC, Ryan ND, Meredith CN, Lipsitz, LA, Evans WJ. High-intensity strength training in nonagenarians. Effects on skeletal muscle. *JAMA* 1990; 263:3029-3034.

Fiatarone MA, O'Neill EF, Ryan ND, Clements KM, Solares GR, Nelson ME, Roberts SB, Kehayias JJ, Lipsitz LA, Evans WJ. Exercise training and nutritional supplementation for physical frailty in very elderly people. *N Engl J Med* 1994; 330: 1769-1775.

Fiatarone Singh MA, Ding W, Manfredi TJ, Solares GS, O'Neill EF, Clements KM, Ryan ND, Kehayias JJ, Fielding RA, Evans WJ. Insulin-like growth factor I in skeletal muscle after weight-lifting exercise in frail elders. *Am J Physiol Endocrinol Metab* 1999; 277: E135-143.

Foldvari M, Clark M, Laviolette LC, Bernstein MA, Kaliton D, Castaneda C, Pu CT, Hausdorff JM, Fielding RA, Singh MA. Association of muscle power with functional status in community-dwelling elderly women. *J Gerontol A Biol Sci Med Sci* 2000; 55: M192-199.

Folstein MF, Folstein SE, McHugh PR. "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. *J Psychiatr Res* 1975; 12:189-198.

Fonseca VA. The metabolic syndrome, hyperlipidemia, and insulin resistance. *Clin Cornerstone* 2005; 7:61-72.

Fors EA, Sexton H, Gotestam KG. The effect of guided imagery and amitriptyline on daily fibromyalgia pain: a prospective, randomized, controlled trial. *J Psychiatr Res* 2002; 36: 179-187.

Fraser SN, Spink KS. Examining the role of social support and group cohesion in exercise compliance. *J Behav Med* 2002; 25: 233-249.

Fried LP, Bandeen-Roche K, Kasper JD, Guralnik JM for the Women's Health and Aging Study Collaborative Research Group. Association of comorbidity with disability in older women: The Women's Health and Aging Study. *J Clin Epidemiol* 1999; 52: 27-37.

Fried LP, Tangen CM, Walston J, Newman AB, Hirsch C, Gottdiener J, Seeman T, Tracy R, Kop WJ, Burke G, McBurnie MA; Cardiovascular Health Study Collaborative Research Group. Frailty in older adults: evidence for a phenotype. *J Gerontol A Biol Sci Med Sci* 2001; 56: M146-156.

Frontera WR, Meredith CN, O'Reilly KP, Evans WJ. Strength training and determinants of VO₂max in older men. *J Appl Physiol* 1990; 68: 329-333.

Frontera WR, Meredith CN, O'Reilly KP, Knuttgen HG, Evans WJ. Strength conditioning in older men: skeletal muscle hypertrophy and improved function. *J Appl Physiol* 1988; 64:1038-1044.

Frontera WR, Suh D, Krivickas LS, Hughes VA, Goldstein R, Roubenoff R. Skeletal muscle fibre quality in older men and women. *Am J Physiol Cell Physiol* 2000; 279: C611-618.

Fry AC. The role of resistance exercise intensity on muscle fibre adaptations. *Sports Med* 2004; 34: 663-679.

Fujiwara T, Saitoh S, Takagi S, Takeuchi H, Isobe T, Chiba Y, Miura T, Shimamoto K. Development and progression of atherosclerotic disease in relation to insulin resistance and hyperinsulinemia. *Hypertens Res* 2005; 28:665-670.

Galper DI, Trivedi MH, Barlow CE, Dunn AL, Kampert JB. Inverse association between physical inactivity and mental health in men and women. *Med Sci Sports Exerc* 2006; 38:173-178.

Galvao DA, Taaffe DR. Resistance exercise dosage in older adults: single- versus multiset effects on physical performance and body composition. *J Am Geriatr Soc* 2005; 53: 2090-2097.

Gardner W, Mulvey EP, Shaw EC. Regression analyses of counts and rates: Poisson, overdispersed Poisson, and negative binominal models. *Psychol Bull* 1995; 118:392-404.

- Gauvin L, Spence JC. Physical activity and psychological well-being: knowledge base, current issues, and caveats. *Nutr Rev* 1996; 54: S53-65.
- Gerety MB, Mulrow CD, Tuley MR, Hazuda HP, Lichtenstein MJ, Bohannon R, Kanten DN, O'Neil MB, Gorton A. Development and validation of a physical performance instrument for the functionally impaired elderly: the Physical Disability Index (PDI). *J Gerontol* 1993; 48:M33-38.
- Gill TM, Allore HG, Holford TR, Guo Z. Hospitalization, restricted activity, and the development of disability among older persons. *JAMA* 2004a; 292:2115-2124.
- Gill TM, Baker DI, Gottschalk M, Peduzzi PN, Allore H, Byers A. A program to prevent functional decline in physically frail, elderly persons who live at home. *N Engl J Med* 2002; 347:1068-1074.
- Gill TM, Baker DI, Gottschalk M, Peduzzi PN, Allore H, Van Ness PH. A prehabilitation program for the prevention of functional decline: effect on higher-level physical function. *Arch Phys Med Rehabil* 2004b; 85:1043-1049.
- Gillespie LD, Gillespie WJ, Robertson MC, Lamb SE, Cumming RG, Rowe BH. Interventions for preventing falls in elderly people. *Cochrane Database Syst Rev* 2003;CD000340.
- Green BH, Copeland JRM, Dewey ME, Sharma V, Saunders PA, Davidson IA, Sullivan C, McWilliam C. Risk factors for depression in elderly people: a prospective study. *Acta Psychiatr Scand* 1992; 86: 213-217.
- Griffin PT, Kogut D. Validity of orally administered Beck and Zung Depression Scales in a state hospital setting. *J Clin Psychol* 1988 44:756-759.
- Grizzle JE, Starmer CF, Koch GG. Analysis of categorical data by linear models. *Biometrics* 1969; 25:489-504.
- Gruzelier JH. A review of the impact on hypnosis, relaxation, guided imagery and individual differences on aspects of immunity and health. *Stress* 2002; 5: 147-163.
- Guccione AA, Felson DT, Anderson JJ, Anthony JM, Zhang Y, Wilson PWF, Kelly-Hayes M, Wolf PA, Kreger BE, Kannel WB. The effects of specific medical conditions on the functional limitations of elders in the Framingham Study. *Am J Public Health* 1994; 84: 351-358.
- Guralnik JM, Branch LG, Cummings SR, Curb JD. Physical performance measures in aging research. *J Gerontol* 1989; 44:M141-146.
- Guralnik JM, Ferrucci L, Simonsick EM, Salive ME, Wallace RB. Lower extremity function in persons over the age of 70 years as a predictor of subsequent disability. *N Engl J Med* 1995; 332:556-561.
- Guralnik JM, Simonsick EM. Physical disability in older Americans. *J Gerontol* 1993; 48:3-10.
- Guralnik JM, Simonsick EM, Ferrucci L, Glynn RJ, Berkman LF, Blazer DG, Scherr PA, Wallace RB. A short physical performance battery assessing lower extremity function: Association with self-reported disability and prediction of mortality and nursing home admission. *J Gerontol* 1994; 49:M85-94.
- Hamilton M. Development of a rating scale for primary depressive illness. *Br J Soc Clin Psychol* 1967; 6:278-296.
- Harris C, DeBeliso MA, Spitzer-Gibson TA, Adams KJ. The effect of resistance-training intensity on strength-gain response in the older adult. *J Strength Cond Res* 2004; 18: 833-838.

- Hassmén P, Koivula N. Mood, physical working capacity and cognitive performance in the elderly as related to physical activity. *Aging (Milano)* 1997; 9:136-142.
- Hauer K, Pfisterer M, Schuler M, Bärtsch P, Oster P. Two years later: a prospective long-term follow-up of a training intervention in geriatric patients with a history of severe falls. *Arch Phys Med Rehabil* 2003; 84:1426-1432.
- Hauer K, Rost B, Rüttschle K, Opitz H, Specht N, Bärtsch P, Oster P, Schlierf G. Exercise training for rehabilitation and secondary prevention of falls in geriatric patients with history of injurious falls. *J Am Geriatr Soc* 2001; 49:10-20.
- Helbostad JL, Sletvold O, Moe-Nilssen R. Effects of home exercises and group training on functional abilities in home-dwelling older persons with mobility and balance problems. A randomized study. *Aging Clin Exp Res* 2004a; 16:113-121.
- Helbostad JL, Sletvold O, Moe-Nilssen R. Home training with and without additional group training in physically frail old people living at home: effect on health-related quality of life and ambulation. *Clin Rehabil* 2004b; 18: 498-508.
- Hirvensalo M, Rantanen T, Heikkinen E. Mobility difficulties and physical activity as predictors of mortality and loss of independence in the community-living older population. *J Am Geriatr Soc* 2000; 48: 493-498.
- Hoeymans N, Wouters ER, Feskens EJ, van den Bos GA, Kromhout D. Reproducibility of performance-based and self-reported measures of functional status. *J Gerontol A Biol Sci Med Sci* 1997; 52:M363-368.
- Holm L, Esmarck B, Suetta C, Matsumoto K, Doi T, Mizuno M, Miller BF, Kjaer M. Postexercise nutrient intake enhances leg protein balance in early postmenopausal women. *J Gerontol A Biol Sci Med Sci* 2005; 60: 1212-1218.
- Hughes VA, Frontera WR, Wood M, Evans WJ, Dallal GE, Roubenoff R, Fiatarone Singh MA. Longitudinal muscle strength changes in older adults: influence of muscle mass, physical activity, and health. *J Gerontol A Biol Sci Med Sci* 2001; 56:B209-217.
- Hunter GR, McCarthy JP, Bamman MM. Effects of resistance training on older adults. *Sports Med* 2004; 34:329-348.
- Hunter GR, Newcomer BR, Larson-Meyer DE, Bamman MM, Weinsier RL. Muscle metabolic economy is inversely related to exercise intensity and type II myofibre distribution. *Muscle Nerve* 2001; 24:654-661.
- Hyatt RH, Whitelaw MN, Bhat A, Scott S, Maxwell JD. Association of muscle strength with functional status of elderly people. *Age Ageing* 1990; 19:330-336.
- Häkkinen K. Voimaharjoittelun perusteet: vaikutusmekanismit, harjoitusmenetelmät ja ohjelmointi. Gummerus, Jyväskylä, 1990.
- Hämäläinen P, Rantanen T, Keskinen M, Meurman JH. Oral health status and change in handgrip strength over a 5-year period in 80-year-old people. *Gerodontology* 2004; 21: 155-160.
- Iannuzzi-Sucich M, Prestwood KM, Kenny AM. Prevalence of sarcopenia and predictors of skeletal muscle mass in healthy, older men and women. *J Gerontol A Biol Sci Med Sci* 2002; 57:M772-777.
- Ibañes J, Izquierdo M, Argüelles I, Forga L, Larión JL, García-Unciti M, Idoate F, Gorostiaga EM. Twice-weekly progressive resistance training decreases abdominal fat and improves insulin sensitivity in older men with type 2 diabetes. *Diabetes Care* 2005; 28:662-667.

- Jackson R, Baldwin B. Detecting depression in elderly medically ill patients: the use of the Geriatric Depression Scale compared with medical and nursing observations. *Age Ageing* 1993; 22:439-453.
- Jette AM, Lachman M, Giorgetti MM, Assmann SF, Harris BA, Levenson C, Wernick M, Krebs D. Exercise—it's never too late: the Strong-for-Life Program. *Am J Public Health* 1999; 89: 66-72.
- Johnson J, Weissman M, Klerman GL. Service utilization and social morbidity associated with depressive symptoms in the community. *JAMA* 1992; 267:1478-1483.
- Kalopotharakos VI, Michalopoulou M, Godolias G, Tokmakidis SP, Malliou PV, Gourgoulis V. The effects of high- and moderate- resistance training on muscle function in the elderly. *J Aging Phys Act* 2004; 12: 131-143.
- Kallinen M, Sipilä S, Alen M, Suominen M. Improving cardiovascular fitness by strength or endurance training in women aged 76-78 years. A population-based, randomized controlled trial. *Age Aging* 2002; 31: 247-254.
- Kamel HK, Maas D, Duthie EH Jr. Role of hormones in the pathogenesis and management of sarcopenia. *Drugs Aging* 2002; 19: 865-877.
- Katula JA, Sipe M, Rejeski WJ, Focht BC. Strength training in older adults: an empowering intervention. *Med Sci Sports Exerc* 2006; 38: 106-111.
- Kemper P. The use of formal and informal home care by the disabled elderly. *Health Serv Res* 1992; 27:421-451.
- Kerr D, Ackland T, Maslen B, Morton A, Prince R. Resistance training over 2 years increases bone mass in calcium-replete postmenopausal women. *J Bone Miner Res* 2001; 16:175-181.
- Kerr D, Morton A, Dick I, Prince R. Exercise effects on bone mass in postmenopausal women are site-specific and load-dependent. *J Bone Miner Res* 1996; 11:218-225.
- Keysor JJ. Does late-life physical activity or exercise prevent or minimize disablement. A critical review of scientific evidence. *Am J Prev Med* 2003; 25:129-136.
- Keysor JJ, Jette AM. Have we oversold the benefit of late-life exercise? *J Gerontol A Biol Sci Med Sci* 2001; 56: M412-23.
- King MB, Whipple RH, Gruman CA, Judge JO, Schmidt JA, Wolfson LI. The performance enhancement project: Improving physical performance in older persons. *Arch Phys Med Rehabil* 2002; 83:1060-1069.
- Kivelä S-L. Depression and physical and social functioning in old age. *Acta Psychiatr Scand* 1994; 377:73-76.
- Kivelä SL, Pahkala K. Depressive disorder as a predictor of physical disability in old age. *J Am Geriatr Soc* 2001; 49: 290-296.
- Klitgaard H, Mantoni M, Schiaffino S, Ausoni S, Gorza L, Laurent-Winter C, Schnohr P, Saltin B. Function, morphology and protein expression of ageing skeletal muscle: a cross-sectional study of elderly men with different training backgrounds. *Acta Physiol Scand* 1990; 140:41-54.
- Kohrt WM, Bloomfield SA, Little KD, Nelson ME, Yingling VR. American College of Sports Medicine position stand: Physical activity and bone health. *Med Sci Sports Exerc* 2004; 36:1985-1996.
- Kraemer WJ, Adams K, Cafarelli E, Dudley GA, Dooly C, Feigenbaum MS, Fleck SJ, Franklin B, Fry AC, Hoffman JR, Newton RU, Potteiger J, Stone MH, Ratamess NA, Triplett-McBride T. American College of Sports Medicine Position Stand. Progression models in resistance training for healthy adults. *Med Sci Sports Exerc* 2002; 34: 364-380.

- Kritz-Silverstein D, Barrett-Connor E, Corbeau C. Cross-sectional and prospective study of exercise and depressed mood in the elderly. *Am J Epidemiol* 2001; 153: 596-603.
- LaCroix AZ, Guralnik JM, Berkman LF, Wallace RB, Satterfield S. Maintaining mobility in late life II. Smoking, alcohol consumption, physical activity, and body mass index. *Am J Epidemiol* 1993; 137: 858-869.
- Lampinen P, Heikkinen E. Reduced mobility and physical activity as predictors of depressive symptoms among community-dwelling older adults: An eight-year follow-up study. *Aging Clin Exp Res* 2003; 15: 205-211.
- Lampinen P, Heikkinen RL, Kauppinen M, Heikkinen E. Activity as a predictor of mental well-being among older adults. *Aging Ment Health* 2006; 10: 454-466.
- Latham N, Anderson C, Bennett D, Stretton C. Progressive resistance strength training for physical disability in older people. *Cochrane Database Syst Rev* 2003a; 2: CD002759.
- Latham NK, Anderson CS, Lee A, Bennett DA, Moseley A, Cameron ID for the FITNESS Collaborative Group. A randomized, controlled trial of quadriceps resistance exercise and vitamin D in frail older people: The Frailty Interventions Trial in Elderly Subjects (FITNESS). *J Am Geriatr Soc* 2003b; 51: 291-299.
- Latham NK, Bennett DA, Stretton CM, Anderson CS. Systematic review of progressive resistance strength training in older adults. *J Gerontol A Biol Sci Med Sci* 2004; 59: 48-61.
- Laukkanen P, Era P, Heikkinen R-L, Suutama T, Kauppinen M, Heikkinen E. Factors related to carrying out everyday activities among elderly people aged 80. *Aging Clin Exp Res* 1994; 6:433-443.
- Laukkanen P, Heikkinen E, Kauppinen M, Kallinen M. Use of drugs by non-institutionalized urban Finns born in 1904-1923 and the association of drug use with mood and self-rated health. *Age Ageing* 1992; 21: 343-352.
- Lawlor DA, Hopker SW. The effectiveness of exercise as an intervention in the management of depression: systematic review and meta-regression analysis of randomized controlled trials. *BMJ* 2001; 322:1-8.
- Leimmer JT, Hurlbut DE, Martel GF, Tracy BL, Ivey FM, Metter EJ, Fozard JL, Fleg JL, Hurley BE. Age and gender responses to strength training and detraining. *Med Sci Sports Exerc* 2000; 32:1505-1512.
- Leveille SG, Guralnik JM, Ferrucci L, Langlois JA. Aging successfully until death in old age: opportunities for increasing active life expectancy. *Am J Epidemiol* 1999; 149:654-664.
- Lexell J. Human aging, muscle mass, and fibre type composition. *J Gerontol A Biol Sci Med Sci* 1995; 50:11-16.
- Lexell J. Muscle structure and function in chronic neurological disorders: the potential of exercise to improve activities of daily living. *Exerc Sports Sci Rev* 2000; 28: 80-84.
- The LIFE study Investigators. Effects of a physical activity intervention on measures of physical performance: Results of the Lifestyle Interventions and Independence for Elders Pilot (LIFE-P) Study. *J Gerontol A Biol Sci Med Sci* 2006; 61: 1157-1165.
- Lin YC, Davey RC, Cochrane T. Tests for physical function of the elderly with knee and hip osteoarthritis. *Scan J Med Sci Sports* 2001; 11:280-286.
- Lindeboom R, Vermeulen M, Holman R, De Haan RJ. Activities of daily living instruments. Optimizing scales for neurologic assessments. *Neurology* 2003; 60:738-742.
- Lindle RS, Metter EJ, Lynch NA, Fleg JL, Fozard JL, Tobin J, Roy TA, Hurley BF. Age and gender comparisons of muscle strength in 654 women and men aged 20-93 yr. *J Appl Physiol* 1997; 83:1581-1587.

- Liu-Ambrose T, Khan KM, Eng JJ, Janssen PA, Lord SR, McKay HA. Resistance and agility training reduce fall risk in women aged 75 to 85 with low bone mass: A 6-month randomized, controlled trial. *J Am Geriatr Soc* 2004; 52: 657-665.
- Livingston G, Watkin V, Milne B, Manela MV, Katona C. Who becomes depressed? The Islington community study of older people. *J Affect Disord* 2000; 58:125-133.
- Lord SR, Ward JA, Williams P, Strudwick M. The effect of a 12-month exercise trial on balance, strength, and falls in older women: a randomized controlled trial. *J Am Geriatr Soc* 1995; 43:1198-1206.
- Luukinen H, Koski K, Laippala P, Kivelä SL. Factors predicting fractures during falling impacts among home-dwelling older adults. *J Am Geriatr Soc* 1997; 45:1302-1309.
- Lynch NA, Metter EJ, Lindle RS, Fozard JL, Tobin JD, Roy TA, Fleg JL, Hurley BF. Muscle quality. I. Age-associated differences between arm and leg muscle groups. *J Appl Physiol* 1999; 86:188-194.
- Maguire BL. The effects of imagery on attitudes and moods in multiple sclerosis patients. *Altern Ther Health Med* 1996; 2:75-79.
- Mallery LH, MacDonald EA, Hubley-Kozey CL, Earl ME, Rockwood K, MacKnight C. The feasibility of performing resistance exercise with acutely ill hospitalized older adults. *BMC Geriatr* 2003; 3:3.
- Manton KG. A longitudinal study of functional change and mortality in the United States. *J Gerontol* 1988; 43: S153-161.
- Mathias S, Nayak US, Isaacs B. Balance in the elderly patients: the "get-up and go"-test. *Arch Phys Med Rehabil* 1986; 67: 387-389.
- Mazzeo RS, Cavanagh P, Evans WJ, Fiatarone M, Hagberg J, McAuley E, Startzell J. American College of Sports Medicine position stand. Exercise and physical activity for older adults. *Med Sci Sports Exerc* 1998; 30: 992-1008.
- McArdle WD, Katch FI, Katch VL. Exercise physiology. Williams and Wilkins, Baltimore, Md, 1996.
- McAuley E, Bane SM, Mihalko SL. Exercise in middle-aged adults: self-efficacy and self-presentational outcomes. *Prev Med* 1995a; 24:319-328.
- McAuley E, Blissmer B, Katula J, Duncan TE, Mihalko SL. Physical activity, self-esteem, and self-efficacy relationship in older adults: a randomized controlled trial. *Ann Behav Med* 2000a; 22:131-139.
- McAuley E, Blissmer B, Marquez DX, Jerome GJ, Kramer AF, Katula J. Social relations, physical activity, and well-being in older adults. *Prev Med* 2000b; 31:608-617.
- McAuley E, Courneya KS, Lettunich J. Effects of acute and long-term exercise on self-efficacy responses in sedentary, middle-aged males and females. *Gerontologist* 1991; 31:534-542.
- McAuley E, Lox C, Duncan TE. Long-term maintenance of exercise, self-efficacy, and psychological change in older adults. *J Gerontol* 1993; 48: P218-224.
- McAuley E, Schaffer SM, Rudolph D. Affective responses to acute exercise in elderly impaired males: the moderating effects of self-efficacy and age. *Int J Aging Hum Dev* 1995b; 41: 13-27.
- McCarthy CJ, Mills PM, Pullen R, Richardson G, Hawkins N, Roberts CR, Silman AJ, Oldham JA. Supplementation of a home-based exercise programme with class-based programme for people with osteoarthritis of the knees: a randomized controlled trial and health economics analysis. *Health Technol Assess* 2004; 8.

- McDermott AY, Mernitz H. Exercise and older patients: prescribing guidelines. *Am Fam Physician* 2006; 74: 437-444.
- McKinney CH, Antoni MH, Kumar M, Tims FC, McCabe PM. Effects of guided imagery and music (GIM) therapy on mood and cortisol in healthy adults. *Health Psychol* 1997; 16: 390-400.
- McMurdo ME, Burnett L. Randomised controlled trial of exercise in the elderly. *Gerontology* 1992; 38: 292-298.
- McNair D, Lorr M, Droppleman L. Manual for the profile of mood states. San Diego, CA: Educational and Industrial Testing Service, 1981.
- McNeil JK, LeBlanc EM, Joyner M. The effect of exercise on depressive symptoms in the moderately depressed elderly. *Psychol Aging* 1991; 6:487-488.
- Metter EJ, Conwit R, Tobin J, Fozard JL. Age-associated loss of power and strength in the upper extremities in women and men. *J Gerontol A Biol Sci Med Sci* 1997; 52: B267-276.
- Miller ME, Rejeski WJ, Reboussin BA, Ten Have TR, Ettinger WH. Physical activity, functional limitations, and disability in older adults. *J Am Geriatr Soc* 2000; 48: 1264-1272
- Mittmann N, Herrmann N, Einarson TR, Busto UE, Lanctot KL, Liu BA, Shulman KI, Silver IL, Narango CA, Shear NH. The efficacy, safety and tolerability of antidepressants in late life depression: a meta-analysis. *J Affect Disord* 1997; 46:191-217.
- Moreland JD, Richardson JA, Goldsmith CH, Clase CM. Muscle weakness and falls in older adults: a systematic review and meta-analysis. *J Am Geriatr Soc* 2004; 52:1121-1129.
- Morgan RO, Virnig BA, Duque M, Abdel-Moty E, Devito CA. Low-intensity exercise and reduction of the risk for falls among at-risk elders. *J Gerontol A Biol Sci Med Sci* 2004; 59:1062-1067.
- Morgan WP. Affective beneficence of vigorous physical activity. *Med Sci Sports Exerc* 1985; 17: 94-100.
- Motl RW, Konopack JF, McAuley E, Elavsky S, Jerome GJ, Marguez DX. Depressive symptoms among older adults; long-term reduction after a physical activity intervention. *J Behav Med* 2005; 28: 385-394.
- Mühlberg W, Sieber C. Sarcopenia and frailty in geriatric patients: implications for training and prevention. *Z Gerontol Geriatr* 2004; 37: 2-8.
- Mulrow CD, Gerety MB, Katen D, Cornell JE, DeNino LA, Chiodo L, Aguilar C, O'Neil MB, Rosenberg J, Solis RM. A randomized trial of physical rehabilitation for very frail nursing home residents. *JAMA* 1994; 271:592-524.
- Myers AM, Malott OW, Gray E, Tudor-Locke C, Ecclestone NA, Cousins SO, Petrella R. Measuring accumulated health-related benefits of exercise participation for older adults: the Vitality Plus Scale. *J Gerontol A Biol Sci Med Sci* 1999; 54: 456-466.
- Mäkinen E. Classifying disability in supervised out-patient care, Yleislääketieteen ja perusterveydenhuollon laitos, Helsingin yliopisto, 1991.
- Nagi SZ. An epidemiology of disability among adults in the United States. *Milbank Mem Fund Q Health Soc* 1976; 54: 439-467.
- Nair KS. Aging muscle. *Am J Clin Nutr* 2005; 81:953-963.

Nelson ME, Fiatarone MA, Morganti CM, Trice I, Greenberg RA, Evans WJ. Effects of high-intensity strength training on multiple risk factors for osteoporotic fractures. A randomized controlled trial. *JAMA*. 1994; 272:1909-1914.

Nelson ME, Layne JE, Bernstein MJ, Nuernberger A, Castaneda C, Kaliton D, Hausdorff J, Judge JO, Buchner DM, Roubenoff R, Fiatarone Singh MA. The effects of multidimensional home-based exercise on functional performance in elderly people. *J Gerontol A Biol Sci Med Sci* 2004; 59:154-160.

Nevitt MC, Cummings SR, Kidd S, Black D. Risk factors for recurrent nonsyncopal falls. *JAMA* 1989; 261:2663-2668.

Nikolaus T, Bach M. Preventing falls in community-dwelling frail older people using a home intervention team (HIT): results from the randomized Falls-HIT trial. *J Am Geriatr Soc* 2003; 51: 300-305.

Oslin DW, Ten Have TR, Streim JE, Datto CJ, Weintraub D, DiFilippo S, Katz IR. Probing the safety of medications in the frail elderly: evidence from a randomized clinical trial of sertraline and venlafaxine in depressed nursing home residents. *J Clin Psychiatry* 2003; 64:875-882.

Ostchega Y, Harris TB, Hirsch R, Parsons VL, Kingston R, Katzoff M. Reliability and prevalence of physical performance examination assessing mobility and balance in older persons in the US: data from the Third National Health and Nutrition Examination Survey. *J Am Geriatr Soc* 2000; 48:1136-1141.

Paluska SA, Schwenk TL. Physical activity and mental health. Current concepts. *Sports Med* 2000; 29: 167-180.

Parjanne M-L. The changing age structure of the population and preparing for its effects in the different sectors of administration. Reports of the Ministry of Social Affairs and Health; 2004:18. Helsinki, 2004.

Parker ND, Hunter GR, Treuth MS, Kekes-Szabo T, Kell SH, Weinsier R, White M. Effects of strength training on cardiovascular responses during a submaximal walk and a weight-loaded walking test in older females. *J Cardiopulm Rehabil* 1996; 16:56-62.

Pate RR, Pratt M, Blair SN, Haskell WL, Macera CA, Bouchard C, Buchner D, Ettinger W, Heath GW, King AC et al. Physical activity and public health. A recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine. *JAMA* 1995; 273: 402-407.

Penninx BWJH, Guralnik JM, Ferrucci L, Simonsick EM, Deeg DJH, Wallace RB. Depressive symptoms and physical decline in community-dwelling older persons. *JAMA* 1998; 279: 1720-1726.

Penninx BWJH, Leveille S, Ferrucci L, van Eijk JThM, Guralnik JM. Exploring the effect of depression on physical disability: longitudinal evidence from the Established Populations for Epidemiologic Studies of the Elderly. *Am J Public Health* 1999; 89:1346-1352.

Penninx BW, Messier SP, Rejeski WJ, Williamson JD, DiBari M, Cavazzini C, Applegate WB, Pahor M. Physical exercise and the prevention of disability in activities of daily living in older persons with osteoarthritis. *Arch Intern Med* 2001; 161:2309-2316.

Penninx BW, Rejeski WJ, Pandya J, Miller ME, Di Bari M, Applegate WB, Pahor M. Exercise and depressive symptoms: a comparison of aerobic and resistance exercise effects on emotional and physical function in older persons with high and low depressive symptomatology. *J Gerontol B Psychol Sci Soc Sci* 2002; 57: P124-132.

Perrig-Chiello P, Perrig WJ, Ehram R, Staehelin HB, Krings F. The effects of resistance training on well-being and memory in elderly volunteers. *Age Ageing* 1998; 27:469-475.

- Perrig-Chiello P, Perrig WJ, Stahelin HB, Krebs-Roubicek E, Ehram R. Autonomie, Wohlbefinden und Gesundheit im Alter: Eine interdisziplinäre Altersstudie (IDA). [Wellbeing, health and autonomy in old age: the Basal IDA Study (Interdisciplinary Aging Study)] *Z Gerontol Geriatr* 1996; 29: 95-109.
- Phillips SM, Tipton KD, Aarsland A, Wolf SE, Wolfe RR. Mixed muscle protein synthesis and breakdown after resistance exercise in humans. *Am J Physiol* 1997; 273:E99-107.
- Poirier P, Lemieux I, Mauriege P, Dewailly E, Blanchet C, Bergeron J, Despres JP. Impact of waist circumference on the relationship between blood pressure and insulin: the Quebec Health Survey. *Hypertension* 2005; 45:363-367.
- Pollock ML, Franklin BA, Balady GJ, Chaitman BL, Fleg JL, Fletcher B, Limacher M, Piña IL, Stein RA, Williams M, Bazzarre T. Resistance exercise in individuals with and without cardiovascular disease. Benefits, rationale, safety, and prescription. *Circulation* 2000; 101:828-833.
- Powell Lawton M. The Philadelphia Geriatric Center Morale Scale: A revision. *J Gerontol* 1975; 30: 85-89.
- Province MA, Hadley EC, Hornbrook MC, Lipsitz LA, Miller JP, Mulrow CD, Ory MG, Sattin RW, Tinetti ME, Wolf SL for the FICSIT group. The effects of exercise on falls in elderly patients. A preplanned meta-analysis of the FICSIT trials. *JAMA* 1995; 273:1341-1347.
- Puhan MA, Schünemann HJ, Frey M, Scharplatz M, Bachmann LM. How should COPD patient exercise during respiratory rehabilitation? Comparison of exercise modalities and intensities to treat skeletal muscle dysfunction. *Thorax* 2005; 60: 367-375.
- Pulska T, Pahkala K, Laippala P, Kivelä SL. Follow-up study of long-standing depression as predictor of mortality in elderly people living in the community. *BMJ* 1999; 318: 432-433.
- Päivärinta A, Verkkoniemi A, Niinistö L, Kivelä SL, Sulkava R. The prevalence and associates of depressive disorders in the oldest-old Finns. *Soc Psychiatry Psychiatr Epidemiol* 1999; 34: 352-359.
- Rai GS, Kiriorns M, Wientjes H. Falls Handicap Inventory (FHI)– an instrument to measure handicaps associated with repeated falls. *J Am Geriatr Soc* 1995; 43: 723-724.
- Ransford HE, Palisi BJ. Aerobic exercise, subjective health and psychological well-being within age and gender subgroups. *Soc Sci Med* 1996; 42: 1555-1559.
- Rantanen T, Era P, Heikkinen E. Maximal isometric knee extension strength and stair-mounting ability in 75- and 80-year-old men and women. *Scan J Rehabil Med* 1996; 28: 89-93.
- Rantanen T, Era P, Heikkinen E. Maximal isometric strength and mobility among 75-year-old men and women. *Age Aging* 1994; 23:132-137.
- Rantanen T, Guralnik MD, Ferrucci L, Penninx BWJH, Leveille S, Sipilä S, Fried LP. Coimpairments as predictors of severe walking disability in older women. *J Am Geriatr Soc* 2001; 49:21-27.
- Rantanen T, Masaki K, Foley D, Izmirlian G, White L, Guralnik JM. Grip strength changes over 27 yr in Japanese-American men. *J Appl Physiol* 1998; 85:2047-2053.
- Rantanen T, Penninx BWJH, Masaki K, Lintunen T, Foley D, Guralnik JM. Depressed mood and body mass index as predictors of muscle strength decline in old men. *J Am Geriatr Soc* 2000; 48:613-617.
- Rantanen T, Guralnik JM, Ferrucci L, Leveille S, Fried LP. Coimpairments: Strength and balance as predictors of severe walking disability. *J Gerontol A Biol Sci Med Sci* 1999; 54: M172-176.

- Rantanen T, Avela J. Leg extension power and walking speed in very old people living independently. *J Gerontol A Biol Sci Med Sci* 1997a; 52: M225-231.
- Rantanen T, Era P, Heikkinen E. Physical activity and the changes in maximal isometric strength in men and women from the age of 75 to 80 years. *J Am Geriatr Soc* 1997b; 45:1439-1445.
- Rejeski WJ, Mihalko SL. Physical activity and quality of life in older adults. *J Gerontol A Biol Sci Med Sci* 2001; 56: 23-35.
- Reuben DB, Valle LA, Hays RD, Siu AL. Measuring physical function in community-dwelling older persons: a comparison of self-administered, interviewer-administered, and performance-based measures. *J Am Geriatr Soc* 1995; 43:17-23.
- Rizzo JA, Baker DI, McAvay G, Tinetti ME. The cost-effectiveness of a multifactorial targeted prevention program for falls among community elderly persons. *Med Care* 1996; 34:954-969.
- Robertson MC, Devlin N, Gardner MM, Campbell AJ. Effectiveness and economic evaluation of a nurse delivered home exercise programme to prevent falls. 1: Randomized controlled trial. *BMJ* 2001a; 322: 697-701.
- Robertson MC, Devlin N, Scuffham P, Gardner MM, Buchner DM, Campbell AJ. Economic evaluation of a community based exercise program to prevent falls. *J Epidemiol Community Health* 2001b; 55: 600-606.
- Robertson MC, Gardner MM, Devlin N, McGee R, Campbell AJ. Effectiveness and economic evaluation of a nurse delivered home exercise programme to prevent falls. 2: Controlled trial in multiple centres. *BMJ* 2001c; 322:701-704.
- Roffe L, Schmidt K, Ernst E. A systematic review of guided imagery as an adjuvant cancer therapy. *Psychooncology* 2005; 14: 607-617.
- Rosendahl E, Lindelöf N, Littbrand H, Yifter-Lindgren E, Lundin-Olsson L, Håglin L, Gustafson Y, Nyberg L. High-intensity functional exercise program and protein-enriched energy supplement for older persons dependent in activities of daily living: A randomized controlled trial. *Aust J Physiother* 2006; 52: 105-113.
- Rubenstein LZ, Josephson KR. The epidemiology of falls and syncope. *Clin Geriatr Med* 2002; 18:141-158.
- Rubenstein LZ, Josephson KR, Trueblood PR, Loy S, Harker JO, Pietruszka FM, Robbins AS. Effects of a group exercise program on strength, mobility, and falls among fall-prone elderly men. *J Gerontol A Biol Sci Med Sci* 2000; 55:M317-321.
- Rubenstein LZ, Robbins AS, Schulman BL, Rosado J, Osterweil D, Josephson KR. Falls and instability in the elderly. *J Am Geriatr Soc* 1988; 36:266-278.
- Ruchlin HS, Elkin EB, Allegrante JP. The economic impact of a multifactorial intervention to improve postoperative rehabilitation of hip fracture patients. *Arthritis Rheum* 2001; 45:446-52.
- Ruuskanen JM, Ruoppila I. Physical activity and psychological well-being among people aged 65 to 84 years. *Age Ageing* 1995; 24: 292-296.
- Ryan AS, Pratley RE, Goldberg AP, Elahi D. Resistive training increases insulin action in postmenopausal women. *J Gerontol A Biol Sci Med Sci* 1996; 51:M199-205.
- Rydwik E, Frändin K, Aker G. Effects of physical training on physical performance in institutionalised elderly patients (70+) with multiple diagnoses. *Age Ageing* 2004; 33: 13-23.

Salkeld G, Cumming RG, O'Neill E, Thomas M, Szonyi G, Westbury C. The cost effectiveness of a home hazard reduction program to reduce falls among older persons. *Aus N Z J Public Health* 2000; 24:265-271.

Salmon P. Effects of physical exercise on anxiety, depression, and sensitivity to stress: A unifying theory. *Clin Psychol Rev* 2001; 21: 33-61.

SAS Institute, Inc. The SAS system for Windows, version 8.2. Cary, NC, USA, 2001.

Sauvage LR, Myklebust BM, Crow-Pan J, Novak S, Millington P, Hoffman MD, Hartz AJ, Rudman D. A clinical trial of strengthening and aerobic exercise to improve gait and balance in elderly male nursing home residents. *Am J Phys Med Rehabil* 1992; 71: 333-342.

Schroll Bjornsbo K, Ferry M, de Groot CP, Schlienger JL. Changes in physical performance in elderly Europeans. SENECA 1993-1999. *J Nutr Health Aging* 2002; 6: 9-14.

Scully D, Kremer J, Meade MM, Graham R, Dudgeon K. Physical exercise and psychological well being: a critical review. *Br J Sports Med* 1998; 32: 111-120.

Seeman TE, Charpentier PA, Berkman LF, Tinetti ME, Guralnik JM, Albert M, Blazer D, Rowe JW. Predicting changes in physical performance in a high-functioning elderly cohort: MacArthur studies of successful aging. *J Gerontol* 1994; 49:M97-108.

Sevick MA, Bradham DD, Muender M, Chen GJ, Enarson C, Dailey M, Ettinger WH Jr. Cost-effectiveness of aerobic and resistance exercise in seniors with knee osteoarthritis. *Med Sci Sports Exerc* 2000; 32: 1534-1540.

Seynes O, Fiatarone Singh MA, Hue O, Pras P, Legros P, Bernard PL. Physiological and functional responses to low-moderate versus high-intensity progressive resistance training in frail elders. *J Gerontol A Biol Sci Med Sci* 2004; 59: 503-509.

Shaw FE, Bond J, Richardson DA, Dawson P, Steen N, McKeith IG, Kenny RA. Multifactorial intervention after a fall in older people with cognitive impairment and dementia presenting to the accident and emergency department: randomised controlled trial. *BMJ* 2003; 326:73-75.

Siebens H, Aronow H, Edwards D, Ghasemi Z. A Randomized controlled trial of exercise to improve outcomes of acute hospitalization in older adults. *J Am Geriatr Soc* 2000; 48:1545-52.

Sieri T, Beretta G. Fall risk assessment in very old males and females living in nursing homes. *Disabil Rehabil* 2004; 26:718-723.

Simonsick EM, Kasper JD, Phillips CL. Physical disability and social interaction: factors associated with low social contact and home confinement in disabled older women (The Women's Health and Aging Study). *J Gerontol B Psychol Sci Soc Sci* 1998; 53:S209-217.

Simonsick EM, Newman AB, Nevitt MC, Kritchevsky SB, Ferrucci L, Guralnik JM, Harris ; Health ABC Study Group. Measuring higher level physical function in well-functioning older adults: expanding familiar approaches in the Health ABC Study. *J Gerontol A Biol Sci Med Sci* 2001; 56:M644-649.

Singh NA, Clemens KM, Fiatarone MA. A randomized controlled trial of progressive resistance training in depressed elders. *J Gerontol A Biol Sci Med Sci* 1997; 52:M27-35.

Singh NA, Stavrinou TM, Scarbek Y, Galambos G, Liber C, Fiatarone Singh MA. A randomized controlled trial of high versus low intensity weight training versus general practitioner care for clinical depression in older adults. *J Gerontol A Biol Sci Med Sci* 2005; 60:768-776.

- Sinoff G, Ore L. The Barthel activities of daily living index: self-reporting versus actual performance in the old (> or = 75 years). *J Am Geriatr Soc* 1997; 45:832-836.
- Sipilä S, Multanen J, Kallinen M, Era P, Suominen H. Effects of strength and endurance training on isometric muscle strength and walking speed in elderly women. *Acta Physiol Scand* 1996; 156: 457-464.
- Sipilä S, Suominen H. Effects of strength and endurance training on thigh and leg muscle mass and composition in elderly women. *J Appl Physiol* 1995; 78:334-340.
- Sjösten N, Kivelä S-L. The effects of physical exercise on depressive symptoms among the aged: a systematic review. *Int J Geriatr Psychiatry* 2006; 21: 410-418.
- Skelton DA, Greig CA, Davies JM, Young A. Strength, power and related functional ability of healthy people aged 65-89 years. *Age Aging* 1994; 23:371-377.
- Skelton DA, Young A, Greig CA, Malbut KE. Effects of resistance training on strength, power, and selected functional abilities of women aged 75 and older. *J Am Geriatr Soc* 1995; 43:1081-1087.
- Spielberger CE, Gorsuch RL, Lushene RE. *Manual for the state-trait anxiety inventory*. Palo Alto, CA: Consulting Psychologist Press, 1970.
- Sloman R. Relaxation and imagery for anxiety and depression control in community patients with advanced cancer. *Cancer Nurs* 2002; 25: 432-435.
- Steinberg M, Cartwright C, Peel N, Williams G. A sustainable programme to prevent falls and near falls in community dwelling older people: results of a randomized trial. *J Epidemiol Community Health* 2000; 54:227-232.
- StataCorp. *Stata statistical Software: Release 8*. College Station, TX, StataCorp LP, 2003.
- Steadman J, Donaldson N, Kalra L. A randomized controlled trial of an enhanced balance training program to improve mobility and reduce falls in elderly patients. *J Am Geriatr Soc* 2003; 51:847-852.
- Steuer J, Bank L, Olsen EJ, Jarvik LF. Depression, physical health and somatic complaints in the elderly: a study of the Zung Self-Rating Depression Scale. *J Gerontol* 1980; 35:683-688.
- Stevens M, Holman CD, Bennett N, de Klerk N. Preventing falls in older people: outcome evaluation of a randomized controlled trial. *J Am Geriatr Soc* 2001; 49:1448-1455.
- Stewart AL, Hays RD, Wells KB, Rogers WH, Spitzer KL, Greenfield S. Long-term functioning and well-being outcomes associated with physical activity and exercise in patients with chronic conditions in the Medical Outcomes Study. *J Clin Epidemiol* 1994; 47: 719-730.
- Strawbridge WJ, Deleger S, Roberts RE, Kaplan GA. Physical activity reduces the risk of subsequent depression for older adults. *Am J Epidemiol* 2002; 156: 328-334.
- Stuck AE, Walthert JM, Nikolaus T, Bula CJ, Hohmann C, Beck JC. Risk factors for functional status decline in community-living elderly people: a systematic literature review. *Soc Sci Med* 1999; 48: 445-469.
- Swift CG. The role of medical assessment and intervention in the prevention of falls. *Age Ageing* 2006; 35-S2: ii65-ii68.
- Syrjala KL, Donaldson GW, Davis MW, Kippes ME, Carr JE. Relaxation and imagery and cognitive-behavioral training reduce pain during cancer treatment: a controlled clinical trial. *Pain* 1995; 63: 189-198.

- Taaffe DR, Duret C, Wheeler S, Marcus R. Once-weekly resistance exercise improves muscle strength and neuromuscular performance in older adults. *J Am Geriatr Soc* 1999; 47:1208-1214.
- Taaffe DR, Pruitt L, Pyka G, Guido D, Marcus R. Comparative effects of high- and low-intensity resistance training on thigh muscle strength, fiber area, and tissue composition in elderly women. *Clin Physiol* 1996; 16: 381-392.
- Takeida K, Nishi M, Miyake H. Zung's Depression Scale as a predictor of death in elderly people: a cohort study in Hokkaido, Japan. *J Epidemiol* 1999; 9:240-244.
- Taniguchi A, Nakai Y, Sakai M, Yoshii S, Hamanaka D, Hatae Y, Kawata M, Yamanouchi K, Okumura T, Doi K, Tokuyama K, Nagasaka S, Fukushima M. Relationship of regional adiposity to insulin resistance and serum triglyceride levels in nonobese Japanese type 2 diabetic patients. *Metabolism* 2002; 51:544-548.
- Thoren P, Floras JS, Hoffmann P, Seals DR. Endorphins and exercise: physiological mechanisms and clinical implications. *Med Sci Sports Exerc* 1990; 22: 417-428.
- Tinetti ME. Performance-oriented assessment of mobility problems in elderly patients. *J Am Geriatr Soc* 1986; 34:119-126.
- Tinetti ME, Baker DI, Gottschalk M, Williams CS, Pollack D, Garrett P, Gill TM, Marottoli RA, Acampora D. Home-based multicomponent rehabilitation program for older persons after hip fracture: a randomized trial. *Arch Phys Med Rehabil* 1999; 80:916-922.
- Tinetti ME, Baker DI, McAvay G, Claus EB, Garrett P, Gottschalk M, Koch ML, Trainor K, Horwitz RI. A multifactorial intervention to reduce the risk of falling among elderly people living in the community. *N Engl J Med* 1994; 331:821-827.
- Tinetti ME, Speechley M, Ginter SF. Risk factors for falls among elderly persons living in the community. *N Engl J Med* 1988; 319:1701-1707.
- Tinetti ME, Williams CS. Falls, injuries due to falls, and the risk of admission to a nursing home. *N Engl J Med* 1997; 337: 1279-1284.
- Toussignant M, Hébert R, Desrosiers J, Hollander M. Economic evaluation of a geriatric day hospital: cost-benefit analysis based on functional autonomy changes. *Age Aging* 2003; 32: 53-59.
- Trappe S, Williamson D, Godard M. Maintenance of whole muscle strength and size following resistance training in older men. *J Gerontol A Biol Med Sci* 2002; 57:B138-143.
- Treuth MS, Hunter GR, Kekes-Szabo T, Weinsier RL, Goran MI, Berland L. Reduction in intra-abdominal adipose tissue after strength training in older women. *J Appl Physiol* 1995a; 78:1425-1431.
- Treuth MS, Hunter GR, Weinsier RL, Kell SH. Energy expenditure and substrate utilization in older women after strength training: 24-h calorimetric results. *J Appl Physiol* 1995b; 78:2140-2146.
- Tsai SL. Audio-visual relaxation training for anxiety, sleep, and relaxation among Chinese adults with cardiac disease. *Res Nurs Health* 2004; 27: 458-468.
- Tsutsumi T, Don BM, Zaichkowsky LD, Delizonna LL. Physical fitness and psychological benefits of strength training in community dwelling older adults. *Appl Human Sci* 1997; 16:257-266.
- Unützer J, Patrick DL, Simon G, Grembowski D, Walker E, Rutter C, Katon W. Depressive symptoms and the cost of health services in HMO patients aged 65 years and older. *JAMA* 1997; 277:1618-1623.

- Van den Akker M, Buntix F, Metsemakers JF, Roos S, Knottnerus JA. Multimorbidity in general practice: prevalence, incidence, and determinants of co-occurring chronic and recurrent diseases. *J Clin Epidemiol* 1998; 51:367-375.
- Viitasalo J, Era P, Leskinen AL, Heikkinen E. Muscular strength and anthropometry in random samples of men aged 31-35, 51-55 and 71-75 years. *Ergonomics* 1985; 28:1563-1574.
- Ware JE. SF-36 Health survey. Manual and interpretation guide. Rhode Island: Quality Metric, 1993.
- Watanabe E, Fukuda S, Shirakawa T. Effects among healthy subjects of the duration of regularly practicing a guided imagery program. *BMC Complement Altern Med* 2005; 5:21.
- White JA, Ismail AH, Bottoms GD. Effect of physical fitness on the adrenocortical response to exercise stress. *Med Sci Sports* 1976; 8: 113-118.
- Wieser M, Haber P. The effect of systematic resistance training in the elderly. *Int J Sports Med* 2007; 28: 59-65.
- Wolf SL, Barnhart HX, Kutner NG, McNeely E, Coogler C, Xu T. Reducing frailty and falls in older persons: An investigation of Tai Chi and computerized balance training. Atlanta FICSIT Group. Frailty and Injuries: Cooperative Studies of Intervention Techniques. *J Am Geriatr Soc* 1996; 44: 489-497.
- Wolff JL, Boulton C, Boyd C, Anderson G. Newly reported chronic conditions and onset of functional dependency. *J Am Geriatr Soc* 2005; 53: 851-855.
- Wolfson L, Judge J, Whipple R, King M. Strength is a major factor in balance, gait, and the occurrence of falls. *J Gerontol A Biol Sci Med Sci* 1995; 50:M291-297.
- Woods NF, LaCroix AZ, Gray SL, Aragaki A, Cochrane BB, Brunner RL, Masaki K, Murray A, Newman AB; Women's Health Initiative. Frailty: emergence and consequences in women aged 65 and older in the Women's Health Initiative Observational Study. *J Am Geriatr Soc* 2005; 53: 1321-1330.
- Whooley MA, Browner WS. Association between depressive symptoms and mortality in older women. *Arch Intern Med*. 1998; 158:2129-2135.
- Woolson RF, Clarke WR. Analysis of categorical incomplete longitudinal data. *J R Statist Soc A* 1984; 147:87-99.
- Yesavage JA, Brink TL, Rose TL. Development and validation of a geriatric depression screening scale: a preliminary report. *J Psychiatr Res* 1983; 17: 37-49.
- Young A. Exercise physiology in geriatric practice. *Acta Med Scand* 1986; 771:227-232.
- Zung WW. The role of rating scales in the identification and management of the depressed patient in the primary care setting. *J Clin Psychiatry* 1990; 51:72-76.
- Zung WWK. A self-rating depression scale. *Arch Gen Psychiatry* 1965; 12:63-70.

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 α , PPAR γ , 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.