Functional tasks exercise improves daily function in older women

Training van functionele taken verbetert het dagelijks functioneren van oudere vrouwen

P. L. de Vreede

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De Vreede Paulus Leonardus
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door

Paulus Leonardus de Vreede

geboren op 30 december 1971, te Pijnacker

promotoren: Prof. dr. S.A. Duursma
Prof. dr. E. van der Wall

copromotor: Dr. H.J.J. Verhaar

Faculteit der Geneeskunde, Universiteit Utrecht

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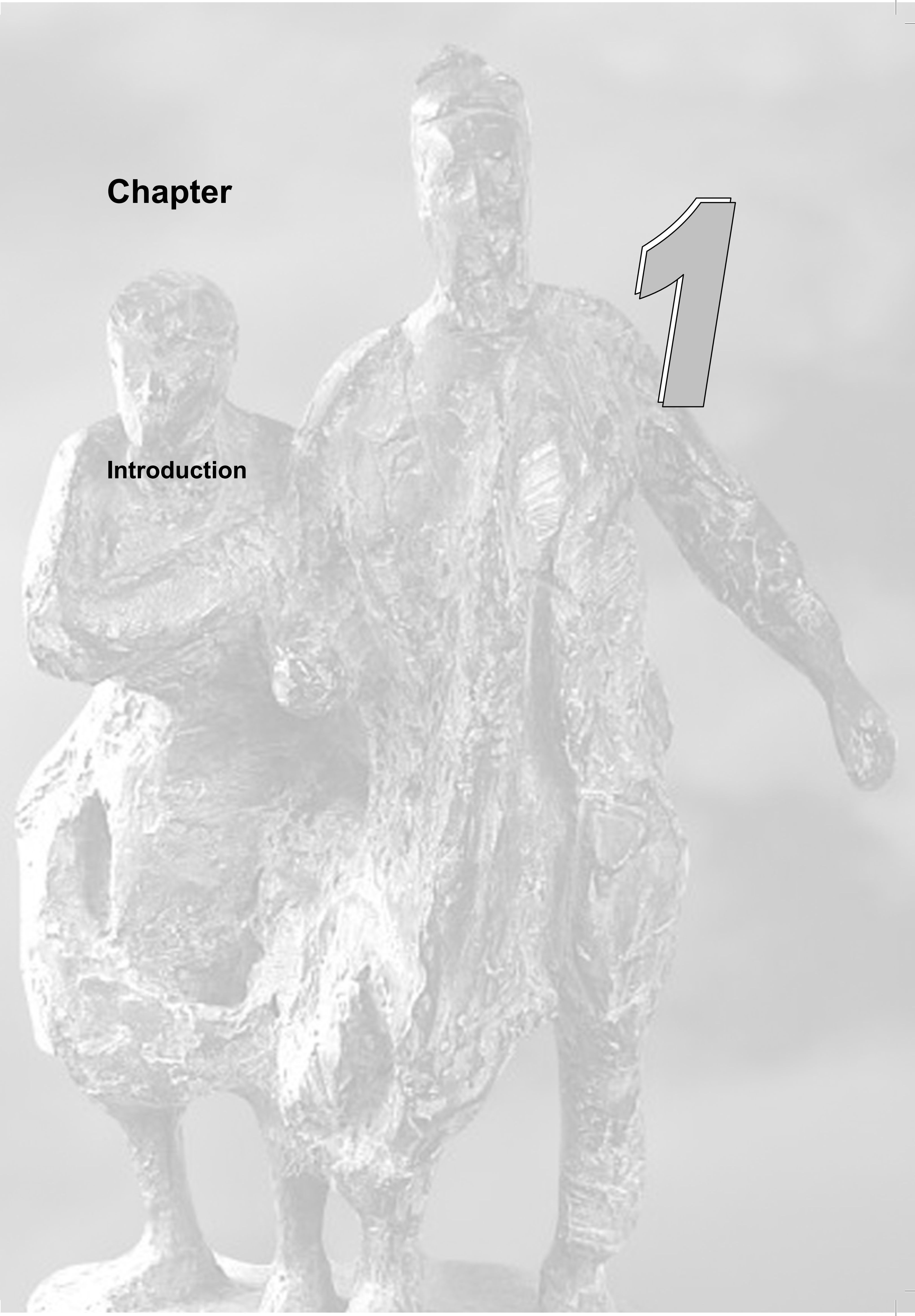
Kijk, daar staan we weer paraat
Met muziek en in de maat
Aan 't begin van iedere les
Soms met 10 en soms met 6
Armen laag en armen hoog
Armen met een grote boog
Een, twee, drie, daar gaan we hoor
Een voet achter, een voet voor
Daarna start het echte werk
En geen rondje om de kerk!
Maar een rondje om de stoelen
Met gewicht zal je bedoelen
Trappen af en trappen op
Met een dienblad voor je kop…..
Zijn we uitgebalanceerd,
Naar de zaal teruggekeerd,
Komt als laatste nog een spel
Bal, ring, stok, touw, weet je wel
Als beloning bij de bar
Maakt men koffie voor ons klaar
En wie waren dan wel die beulen
Waar wij iedere week mee heulen?!
Paul en Karin, Evelien
Hierna houden we 't voor gezien
Ook al was het even wennen
Niemand van ons zal ontkennen
Meer bewegen met z'n allen,
Is ons zeker goed bevallen!
Toch wordt door ons niet getreurd
Nu zijn wij aan de beurt
Om jullie aan 't werk te zetten!
Het is zaak om op te letten
Zet de puzzle in elkaar
Vooruit jongens, starten maar!

De deelneemsters van groep 6

Voor Nicole

Voor mijn ouders

CONTENTS



Chapter 1

Introduction

INTRODUCTION

As in other countries, the population of the Netherlands is aging. The number of Dutch people aged 65 years or older will increase from approximately 2.2 million, 13.7% of the total population in 2002, to approximately 3.8 million, 21.5% of the total population, by 2030.[1,2] Approximately 88% of individuals older than 65 have at least one chronic health limitation and a number of older adults suffer from impaired functioning or well-being.[3] Old age and disablement are the main determinants of health care use, and health issues regarding the older population are becoming increasingly important.[4] As a consequence, the national health objectives for older people target increasing the number of years of healthy, independent life and reducing limitations in activities of daily living (ADLs).

Ageing is characterised by a diminished function in multiple physiological domains, including muscle strength, neuromuscular coordination, balance, and cardiovascular function.[5-8] The cumulative effect of these diminished functions is a reduction in physical reserve.[6,9] Physical reserve is the physiological capacity in excess of that needed for daily activities [10] and provides a margin of safety that absorbs age- or disease-related changes without a loss in function.[11] As physical reserve deteriorates, individuals approach a threshold of independence, below which any further loss of capacity is associated with a 17-fold to 20-fold decrease in physical function.[12] When physical capacity falls below the ability required for the performance of daily tasks, functional limitations and a loss of independence may occur.[3,10] Ultimately, loss of physical reserve can lead to institutionalisation, morbidity, and mortality.[5]

Physical capacity starts to decline in the fourth decade,[12] whereas the prevalence of disability starts to decrease markedly only after the age of 75 years.[13] The delay between the start of the loss of function and the loss of physical capacity is attributed to the physical reserve.[8] Williamson and Fried observed that in the early stages of physical decline people adopt modification strategies to cope with the demands of independent living, e.g., cooking fewer meals or using only a limited part of their home.[14] Modification strategies can probably forestall disability for a period of time.[14] Reserves depleted below the level required for daily tasks will lead to limitations in the performance of functional tasks, such as walking, stair climbing, rising from a chair, housekeeping and shopping.

In the Netherlands, approximately 20% of people between 65 and 75 years of age report problems with ADLs, a proportion which increases to 48% in people older than 85.[15] Climbing stairs, shopping, rising out of a chair or bed, house cleaning, washing and dressing oneself are the first ADLs to be affected.[15] Each year about 10% of non-disabled community-dwelling adults, aged 75 or older, lose their independence.[16] The loss of independence results in a decreased quality of life and is the most distressing aspect of ageing for many older adults.[17] Limitations in physical function of a growing segment of the population herald an increased expenditure for health care and long-term care systems.[17-21]

Understanding the factors that cause the decline in independence is necessary for designing successful interventions. The decline is partly caused by the ageing process and is accelerated by a sedentary lifestyle and disease.[3,8,21,22] The working capacity of sedentary individuals has been shown to decrease by 30% between the ages of 30 and 70 years, with half of this decrease being due to disuse and the other half to ageing.[2]

Ageing is accompanied by a loss of skeletal muscle mass, alterations in muscle quality,[23,24] postural hypotension, deterioration in joint mobility and neuromuscular coordination, and deterioration of the cardiovascular and respiratory systems.[25] While ageing is an irreversible process, the effect of a sedentary lifestyle is not in most people. [3,26]

Although the benefits of regular physical activity have been well documented, most adults in developed countries do not exercise.[22,27-30] For example, only 24% of the Dutch population aged 55 years or older engage in 30 minutes of moderate physical activity 5 or more days per week, 30% are semi-active, and 46% report no leisure physical activity.[31] Women report the least regular physical activity of all demographic groups.[28,30]

Participation in a regular exercise programme is considered to be an effective strategy to reduce or prevent functional decline with ageing. Older people can improve muscle strength, maximal force, power, and rapid force development by resistance training.[8,24,32-40] Solid evidence is available regarding the positive effects of exercise on flexibility, aerobic capacity, balance, gait,[22,24,26,38,40-50] and bone,[49] and in reducing the risk of falls and fractures.[40-42,51,52] In addition to these effects, exercise can also provide a diversion from daily routines and stress, with a positive effect on feelings of enjoyment, companionship and accomplishment.[28,53]

However, there is less certainty about the effect of exercise programmes on the performance of ADLs.[22,24,40,44,48,54-58] Resistance strength training is the type of exercise mostly used in trials in older adults, but an increase in strength is not necessarily converted into an effect on ADL.[24,32,59-64] Systematic reviews have failed to find strong and consistent evidence supporting a beneficial effect of exercise in general on daily activities, disability and health-related quality of life (HRQOL).[65-68]

In addition, it is still unclear whether the effects of exercise interventions are sustained for a long time after completion of an exercise programme.[8] The lack of evidence for the effect of exercise on functional tasks may have several causes. Methodological limitations, such as lack of a control group, no randomisation or a small sample size, may influence the results of studies.[68] The diversity of exercise programmes makes it difficult to determine whether a strategy is effective and which type of exercise is most effective in terms of performance of daily tasks.[22,44,65] A wide range of exercises has been tested for effect on functional performance, including resistance strength training, exercises to improve balance, aerobic functions or stretching and flexibility capacity;[32,44,55,69] however, most exercise interventions aim to enhance functional tasks by improving just one function, mostly muscle strength, flexibility, or balance.[24,38,46-48,58,70] The performance of functional tasks, however, is complex and involves an interplay of cognitive, perceptual and motor functions, and is closely linked to the individual's dynamic environment.[71-74] To achieve the greatest effect, exercise training should simulate, as closely as possible, the conditions of daily tasks.[71,72] The American College of Sports Medicine recommends a frequency of training of 3-5 times per week, intensity of training 60-90% of maximum heart rate, or 50-85% of maximum oxygen uptake or maximum heart rate reserve, duration of training 20-60 minutes, dependent on the intensity, for developing and maintaining cardiorespiratory fitness, body composition and muscular strength and endurance in healthy adults.[75] Adherence to these recommendations would help to improve the comparability of intervention studies.

Finally, when collecting data it is vital to establish exactly what question(s) is (are) have to be answered, because this determines the appropriate data to be collect.[76] Studies of the effects of exercise on physical functional performance have often focused on selected intermediate outcome measures, such as muscle strength, balance and gait,[21,40,55] instead of functional performance. Yet other studies have assessed the performance of daily activities with self-report based questionnaires,[54,58,77] but such instruments lack sensitivity to change in relatively healthy subjects.[44,78,79] As a result, insufficient information is available to ascertain whether exercise training can reduce or delay dependency in performing daily tasks in community-dwelling older people.[5] Therefore, alternative outcome measures should be incorporated in exercise studies that aim to improve physical functional performance. Also, the mechanisms that underlie successful initiation and adherence to exercise programmes are not well understood.[80,81]

The aims of the study

The aim of the studies described in this thesis was to study the difference in effect between functional tasks exercises and resistance strength exercises on the functional performance and quality of life of older community-dwelling women. Specific research questions were:

1. To evaluate the feasibility of a new functional tasks exercise programme, designed to improve functional performance of community-dwelling older women, by comparing it with a resistance exercise programme (chapter 2).
2. To determine the intra-examiner reliability and construct validity of the Assessment of Daily Activity Performance (ADAP) test in a community-living older population, and to identify the importance of tester experience (chapter 3).
3. To determine whether a functional tasks exercise programme and a resistance exercise programme have different effects on the ability of community-living older people to perform daily tasks (chapter 4).
4. To determine whether a functional tasks exercise programme and a resistance exercise programme have a different effect on the health-related quality of life (HRQOL) of community-dwelling older women (chapter 5).
5. To discuss the differences in participants' satisfaction between a functional tasks exercise programme and a resistance exercise programme, and to explore the impact of participants' satisfaction and health-status on exercise compliance and effectiveness of the two programmes (chapter 6).

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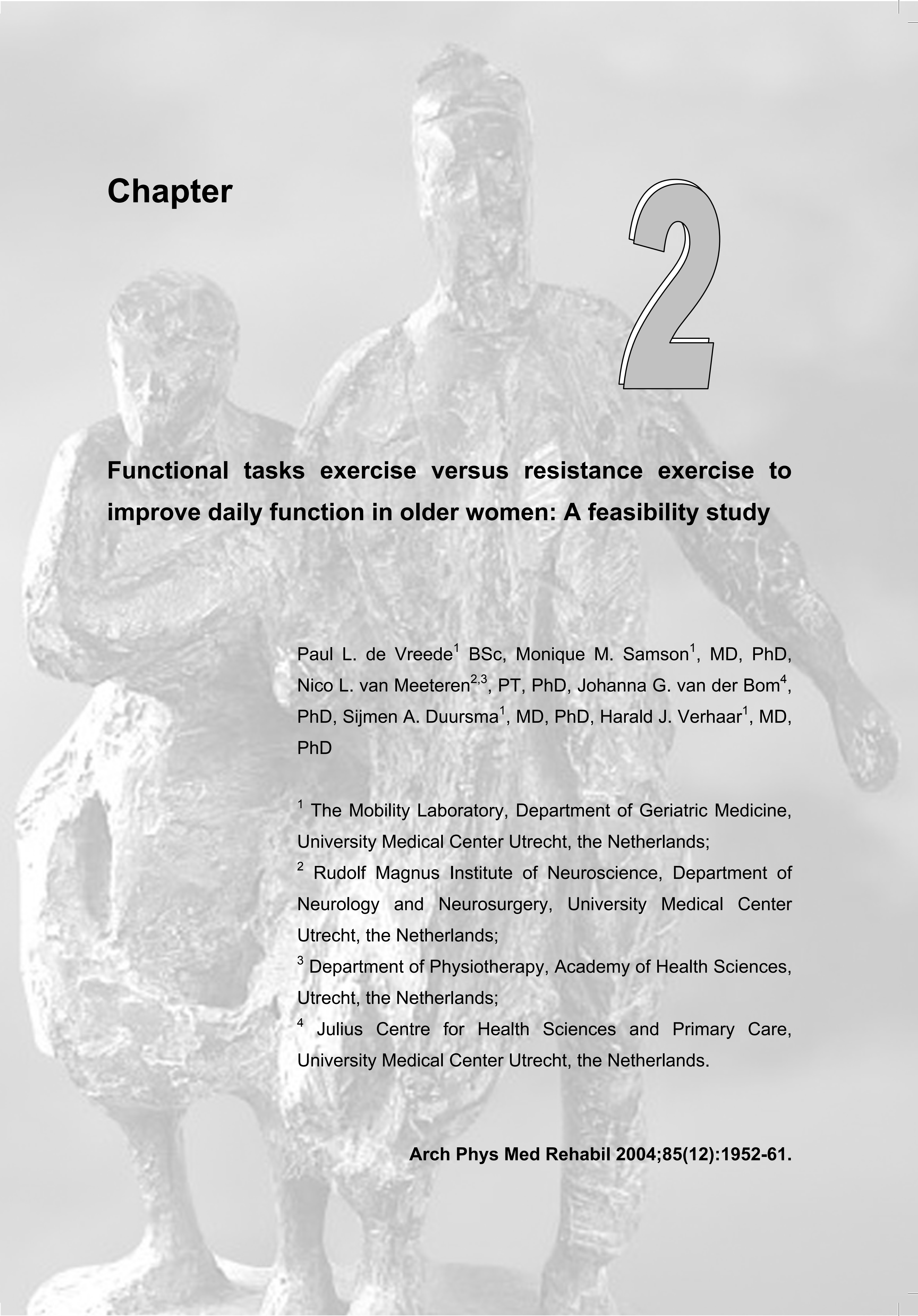

Chapter 2

Functional tasks exercise versus resistance exercise to improve daily function in older women: A feasibility study

Paul L. de Vreede[1] BSc, Monique M. Samson[1], MD, PhD, Nico L. van Meeteren[2,3], PT, PhD, Johanna G. van der Bom[4], PhD, Sijmen A. Duursma[1], MD, PhD, Harald J. Verhaar[1], MD, PhD

[1] The Mobility Laboratory, Department of Geriatric Medicine, University Medical Center Utrecht, the Netherlands;
[2] Rudolf Magnus Institute of Neuroscience, Department of Neurology and Neurosurgery, University Medical Center Utrecht, the Netherlands;
[3] Department of Physiotherapy, Academy of Health Sciences, Utrecht, the Netherlands;
[4] Julius Centre for Health Sciences and Primary Care, University Medical Center Utrecht, the Netherlands.

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ABSTRACT

Objective: To evaluate the feasibility of a new functional tasks exercise program, designed to improve functional performance of community-dwelling older women, by comparing it with a resistance exercise program.

Design: A 12-week, randomized, single-blind pilot study

Setting: A community leisure center.

Participants: Twenty-four community-dwelling, medically stable women (mean age, 74.6 ± 4.8 y) were randomized to the functional tasks exercises (function group) or the resistance exercises (resistance group). Three participants withdrew from the study.

Interventions: Exercises were given 3 times weekly for 12 weeks. The functional tasks exercise program aimed to improve daily tasks in the domains first affected in older adults, whereas the resistance exercise program focused on strengthening the muscle groups that are important for functional performance.

Main Outcome Measures: Participant satisfaction with the exercises, Assessment of Daily Activity Performance (ADAP), and, as a secondary outcome, muscle strength and power.

Results: Exercise adherence was 81% in the function group and 90% in the resistance group. Participants reported greater satisfaction with the resistance exercises than with the functional exercises. The ADAP total score improved with time (*P* = .001; mean change function group, 7.5U; 95% confidence interval [CI], 2.1 – 12.8; resistance group, 2.8U, 95% CI, -0.4 – 5.9), as did isometric knee extensor strength (*P* = .001; mean change function group, 6.4%; 95% CI, -1.6 – 14.5; resistance group, 14.4%; 95% CI, 6.4 – 2.2). Testing for differences in outcomes between the 2 groups showed no statistically significant differences.

Conclusions: The functional tasks exercise program is feasible and shows promise of being more effective for functional performance than a resistance exercise program. A randomized controlled trial with a larger sample size is needed to test the difference between the 2 programs.

INTRODUCTION

Aging is strongly associated with impaired mobility and decreased physical functional performance.[1,2] As a consequence, there is a loss of independence and quality of life, and the risk of falls and fractures increases.[3,4] Approximately 20% of people between 65 and 75 years of age need assistance performing activities of daily living (ADLs), and this increases to 48% in people older than 85.[5] Climbing stairs, shopping, rising out of a chair or bed, house cleaning, and washing and dressing oneself are the first ADLs to be affected.[5] The decline in functional task performance is partly caused by the aging process and is accelerated by a sedentary lifestyle. Although aging is an irreversible process, the effects of decreased physical activity can be reversed in most people.[1]

Many studies [3,6-8] have shown that regular exercise is beneficial to basic physical function in older adults, increasing muscle strength, balance, endurance, and flexibility. However, the effects of exercise programs on the performance of daily tasks have not been proven indisputably.[9-12] This may be because most exercise interventions aim to enhance performance of functional tasks by improving just 1 basic physical function, mostly muscle strength, flexibility, or balance. The performance of functional tasks, however, is more complex and involves an interplay of cognitive, perceptual, and motor functions, and is closely linked to the individual's dynamic environment.[13] That is, increasing muscle strength to improve the performance of complex activities violates the principles of training specificity, one of the most important principles for exercise training.[14] Training specificity implies that the performance of any given activity is maximized by training in that given activity.[14,15] Thus, to elicit the greatest effect, exercise training should simulate, as closely as possible, the conditions of daily tasks. Further, the exercises should be feasible, in terms of participant acceptance, drop-out, and side effects. The primary aim of the present pilot study was to evaluate the feasibility and the ability to affect physical functional performance of our functional tasks exercise program compared with a resistance exercise program. Feasibility was determined by information on participant satisfaction, drop-out, and attendance, as well as occurrence of adverse events. Physical functional performance was measured with the Assessment of Daily Activity Performance (ADAP), a method of assessing physical function that was patterned after the Continuous-scale Physical Functional Performance (CS-PFP) test.[16]

METHODS

Design

This study is a single-blind, randomized pilot trial and was approved by the Medical Ethics Board of the University Medical Center Utrecht, the Netherlands. Exercise sessions were held at a local leisure center in the Utrecht region from September 2000 to December 2000, and assessments were performed at the Mobility Laboratory of the Department of Geriatric Medicine at the University Medical Center Utrecht. Written informed consent was obtained from all participants after they had read the information brochure on the study.

Study population

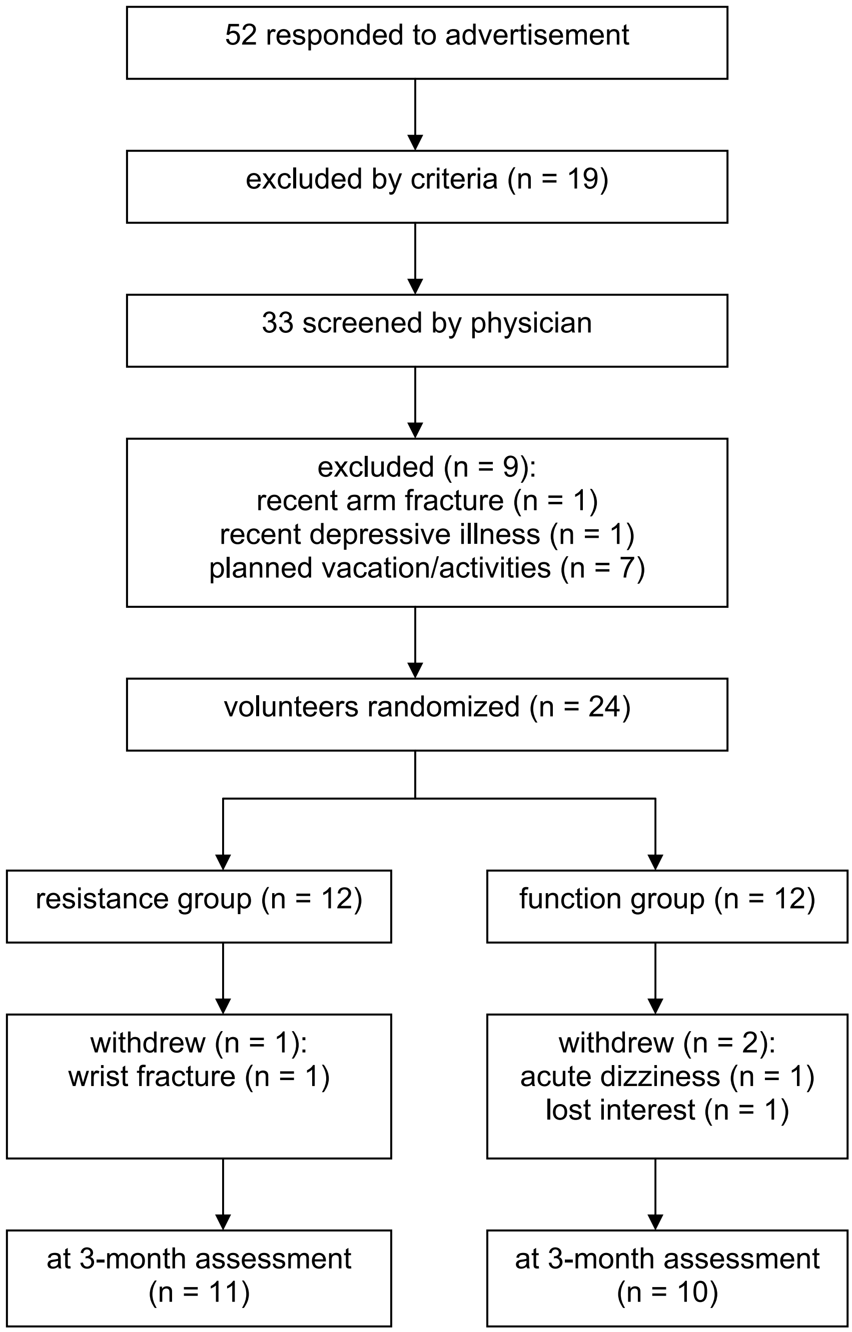
Twenty-four community-dwelling women older than 70 years were recruited through local newspapers from the Utrecht region. Figure 1 shows the flow of participants through the trial.

Participants had to be medically stable, as assessed by a validated questionnaire for participation in an exercise program for older adults.[17] A physician screened potential participants by using their medical history and a physical examination. Exclusion criteria included recent fractures, unstable cardiovascular or metabolic diseases, severe airflow obstruction, recent depression or emotional distress, or any reason for a loss of mobility for more than 1 week in the previous 2 months. Participants exercising at a sports club 3 times a week or more were also excluded. After inclusion, participants were randomly assigned to either the functional tasks exercise program (function group) or the resistance exercise program (resistance group).

Interventions

Both exercise interventions were given 3 times weekly in 1-hour sessions for 12 weeks, with sessions separated by a day of rest. Group size varied from 8 to 11 participants for the functional tasks exercise program and from 9 to 12 participants for the resistance exercise program per session.

Figure 1. Trial profile.



Training sessions were supervised by at least 2 experienced instructors (a physical therapist, a human movement therapist, or a physical education teacher). A physician visited the exercise location regularly, and, if necessary, answered health-related questions.

During exercises, participants of both programs recorded their exercise performances in a personal file, to provide both themselves and their instructors with feedback about their progress. Sessions were divided into a 10-minute warm-up period consisting of aerobic exercises, a 40-minute period of core exercises, and a 10-minute cool-down period consisting of flexibility exercises for limbs and trunk. The core exercises were specific to the group assignment; all other components of the intervention were consistent across groups. The warm-up and cool-down periods were group activities and accompanied by music. The core exercises of both programs were performed in training pairs (dyad training)[18], with an emphasis on interaction and enjoyment. Training partners took turns observing and doing the exercises (dyad-alternate). Exercise intensity in both programs was set at 6 to 8 on a 10-point rating of perceived exertion (RPE) scale (1 , very, very light; 10, very, very hard).[19] Several studies[19,20] have shown that these RPE scales can validly provide information about the intensity of resistance exercise. Further, use of the RPE correlates with blood lactate, heart rate, pulmonary ventilation, and oxygen consumption responses to exercise.[21] If an exercise was rated only “somewhat hard”, participants in the function group were instructed to increase the weight carried, the number of repetitions, or the distance traveled. Additionally, resistance could also be increased by putting on a weighted vest (1 - 10 kg) during the tasks. The participants in the resistance group were instructed to increase the load if an exercise was rated only “somewhat hard”.

Functional tasks exercise program

Appendix 1 gives an overview of the exercises of the functional tasks exercise (FUNTEX) program. The aim of the 40-minute core exercises was to improve daily tasks in the domains first affected in older adults,[5] namely, moving with a vertical component, moving with a horizontal component, transporting an object, and changing between the lying-sitting-standing position. During each exercise class, participants performed tasks for at least 2 of these domains in 3 sessions of 5 to 10

repetitions. The 12-week program was divided in a practice phase (2wk), a variation phase (4wk), and a daily tasks phase (6wk).
Exercises in the practice phase consisted of short, simple tasks. Weight transported and repetitions were noted. In the variation phase, participants applied these basic tasks to various training conditions, such as environment, attributes, and interaction between participants. Trainers registered the time it took to complete a task in this phase. Participants were encouraged to perform the tasks as quickly as possible and to increase the weight carried, the number of repetitions, and the distance walked. The daily tasks phase consisted of a combination of the 5 domains, in order to make the tasks as similar to daily tasks as possible. Once more, time, weight, distance traveled, and number of repetitions were noted.
During each phase, the instructors could complicate or simplify motor, environment, and cognitive aspects of the tasks in correspondence to the capability of each participant. Each aspect could be changed in a stable or a variable way. For instance, during the task "rise from a chair, step onto a raised platform (20cm), and take different objects from a high shelf" from the daily tasks phase, the motor aspects could be altered by collecting more objects (stable) or transporting the objects in different manners (variable). The environment could be adapted by changing the height of the raised platform (stable) or by letting 2 participants of different training pairs step together onto the raised platform (variable). The cognitive aspects could be altered by collecting the objects in a certain sequence (e.g., by color) (stable) or letting 2 participants collect the objects in a certain combination (e.g., if 1 person takes a green object, the next person has to collect a red object) (variable). Detailed description of the exercises can be obtained from the authors.

Resistance exercise program

The 40-minute core resistance exercises were designed according to the American College of Sports Medicine position stand on exercise and physical activity for older adults [8] and based on the exercises of the Fit For Your Life resistance training program of Morris et al.[22] Exercises were aimed to strengthen the muscle groups that are important for daily tasks, namely, the wrist flexors and extensors; elbow flexors and extensors; shoulder abductors, adductors, and rotators; trunk flexors and extensors; hip flexors, extensors, abductors, and adductors; knee flexors and extensors; and ankle dorsi- and plantar flexors. In a typical progressive resistance training protocol, 3 to 4 muscle groups were trained in 3 sets of 10 repetitions in each exercise class. Dumbbells (0.5 – 8.0 kg) and elastic tubing (3 resistances of elastic bands) were used for resistance during wrist, elbow, shoulder, ankle, and trunk exercises. Ankle weights (0.25 – 10.00 kg) were used for resistance during hip and knee exercises. To strengthen ankle plantarflexors, the body weight was used for resistance by raising the body up as high as possible on the toes. The participants were instructed to increase the load if an exercise was rated only “somewhat hard” by using heavier dumbbells, by putting more weights in the ankle weights, or by using an elastic band with a higher resistance level. The elastic bands could also be shortened for more resistance. Participants alternated upper- and lower-body exercises to prevent overuse injuries, with approximately 2 minutes of rest between sets. The number of repetitions and the resistance level of each set were registered in the personal files. The exact set of exercises can be obtained from the authors.

Measurements

Primary outcome measures were the feasibility of both exercise programs and physical functional performance. Feasibility was determined from information on participant satisfaction, drop-out, attendance, and the occurrence of adverse events. Physical functional performance was assessed using the ADAP test. Secondary outcome measures included the Timed Up & Go (TUG) test and muscle function tests. Participant satisfaction was assessed postintervention. During the interventions, attendance and adverse events were registered in program diaries by the exercise instructors. Physical functional performance, the TUG test, and muscle function tests were assessed at baseline and at 12 weeks by an experienced examiner who was blinded for the training conditions. Participants were specifically instructed not to reveal the type of exercise program followed.

Primary outcome measures

Participant satisfaction

Participant satisfaction was determined postintervention with a 22-item, anonymously completed questionnaire. Information was obtained on general satisfaction with the program, intensity, duration, and pace of the program, exercise location, transport to the location, and planned continuation of an exercise program. The motivation to attend classes during the first, second, and third months was asked retrospectively.

Physical functional performance

Physical functional performance was assessed quantitatively using the ADAP. The ADAP allows the participant to perform at maximal ability by maximizing the weight carried and working at the fastest speed possible or reaching the greatest distance and was patterned after the CS-PFP test as demonstrated by Cress et al[16,23] to be reliable, valid and sensitive to change in function. The CS-PFP was modified to Dutch dimensions for bed size (190x200cm; height, 60cm vs. 134x192cm; height, 50cm), height of the kitchen counter (114cm vs. 88cm), and height of the washing machine (88.5cm vs. 91cm). The vertical reach was replaced by a standing forward reach test, because the combination of a forward standing reach and a sit-and-reach task (putting a Velcro-closed strap over the shoe) is a more familiar method in the literature to determine upper-body flexibility than the combination of the vertical reach test and a sit-and-reach task as proposed by others.[16,24,25] Measurement protocols and participant instructions were standardized. For the standing forward reach the protocol of Duncan et al [24] was followed. The ADAP includes 16 common tasks, such as transferring laundry and boarding a bus, performed at maximal effort. The ADAP provides a total score and 5 physical domain scores: upper-body strength, lower-body strength, flexibility, endurance, and balance and coordination. In general, scores on a specific task can contribute to 1, 2, or 3 domains. Tasks quantified by both weight transported and time are carrying a weighted pan, pouring water from a jug into a cup, carrying weight up and down a bus platform, and carrying groceries. Tasks quantified by time alone are transferring laundry from a washer to a dryer, putting on and removing a jacket, floor sweeping, vacuuming, making a bed, climbing stairs, getting down and up from the floor, pulling open a door, putting a Velcro-closed strap over the shoe, and picking up 4 scarves from the floor. Tasks quantified by distance are the 6-minute walk and standing forward reach. By using Excel software, each task was scaled 0 to 100 according to the formula:

observed score = (observed score – lower limit) / (upper limit – lower limit) x 100.

If the observed score was equal to the lower limit, the score was 0. For an observed score equal to the upper limit, the score was 100. Unattempted tasks were scored 0. Time was converted to speed as $1/t$, so that higher numbers reflect a better function for each of the dimensions (weight, distance, and speed) measured. Cress et al [16,23] showed this test to be valid and responsive to change. Unpublished work (de Vreede et al, 2000) showed the ADAP test to be a reliable instrument. By using a test-retest design, 9 community-living women (mean age 74.1 ± 3.4 y) were tested by the examiner at a 1-week interval. The intraclass correlation coefficient (ICC) was .96 for the ADAP total score.

Secondary outcome measures

TUG test

In the TUG test, the time an individual needs to rise from a standard arm chair (seat, 46cm high), walk 3m, turn around, return to the chair, and sit down again is measured.[26] The test was performed 3 times as quickly as possible. The quickest time, recorded in seconds, was used for analysis. Samson et al [27] showed that the TUG test is reliable and valid and Skelton and McLaughlin[28] found this test to be responsive to change in older adults.

Muscle function tests

Maximum voluntary isometric knee extension strength was measured in both legs with a fixed strain gauge (AFG-Advanced Force Gauge, Mecmesin Inc, Santa Rosa, California, USA).[27,29] Participants were seated in an adjustable straight-back chair with the pelvis fixed by an adjustable strap and the strain gauge attached by a strap just proximal to the ankle. The participants extended the fixed leg isometrically to a maximum with the knee flexed to 90°. The highest score of 5 attempts with approximately 1 minute of rest between attempts was recorded in newtons. Peak values for the left and right legs were averaged and used for analysis. Isometric knee extension strength has been shown to be reliable, valid, and responsive to change in older adults.[27,30]

Maximum voluntary isometric elbow flexor strength was measured in both arms with a hand-held dynamometer (MicroFET, Hoggan Health Industries, Draper, Utah, USA).[31] Participants were positioned supine on a table with arms slightly abducted, elbow flexed at 90°, and the wrist in neutral position. The MicroFET device was placed on the anterior surface of the forearm, just proximal to the wrist. The participants pulled as hard as possible by flexing the elbow while the examiner kept the dynamometer in place by matching the force of the participant with 2 hands. The highest score of 3 attempts with approximately 1 minute of rest between attempts was recorded in newtons. Peak values for the left and right arms were averaged and used for analysis. Unpublished work (Heeffer et al, 2000) showed isometric elbow flexor strength to be reliable (ICC = .96) when tested in 15 women (mean age, 80.4 ± 6.5 y).

Handgrip strength was measured with a mechanical handgrip dynamometer (Takei Kiki Kogyo 5101, Japan).[27,32] Grip size was adjusted to fit each subject's hand and the same grip size was used at all visits. Participants were instructed to stand up straight with the dynamometer in 1 hand and close to their body while holding their arm vertical and the wrist in a neutral position. The best score of five attempts with approximately 1 minute of rest between attempts was recorded in kilogram force (kgF). Peak values for the left and right hands were averaged and used for analysis. Handgrip strength is reliable, valid, and responsive to change in older adults.[27,30]

Explosive leg extension power was measured with the Nottingham power rig (NUMAS, University of Nottingham Medical Faculty Workshops, Nottingham, UK) in both legs.[33] Participants, seated with arms folded, delivered power by pressing a footplate as hard and quickly as possible through a distance of .165m, setting a flywheel in motion. Seat position was adjusted so that the knee angle at the start was 90°. The measurements were repeated until no further improvement was seen, up to a maximum of 10 pushes.[27] The highest recorded power output was recorded in Watt (W). Peak values for the left and right legs were averaged and used for analysis. Bassey[33] and Skelton and colleagues[34] demonstrated that this test is reliable, valid, and responsive.

Statistical analysis

All data were analyzed with SPSS statistical software (SPSS Inc. SPSS reference guide. Chicago: SPSS Inc, 1990). Baseline differences in group characteristics were analyzed by univariate analyses of variance. The nonparametric Mann-Whitney *U* test was used to compare the outcomes of the satisfaction questionnaire between the function group and the resistance group. To compare the motivation item of the questionnaire within the groups, the nonparametric Friedman test was used. General linear model repeated-measures analyses were used to analyze the effect of time, treatment, and time by treatment interactions for all outcome variables at baseline and 12 weeks, with significance set at *P* equal .05. Effect size between the groups was determined as follows:

Effect size = (delta function group – delta resistance group) / pooled standard deviation (SD). Effect sizes of 0.2, 0.5, and 0.8 are considered to be small, moderate, or large, respectively.[35]

Table 1. Baseline characteristics of functional tasks exercise program group and resistance exercise program group.

Characteristics	*Function group (n = 12)*	*Resistance group (n = 12)*	*P-value*
Age (yr)	75.3 ± 6.4	74.0 ± 2.6	.54
Height (m)	1.6 ± 0.1	1.6 ± 0.1	.79
Weight (kg)	67.2 ± 8.5	63.9 ± 12.5	.46
ADAP test			
Total score	43.4 ± 16.2	43.2 ± 12.9	.98
Upper-body strength	41.5 ± 16.8	40.1 ± 9.2	.80
Lower-body strength	38.4 ± 17.3	38.3 ± 14.4	.99
Flexibility	45.4 ± 18.8	45.0 ± 15.7	.96
Balance and coordination	42.2 ± 15.9	42.6 ± 16.8	.95
Endurance	44.3 ± 16.6	44.5 ± 15.6	.98
TUG test (s)	6.2 ± 2.2	5.8 ± 1.6	.61
Muscle function			
IKES (N)	249.9 ± 102.6	238.2 ± 66.9	.74
HGS (kgF)	20.0 ± 6.4	20.5 ± 5.2	.85
IEFS (N)	142.9 ± 29.7	146.6 ± 17.4	.71
LEP (W)	104.3 ± 38.8	85.4 ± 37.3	.25

NOTE: Values are means ± SD.
Abbreviations: ADAP, assessment of daily activity performance; TUG, timed up & go; IKES, isometric knee extensor strength; HGS, handgrip strength; IEFS, isometric elbow flexor strength; LEP, leg extensor power.

RESULTS

Participants

Of the 52 respondents to the advertisement in the newspaper, 44 were considered potentially eligible after screening by telephone. Those eligible to participate received information brochures by mail. Thirty-three of these participants were willing to participate after reading the information and were invited for the medical examination. Two participants failed the examination, one because of an arm fracture 1 week earlier and the other because of a recent depressive illness. Seven participants were not able to participate due to planned vacations or activities conflicting with the 12-week training period (fig 1).

The baseline characteristics of the 24 participants randomly assigned to the FUNTEX program (function group) or the resistance exercise program (resistance group) are shown in table 1. The mean age of the function group was 75.3 ± 6.4 years (range, 70 – 91 y) and of the resistance group, 74.0 ± 2.6 years (range, 70 – 77 y). No differences were found between the groups for baseline scores for physical functional performance or muscle function.

Primary outcomes

Attendance and Adherence

In the function group, 2 participants dropped out during the first 2 weeks: one suffered from acute dizziness and the other lost interest. In the resistance group, 1 participant dropped out after 4 weeks due to a wrist fracture after a fall at home.

No significant difference in attendance was found between the exercise groups (P = .359; 95% confidence interval [CI], -13.2 to 34.0). Participants in the function group attended, on average, 81% ± 35.9% of the exercise classes (range, 0% – 100%); participants in the resistance group attended, on average, 90% ± 12.6% of the exercise classes (range, 58% –100%). The large SD for the function group was caused by the 2 participants who dropped out during the first 2 weeks of the intervention period. Without drop-outs, the participants in the function group attended, on average, 96% ± 4.6% of the exercise classes (range, 86% – 100%), and participants in the strength group attended, on average, 94% ± 7.8% of the exercise classes (range, 78% – 100%).

Adverse Events

Adverse events were monitored by the instructors at the end of each exercise class. Further, every week participants filled in a form on which adverse events could be registered. No significant difference in adverse events was seen between the exercise groups. Five participants in the function group and 4 in the resistance group reported muscle pains after the exercise sessions, but the pain was gone after 2 days. During exercises, 3 participants in the function group reported joint pain: 2 in an osteoarthritic knee and 1 in a prosthetic hip joint. Five complaints of joint pain were reported in the resistance group: 2 in an osteoarthritic wrist, 2 in an osteoarthritic knee, and 1 in an osteoarthritic shoulder, which necessitated adaptation of their personal training regimen. Three participants in the function group and 1 in the resistance group complained of lower back pain, also necessitating changes to their training regimen. In the function group, 1 participant sprained an ankle, but not while exercising. No cardiovascular complications occurred during any testing or training session.

Program evaluation

Table 2 shows the results of the participant satisfaction questionnaire. All participants of the resistance group (including the drop-out) returned the questionnaire. The 2 participants who withdrew from the function group did not to return the questionnaire. Overall, the exercise program was judged better by the resistance group than by the function group. The resistance exercise program also tended to be rated better on a 10-point scale (1, very bad; 10, excellent) than the functional tasks exercise program. Although not significant, the intensity and pace of the functional tasks exercise program were considered better than the same aspects of the resistance exercise program. The resistance group rated the supervision of the instructors better than did the function group. During the first month of the intervention, the resistance group seemed more motivated than the function group. However, during the third month, motivation in the resistance group decreased, whereas motivation in the function group did not change significantly. Most (83%) participants of the resistance group experienced a subjective exercise effect, whereas only 40% of the function group did (P = .040). Mostly, participants noted an effect after 6 weeks of exercise (56% in resistance group, 67% in function group). All participants in the resistance group wanted to continue participation in an exercise program, although most (67%)

Table 2. Evaluation of the exercise programs by members of the functional tasks exercise program group and resistance exercise program group.

Questions	*Function group (n = 10) n (%)*	*Resistance group (n = 12) n (%)*	*P-value*
What is your overall judgement on the exercise program?			<.001
Fairly good	1 (10)	0 (0)	
Good	9 (90)	3 (25)	
Very good	0 (0)	9 (75)	
How would you rate the core exercises?			.15
Light	0 (0)	3 (25)	
Fairly heavy	7 (70)	7 (58)	
Heavy	3 (30)	2 (17)	
How would you rate the intensity of the exercises?			.17
Too light	0 (0)	1 (8)	
Light	1 (10)	0 (0)	
Fairly heavy	5 (50)	10 (83)	
Heavy	4 (40)	1 (8)	
How would you rate the duration of the program?			.62
Too short	0 (0)	1 (8)	
Short	1 (10)	1 (8)	
Ideal	9 (90)	10 (83)	
How would you rate the pace of the exercises			.14
Slow	1 (10)	2 (17)	
Fairly fast	4 (40)	8 (67)	
Fast	5 (50)	2 (17)	
How would you rate the supervision of the instructors?			.04
Good	6 (60)	2 (17)	
Very good	4 (40)	10 (83)	
How motivated were you to attend classes?			
During the first month			.08
Considered quitting	1 (10)	0 (0)	
Motivated	3 (30)	1 (8)	

Very motivated	6 (60)	11 (92)	
During the second month			.09
Considered quitting	1 (10)	0 (0)	
Motivated	4 (40)	2 (17)	
Very motivated	5 (50)	10 (83)	
During the third month			.69
Considered quitting	0 (0)	1 (9)	
Motivated	6 (60)	4 (36)	
Very motivated	4 (40)	6 (55)	
Did you experience an exercise effect?			.04
Yes	4 (40)	10 (83)	
No	6 (60)	2 (17)	
When did you experience the effect?			.83
After 2 weeks	1 (33)	3 (33)	
After 6 weeks	2 (67)	5 (56)	
After 12 weeks	0 (0)	1 (11)	
How would you rate the overall organization?			.10
Good	5 (50)	2 (17)	
Very good	5 (50)	10 (83)	
Do you wish to continue following exercises?			.11
Yes	8 (80)	12 (100)	
No	2 (20)	0 (0)	
Similar exercise program	5 (60)	4 (33)	
Different exercise program	3 (40)	8 (67)	
How would you rate the exercise program on a scale from 1 to 10 (1, very bad; 10, excellent)?	7.9 ±1.0	8.7 ±0.8	.06*

NOTE: Values are n (%) or mean ± SD. The nonparametric Mann-Whitney *U* test was used to compare the outcomes of the satisfaction questionnaire between the function and the resistance groups.
* The *t* test was used to compare the rating between the function and the resistance groups on a scale from 1 to 10.

preferred a different type of exercise. In the function group, 80% wanted to continue participation in an exercise program, of whom 60% wanted to continue with the functional tasks exercises. Alternative exercises mentioned by the resistance group were exercises at home and flexibility exercises. In the function group, fitness and aerobics were mentioned as alternative exercises.

Internal training progression

The personal training files of the participants provided feedback about the progression during the exercise programs. For example, during the 12-week training program, participants in the function group increased the weight transported per repetition by 87% (range, 0% – 230%). The weight carried during climbing a short stair was increased by 77% (range, 0% – 110%). The participants in the resistance group, for example, increased exercise resistance during wrist exercises on average by 111% (range, 0% – 400%), during elbow exercises by 73% (range, 0% – 200%), during shoulder exercises by 74% (range, 0% – 300%), during trunk exercises by 70% (range, 17% – 200%), during hip exercises by 108% (range, 0% – 600%), during knee exercises by 66% (range, -100% to 200%), and during ankle exercises by 65% (range, 14% – 233%).

Physical functional performance measures

Physical functional performance at baseline and 3 months is presented in table 3. Both the function and the resistance groups increased scores for ADAP test total score (P = .001), functional upper-body strength (P = .009), functional lower-body strength (P = .001), upper-body flexibility (P = .008), balance and coordination (P = .009), and endurance (P = .001) at 3 months. No significant difference between the exercise groups was seen in total ADAP score (P = .101), functional upper-body strength (P = .453), functional lower-body strength (P = .229), upper-body flexibility (P = .099), balance and coordination (P = .117), and endurance (P = .056). Except for the small effect size (effect size, .34) for upper-body strength, effect sizes were moderate (lower-body strength effect size, .54) to large (endurance effect size, .83) in favor of the functional tasks exercise program.

Table 3. Physical functional performance at baseline and 3 months, by group.

Performance Tests	*Function group (n=10)*	*Resistance group (n=11)*	*Time* *P*	*Group x Time* *P*	*Function vs. Resistance* Effect Size
ADAP test					
Total score					
Pre	44.3 ± 16.6	42.5 ± 13.3	.001	.10	.72
Post	51.8 ± 12.1	45.3 ± 13.2			
Upper-body strength					
Pre	42.0 ± 17.7	38.6 ± 8.0	.009	.45	.34
Post	47.8 ± 10.2	41.9 ± 8.6			
Lower-body strength					
Pre	40.0 ± 18.1	36.9 ± 14.3	.001	.23	.54
Post	46.8 ± 15.2	40.5 ± 13.1			
Upper-body flexibility					
Pre	45.3 ± 18.8	44.4 ± 16.3	.008	.10	.72
Post	57.7 ± 13.4	47.6 ± 15.0			
Balance and coordination					
Pre	43.6 ± 16.6	42.4 ± 17.6	.009	.12	.69
Post	52.5 ± 16.0	44.8 ± 18.3			
Endurance					
Pre	45.3 ± 17.3	44.1 ± 16.3	.001	.06	.83
Post	54.3 ± 14.6	47.1 ± 16.4			
TUG test (s)					
Pre	6.0 ± 2.2	5.8 ± 1.7	.40	.73	-.16
Post	5.8 ± 1.5	5.7 ± 1.4			

NOTE: Values are mean ±SD
ADAP, assessment of daily activity performance; TUG, timed up & go.

Secondary outcomes

Muscle function test results are given in table 4 and TUG test results are shown in table 3. No time or group by time interaction was seen for TUG (table 3). Isometric knee extensor strength increased in the function group and in the resistance group over the intervention period (*P* = .001). No change over time was seen for isometric elbow flexor strength (*P* = .819), handgrip strength (*P* = .436), and leg extension power (*P* = .161). There were no statistically significant differences in changes of muscle function between the 2 groups. Except for the small effect sizes for TUG and isometric elbow flexor strength (effect size, -.16; -.21, respectively), effects were moderate (isometric knee extensor strength effect size, -.59 in favor of the resistance group) to large (leg extension power effect size, .82 in favor of the function group).

Table 4. Muscle function at baseline and 3 months, by group.

Muscle Function Tests	*Function group (n=10)*	*Resistance group (n=11)*	*Time*	*Group x Time*	*Function vs. Resistance*
			P	*P*	Effect Size
IKES (N)					
Pre	256.6 ± 111.2	237.0 ± 70.0	.001	.19	-.59
Post	271.5 ± 122.9	269.2 ± 75.0			
HGS (kgF)					
Pre	20.4 ± 6.8	19.9 ± 5.0	.82	.09	.74
Post	21.5 ± 5.3	19.0 ± 4.4			
IEFS (N)					
Pre	153.4 ± 25.9	146.9 ± 18.4	.44	.65	-.21
Post	154.4 ± 21.4	150.6 ± 22.0			
LEP (W)					
Pre	109.1 ± 38.0	89.2 ± 37.1	.16	.06	.82
Post	121.2 ± 42.8	87.4 ± 35.5			

NOTE: Values are mean ±SD
IKES, isometric knee extensor strength; HGS, handgrip strength; IEFS, isometric elbow flexor strength; LEP, leg extensor power.

DISCUSSION

Our newly developed functional tasks exercise program appears feasible and is well tolerated by women over the age of 70 years living in the community. The drop-out rate of both exercise programs (17% in the function group, 8% in the resistance group) was comparable to that of other exercise studies involving older community-living subjects.[11,12]

The high attendance and the results of the satisfaction questionnaire showed the high acceptance for both programs. Overall, the resistance exercise program was rated better by the participants than the functional tasks exercise program. Additionally, although all participants were informed about the exercise programs before inclusion, several participants in the function group stated that the functional tasks exercise program did not meet their expectations. The lower rating of the functional tasks exercise by the participants may be because resistance training programs are widely used and thus more familiar.

This failure to meet participant expectations could also explain the diminished motivation of the function group during the first month. However, motivation in the resistance group decreased in the third month, whereas that of the function group was stable. Most participants in the function group who wanted to continue participating in an exercise program preferred the functional tasks exercise program. In the resistance group, 67% of the participants wanted to continue to exercise but in a different way. Another reason for the changed motivation of the function group could be that the simple, basic tasks during the start of the exercise program were boring, and it was only when the complexity and variation increased during the variation and daily tasks phase that the participant motivation increased.

This study suggests that, over a 12-week period, the functional tasks exercise and the resistance exercise programs may positively change functional task performance in older, community-living women. Although group by time analyses showed no significant differences between exercise groups, the changes in ADAP total and domain scores were consistently higher in the function group. Given an estimated effect size of .72, power of 80%, and 2-tailed α of .05, the sample size needed to detect a difference between groups was 30 in each intervention group.

Although changes in ADAP scores in the resistance group were somewhat small, changes in scores of the function group (7.5U increase for ADAP total score) were comparable to those reported by Cress et al [23] after a 6-month exercise program of combined stair climbing and resistance training in older adults (7.8U increase for CS-PFP total score). With a focus on endurance and strength domains, Cress found no change in flexibility or balance and coordination domains.

Isometric knee extensor strength improved by 14.4% in the resistance group and by 6.5% in the function group. The improvement in the resistance group is in agreement with the effect of resistance training regimens in other studies.[9,12] Even though the resistance group continued to show improvement during the program, changes in elbow flexor strength were somewhat disappointing. Other studies[12,36] have demonstrated a positive effect of resistance exercise on elbow flexor strength. These studies, however, trained fewer muscle groups. Therefore, a change in the resistance exercise program, to focus on fewer muscle groups, may increase the effect on elbow flexor strength. A possible explanation for the lack of effect of exercise on handgrip strength in the strength group is that the hand muscles were not trained specifically. Leg extension power tended to increase more in the function group than in the resistance group, which is consistent with the findings of Skelton et al,[12] who found leg extension power to be more representative than isometric strength as a functional measure in older adults.

The results of this pilot study suggest that the quantitative assessment of functional task performance with the ADAP test can detect a change in daily task performance in a relatively healthy group of older adults, with a small therapeutic window. Because of the substitution of the vertical reach with a forward standing reach, the domain upper-body flexibility was determined by the tasks putting on and removing a jacket, putting a Velcro-closed strap over the shoe (sit-and-reach), and the forward standing reach. A combination of tests has been proposed in other studies.[24,25] Furthermore, Schenkman et al [37] showed a relationship between spinal flexibility and forward standing reach.

The current feasibility study has some weaknesses. First, a control group should be included in further studies, to understand fully the impact of the exercise programs. Second, the ADAP needs more extensive investigation of its reliability. And last, the increase of 7.5U for total ADAP with a 12-week functional tasks exercise program appears to be relevant and important. Cress et al[23] suggested that an increase of 7.8U on the CS-PFP might mean that an individual carries 14% more weight, while moving 10% more quickly. However, further research is necessary to determine the actual clinical importance of the changes in ADAP scores induced by the functional tasks exercise program.

In conclusion we showed that the newly designed functional tasks exercise program was feasible and associated with an improvement in functional performance. In comparison to a resistance exercise program, the impact on functional performance was larger, with effect sizes in the range of moderate to large. A study with an adequate sample size is needed to draw more definitive conclusions.

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APPENDIX 1: The functional tasks exercise program

Practice phase (2 wk)

1. Step forward onto a raised (20cm) platform, or step.
2. Step sideways onto a step.
3. Step on and off a step. Repeat for 1 minute.
4. Step forward over the step.
5. Step sideways over the step.
6. Step over the step. Repeat for 1 minute.
7. Walk for 2 minutes.
8. Walk though an obstacle course.
9. Walk through an obstacle course carrying a tray.
10. Lift a weighted box (from knee high).
11. Lift (from knee high) and carry a weighted box.
12. Lift a weighted box (from the floor).
13. Lift (from the floor) and carry a weighted box.
14. Get up out of a chair and carry a small object.
15. Get out of bed and carry a small object.

Variation phase (4 wk)

16. Walk over carpet tiles.
17. Walk over carpet tiles, picking up an object from the floor.
18. Walk along a straight line (painted on the floor).
19. Walk along a straight line carrying a tray.
20. Get up from hands and knees and carry an object.
21. Rise from a chair while holding an object. Put the object on a low shelf.
22. Climb a short flight of stairs (5-7 steps) holding a small object in 1 hand.
23. Climb a short flight of stairs sideways.
24. Climb a short flight of stairs while carrying a plastic bottle of water on a tray.
25. Climb a short flight of stairs while carrying a plastic bottle of water on a tray carried by 2 people.
26. Walk along a curved line (painted on the floor).
27. Move different objects between shelves of different height (one hand).

28. Move different objects between shelves of different height (two hands).
29. Walk along a straight line and reach forward / sideways.
30. Carry and pack a box for 2 minutes.
31. Walk through an obstacle course carrying a weighted bucket.
32. Get up from the floor and carry an object.
33. Get up from the floor and carry an object for 2 minutes.
34. Climb stairs (12-17 steps) while carrying a small object.
35. Climb stairs sideways.
36. Climb stairs while carrying a plastic bottle of water on a tray.
37. Push a ring a over the floor with a stick through an obstacle course.
38. Pick up sandbags from the floor and put them in a bucket.
39. Walk along a straight line with obstacles.
40. Rise from a chair while carrying a plastic bottle of water on a tray.
41. Rise from a bed and carry an object.
42. Step on and off a step. Repeat for 1 minute.
43. Step sideways on and off a step. Repeat for 1 minute.
44. Step onto a step raised as high as possible.
45. Carry a weighted bucket (1 hand) through an obstacle course.
46. Carry two weighted buckets through an obstacle course.
47. Carry a weighted bucket with two hands through an obstacle course.

Daily tasks phase (6 wk)

48. Walk over carpet tiles, picking up items from floor and putting them in a bucket.
49. Pick up an object from the floor while sitting and then put the object on a shelf.
50. Rise from a chair and pick up an object from the floor. While sitting, throw the object in a basket.
51. Get up from the floor and move different objects onto different shelves.
52. Climb stairs (12-17 steps) holding a small object in 1 hand.
53. Fill a bucket with weights and then climb stairs carrying the weighted bucket.
54. Take clothes and sandbags from a low shelf, carry them in a basket through an obstacle course, and put them back of the shelf.

55. Take different objects from shelves and carry them in shopping bags through an obstacle course.
56. Lift (from knee high) and carry a weighted box.
57. Walk and pick up objects from the floor and throw them in a basket. Repeat for 3 minutes.
58. Walk over different surfaces (plain floor, mattress, sandbags). Repeat for 3 minutes.
59. Rise from a bed (or a chair), pick up an object from the floor, and throw it into a basket.
60. Complete obstacle course, stepping on and off the step (4 times), and stepping over the step (2 times) (relay).
61. Rise from a chair, step onto the step, and take different objects from a high shelf.
62. Get up from the floor and carry a weighted bucket.
63. Lift (from the floor) and carry a weighted box. Repeat for 2 minutes.
64. Walk through an obstacle course while carrying a plastic bottle of water on a tray. Repeat for 3 minutes (relay).
65. Carry weighted bags through an obstacle course.
66. Rise from a chair (or a bed), walk along a straight line, and kick a ball into a goal.
67. Step on and off the step. Repeat for 1 minute.
68. Step sideways on and off the step. Repeat for 1 minute.
69. Carry different objects with a box, shopping bag, tray and bucket.
70. Rise from a chair and carry an object over the step.
71. Complete an obstacle course involving rising from a chair (3 times) and rising from a bed (3 times) while carrying a plastic bottle of water on a tray (relay).
72. Climb stairs carrying a weighted bucket (relay).
73. Carry a weighted bucket through an obstacle course (incl. stepping on and off the step [4 times] and stepping over the step [2 times]).
74. Push a ring over the floor with a stick through an obstacle course.

Chapter 3

Reliability and validity of the assessment of daily activity performance (ADAP) in community-dwelling older women

Paul L. de Vreede[1] BSc, Monique M. Samson[1], MD, PhD, Nico L. van Meeteren[2,3], PT, PhD, Sijmen A. Duursma[1], MD, PhD, Harald J. Verhaar[1], MD, PhD

[1] Mobility Laboratory, Department of Geriatric Medicine, University Medical Center Utrecht, the Netherlands;
[2] Rudolf Magnus Institute of Neuroscience, Department of Neurology and Neurosurgery, University Medical Center Utrecht, the Netherlands;
[3] Department of Physiotherapy, Academy of Health Sciences, Utrecht, the Netherlands

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ABSTRACT

Background and aims: The Assessment of Daily Activity Performance (ADAP) test was developed, patterned after the Continuous-scale Physical Functional Performance (CS-PFP) test, to provide a quantitative assessment of older adults' physical functional performance. The aim of this study was to determine the intra-examiner reliability and construct validity of the ADAP in a community-living older population, and to identify the importance of tester experience.

Methods: Forty-three community-dwelling, older women (mean age 75 yr ± 4.3) were randomised to the test-retest reliability study (n = 19) or the validation study (n = 24). Intra-examiner reliability of an experienced (tester 1) and an inexperienced tester (tester 2) was assessed by comparing test and retest scores of 19 participants. Construct validity was assessed by comparing the ADAP scores of 24 participants with self-perceived function using the SF-36 Health Survey, muscle function tests, and the Timed Up and Go test (TUG).

Results: Tester 1 had good consistency and reliability scores (mean difference between test and retest scores, -1.05 ± 1.99; 95% confidence interval (CI), -2.58 to .48; Cronbach's alpha (α) range, .83 to .98; intraclass correlation (ICC) range, .75 to .96; Limits of Agreement (LoA), -2.58 to 4.95). Tester 2 had lower reliability scores (mean difference between test and retest scores, -2.45 ± 4.36; 95% CI, -5.56 to .67; α range, .53 to .94; ICC range, .36 to .90; LoA, -6.09 to 10.99), with there being a systematic difference between test and retest scores for the ADAP domain lower-body strength (-3.81; 95% CI, -6.09 to -1.54). ADAP correlated with SF-36 Physical Functioning scale (r = .67), TUG test (r = -.91), and with isometric knee extensor strength (r = .80).

Conclusions: The ADAP test is a reliable and valid instrument. Our results suggest that testers should practise using the test, to improve reliability, before using it in clinical practice.

INTRODUCTION

In exercise studies, the most commonly used measures of physical function are self-report activities of daily living (ADL) questionnaires, such as the Katz and Barthel index (1-3), health-related quality of life questionnaires, such as the Short Form Health Survey (SF-36) (4-6), and selected intermediate outcome measures, such as muscle strength and gait speed.(4, 7-10) However, the extent to which these assessments are responsive to meaningful changes in the functioning of community-living, healthy individuals has been questioned (4, 11, 12). For example, ADL questionnaires usually fail to detect changes in healthy participants because of ceiling effects (11, 13, 14). Furthermore, although improved intermediate outcome measures, such as muscle strength or gait speed, have been equated with improved performance of daily activities (7, 9, 10, 15), an increase in muscle strength or walking speed does not necessarily mean that the performance of functional tasks is improved (4, 14). Thus, when evaluating interventions aimed at improving the ability of healthy individuals to perform everyday activities, it is essential to use measures of physical function that are not affected by ceiling effects.

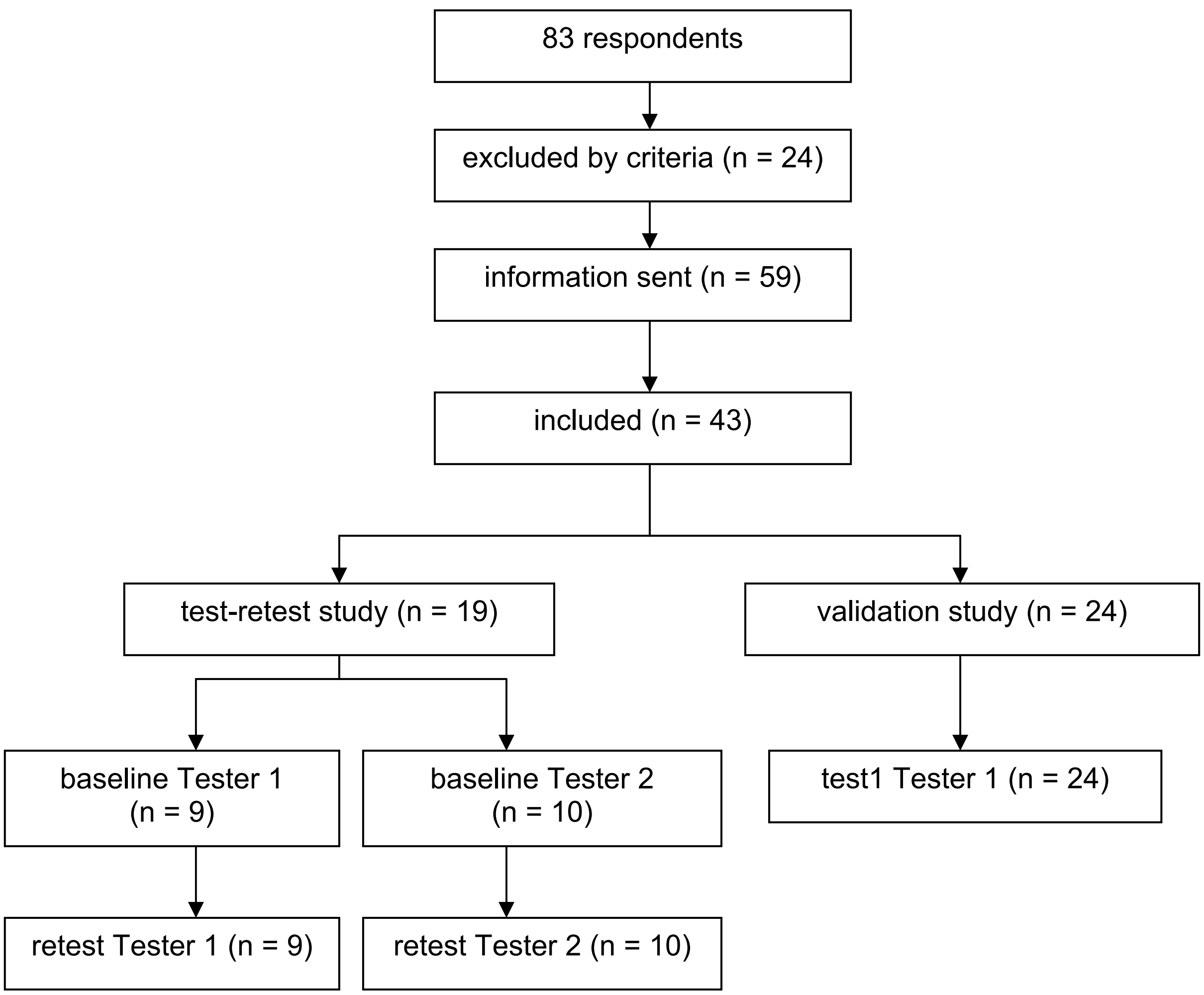
We developed the quantitative Assessment of Daily Activity Performance (ADAP) test (16, 17). This method was patterned after the Continuous-scale Physical Functional Performance (CS-PFP) test, as demonstrated by Cress et al to be reliable, valid, sensitive to change, and without ceiling or floor effects (11, 18). The CS-PFP test was modified to Dutch dimensions for bed size, height of the kitchen counter, and height of the washing machine. The vertical reach task was replaced by the functional reach test (19). These modifications of the CS-PFP test makes that the ADAP test differs on approximately 30% of the tasks performed during the test. Therefore, the ADAP test should be approached as a different test and validity and reliability need to be established. The aim of this study was to examine the reliability and construct validity of the ADAP test in a sample of community-living older people. Because a tester's experience may affect test results (20, 21), we compared the ADAP test results of an experienced tester from our mobility laboratory with those of an inexperienced tester.

METHODS

Participants and examiners

Eighty-three community-dwelling women older than 70 years were recruited from the Utrecht region through newspaper advertisements. Of the 83 respondents, 24 were excluded after telephone interviews. Exclusion criteria included: recent fractures; unstable cardiovascular, metabolic, musculoskeletal condition, or other chronic illnesses that might limit testing; severe airflow obstruction; recent depression or emotional distress; or any reason for a loss of mobility for more than 1 week in the previous 2 months. After reading about the study, 43 respondents participated in the present study. Figure 1 shows the flow of participants through the study. Nineteen participants were randomly assigned by computer to a test-retest trial to determine reliability, and 24 respondents were assigned to the validation study.

Figure 1. Study profile



The 19 participants of the test-retest trial were randomly assigned by computer to one of two testers (Tester 1 and Tester 2). Tester 1 was a 26-year-old female research assistant and Tester 2 was a 29-year-old male PhD-student. Before the start of this trial, Tester 1 had administered the ADAP 29 times and Tester 2 only 4 times. All measurements of the validation study were obtained by the experienced Tester 1 after the measurements of the reliability study.

This study was approved by the Medical Ethics Board of the University Medical Center Utrecht University Hospital in the Netherlands. Written informed consent was obtained from all participants after they had read the information brochure on the study.

Measurements

The tests were administered at the Mobility Laboratory. Participants of the test-retest study were tested on two separate occasions, 1 week apart at a similar time of day (early morning, late morning, early afternoon, or late afternoon) by the same examiner. At the beginning of each test session, participants were asked if during the week prior to the test something had occurred that might have influenced their performance on the ADAP test (e.g. illness, injury, or stressful situation). After the ADAP, the participants of the validation study completed the SF-36 Health Survey, followed by several muscle function tests, and the Timed Up and Go (TUG) test.

Assessment of Daily Activity Performance (ADAP)

The ADAP test was patterned after the Continuous-scale Physical Functional Performance© (CS-PFP) test, as demonstrated by Cress et al to be reliable, valid and sensitive to change in function (11, 18). Like the CS-PFP test, the ADAP includes 16 common tasks, such as transferring laundry and boarding a bus, and allows the participant to perform at maximal ability by maximizing the weight carried and working at the fastest speed possible or reaching the greatest distance (11, 16). The CS-PFP test was modified to Dutch dimensions for bed size (190 cm x 200 cm; height 60 cm), height of the kitchen counter (114 cm), and height of the washing machine (88.5 cm). Vertical reach was replaced by the functional reach test (19) because the combination of a forward standing reach and a sit-and-reach task (putting a Velcro-closed strap over the shoe) is a more familiar method in the literature to determine upper-body flexibility than the combination of the vertical reach test and a sit-and-reach task as proposed by others (19, 22). Furthermore, Schenkman et al demonstrated a relationship between spinal flexibility and functional reach (23). Measurement protocols and participant instructions were standardised. The ADAP measures whole-body physical function, assessing upper and lower-body strength, upper-body flexibility, balance and coordination, and endurance. In general, scores on a specific task can contribute to one, two, or three domains. Tasks quantified by both weight carried and time are “carrying a weighted pan”, “pouring water from a jug into a cup”, “carrying weight up and down a bus platform”, and “carrying groceries”. Tasks quantified by time alone are “transferring laundry from a washer to a dryer”, “putting on and taking off a jacket”, “floor sweeping”, “vacuuming”, “making a bed”, “climbing stairs”, “getting down and up from the floor”, “opening a door”, “putting a hook-and-loop strap over a shoe”, and “picking up four scarves from the floor”. Tasks quantified by distance are “6-minute walk” and “functional reach”.

The scoring procedures of the ADAP test are provided in the Appendix. Each task was scaled 0 to 100 according to the formula: Observed score = (observed score – lower limit) / (upper limit – lower limit) x 100. If the observed score was less or equal to the lower limit, the score was 0. For an observed score greater than or equal to the upper limit, the score was 100. Unattempted tasks received a score of 0. Time was converted to speed (1/t) so that higher numbers reflect a better function for each of the units measured: weight, distance, and speed. Domain scores are calculated as the mean of task scores that contribute to the domain as presented in the Appendix. The ADAP total score is calculated as the mean of all task scores. The average time required to complete the test for community-living older women is 60 minutes. The main role of the tester in the ADAP consists of explaining the tasks to the participant and registering the time needed to complete a task and the weight carried during a task. We reported previously that the ADAP test can detect a change in daily task performance after a 12-week of exercise period in a relatively healthy group of older women (17). A description of the protocol to perform the ADAP can be obtained from the authors.

Self-Perceived Function

Self-perceived function of the 24 participants in the validation study was determined using the Dutch language version of the SF-36 Health Survey (24). The SF-36 is a 36-item questionnaire that measures physical and mental disability and well-being. It includes eight multi-item scales that measure physical functioning (PF), role limitations due to physical health problems (RP), bodily pain (BP), general health perceptions (GH), vitality (VT), social functioning (SF), role limitations due to emotional problems (RE), and mental health (MH). Scales are scored from 0 (poorer health) to 100 (better health). The Dutch language version of the SF-36 has proven to be a practical, reliable, and valid instrument for use in general population surveys in the Netherlands (24).

Timed Up and Go (TUG)

In the Timed Up and Go, the time an individual needs to rise from a standard arm chair (seat 46 cm high), walk 3 meters, turn around, return to the chair, and sit down again is measured (16, 25, 26). The test was performed three times as quickly as possible. The quickest time, recorded in seconds (sec), was used for analysis.

Muscle function

Isometric knee extensor strength (IKES) was measured in both legs with a fixed strain gauge (AFG-Advanced Force Gauge, Mecmesin Inc, Santa Rosa, California, USA) (16, 27, 28). The highest score of five attempts was recorded in Newton (N).

Isometric elbow flexor strength (IEFS) was measured in both arms with a hand-held dynamometer (microFET, Hoggan Health Industries, Draper, Utah, USA) (16, 29, 30). The highest score of three attempts was recorded in Newton (N).

Handgrip strength (HGS) was measured with a mechanical handgrip dynamometer (Takei Kiki Kogyo 5101, Japan) (16, 29). The best score of five attempts was recorded in kilogram force (kgF).

Leg extension power (LEP) was measured in both legs with the Nottingham power rig (NUMAS, University of Nottingham Medical Faculty Workshops, Nottingham, UK) (16, 29, 31). The measurements were repeated until no further improvement was seen, up to a maximum of 10 pushes (16, 27). The highest recorded power output was recorded in Watt (W).

Peak values for the left and right legs, arms or hands of IKES, IEFS, HGS and LEP were averaged and used for analysis.

Statistics

All statistical analyses were performed with SPSS software (SPSS Inc. Spss reference guide. Chicago: SPSS Inc, 1990). Univariate analysis of variance was used to test for differences in baseline characteristics between groups.

Reliability and Internal Consistency

Often, the reliability of physical measures is established by calculating the Pearson correlation coefficient (11, 20), a method that is considered inadequate to determine reliability because of the incapacity to detect systematic differences (20, 32). To assess reliability, first, the coefficient of internal consistency was measured with Cronbach's alpha (α). An alpha of 0.6 or greater indicated that the items in the scale measured the same contribute. Second, test-retest reliability was measured with the intraclass correlation (ICC), calculated with a one-way random model, and with the mean difference and limits of agreement (20, 32, 33). The latter were calculated using Brand and Altman plots (32), in which the limits of agreement (D – 2s, D + 2s) were put into the standard mathematical expression as delta – 2SD and delta + 2SD, in which delta is the mean of the differences between two ratings for the same subject, and SD is the standard deviation of the differences. Because the measurement errors probably follow a Gaussian distribution, 95% of the differences will lie between these limits of agreement, more precisely, between delta – 1.96SD and delta + 1.96SD.

Levene's test for equality of variance was performed to compare the test-retest differences between Tester 1 and Tester 2.

Construct validity

We hypothesized that maximum muscle strength, muscle power, mobility, and self-perceived physical function would be positively associated with ADAP scores. The ADAP test results were compared with the results of IKES, IEFS, HGS, LEP, TUG, and SF-36 by calculating bivariate Pearson correlations between these tests and total and subscale scores of the ADAP.

RESULTS

Reliability

Characteristics of the participants are listed in Table 1. No differences were found between the participants examined by Tester 1, the participants examined by Tester 2 and the participants of the validation study for baseline scores for weight, height, age or physical functional performance. The nine participants randomised to Tester 1 had a mean age of 74.1 ± 3.4 years (range, 70 – 80 years) and the 10 participants randomised to Tester 2 had a mean age of 75.8 ± 3.9 years (range, 70 – 83 years). No participants reported incidents that might have influenced test performance.

Table 1. Baseline characteristics of participants

Characteristics	*Tester1 n = 9*	*Tester 2 n = 10*	*Validity n = 24*	*P-value*
Age, years	74.1 ± 3.4	75.8 ± 3.9	74.6 ± 4.8	.68
Weight, kilograms	73.8 ± 11.9	66.1 ± 7.4	65.5 ± 10.6	.12
Height, meters	1.62 ± 0.05	1.61 ± 0.04	1.59 ± 0.05	.46
ADAP test				
Total score	40.0 ± 7.4	47.7 ± 6.3	43.3 ± 14.3	.36
Upper-body strength	42.8 ± 9.7	48.4 ± 5.7	40.8 ± 13.3	.22
Upper-body flexibility	45.9 ± 9.0	47.9 ± 10.5	45.2 ± 16.9	.88
Lower-body strength	34.4 ± 8.7	40.8 ± 6.2	38.3 ± 15.5	.55
Balance and coordination	34.4 ± 8.7	44.7 ± 9.6	42.4 ± 16.0	.23
Endurance	37.8 ± 8.0	49.2 ± 8.4	44.4 ± 15.8	.18
SF-36				
Physical Component Summary (PCS)			72.2 ± 16.4	
Mental Component Summary (MCS)			80.7 ± 14.9	
Physical Functioning (PF)			75.4 ± 16.6	
Role-Physical (RP)			71.9 ± 36.4	
Bodily Pain (BP)			75.3 ± 18.8	
General Health (GH)			66.3 ± 16.9	
Vitality (VT)			69.8 ± 16.6	
Social Functioning (SF)			90.1 ± 13.3	

Role-Emotional (RE)	84.7 ± 34.0
Mental Health (MH)	78.0 ± 12.5
TUG, seconds	6.0 ± 1.9
IKES, N	244.1 ± 84.9
IEFS, N	144.8 ± 23.9
LEP, W	95.3 ± 38.5
HGS, kg Force	20.3 ± 5.7

Note: Values are means ± SD
Abbreviation: ADAP, assessment of daily activity performance; SF-36, Short Form 36 Health Survey; TUG, timed up and go; IKES, isometric knee extensor strength; IEFS, isometric elbow flexor strength; LEP, leg extensor power; HGS, handgrip strength; N, newtons; W, watts.

Cronbach's alpha, ICCs, and the parameters according to the Bland and Altman plot (mean difference, limits of agreement) are presented in Table 2. The values for Cronbach's alpha indicated a good internal consistency for Tester 1 (alpha range, .83 to .98) and for Tester 2 (alpha range, .80 to .94), with the exception of ADAP upper-body strength (alpha .53). The variance in the difference between test and retest scores differed between the testers for ADAP balance and coordination and endurance scores.

The total score of the ADAP test at baseline and for the retest are presented in Figure 2. The mean difference between test and retest scores did not differ significantly from zero for Tester 1, whereas it did for Tester 2 for ADAP lower-body strength (-3.81; 95% confidence interval [CI], -6.09 to -1.54). Tester 1 showed a high reliability for ADAP total and domain scores (ICC range, .75 to .96), whereas Tester 2 had lower ICC's for ADAP total and domain scores (ICC range, .36 to .76), except for upper-body flexibility (ICC .90). The ADAP upper-body strength measurements of Tester 2 were not reliable (ICC .36). A scatter plot of the difference between scores against the mean ADAP total score for Tester 1 and 2 is presented in Figure 3. The horizontal lines in these graphs represent the limits of agreement. There was a greater difference between test and retest scores for Tester 2 (range, -6.54 to 6.48) than for Tester 1 (range, -2.10 to 3.59). The limits of agreement were also larger for Tester 2 (-6.09 to 10.99) than for Tester 1 (-2.58 to 4.95).

Figure 2. Scatterplot of the ADAP total score at baseline and retest.

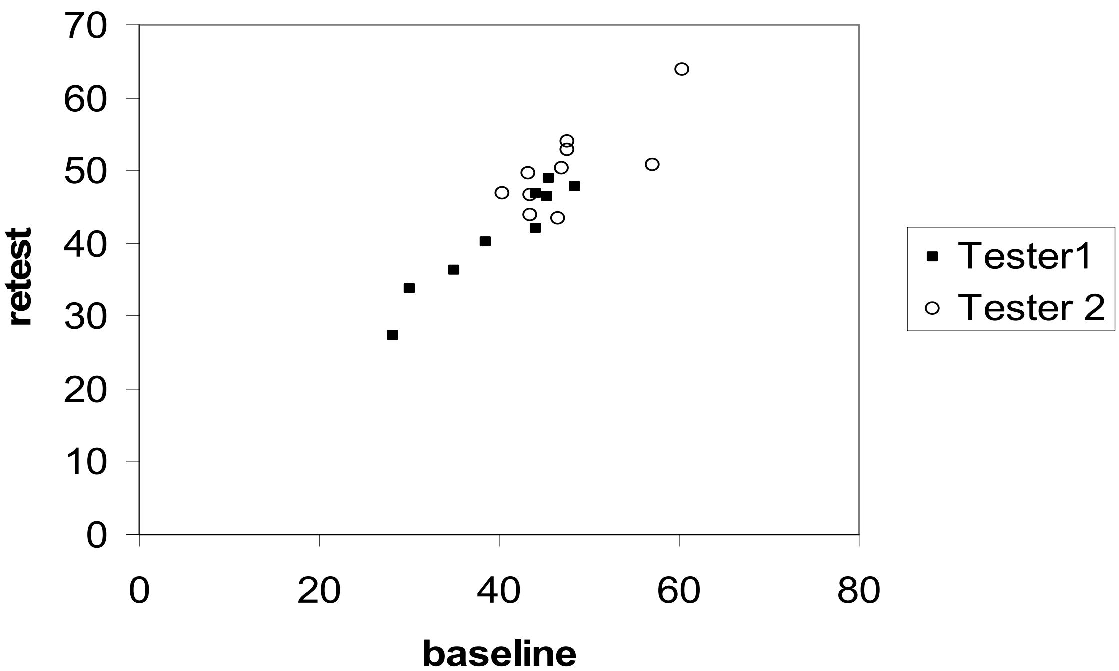
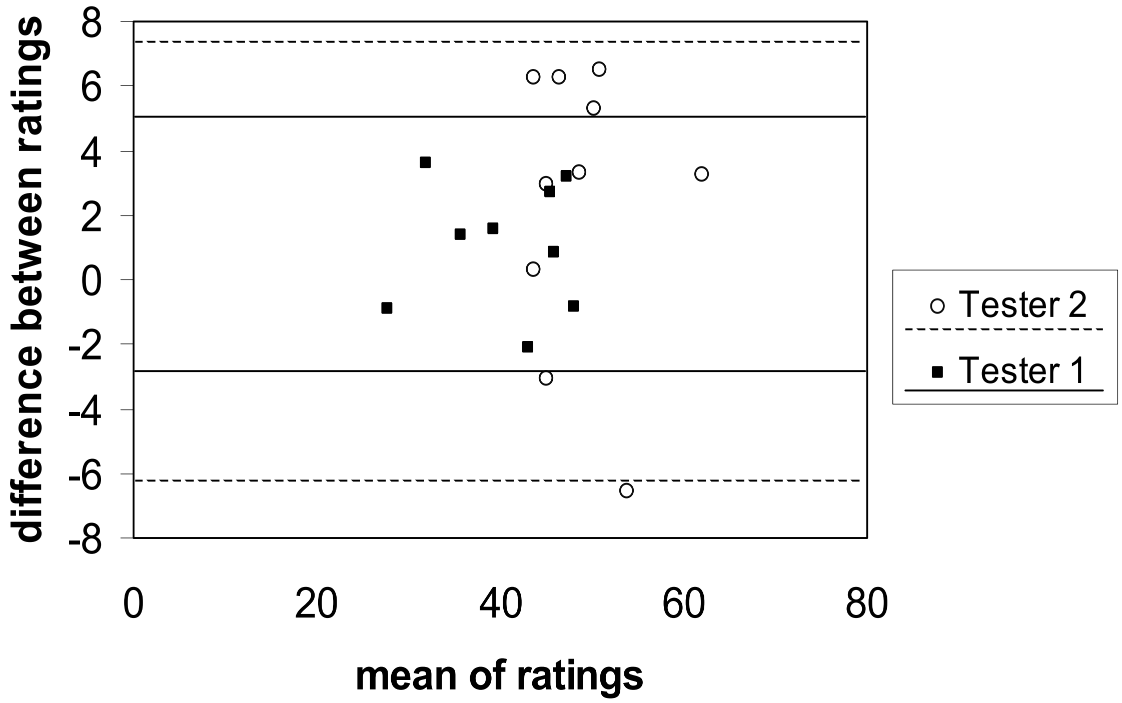


Table 2. Intra-tester consistency and reliability for the ADAP test in a test-retest design with an experienced tester (Tester 1) and an inexperienced Tester (tester 2).

	Tester 1 *n = 9*				*Tester 2* *n = 10*				*Tester 1 vs. Tester 2*
ADAP	Mean difference (95% CI)	Alpha	ICC	LoA	Mean difference (95% CI)	Alpha	ICC	LoA	P-value
Total score	-1.05 ± 1.99 (-2.58 to .48)	.98	.96	-2.85 to 4.95	-2.45 ± 4.36 (-5.56 to .67)	.86	.70	-6.09 to 10.99	.08
Upper-body strength	-1.42 ± 4.90 (-5.18 to 2.34)	.91	.84	-8.17 to 11.02	-1.70 ± 5.47 (-5.62 to 2.21)	.53	.36	-9.03 to 12.43	.83
Upper-body flexibility	1.66 ± 6.81 (-3.58 to 6.90)	.83	.75	-15.01 to 11.69	.15 ± 4.34 (-2.96 to 3.25)	.94	.90	-8.65 to 8.36	.07
Lower-body strength	-2.24 ± 3.65 (-5.05 to .57)	.96	.91	-4.92 to 9.40	-3.81 ± 3.19 (-6.09 to -1.54)	.94	.74	-2.43 to 10.06	.51
Balance and coordination	-1.43 ± 3.18 (-3.87 to 1.01)	.97	.93	-4.79 to 7.66	-3.03 ± 8.14 (-8.85 to 2.80)	.80	.65	-12.92 to 18.97	.03
Endurance	-1.44 ± 2.41 (-2.58 to .48)	.98	.95	-3.28 to 6.16	-2.27 ± 5.56 (-6.24 to 1.71)	.87	.76	-8.63 to 13.16	.03

Note: Abbreviations: ADAP, Assessment of Daily Activity Performance; CI, confidence interval; Alpha, Cronbach's alpha; ICC, intraclass correlation; LoA, limits of agreement.

Figure 3. Bland and Altman scatterplot of the intratester reliability of the ADAP total score.



Note: Difference between scores against the mean of ratings (sum scores). Horizontal lines show the limits of agreement for Tester 1 and Tester 2 (dotted lines).

Construct validity

The mean age of the participants was 74.6 ± 4.8 years (range 70 – 91 years) (Table 1). SF-36 scores and muscle strength results were high, indicating that the participants were in good physical and mental health. Bivariate correlations between ADAP scores, SF-36 scales, and strength and mobility tests are shown in Table 3. ADAP total and all domain scores correlated significantly with the physical component summary scale (PCS) and physical functioning scale (PF). Also, ADAP total and domain scores correlated with the scales Bodily Pain (BP) and General Health (GH). ADAP total and domain scores also were highly correlated with TUG test (range, r = -.77 to -.91), IKES (range, r = .64 to .80), LEP (range, r = .56 to .63), and HGS (range, r = .51 to .74) scores.

Table 3. Correlation coefficients between ADAP test, self-perceived function (SF-36), muscle function, and mobility measures.

SF-36	*GH*	*MH*	*PF*	*RP*	*VT*	*SF*	*RE*	*BP*	*PCS*	*MCS*
ADAP										
Total score	.45*	.23	.67**	.30	.38	.33	.39	.59**	.64**	.25
Upper-body strength	.50*	.30	.78**	.36	.51*	.34	.47*	.62**	.71**	.33
Upper-body flexibility	.35	.32	.56**	.43*	.42*	.23	.36	.58**	.62**	.27
Lower-body strength	.45*	.13	.69**	.26	.33	.35	.43*	.56**	.63**	.22
Balance & coordination	.43*	.11	.55**	.21	.25	.36	.32	.49*	.55*	.17
Endurance	.42*	.19	.60**	.24	.32	.32	.33	.55**	.59**	.20

	TUG	*IKES*	*IEFS*	*LEP*	*HGS*
ADAP					
Total score	-.91**	.80**	.54**	.63**	.62**
Upper-body strength	-.80**	.76**	.59**	.56**	.74**
Lower-body strength	-.84**	.77**	.55**	.53**	.63**
Upper-body flexibility	-.77**	.64**	.42*	.57**	.53**
Balance and coordination	-.85**	.76**	.50*	.59**	.51*
Endurance	-.91**	.77**	.50*	.62**	.56**

Note: Values are Pearson *r*; * *p*<.05; ** *p*<.01
Abbreviations: ADAP, Assessment of Daily Activity Performance; SF-36, Short Form 36 Health Survey; GH, General Health; MH, Mental Health; PF, Physical Functioning; RP, Role-Physical; VT, Vitality; SF, Social Functioning; RE, Role-Emotional; BP, Bodily Pain; PCS, Physical Component Summary; MCS, Mental Component Summary; TUG, timed up and go; IKES, isometric knee extensor strength; IEFS, isometric elbow flexor strength; LEP, leg extensor power; HGS, handgrip strength.

DISCUSSION

The results of this study show that the Assessment of Daily Activity Performance (ADAP) is a reliable and valid instrument for measuring physical function in community-dwelling older women.

While intraclass correlation coefficients (ICC) or Pearson product moment are often used to determine the reliability of an instrument (20), they are considered inappropriate because they do not detect systematic differences (20, 32). In the present study, we used the intraclass correlation coefficient (ICC), mean difference and Limits of Agreement, and Cronbach's alpha internal consistency analysis to determine the reliability of the ADAP, because of their complementary value (20, 33). Furthermore, according to Bland and Altman (32) the scatter plot of differences between test and retest scores plotted against the mean of the scores provides insight into the distribution of differences between two measurements, and the limits of agreement represent an estimate of the range of rating-pair differences with 95% of the differences between two ratings. Results showed that the internal consistency and intra-rater reliability of the test were higher when an experienced tester (Tester 1) administered the test. The limits of agreement were smaller for Tester 1 (-2.58 to 4.95), who administered the test 29 times before the study, than for Tester 2 (-6.09 to 10.99), who had administered the test only 4 times previously. The results obtained by the less experienced tester were less consistent and less reliable. There was also a statistically significant difference between test and retest scores for the ADAP domain lower-body strength. In the tests of the ADAP, participants are encouraged by the tester to exert maximum effort. These maximum capacity measurements probably were more consistent for the experienced tester, and thus a trained tester may be better able to stimulate participants. The main role of the tester in the ADAP consists of explaining the tasks to the participant and registering the time needed to complete a task and the weight carried during a task. The results of the present study suggest that before using the ADAP a tester first has to complete a learning phase to obtain reliable measurements.

Cress and colleagues (11) used the Pearson product moment to determine reliability of the CS-PFP test, on which the ADAP is based. Our data for the experienced tester (Tester 1) are consistent with their data. In a test-retest design, Cress et al found correlation coefficients ranging from .85 for upper-body flexibility to .97 for CS-PFP total score. We found ICC values of .75 for upper-body flexibility and .96 for the ADAP total score.

We found that ADAP test scores correlated moderately with scores for the SF-36 physical health summary scale and physical functioning scale. ADAP scores were strongly correlated with knee extensor strength and TUG test scores, suggesting that the ADAP test is a good indicator of maximum physical performance. These findings are consistent with those of the validation study of the CS-PFP test of Cress and colleagues (11).

The ADAP test was patterned after the CS-PFP test because of its capacity to measure quantitatively, without ceiling effects, changes in performance that are expected in exercise interventions. The CS-PFP test is also sensitive to change in healthy, community-living older adults (18). In future research we intend to use the ADAP in descriptive and evaluation studies to determine the effect of a 12-week exercise programme on physical function in community-living older adults.

A limitation of the present reliability study is that only two testers were used to determine the reliability of the ADAP. Further, because the experienced and inexperienced examiners examined different samples of subjects, the difference in test-retest reliability between the two testers may not be necessarily caused by differences in the experience of the observers. More testers that examine the same sample of subjects should be used in future studies to evaluate the reliability of the ADAP and the influence of tester’s experience. During recruitment, 16 potential participants withdrew after reading about the study. Often, the duration and physical load of the tests were mentioned as reasons for withdrawal, which suggests that the ADAP might be less suitable for testing fragile, older individuals. It would be of interest to examine the possibility to develop a short version of the ADAP test for testing fragile older people.

In conclusion, when administered by an experienced tester, ADAP is a reliable and valid instrument. Before the ADAP is used in research trials, it is recommended that testers gain experience in test administration and scoring. Further research is needed to evaluate the exact influence of tester experience and to determine how many test sessions are needed before a tester obtains reliable measurements.

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APPENDIX: The assessment of daily activity performance (ADAP) test

1. Carrying a weighted pan between kitchen counters

   Time score =

   (1/observed score – 1/8.33 sec) / (1/2.47 sec – 1/8.33 sec) x 100

   Weight score =

   (observed score – 1.4 kg) / (30.3 kg – 1.4 kg) x 100
2. Pouring water from a jug into a cup

   Time score =

   (1/observed score – 1/36.15 sec) / (1/6.8 sec – 1/36.15 sec) x 100

   Weight score =

   (observed score – 1.125 kg) / (4.5 kg – 1.125 kg) x 100
3. Carrying weight in a luggage bag up and down a 3-stair bus platform

   Time score =

   (1/observed score – 1/85.22 sec) / (1/11.75 sec – 1/85.22 sec) x 100

   Weight score =

   (observed score – 0.9 kg) / (30.6 kg – 0.9 kg) x 100
4. Carrying groceries through a door, up and down a 3-stair platform and lifting groceries on a counter.

   Time score =

   (1/observed score – 1/118.19 sec) / (1/33.15 sec – 1/118.19 sec) x 100

   Weight score =

   (observed score – 1.1 kg) / (27.69 kg – 1.1 kg) x 100
5. Transferring laundry from a washer to a dryer

   Time score =

   (1/observed score – 1/141.35 sec) / (1/21.31 sec – 1/141.35 sec) x 100

   Transferring laundry from a dryer to a counter

   Time score =

   (1/observed score – 1/113.06 sec) / (1/11.19 sec – 1/113.06 sec) x 100
6. Putting on and taking off a jacket

   Time score =

   (1/observed score – 1/39.76 sec) / (1/7.72 sec – 1/39.76 sec) x 100

7. Floor sweeping

   Time score =

   (1/observed score – 1/91.88 sec) / (1/18.78 sec – 1/91.88 sec) x 100

8. Vacuuming

   Time score =

   (1/observed score – 1/125.57 sec) / (1/19.34 sec – 1/125.57 sec) x 100

9. Making a bed

   Time score =

   (1/observed score – 1/151.41 sec) / (1/39.43 sec – 1/151.41 sec) x 100

10. Climbing stairs (13 steps)

    Time score =

    (1/(observed score/13) – 1/2.63 sec) / (1/0.32 sec – 1/2.63 sec) x 100

11. Getting down and up from the floor

    Time score =

    (1/observed score – 1/89.18 sec) / (1/3.53 sec – 1/89.18 sec) x 100

12. Opening a door

    Time score =

    (1/observed score – 1/11.94 sec) / (1/2.83 sec – 1/11.94 sec) x 100

13. Putting a hook-and-loop strap over a shoe

    Time score =

    (1/observed score – 1/17.15 sec) / (1/3.28 sec – 1/17.15 sec) x 100

14. Picking up four scarves from the floor

    Time score =

    (1/observed score – 1/36.09 sec) / (1/4.63 sec – 1/36.09 sec) x 100

15. 6-minute walk

    Distance score =

    (observed score m – 166 m) / (798 m – 166 m) x 100

16. Functional reach

    Distance score =

    ((observed score m / height m) – 0.033 m) / (0.294 m – 0.033 m) x 100

Allocation of task scores to ADAP domain scores

Tasks	***Upper-body strength***	***Upper-body flexibility***	***Lower-body strength***	***Balance & coordination***	***Endurance***
Weighted pan	Weight score			Time score	
Pouring water	Weight score			Time score	
Bus platform	Weight score		Weight score	Time score	
Groceries	Weight score		Weight score	Time score	
Laundry	Time scores		Time scores		
Jacket		Time score			
Floor sweeping			Time score	Time score	
Vacuuming			Time score	Time score	
Making a bed			Time score	Time score	
Climbing stairs			Time score		
Floor sit			Time score	Time score	
Opening a door	Time score				
Shoe strap		Time score			
Picking up scarves				Time score	
6-minute walk					Distance score
Functional reach		Distance score			
Total Time					Time score

Chapter 4.1

Functional tasks exercise versus resistance strength exercise to improve daily function in older women: A randomized controlled trial

Paul L. de Vreede BSc,[1] Monique M. Samson MD, PhD,[1] Nico L.U. van Meeteren PT, PhD,[2,3] Sijmen A. Duursma MD, PhD,[1] and Harald J.J. Verhaar MD, PhD[1].

[1] Mobility Laboratory, Department of Geriatric Medicine, University Medical Center Utrecht, the Netherlands;
[2] Rudolf Magnus Institute of Neuroscience, Department of Neurology and Neurosurgery, University Medical Center Utrecht, the Netherlands;
[3] Department of Physiotherapy, Academy of Health Sciences, Utrecht, the Netherlands

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ABSTRACT

Objectives: To determine whether a functional tasks exercise program and a resistance exercise program have different effects on the ability of community-living older people to perform daily tasks.

Design: A randomized, controlled, single-blind trial.

Setting: Community leisure center in Utrecht, the Netherlands.

Participants: Ninety-eight healthy women aged 70 and older were randomly assigned to the functional tasks exercise program (function group, n = 33), a resistance exercise program (resistance group, n = 34) or a control group (n = 31). Participants attended exercise classes three times a week for 12 weeks.

Measurements: Functional task performance (Assessment of Daily Activity Performance (ADAP)), isometric knee extensor strength (IKES), handgrip strength, isometric elbow flexor strength (IEFS) and leg extension power were measured at baseline, at the end of training (at 3 months) and 6 months after the end of training (at 9 months).

Results: The ADAP total score in the function group (mean change 6.8, 95% confidence interval (CI) = 5.2 – 8.4) increased significantly more than that in the resistance group (3.2, 95% CI = 1.3 – 5.0; *P* = .007) or the control group (0.3, 95% CI = -1.3 – 1.9; *P* <.001). Moreover, the ADAP total score of the resistance group did not change significantly compared with that of the control group. In contrast, IKES and IEFS increased significantly in the resistance group (12.5%, 95% CI = 3.8 – 21.3 and 8.6%, 95% CI = 3.1 – 14.1, respectively) compared with the function group (-2.1%, 95% CI = -5.4 – 1.3; *P* = .003 and 0.3%, 95% CI = -3.6 – 4.2; *P* = .03, respectively) and the control group (-2.7%, 95% CI = -8.6 – 3.2; *P* = .003 and 0.6%, 95% CI = -3.4 – 4.6; *P* = .04, respectively). Six months after the end of training, the increase in ADAP scores was sustained in the function group (*P* = .002).

Conclusion: Functional tasks exercises are more effective than resistance exercises at improving functional task performance in healthy elderly women and may have an important role in maintaining an independent lifestyle.

INTRODUCTION

A sedentary lifestyle is considered to be one of the most important factors contributing to loss of independent performance of daily tasks.[1-3] Many randomized trials have demonstrated the positive effect of regular exercise on older people's muscle strength, flexibility, aerobic capacity, and balance[3-7] and on reducing the risk of falls and fractures and preventing (coronary) disease,[5,6] but the effect of currently available exercise programs on the performance of daily tasks remains unclear.[3,7] Moreover the diversity of programs available makes it difficult to determine which type of exercise has most effect on the performance of daily tasks.[3,7,8]

Resistance strength training is the type of exercise mostly frequently tested in trials involving older adults,[7] but improved muscle strength does not consistently result in improved functional task performance.[7,9,10] Although several exercise studies have focused on selected intermediate outcome measures, such as muscle strength, balance, and gait analysis,[5,11,12] it has not been demonstrated that an increase in these outcome measures automatically results in improved performance of daily tasks.

Furthermore, several studies have reported that the muscle strength gain induced by resistance programs is lost after a short detraining period.[13] When physical exercise is stopped (detraining), the body adjusts to the diminished physiological demand, and the beneficial adaptations may be lost.[14] Because older adults are more likely to interrupt an exercise programs because of ill health,[15] exercise programs should aim to elicit longer-lasting effects.

To improve the ability of older people to perform daily tasks, an exercise program was developed focusing on functional tasks of everyday life, tasks that are affected early in the ageing process.[16] In a pilot study, the new functional tasks exercise program proved to be feasible and well tolerated by community-living older women.[17]

The aim of the present study was to determine whether the functional tasks exercise program and a resistance exercise program have different training and detraining effects on the ability of community-living older people to perform daily tasks, as measured using the Assessment of Daily Activity Performance (ADAP).

METHODS

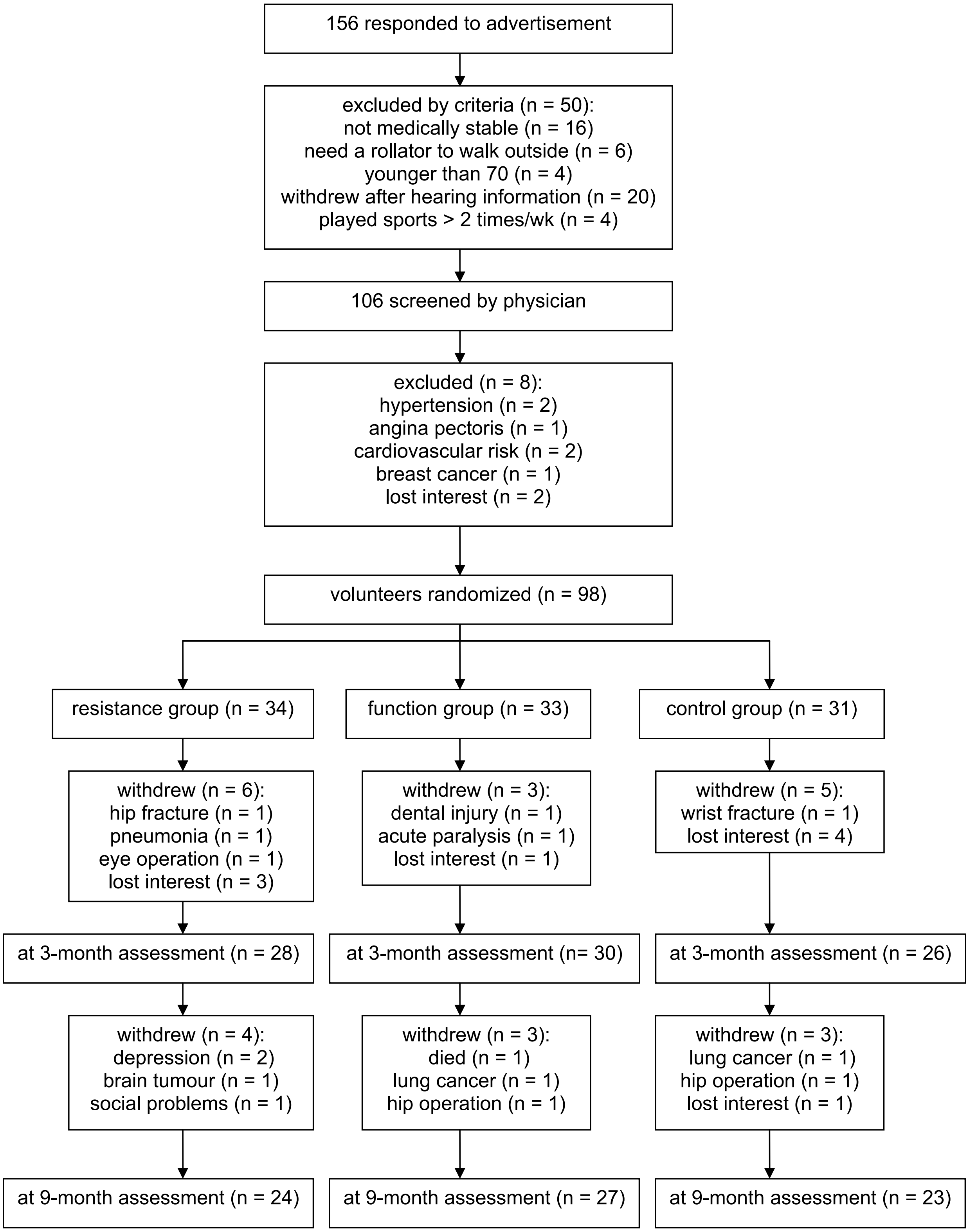
Design and Participants

Community-dwelling women aged 70 and older were recruited by means of advertisements placed in the local newspaper for inclusion in a single-blinded, randomized controlled trial. The medical ethics board of the University Medical Center Utrecht in the Netherlands approved the study. Figure 1 shows the flow of participants through the trial. Of the 156 respondents, 50 were excluded after telephone interviews, during which it was determined, using a validated questionnaire, whether participants were medically fit enough to participate in an exercise program for older people.[18] Exclusion criteria included recent fractures, unstable cardiovascular or metabolic diseases, musculoskeletal disease or other chronic illnesses that might limit training or testing, severe airflow obstruction, recent depression or emotional distress, or loss of mobility for more than 1 week in the previous 2 months. Respondents who exercised at a sports club three times a week or more were also excluded. Of the 106 potential participants who were screened for medical history and underwent a physical examination, eight subjects failed the examination. During the screening procedure, the physician also administered the Specific Activity Scale (SAS).[19] The 98 women who met the inclusion criteria gave written informed consent and were randomly assigned by computer using a random numbers table to the new functional tasks exercise program (function group, n = 33), the resistance exercise program (resistance group, n = 34), or the control group (control group, n = 31).

Exercise interventions

The exercise programs were followed at a local leisure center in the Utrecht region during three periods of 12 weeks (January to March, April to June, and September to December 2001). The control group was run concurrently with the exercise groups. Exercises were performed three times a week in 1-hour sessions for 12 weeks, with sessions separated by 1 day of rest. Group size varied from six to 12 participants per session for both exercise programs. At least two experienced instructors (physiotherapist and sports teacher) supervised training sessions.

Figure 1. Study profile



During the exercises, participants in both programs registered their exercise performance in a personal file to provide themselves and their instructors with feedback about their progress. Sessions were divided into a 10-minute warm-up period of aerobic exercises, a 40-minute core exercise period, and a 10-minute cool-down period of flexibility exercises for limbs and trunk. The core exercises were specific to the group assignment; all other components were consistent across groups. The warm-up and cool-down periods were undertaken as group activities and accompanied by music.

The core exercises of both programs were performed in training pairs (dyad training),[20] with emphasis on interaction and enjoyment. Training partners took turns between observational and physical practice (dyad alternate). Exercise intensity in both exercise programs was set at 7 to 8 on a 10-point rating perceived exertion scale (1 = very, very light; 10 = very, very hard).[21] Several studies have demonstrated that these ratings of perceived exertion scales can validly provide information regarding the intensity of resistance exercise.[21-23] Participants in the function group were instructed to increase the weight carried, the number of repetitions, or the distance walked if an exercise was rated only “somewhat hard”. Resistance could also be increased by putting on a weighted vest (1 – 10 kg) during the tasks. The participants in the resistance group were instructed to increase the load if an exercise was rated only “somewhat hard”.

Functional tasks exercise program

The aim of the 40-minute core exercises was to improve daily tasks in the domains first affected in older adults [16], namely, moving with a vertical component, moving with a horizontal component, carrying an object, and changing between lying-sitting-standing position (detailed exercise protocol available from the authors). During each exercise class, participants performed tasks for at least two of these domains in three sessions of five to 10 repetitions. The 12-week program was divided into a practice phase (2 weeks), a variation phase (4 weeks) and a daily tasks phase (6 weeks).

Exercises in the practice phase consisted of short, simple tasks. The weight transported and repetitions were noted. In the variation phase, participants applied these basic tasks in various training conditions, such as environment, attributes, and interaction between participants. Trainers registered the time it took to complete a task in this phase. Participants were encouraged to perform the tasks as quickly as possible and to increase the weight carried, the number of repetitions, and the distance walked. The daily tasks phase consisted of a combination of the four domains, to make the tasks as similar to daily tasks as possible. Again, time, weight, distance walked, and number of repetitions were noted.

During each phase, the instructors could complicate or simplify motor, environment, and cognitive aspects of the tasks depending on the participant's ability. Each aspect could be changed in a stable and a variable way. For instance, during the task "rise from a chair, step onto a raised platform (20cm), and take different objects from a high shelf" from the daily tasks phase, the motor aspects could be altered by collecting more objects (stable) or carrying the objects in different manners (variable). The environment could be adapted by changing the height of the raised platform (stable) or by letting two participants of different training pairs step together onto one raised platform (variable). The cognitive aspects could be altered by collecting the objects in a certain combination (e.g., by color) (stable) or by letting two participants collect the objects in a certain combination (e.g., if one person takes a green object, the next person has to collect a red object) (variable). Detailed description of the exercises used can be obtained from the authors.

Resistance strength exercise program

The core resistance exercises were designed according to the American College of Sports Medicine recommendations for exercise and physical activity for older adults [6] and based on the exercises of the Fit for Your Life resistance training program.[24] The aim of the exercises was to strengthen the muscle groups that are important for daily task performance, namely, elbow flexors and extensors; shoulder abductors, adductors and rotators; trunk flexors and extensors; hip flexors, extensors, abductors and adductors; knee flexors and extensors; and ankle dorsal and plantar flexors. In a typical progressive resistance protocol, three to four muscle groups were trained in three sets of 10 repetitions. Dumbbells (0.5 – 8kg) and elastic tubing (three resistances of elastic bands) were used for resistance during elbow, shoulder, and trunk exercises. Ankle weights (0.25 – 10kg) were used for resistance during hip and knee exercises. To strengthen ankle plantar flexors, body weight was used for resistance by raising the body up as high as possible on the toes. Participants alternated upper and lower body exercises to prevent overuse injuries, with approximately 2 minutes of rest allowed between sets. If an exercise was rated only "somewhat hard", the participants were instructed to increase the load by using heavier dumbbells, by putting more weight in the ankle weights, or by using an elastic band with a higher resistance level. The elastic bands could also be shortened for more resistance. The number of repetitions and the resistance level of each set were registered in participants' personal files. The exact set of exercises used can be obtained from the authors.

Control group

The nonexercising subjects of the control group were asked to keep to their normal pattern of activity during the 3-month intervention period.

Measurements

An experienced examiner who was blinded to the training conditions performed assessments at baseline, after the 3-month intervention period, and after a 6-month detraining period (at 9 months) at the Mobility Laboratory of the Department of Geriatric Medicine at the University Medical Center Utrecht. At the beginning of the assessments, participants were specifically instructed not to reveal the type of exercise program followed. To verify the blinding status, the examiner filled out a form at the end of the 3-month measurements stating whether or not the participant had revealed her treatment status. The examiner was also asked to estimate the treatment status of the participant (function, resistance, or control). Physical functional performance was measured using the ADAP and the Timed Up & Go test (TUG). Muscle function tests included isometric knee extensor strength (IKES), isometric elbow flexor strength (IEFS), handgrip strength (HGS), and leg extension power (LEP).

Preliminary investigations of community-living adults demonstrated TUG, IKES, HGS, and LEP tests to be reliable and valid.[25] The ADAP has been found to be a reliable instrument. In a test-retest design, 19 community-living, older women (mean age 75.0 ± 3.6) were tested with a 1-week interval. The intraclass correlation coefficient (ICC) of the examiner of the present study was .96 for ADAP total score and ranged .75 to .95 for domain scores. The ADAP total score correlated significantly with the 36-item Health Survey physical component summary (PCS) scale (correlation coefficient r = .64) and physical functioning scale (r = .67) and the IKES (r = .80). The IEFS test was found reliable (ICC = .96) in a test-retest design with 15 older women (mean age 80.4 ± 6.5) and a 1-week interval between measurements. The IEFS correlated significantly with a fixed strain gauge (AFG-Advanced Force Gauge, Mecmesin Inc, Santa Rosa, California, USA) (r = .78) (unpublished results).

Physical functional performance

Physical functional performance was quantitatively assessed using the ADAP.[17] This method, which allows the participant to perform at maximal ability by maximizing the weight carried and working at the fastest speed possible or reaching the greatest distance, was patterned after the Continuous-scale Physical Functional Performance (CS-PFP) test, as demonstrated to be reliable, valid, and sensitive to change in function.[17,26,27] The CS-PFP test was modified to Dutch dimensions for bed size (190 cm x 200 cm; height 60 cm), height of the kitchen counter (114 cm), and height of the washing machine (88.5 cm). The functional reach test replaced the vertical reach.[28] Measurement protocols and participant instructions were standardized. For functional reach, the protocol of Duncan et al. was followed.[28] Like the CS-PFP test, the ADAP includes 16 common tasks, such as transferring laundry and boarding a bus, performed at maximal effort. The ADAP provides a total score and five physical domain scores: upper-body strength, lower-body strength, flexibility, endurance, and balance and coordination. In general, scores on a specific task can contribute to one, two, or three domains. Tasks quantified by weight carried and time are carrying a weighted pan, pouring water from a jug into a cup, carrying weight up and down a bus platform, and carrying groceries. Tasks quantified by time alone are transferring laundry from a washer to a dryer, putting on and removing a jacket, sweeping the floor, vacuuming, making a bed, climbing stairs, getting down onto and up from the floor, pulling open a door, closing a hook-and-loop strap over the shoe, and picking up four scarves from the floor. Tasks quantified by distance are 6-minute walk and functional reach.

Each task was scaled 0 to 100 according to the formula:

observed score = (observed score – lower limit) / (upper limit – lower limit) x 100

If the observed score was less or equal to the lower limit, the score was 0. For an observed score greater than or equal to the upper limit, the score was 100. Unattempted tasks received a score of 0. Time was converted to speed (1/t) so that higher numbers reflect a better function for each of the units measured: weight, distance, and speed. The exact upper and lower limits used can be obtained from the authors.

Timed Up & Go test

In this test, the time an individual needs to rise from a standard arm chair (seat 46cm high), walk 3 m, turn around, return to the chair, and sit down again is measured.[17,29,30] The test was performed three times as quickly as possible. The quickest time, recorded in seconds, was used for analysis.

Muscle function tests

IKES was measured in both legs using a fixed strain gauge (AFG-Advanced Force Gauge, Mecmesin Inc, Santa Rosa, California, USA).[17,25,31] The highest score of five attempts was recorded in newtons. IEFS was measured in both arms using a hand-held dynamometer (microFET, Hoggan Health Industries, Draper, Utah, USA).[9,17,32] The highest score of three attempts was recorded in newtons. HGS was measured using a mechanical handgrip dynamometer (Takei Kiki Kogyo 5101, Tokyo, Japan).[9,17] The best score of five attempts was recorded in kilogram force. LEP was measured in both legs using the Nottingham power rig (NUMAS, University of Nottingham Medical Faculty Workshops, Nottingham, UK).[9,17,33] The measurements were repeated until no further improvement was seen, up to a maximum of 10 pushes.[25] The highest recorded power output was recorded in watts.

Statistical analysis

All data were analysed using SPSS statistical software (SPSS Inc., Chicago, IL, USA). In a pilot study, a sample size of 30 to 35 participants per group was estimated to provide more than 80% power at a significance level of $P < .05$ to detect a difference between exercise groups of 10% to 15% in ADAP total score and IKES.

Univariate analysis of variance was used to test for differences in baseline characteristics between intervention groups and to test for differences between dropouts and participants that completed the study. SAS scores were compared between groups using Kruskal-Wallis nonparametric test.

Peak values over the left and right legs, arms, or hands of IKES, IEFS, HGS, and LEP were averaged and used for analysis. Three-group analyses of variance with a post hoc Bonferroni correction was used to compare changes in test performance between interventions. Changes were calculated as the mean change and mean percentage change between scores at baseline and 3 months and between scores at baseline and 9 months.

RESULTS

The baseline characteristics of the participants are shown in Table 1. Mean age was 74.7 ± 3.5 (range 70 – 82) in the function group, 74.8 ± 4.0 (range 70 – 83) in the resistance group, and 73.0 ± 3.2 (range 70 – 84) in the control group. More than half of the participants were widowed (control group 55%, resistance group 44%, function group 58%). No significant differences between the groups were found in baseline scores for ADAP scores or muscle function. The distribution of SAS scores demonstrated that randomization was successful. The examiner guessed the correct intervention in only 37% of the cases (chi square = 0.519; *P* = .47).

Table 1. Baseline characteristics

Characteristics	*Control group (n = 31)*	*Resistance group (n = 34)*	*Function group (n = 33)*
Age, mean ± SD	73.0 ± 3.2	74.8 ± 4.0	74.7 ± 3.5
Marital status, %			
Married	42	50	36
Single	3	6	6
Widowed	55	44	58
Disease status, %			
Hypertension	30	28	33
Arthritis	30	28	23
Prosthetic hip/knee	4	13	20
Diabetes mellitus	4	0	3
Medication 3 or more	26	16	23
Osteoporoses	11	16	10
Height, meters, mean ± SD	1.62 ± 0.06	1.62 ± 0.08	1.63 ± 0.06
Weight, kg, mean ± SD	71.3 ± 11.4	70.7 ± 12.1	69.4 ± 9.0

Specific activity scale, n (%)			
Class 1	14 (45)	14 (41)	14 (42)
Class 2	15 (48)	19 (56)	18 (55)
Class 3	2 (7)	1 (3)	1 (3)
Class 4	0	0	0
Assessment of daily activity performance test, mean ± SD			
Total score	47.7 ± 9.6	45.7 ± 8.1	47.4 ± 9.9
Upper-body strength	50.5 ± 11.7	49.3 ± 6.5	50.6 ± 9.3
Lower-body strength	40.8 ± 10.5	39.5 ± 8.9	40.3 ± 11.3
Flexibility	49.1 ± 11.4	49.4 ± 9.9	54.8 ± 11.5
Balance and coordination	41.9 ± 9.6	39.4 ± 10.4	40.1 ± 11.2
Endurance	46.6 ± 10.0	44.4 ±9.7	45.7 ± 11.0
Timed Up and Go, seconds	5.1 ± 1.0	5.4 ± 1.0	5.1 ± 1.1
Muscle function, mean ± SD			
IKES, N	306.4 ± 77.1	282.5 ± 90.5	307.3 ± 79.5
HGS, kg Force	22.1 ± 3.9	21.9 ± 4.1	21.7 ± 3.7
IEFS, N	165.5 ± 27.6	158.6 ± 34.6	166.2 ± 29.1
LEP, W	127.5 ± 45.8	105.8 ± 39.9	113.9 ± 37.4

Note: SD, standard deviation; N, newtons; W, watts; IKES, isometric knee extensor strength; HGS, handgrip strength; IEFS, isometric elbow flexor strength; LEP, leg extensor power.

Between the baseline and 3-month measurements three participants in the function group, six in the resistance group, and five in the control group withdrew (Figure 1). After 6 months of detraining, three participants in the function group, two in the resistance group, and three in the control group dropped out (Figure 1). The baseline data for participants that withdrew did not differ from those for the 74 participants who completed the study.

Training compliance, defined as the number of exercise classes attended as a percentage of the total number of classes, was 83.0 ± 26.6% (range 0 – 100%) in the function group and 74 ± 34.6% (range 0 – 100%) in the resistance group. Without dropouts, participants in the function group attended on average 90 ± 9.1% of the exercise classes (range 66 – 100%), and participants in the resistance group attended on average 90 ± 8.1% of the exercise classes (range 71 – 100%). The following adverse events were reported and required adaptation of the personal training program in the function group: muscle pain (n = 8), osteoarthritic joint pain (n = 5), prosthetic joint pain (n = 4), and lower back pain (n = 4) and in the resistance group: muscle pain (n = 10), osteoarthritic joint pain (n = 5), prosthetic joint pain (n = 3), and lower back pain (n = 4). One participant in the resistance group strained a hamstring muscle, as a result of which two exercise classes were missed and the personal training program was adapted. Despite these reported complaints, all participants completed the exercise programs.

Table 2 shows that, at the end of the 12-week training period, the function group had an higher ADAP total score and greater upper-body strength, lower-body strength, upper-body flexibility, balance and coordination, and endurance than the control group. Changes in TUG did not differ between the function group and the control group. ADAP balance and coordination was better in the resistance group than in the control group, but no difference was seen for ADAP total score, upper-body strength, lower-body strength, upper-body flexibility, endurance, or TUG.

The function group had a significantly greater increase at the end of the 12-week training period in ADAP total score, lower-body strength, balance and coordination, and endurance than the resistance group. No difference in the effect of exercise between the function group and the resistance group was found for ADAP upper-body strength, upper-body flexibility, or TUG.

At the end of the 12-week training program, the change in IKES, IEFS, and HGS was not significantly different between the function group and the control group. LEP increased significantly more in the function group than in the control group. IKES and IEFS were increased more in the resistance group than in the control group, but no change was seen in HGS. LEP increased significantly more in the resistance group than in the control group. The resistance group had a significantly greater improvement in IKES and IEFS than the function group.

Table 2. Changes in outcome measures between baseline and 3-months measures.

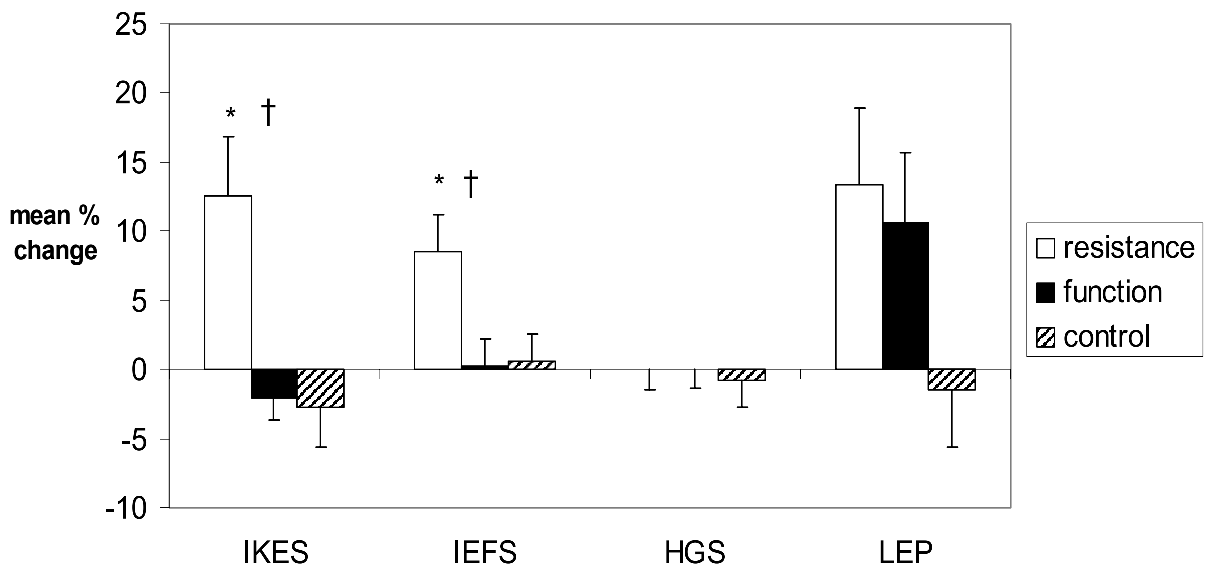
Measure	*Control group (n = 26)*			*Resistance group (n = 28)*			*Function group (n = 30)*			*Resistance versus Function*
ADAP	Mean ± SD	95% CI	*P*-value*	Mean ± SD	95% CI	*P*-value†	Mean ± SD	95% CI	*P*-value†	*P*-value‡
Total	0.3 ± 3.8	-1.3 – 1.9	.69	3.2 ± 4.8	1.3 – 5.0	.06	6.8 ± 4.3	5.2 – 8.4	<.001	.007
Upper-body strength	1.3 ± 3.4	-0.2 – 2.7	.08	1.9 ± 4.7	0.1 – 3.7	1.00	4.3 ± 4.9	2.4 – 6.1	.05	.15
Lower-body strength	1.9 ± 3.0	0.6 – 3.1	.005	2.9 ± 4.8	1.0 – 4.7	1.00	7.4 ± 4.9	5.5 – 9.2	<.001	.001
Upper-body flexibility	-3.0 ± 5.9	-5.4 – -0.6	.02	1.9 ± 10.2	-2.1 – 5.9	.14	7.4 ± 9.5	3.8 – 11.0	<.001	.07
Balance and coordination	0.4 ± 5.7	-2.0 – 2.7	.74	4.6 ± 6.0	2.2 – 6.9	.05	8.7 ± 6.6	6.2 – 11.2	<.001	.04
Endurance	-0.1 ± 5.1	-2.2 – 2.1	.95	3.3 ± 5.7	1.1 – 5.5	.09	8.0 ± 5.7	5.8 – 10.1	<.001	.005
TUG, seconds	0.1 ± 0.7	-0.2 – 0.4	.45	-0.1 ± 0.7	-0.3 – 0.2	1.00	-0.1 ± 0.7	-0.3 – 0.2	.84	1.00
IKES, N	-8.2 ± 37.1	-23.5 – 7.1	.28	23.7 ± 30.1	12.0 – 35.3	.001	-7.0 ± 25.2	-16.6 – 2.6	1.00	.001

HGS, kg Force	-0.3 ± 2.0	-1.1 – 0.5	.48	-0.2 ± 1.5	-0.8 – 0.4	1.00	-0.1 ± 1.5	-0.6 – 0.5	1.00	1.00
IEFS, N	0.0 ± 14.6	-6.0 – 6.1	1.00	10.6 ± 16.0	4.4 – 16.8	.06	-1.0 ± 17.4	-7.6 – 5.7	1.00	.03
LEP, W	-7.0 ± 26.1	-17.8 – 3.8	.19	10.8 ± 25.8	0.6 – 21.0	.05	11.2 ± 27.5	0.7 – 21.6	.04	1.00

Note: Positive change scores indicate improvement, except for TUG scores.
SD, standard deviation; CI, confidence interval; ADAP, assessment of daily activity performance; TUG, timed up and go; IKES, isometric knee extensor strength; HGS, handgrip strength; IEFS, isometric elbow flexor strength; LEP, leg extensor power; N, newtons; W, watts.
* *T* test mean change between baseline and 3-month scores control group; † Analyses of variance (ANOVA) with a Bonferroni correction for comparison between exercise group and control group; ‡ ANOVA with a Bonferroni correction for comparison between resistance group and function group

Figure 2 shows the mean percentage change in strength measures after the training period. Mean percentage change in IKES and IEFS was significantly higher in the resistance group than in the control and function groups. Nine months after baseline, the changes in the ADAP total score, upper-body strength, lower-body strength, balance and coordination, and endurance of the control group were significantly different from those of the function group but not the resistance group (Table 3).
The changes in IKES, IEFS, and HGS between baseline and 9 months were not significantly different between the control, resistance and function groups. LEP was significantly higher for the resistance and function groups than for the control group.

Figure 2. Mean percentage change muscle function tests between baseline and 3-month measurements.



Note: IKES, isometric knee extensor strength; HGS, handgrip strength; IEFS, isometric elbow flexor strength; LEP, leg extensor power.
P ≤ .05 Analyses of variance with a Bonferroni correction for comparison between *resistance and control groups and †resistance and function groups.

Table 3. Changes in outcome measures between baseline and 9-month measures.

Measure	*Control group (n = 23)*			*Resistance group (n = 24)*			*Function group (n = 27)*			*Resistance versus Function*
ADAP	Mean ± SD	95% CI	*P*-value*	Mean ± SD	95% CI	*P*-value†	Mean ± SD	95% CI	*P*-value†	*P*-value‡
Total	1.2 ± 4.8	-1.0 – 3.1	.29	3.0 ± 4.7	1.0 – 5.1	.52	6.1 ± 5.0	4.0 – 8.2	.002	.10
Upper-body strength	0.1 ± 3.8	-1.5 – 1.8	.88	1.8 ± 4.0	0.0 – 3.6	.77	4.1 ± 6.4	1.4 – 6.8	.02	.35
Lower-body Strength	1.7 ± 5.3	-0.5 – 4.0	.12	2.9 ± 4.8	0.8 – 5.0	1.00	6.0 ± 6.2	3.4 – 8.7	.03	.17
Upper-body Flexibility	0.3 ± 11.2	-4.8 – 4.8	.99	0.9 ± 11.5	-4.2 – 6.0	1.00	5.1 ± 11.4	0.2 – 9.9	.39	.65
Balance and Coordination	3.5 ± 7.3	-0.2 – 6.3	.06	5.3 ± 6.6	2.4 – 8.2	.90	8.7 ± 7.3	5.6 – 11.8	.03	.33
Endurance	1.9 ± 6.2	-1.0 – 4.3	.22	3.3 ± 5.5	0.9 – 5.8	.09	7.3 ± 6.1	4.7 – 9.9	.005	.08
TUG, seconds	0.6 ± 0.9	0.2 – 1.0	.009	0.3 ± 0.8	0.0 – 0.7	1.00	0.2 ± 0.7	-0.1 – 0.6	.43	1.00
IKES, N	-7.2 ± 40.4	-24.6 – 10.3	.87	0.4 ± 42.1	-18.2 – 19.1	1.00	-10.7 ± 20.6	-19.6 – -1.8	1.00	.90

HGS, kg Force	0.8 ± 2.0	-0.1 – 1.6	.07	-0.1 ± 2.6	-1.3 – 1.0	.40	0.4 ± 1.5	-0.3 – 1.0	1.00	1.00
IEFS, N	7.6 ± 27.6	-4.4 – 19.5	.20	4.8 ± 27.5	-7.4 – 17.0	1.00	4.3 ± 23.5	-5.6 – 14.2	1.00	1.00
LEP, W	-6.2 ± 29.6	-19.0 – 6.6	.33	16.5 ± 24.1	5.8 – 27.2	.01	17.2 ± 24.0	7.1 – 27.4	.009	1.00

Note: Positive change scores indicate improvement, except for TUG scores
SD, standard deviation; CI, confidence interval; ADAP, assessment of daily activity performance; TUG, timed up and go; IKES, isometric knee extensor strength; HGS, handgrip strength; IEFS, isometric elbow flexor strength; LEP, leg extensor power; N, newtons; W, watts.
* *T* test mean change between baseline and 3-month scores control group; † Analyses of variance (ANOVA) with a Bonferroni correction for comparison between exercise group and control group ; ‡ ANOVA with a Bonferroni correction for comparison between resistance group and function group.

DISCUSSION

To our knowledge, this is the first randomised, controlled trial to demonstrate that functional tasks exercise improves the performance of daily tasks by healthy, community-living, older women significantly more than resistance strength exercise does. Moreover, this improvement was sustained after a 6-month detraining period. Although isometric knee and elbow strength was greater in the resistance group than in the function and control groups immediately after training, this gain in muscle strength was lost after 6 months of detraining.

The effects of the functional tasks exercise on the functional performance correspond with those reported by two other studies[10,27] on the CS-PFP test, after which the ADAP was patterned. After a 6-month period of combined stair climbing, lower-body endurance, and resistance exercise, improvements in the CS-PFP total, upper-body strength, lower-body strength, and endurance scores were found,[27] and strength training was found to have a limited effect on the CS-PFP test.[10] Recent reviews of randomized, controlled trials have found that the effects of resistance exercise programs on functional-task performance of older adults were inconsistent and of modest magnitude.[3,7] The fact that most exercise programs are not consistent with the principles of training specificity could explain this. According to this principle, the nature of the implied stimulus determines the nature of the physical change.[14] Thus, exercises should focus on the complex interplay of cognitive, perceptual, an motor functions that are involved in the performance daily tasks.[34] Furthermore, daily task performance is most frequently assessed using questionnaires about activities of daily living.[9,35] Nevertheless, these instruments often fail to detect changes because of ceiling effects in relatively healthy participants.[7,26] In addition, in many trials, an increase in muscle strength or gait speed is equated with improved daily task performance,[4,11-13,36] although this association has not been indisputably demonstrated .

This is the first study to show that functional tasks and strength-training programs have different effects over time after detraining. Although the improvements in ADAP score achieved in the function group lasted over the 6-month detraining period, this was not the case for the muscle strength gains in the resistance group, thereby confirming the results of another study that showed a loss of muscle strength with strengthening regimens during a detraining period.[13]Nevertheless, the changes in

LEP were significantly higher for the resistance and function groups than for the control group, although it should be borne in mind that changes in physical activity during the 6-month detraining period could have influenced the 9-month follow-up. Because the exercises of the functional tasks exercise program resembled daily tasks, the participants may have been stimulated to become more active in their free time. In contrast, the resistance exercises are less transferable to daily life situations, and so the resistance group participants were probably less likely to continue with these exercises in their free time. Further research on this topic is necessary to determine whether the functional tasks exercise program has a different motivational effect on activity than a resistance exercise program.

The recruitment strategy used, namely, advertisements in the local newspaper, may have recruited a relatively healthy population. It was assumed that, by excluding the most active respondents (respondents who exercised at a sports club more than two times a week), a more representative group of participants would be obtained, although the SAS scores showed that the respondents were of moderate to good health, a finding that the results of the TUG test and IKES supported.[25,37]

A possible weakness of this study is that, because 25% of the included participants did not participate in the 9-month follow-up, a selection bias may have occurred at 9 months. Nevertheless, t test analyses of baseline scores demonstrated that the dropouts between the baseline and 3-month measurements and the dropouts between the 3-month and 9-month measurements did not differ from the participants who completed the study and that dropout did not lead to an altered group composition. Also, exercise intensity in both exercise programs was moderate to high. Although the increases at 3 months in IKES and IEFS in the resistance group were consistent with earlier results obtained with comparable resistance exercise programs,[9,12,36,38] the American College of Sports Medicine suggested that higher intensity resistance training could induce higher strength gains.[6] Further research is needed to determine whether higher strength gains are required to translate into functional gains.

In conclusion, this study demonstrates the functional tasks exercise program to be more effective than a resistance exercise program on the performance of daily tasks by healthy, community-living older women. Moreover, the effects of the functional tasks exercises were preserved for longer than the gain in strength achieved with resistance exercises. Future research should consider specific functional tasks when designing exercise interventions to increase the ability of older individuals to perform daily tasks.

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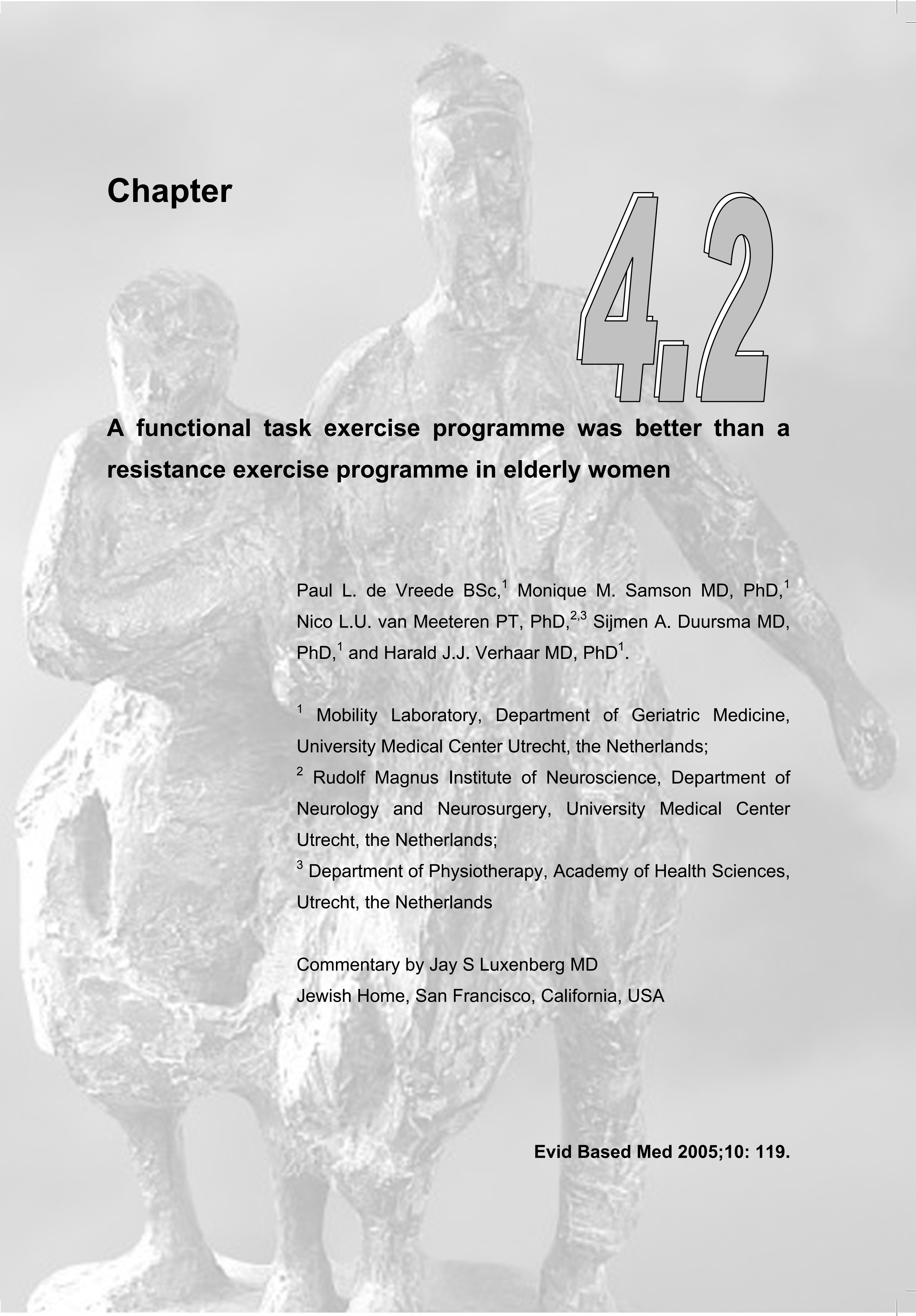

Chapter 4.2

A functional task exercise programme was better than a resistance exercise programme in elderly women

Paul L. de Vreede BSc,[1] Monique M. Samson MD, PhD,[1] Nico L.U. van Meeteren PT, PhD,[2,3] Sijmen A. Duursma MD, PhD,[1] and Harald J.J. Verhaar MD, PhD[1].

[1] Mobility Laboratory, Department of Geriatric Medicine, University Medical Center Utrecht, the Netherlands;
[2] Rudolf Magnus Institute of Neuroscience, Department of Neurology and Neurosurgery, University Medical Center Utrecht, the Netherlands;
[3] Department of Physiotherapy, Academy of Health Sciences, Utrecht, the Netherlands

Commentary by Jay S Luxenberg MD
Jewish Home, San Francisco, California, USA

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A functional task exercise programme was better than a resistance exercise programme in elderly women

de Vreede PL, Samson MM, van Meeteren NL, Duursma SA, Verhaar HJ. 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.

Clinical impact ratings GP/FP/Primary care ★★★★★☆☆ Geriatrics ★★★★★★☆
Physical medicine & rehabilitation ★★★★★☆☆

Q In elderly community dwelling women, is a functional task exercise programme (FTP) better than a resistance exercise programme (REP) for improving activities of daily living?

METHODS

Design: randomised controlled trial.

Allocation: allocation concealed.*

Blinding: blinded (data collectors).*

Follow up period: 12 weeks.

Setting: community leisure centre in Utrecht, the Netherlands.

Patients: 98 elderly women >70 years of age (mean age 74 y) who were medically fit to participate in an exercise programme. Exclusion criteria included recent fractures, unstable cardiovascular or metabolic diseases, and musculoskeletal disease or other chronic illness that might limit training or testing.

Intervention: (i) FTP (core exercises done for > 2 of 4 domains [moving with a vertical or horizontal component, carrying an object, and changing between lying-sitting-standing position] in 3 sessions of 5–10 repetitions) (n = 33), (ii) REP (exercises to strengthen the muscle groups that are important for daily task performance in 3 sets of 10 repetitions) (n = 34), or (iii) control (normal pattern of activity) (n = 31). Exercises were done 3 times / week (1 h sessions).

Outcomes: functional performance (Assessment of Daily Activity Performance [ADAP] and Timed Up and Go [TUG]) and muscle function (isometric knee extensor strength [IKES], isometric elbow flexor strength [IEFS], handgrip strength [HGS], and leg extension power [LEP]).

Patient follow up: 86%.

*See glossary.

MAIN RESULTS

Participants in the FTP had a greater increase in ADAP total score compared with those who received REP (table) or the control intervention ($p < 0.001$). FTP and REP groups did not differ for TUG, HGS, or LEP (table). The REP and control groups did not differ for ADAP total score ($p = 0.06$), TUG ($p = 1.00$), or HGS ($p = 1.00$). REP improved IKES and IEFS more than FTP (table).

CONCLUSION

In elderly community dwelling women, a functional task exercise programme was better than a resistance exercise programme for improving physical functional performance.

Table. Functional task exercise programme (FTP) v resistance exercise programme (REP) for improving physical and muscle function*

Outcomes at 3 months	Mean change from baseline			Difference in mean change from baseline between FTP and REP (95% CI)	
	FTP	REP	Control		*p* Value
Assessment of Daily Activity Performance total	6.8	3.2	0.3	3.6 (1 to 6)	0.007
Timed Up and Go (sec)	20.1	20.1	0.1	0 (20.4 to 0.4)	1.00†
Isometric knee extensor	27.0	23.7	28.2	30.7 (16 to 45)	0.001
Hand grip strength	20.1	20.2	20.3	0.1 (20.7 to 0.9)	1.00†
Isometric elbow flexor strength	21.0	10.6	0.0	11.6 (2.8 to 20)	0.03
Leg extension power	11.2	10.8	27.0	0.4 (214 to 14)	1.00†

*CI defined in glossary. Difference in mean change from baseline and CI calculated from data in article. † Not significant.

COMMENTARY

Use it or lose it. Although geriatricians hear this mantra throughout their training, little evidence exists that prescribing an exercise programme focusing on functional tasks of everyday life has any advantage over the much more common practice of prescribing resistance exercises to improve strength and endurance. After a 12 week training programme in the study by de Vreede et al, the benefit of FTP for strength, balance, coordination, and ADAP persisted after 6 more months, whereas no persistent benefit was found in the REP group. In addition, participants randomised to the FTP group had fewer dropouts due to loss of interest and other causes than did the REP and non-exercise control groups. De Vreede *et al* showed that the FTP group had a >10% increase in ADAP, which is considered clinically significant. Although the reliability and validity of ADAP have not yet been published, it is closely patterned after the well validated Continuous-Scale Physical Functional Performance. This latter scale showed a similar magnitude of difference between functionally independent community dwelling elderly patients and the most independent residents of a long term care facility.[1] Although other studies have shown a functional benefit of task specific exercise,[2] the study by de Vreede *et al* (which compared a similar regimen with resistance exercise) showed similar benefit for increasing strength but not for improving functional task performance. We should consider recommending functionally relevant exercise to our elderly patients.

Jay S Luxenberg, MD, Evidence-Based Medicine, BMJ-journals
Jewish Home, San Francisco, California, USA

1 Cress ME, Buchner DM, Questad KA, et al. *Arch Phys Med Rehabil* 1996;77:1243–50.

2 Alexander NB, Galecki AT, Grenier ML, et al. *J Am Geriatr Soc* 2001;49:1418–27.

For correspondence: P L de Vreede, University Medical Center, Utrecht, the Netherlands. p.l.devreede@freeler.nl.
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Chapter 5

The effect of functional tasks exercise and resistance exercise on health-related quality of life and physical activity: A randomised controlled trial.

Paul L. de Vreede[1] BSc, Nico L. van Meeteren[2,3], PT, PhD, Monique M. Samson[1], MD, PhD, Harriet M. Wittink[3,4], PT, PhD, Sijmen A. Duursma[1], MD, PhD, Harald J. Verhaar[1], MD, PhD

[1] Mobility Laboratory, Department of Geriatric Medicine, University Medical Center Utrecht, the Netherlands;
[2] Rudolf Magnus Institute of Neuroscience, Department of Neurology and Neurosurgery, University Medical Center Utrecht, the Netherlands;
[3] Department of Physiotherapy-Research, Academy of Health Sciences, Utrecht, the Netherlands;
[4] MSc Physiotherapy-research, Utrecht University, Department of Physical Therapy, University of Professional Education, Utrecht, the Netherlands

Submitted

ABSTRACT

Background: Data regarding the effect of exercise programmes on older adults' health-related quality of life (HRQOL) habitual physical activity are inconsistent.

Objective: To determine whether a functional tasks exercise programme (enhances functional capacity) and a resistance exercise programme (increases muscle strength) have a different effect on the health-related quality of life (HRQOL) and physical activity of community-dwelling older women.

Methods: Ninety-eight women were randomised to a functional tasks exercise programme (function group), a resistance exercise programme (resistance group), or normal activity group (control group). Participants attended exercise classes three times a week for 12 weeks. The SF-36 Health Survey questionnaire and self-reported physical activity were obtained at baseline, directly after completion of the intervention (3 months), and 6 months later (9 months).

Results: At 3 months, no difference in mean change in HRQOL and physical activity scores was seen between the groups, except for an increased SF-36 physical functioning score for the resistance group compared with the control group (p = .02) and the function group (p =.05). Between 3 and 9 months, the self-reported physical functioning score of the function group decreased to below baseline (p = .03), and physical activity (p = .04) decreased in the resistance group compared with the function group.

Conclusions: Exercise has a limited effect on the HRQOL and self-reported physical activity of community-living older women. Our results suggest that in these subjects HRQOL measures may be affected by ceiling effects and response shift. Studies should include performance-based measures in addition to self-report HRQOL measures, to obtain a better understanding of the effect of exercise interventions in older adults.

INTRODUCTION

We reported previously that functional tasks exercise had a beneficial impact on the capacity of older women to perform daily activities and could play an important role in maintaining independence, whereas resistance exercise, which increases muscle strength, had no effect on daily activity performance.[1] However, physical capacity does not completely explain the ability to perform daily activities independently, and psychosocial factors may be important.[2,3] Thus, in addition to performance-based physical function, we were interested in the impact of functional tasks exercise and resistance exercises on the health-related quality of life (HRQOL) of older women. Although HRQOL scales has been measured before in studies of exercise in older individuals,[4-10] the effect of structured exercise programmes on HRQOL remains unclear. Schechtman and Ory concluded in a meta-analysis that exercise had a modest effect on older people's HRQOL,[4] and Latham et al found a limited effect of resistance training on older people's HRQOL.[5]

Habitual physical activity is an essential aspect of life [3] and is important for maintaining quality of life among older people.[6] Because older people often fail to continue exercise activities after participation in training programmes,[11] such programmes should aim to improve the habitual activity pattern, so that exercise becomes an inherent part of daily life, which enhances self-efficacy in managing healthy behaviour. The effect of exercise interventions on behaviour regarding physical activity is not well understood.[12]

Here, we tested our hypothesis that functional tasks exercises and resistance exercises have a different effect on the HRQOL and habitual physical activity of older women.

METHODS

Study design and participants

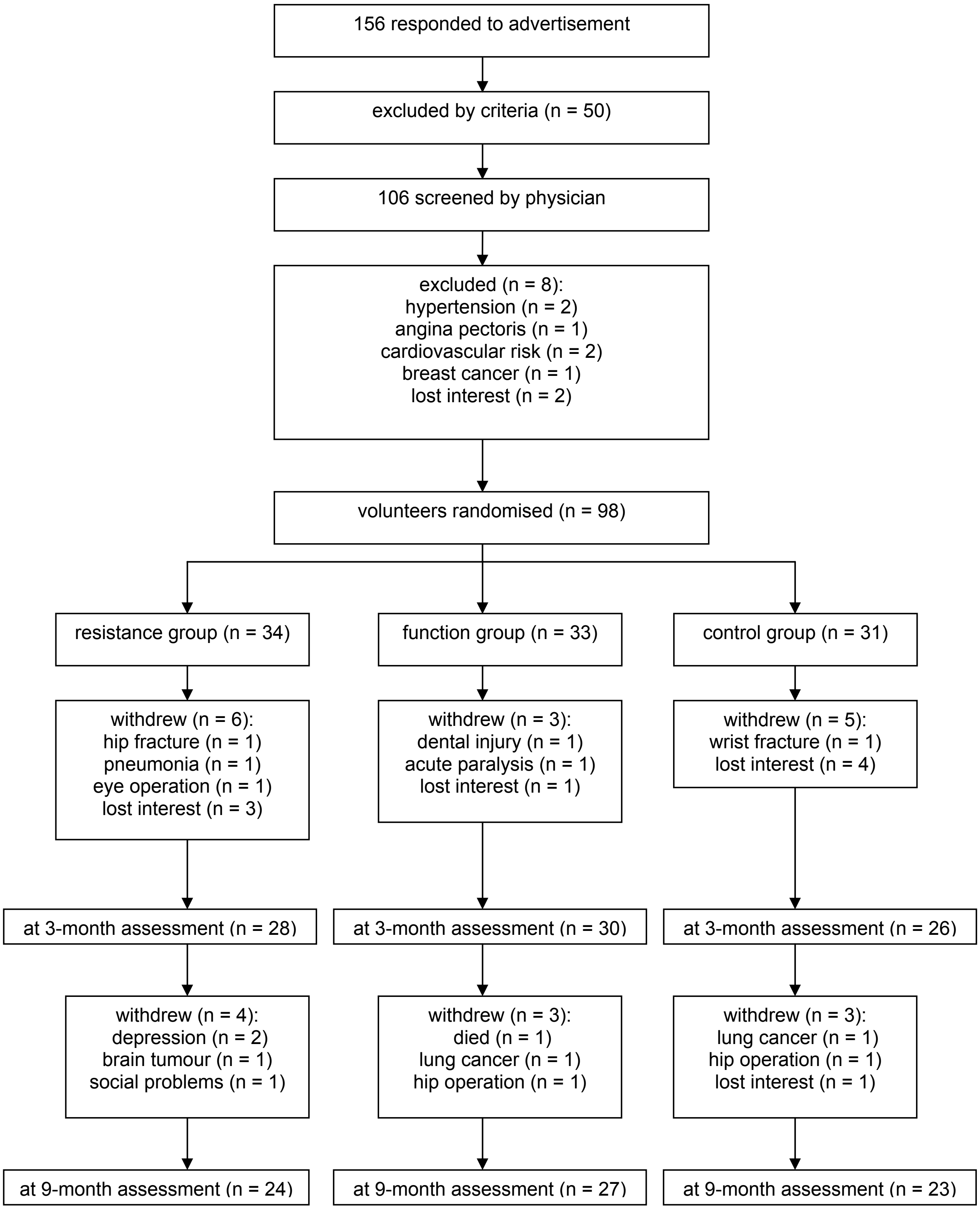
The study was part of a single-blinded, randomised controlled trial on the effect of exercise programmes on the physical functioning of older individuals.[1] The Medical Ethics Board of the University Medical Center in Utrecht, the Netherlands, approved the study. Hundred-six community-living, medically stable women older than 70 years were recruited through advertisements in a local newspaper. Exclusion criteria were recent fractures; unstable cardiovascular or metabolic diseases; musculoskeletal condition or other chronic illnesses that might limit training or testing; severe airflow obstruction; recent depression or emotional distress; loss of mobility for more than 1 week in the previous 2 months. Also excluded were respondents who exercised at a sports club three times a week or more. Potential participants were screened for medical history and underwent a physical examination. Eight subjects failed the examination because of hypertension (two), cardiovascular illness within the previous 10 years (three), breast cancer (one), planned vacation conflicting with the intervention period (one), and failure to show up for the examination (one). Figure 1 shows the flow of participants through the trial. Ninety-eight women gave written informed consent and were allocated randomly, using a random numbers table, to the functional tasks exercise programme (function group; n = 33), the resistance exercise programme (resistance group; n = 34), or the normal activity group (control group; n = 31).

Interventions

The exercise programmes were followed three times a week in 1-hour sessions for 12 weeks at a local leisure centre in the province of Utrecht, with sessions separated by 1 day of rest. Group size varied from six to 12 participants per session. Training sessions were supervised by at least two experienced instructors (physiotherapist and sports teacher).

Exercise intensity in both exercise programmes was set at 7 to 8 (moderate to high) on a 10-point rated perceived exertion (RPE) scale (1 = very, very light; 10 = very, very hard).[1,13,14] If an exercise was rated only “somewhat hard”, participants in the function group were instructed to increase the weight carried, the number of repetitions, or the distance walked. Resistance could also be increased by wearing a weighted vest (1 – 10 kg) during the exercises. The participants in the resistance group were instructed to increase the load if an exercise was rated only “somewhat hard”. Several studies have validated the use of RPE scales to obtain information regarding the intensity of resistance exercise.[14-16]

Figure 1. Trial profile



Functional tasks exercise programme (FUNTEX)

The exercises of the FUNTEX programme are described elsewhere.[1,13] The aim of the 40-minute core exercises was to improve the ability to perform daily tasks in the domains first affected in older people,[17] namely, moving with a vertical component, moving with a horizontal component, carrying an object, and changing position between lying, sitting, and standing. During each exercise class, participants performed tasks in at least two of these domains in three sessions of 5 – 10 repetitions. The 12-week programme was divided into a practice phase (2 weeks), a variation phase (4 weeks), and a daily tasks phase (6 weeks). In a randomised controlled trial, the FUNTEX programme improved the performance of daily tasks, as measured with the Assessment of Daily Activity Performance (ADAP) test.[1]

Resistance strength exercise programme

The core resistance exercises were designed according to the American College of Sports Medicine recommendations for exercise and physical activity for older adults[16] and based on the exercises of the Fit For Your Life resistance-training programme.[18] The aim of the exercises is to strengthen the muscle groups used to perform daily tasks: elbow flexors and extensors; shoulder abductors, adductors and rotators; trunk flexors and extensors; hip flexors, extensors, abductors and adductors; knee flexors and extensors; and ankle dorsal and plantar flexors. In a progressive resistance protocol, three to four muscle groups were trained in three sets of 10 repetitions. In a randomised controlled trial, this resistance exercise programme improved the strength of the muscles of the arms and legs in older women.[1]

Control group

The non-exercising subjects of the control group were asked to keep to their normal pattern of activity during the 3-month intervention period.

Measurements

Data were recorded before randomisation, at the end of the intervention (3 months) and 6 months later (9 months). Outcome measures consisted of health-related quality of life (HRQOL), assessed with the SF-36 Health Survey,[19] and physical activity, assessed with a physical activity questionnaire.[20] The questionnaires were self-administered at the Mobility Laboratory of the Department of Geriatric Medicine at the University Medical Center. If a participant was not able to visit the Mobility Laboratory within 3 weeks of finishing the intervention, the questionnaires were administered by mail.

Health-Related Quality of Life (HRQOL)

Health-related quality of life was assessed with the Dutch language version of the SF-36 Health Survey.[19,21] The SF-36 is a 36-item questionnaire designed to obtain a person's assessment of his/her physical functioning, well-being and general health. Eight scales are scores: physical functioning (PF), role limitations due to physical health problems (RP), bodily pain (BP), general health perceptions (GH), vitality (VT), social functioning (SF), role limitations due to emotional problems (RE), and mental health (MH). Physical component summary (PCS) and mental component summary (MCS) scores were calculated according to the Manual Guide,[19] using the norm scores for Dutch older people (> 70 years) from Aaronson et al.[21] Scales were scored from 0 (poorer health) to 100 (excellent health).[19,22] The Dutch language version SF-36 has proven to be practical, reliable, and valid.[21,22] The SF-36 has been used extensively in exercise studies and in older people.[6-10,23,24]

Physical activity

Physical activity was assessed with a questionnaire developed for older adults by Voorrips et al.[20] The questionnaire scores household activities, sporting activities, and other physically active leisure-time activities, to generate a single activity score. Respondents were asked to report habitual physical activities. Household activities were scored from 'very active' to 'inactive' (4 or 5 ratings). Participants were asked about the type of activity, hours per week spent on it, and period of the year in which the activity was normally performed. All activities were classified according to work posture and movements: intensity was based on the net energetic cost of activities. The questionnaire is reliable and valid for use in older people.[20]

Statistics

All statistical analyses were performed with SPSS software (SPSS Inc. SPSS reference guide. Chicago: SPSS Inc, 1990). Univariate analysis of variance was used to compare baseline values between groups. Within-group analyses were performed by using paired samples T-test. Between-group analyses of mean change scores between baseline and 3 months, and between baseline and 9 months were performed by using analysis of co-variance (ANCOVA) with the baseline values of the dependent variable as co-variate and a priori contrast analyses to account for multiple comparisons. Data for 3 months and 9 months were compared by using ANCOVA with the 3-month values as co-variate.

RESULTS

Baseline scores for the SF-36 scales for Social Functioning (SF), Mental Health (MH), Bodily Pain (BP), and Mental Component Summary (MCS) were significantly higher in the function group than in the control group (Table 1). The resistance group had a significantly lower Physical Functioning (PF) score at baseline than the control group and significantly lower Physical Functioning (PF), Role limitations Physical (RP), Bodily Pain (BP), General Health (GH), and Physical Component Summary (PCS) score than the function group. Baseline physical activity scores did not differ between the groups, except for Sports activities between the resistance group and the control group.

Between baseline and 3 months, three participants in the function group, six in the resistance group, and five in the control group withdrew (Figure 1). The reasons for withdrawal were loss of interest (eight); dental injury after a fall at home (one); acute paralysis in a leg (one); hip fracture after a fall at home (one); pneumonia (one); eye operation (one); and wrist fracture (one). During the subsequent 6 months, three participants in the function group, two in the resistance group, and three in the control group dropped out because of death due to a brain tumour (one); hospitalisation (lung cancer, two; brain tumour, one); hip operation (two); depression (two), social problems (one); and loss of interest (one). The baseline data for participants who withdrew did not differ from the data of the 74 participants who completed the study.

Training compliance, defined as the number of exercise classes attended as a proportion of the total number of classes, was 90 ± 9.1% (range, 66% to 100%) in the function group and 90 ± 8.1% (range, 71% to 100%) in the resistance group.

Table 1. Baseline characteristics

Characteristics	*Control group (n = 31)*	*Resistance group (n = 34)*	*Function group (n = 33)*
Age, mean ± SD	73.0 ± 3.2	74.8 ± 4.0	74.7 ± 3.5
Marital status, %			
Married	42	50	36
Single	3	6	6
Widowed	55	44	58
Disease status, %			
Hypertension	30	28	33
Arthritis	30	28	23
Prosthetic hip/knee	4	13	20
Diabetes	4	0	3
Medication 3 or more	26	16	23
Osteoporosis	11	16	10
Height, meters mean ± SD	1.62 ± 0.06	1.62 ± 0.08	1.63 ± 0.06
Weight, kg mean ± SD	71.3 ± 11.4	70.7 ± 12.1	69.4 ± 9.0
SF-36, mean ± SD			
Physical Functioning	82.4 ± 14.3	72.9 ± 18.0	82.7 ± 15.6
Role Limitation Physical	70.2 ± 39.5	67.7 ± 39.7	83.3 ± 35.2
Bodily Pain	69.1 ± 20.5	73.0 ± 20.3	82.2 ± 19.6
General Health	70.8 ± 15.5	66.3 ± 13.0	74.6 ± 13.3
Vitality	67.9 ± 14.5	69.6 ± 15.0	73.6 ± 16.6
Social Functioning	79.8 ± 15.0	82.4 ± 20.4	88.6 ± 18.6
Role Limitation Emotional	82.8 ± 30.9	75.5 ± 37.0	84.9 ± 33.4
Mental Health	73.7 ± 14.5	74.5 ± 19.6	82.7 ± 12.2
Physical Component Summary	49.4 ± 7.5	47.9 ± 8.3	51.8 ± 7.3
Mental Component Summary	50.7 ± 8.2	51.2 ± 11.2	54.0 ± 7.8
Physical activity, mean ± SD			
Total activity	16.5 ± 9.4	12.8 ± 7.3	14.6 ± 5.6
Household	2.0 ± 0.6	2.1 ± 0.5	2.1 ± 0.4
Sports	3.1 ± 3.2	1.1 ± 1.9	1.9 ± 2.7
Leisure Time	11.3 ± 7.9	9.6 ± 6.7	10.6 ± 5.3

Note: SD, standard deviation; SF-36, 36-item Health Survey.

Health-related quality of life

At the end of the 3-month intervention, the SF-36 PF score had increased more in the resistance group than in the control and function groups (Table 2). There were no differences in the mean change scores for the other scales and summary scores between the function group and the control group or between the resistance group and the function group.

Between 3 months and 9 months, the SF-36 PF score and PCS score decreased more in the function group than in the control group (Table 3).

Compared to baseline scores, at 9 months the control group reported less bodily pain (SF-36 BP) and a trend was seen for an increased PCS score (Table 4). The resistance group showed a trend for a decrease in SF-36 BP scores from baseline compared with the control group. SF-36 PF, BP, and PCS scores decreased more in the function group than in the control group. The SF-36 PF score decreased more in the function group than in the resistance group.

Physical activity

At the end of the 3-month intervention, no difference in change scores was seen within or between the groups, except for a decreased household activity score in the resistance group compared with the control group (Table 2). At 9 months, the resistance group had a lower total physical activity score than the function group and tended to have a lower score than the control group (Table 3). The change in physical activity score between baseline and 9 months was not significantly different in the three groups (Table 4).

Table 2. Changes in outcome measures between baseline and 3-month measures.

Measure	*Control group (n = 26)*			*Resistance group (n = 28)*			*Function group (n = 30)*			*Resistance vs. Function*
SF-36	Mean ± SD	95% CI	*P*-value*	Mean ± SD	95% CI	*P*-value†	Mean ± SD	95% CI	*P*-value†	*P*-value‡
PF	-0.5 ± 11.3	-4.9 – 3.9	.80	7.7 ± 12.4	2.9 – 12.5	.02	0.2 ± 8.1	-2.9 – 3.2	.73	.05
RP	7.1 ± 38.4	-7.8 – 22.0	.33	10.7 ± 37.5	-3.8 – 25.3	.82	-2.6 ± 16.8	-9.0 – 3.8	.72	.56
BP	3.8 ± 23.9	-5.5 – 13.0	.41	1.4 ± 15.7	-4.7 – 7.5	.76	-4.3 ± 18.9	-11.5 – 2.9	.57	.77
GH	-0.6 ± 12.1	-5.3 – 4.1	.78	4.3 ± 15.6	-1.7 – 10.4	.31	1.5 ± 9.6	-2.2 – 5.1	.26	.92
VT	3.4 ± 11.1	-0.9 – 7.7	.12	2.7 ± 12.7	-2.2 – 7.6	.91	2.9 ± 12.3	-1.7 – 7.6	.56	.48
SF	3.6 ± 20.7	-4.4 – 11.6	.37	4.0 ± 17.7	-2.8 – 10.9	.84	0.9 ± 18.6	-6.2 – 7.9	.47	.60
RE	8.3 ± 33.5	-4.7 – 21.3	.20	9.5 ± 41.4	-6.5 – 25.6	.52	2.3 ± 21.7	-6.0 – 10.6	.68	.82
MH	3.1 ± 10.5	-0.9 – 7.2	.12	3.9 ± 10.4	-0.2 – 7.9	.76	2.6 ± 9.6	-1.1 – 6.3	.26	.41

PCS	0.2 ± 6.8	-2.5 – 2.8	.89	2.1 ± 7.1	-0.7 – 4.9	.38	-1.1 ± 4.6	-2.8 – 0.7	.72	.23
MCS	2.5 ± 7.7	-0.5 – 5.4	.10	1.9 ± 9.6	-1.8 – 5.7	.81	1.7 ± 6.9	-0.9 – 4.3	.49	.35
Phys. Activity										
Total	-0.7 ± 8.1	-4.0 – 2.6	.67	1.3 ± 7.4	-1.6 – 4.2	.96	-1.3 ± 5.8	-3.4 – 1.0	.32	.28
Household	0.1 ± 0.5	-0.1 – 0.3	.16	-0.1 ± 0.3	-0.2 – 0.1	.05	0.0 ± 0.3	-0.1 – 0.1	.14	.60
Sports	0.1 ± 2.3	-0.8 – 1.1	.80	1.4 ± 1.6	0.7 – 2.0	.53	0.4 ± 2.4	-0.5 – 1.3	.61	.22
Leisure time	-1.1 ± 7.7	-4.2 – 2.1	.55	0.0 ± 8.0	-3.1 – 3.1	.91	-1.7 ± 5.5	-3.7 – 0.4	.51	.43

Note: SD, standard deviation; CI, confidence interval; PF, physical functioning physical; RP, role limitations physical; BP, bodily pain; GH, general health perceptions; VT, vitality; SF, social functioning; RE, role limitations emotional; MH, mental health; PCS, physical component summary; MCS, mental component summary.

* *T* test mean change between baseline and 3-month scores control group; † Analyses of co-variance (ANCOVA) between exercise group and control group with the baseline values as co-variate and a priori contrast analyses to account for multiple comparisons; ‡ ANCOVA between resistance and function groups with the baseline values as co-variate and a priori contrast analyses to account for multiple comparisons.

Table 3. Changes in outcome measures between 3-month and 9-month measures.

Measure	*Control group (n = 23)*			*Resistance group (n = 24)*			*Function group (n = 27)*			*Resistance vs. Function*
SF-36	Mean ± SD	95% CI	*P*-value*	Mean ± SD	95% CI	*P*-value†	Mean ± SD	95% CI	*P*-value†	*P*-value‡
PF	-0.2 ± 9.9	-4.8 – 4.3	.91	-7.0 ± 15.2	-13.5 – -0.4	.17	-10.8 ± 19.3	-18.6 – -3.0	.03	.40
RP	2.4 ± 37.0	-14.5 – 19.2	.77	-15.2 ± 33.5	-29.7 – -0.7	.07	-13.5 ± 48.1	-32.9 – 6.0	.12	.75
BP	1.5 ± 20.4	-7.8 – 10.8	.74	-6.8 ± 26.1	-18.1 – 4.4	.15	-5.9 ± 23.0	-15.2 – 3.4	.22	.79
GH	2.6 ± 14.3	-3.9 – 9.1	.42	-1.6 ± 12.1	-6.9 – 3.6	.13	-3.1 ± 8.2	-6.4 – 0.2	.12	1.00
VT	-4.8 ± 12.4	-10.4 – 0.9	.09	-4.8 ± 14.7	-11.1 – 1.6	.83	-2.3 ± 13.3	-7.7 – 3.1	.29	.19
SF	-2.4 ± 18.8	-10.9 – 6.2	.57	-6.5 ± 14.5	-12.8 – -0.2	.36	-1.4 ± 12.9	-6.7 – 3.8	.74	.19
RE	-11.1 ± 30.4	-25.0 – 2.7	.11	-15.9 ± 29.9	-28.9 – -3.0	.41	-2.6 ± 33.9	-16.3 – 11.1	.48	.11
MH	-1.0 ± 14.4	-7.5 – 5.6	.76	-5.0 ± 10.3	-9.5 – -0.6	.23	-2.2 ± 10.8	-6.5 – 2.2	.79	.14

PCS	1.4 ± 7.1	-1.8 – 4.7	.37	-2.3 ± 8.7	-6.1 – 1.5	.08	-3.7 ± 7.7	-6.8 – -0.7	.01	.47
MCS	-2.7 ± 8.9	-6.8 – 1.3	.17	-3.4 ± 4.9	-5.5 – -1.2	.75	-1.7 ± 12.9	-6.8 – 3.4	.54	.33
Phys. Activity										
Total	-0.8 ± 7.3	-4.1 – 2.4	.60	-3.7 ± 8.1	-7.2 – -0.2	.06	0.9 ± 6.1	-1.6 – 3.3	.91	.04
Household	-0.1 ± 0.2	-0.2 – 0.0	.08	0.0 ± 0.2	-0.1 – 0.1	.24	0.0 ± 0.3	-0.1 – 0.1	.40	.72
Sports	-0.1 ± 3.1	-1.5 – 1.3	.88	-0.9 ± 2.7	-2.1 – 0.3	.16	-0.2 ± 2.9	-1.4 – 0.9	.45	.48
Leisure time	-0.7 ± 6.8	-3.7 – 2.3	.65	-2.9 ± 8.8	-6.7 – 1.0	.22	1.1 ± 5.5	-1.1 – 3.3	.62	.08

Note: SD, standard deviation; CI, confidence interval; PF, physical functioning physical; RP, role limitations physical; BP, bodily pain; GH, general health perceptions; VT, vitality; SF, social functioning; RE, role limitations emotional; MH, mental health; PCS, physical component summary; MCS, mental component summary.

* *T* test mean change between baseline and 3-month scores control group; † Analyses of co-variance (ANCOVA) between exercise group and control group with the 3-month values as co-variate and a priori contrast analyses to account for multiple comparisons; ‡ (ANCOVA) between resistance group and function group with the 3-month values as co-variate and a priori contrast analyses to account for multiple comparisons

Table 4. Changes in outcome measures between baseline and 9-month measures.

Measure	*Control group (n = 23)*			*Resistance group (n = 24)*			*Function group (n = 27)*			*Resistance vs. Function*
SF-36	Mean ± SD	95% CI	*P*-value*	Mean ± SD	95% CI	*P*-value†	Mean ± SD	95% CI	*P*-value†	*P*-value‡
PF	0.9 ± 9.8	-3.5 – 5.3	.670	2.0 ± 15.8	-4.9 – 8.8	.85	-9.3 ± 20.7	-17.5 – -1.1	.04	.03
RP	15.9 ± 43.3	-3.3 – 35.1	.10	-3.3 ± 37.2	-19.3 – 12.8	.08	-15.7 ± 44.5	-33.3 – 1.9	.06	.89
BP	9.5 ± 18.5	1.2 – 17.7	.03	-3.2 ± 24.0	-13.6 – 7.2	.07	-11.9 ± 22.2	-20.7 – -3.1	.02	.55
GH	2.1 ± 14.2	-4.2 – 8.4	.50	3.9 ± 15.3	-2.8 – 10.5	.61	-1.2 ± 12.1	-6.0 – 3.6	.40	.77
VT	1.1 ± 12.6	-4.5 – 6.7	.68	-1.7 ± 10.3	-6.2 – 2.7	.38	0.2 ± 7.8	-2.9 – 3.3	.88	.29
SF	6.3 ± 17.1	-1.4 – 13.9	.10	-1.6 ± 24.2	-12.1 – 8.8	.30	-0.9 ± 18.3	-8.2 – 6.3	.80	.41
RE	3.0 ± 14.2	-3.3 – 9.3	.33	-8.7 ± 35.1	-23.9 – 6.5	.12	-3.7 ± 31.1	-16.0 – 8.6	.60	.27
MH	2.9 ± 10.2	-1.6 – 7.4	.20	-2.8 ± 11.5	-7.7 – 2.2	.08	-0.2 ± 11.1	-4.6 – 4.3	.92	.09

PCS	2.7 ± 6.5	-0.1 – 5.6	.06	0.9 ± 9.7	-3.3 – 5.2	.26	-4.8 ± 8.5	-8.1 – -1.5	.004	.08
MCS	1.0 ± 4.5	-1.0 – 3.0	.30	-2.3 ± 9.0	-6.2 – 1.6	.18	0.1 ± 8.8	-3.3 – 3.5	.92	.20
Phys. Activity										
Total	-1.5 ± 8.8	-5.3 – 2.3	.41	-2.8 ± 8.7	-6.6 – 0.9	.12	-0.5 ± 8.0	-3.6 – 2.7	.70	.21
Household	0.1 ± 0.5	-0.2 – 0.3	.49	-0.1 ± 0.4	-0.2 – 01	.47	0.0 ± 0.3	-0.1 – 0.2	.58	.84
Sports	0.0 ± 2.2	-0.9 – 1.0	.95	0.5 ± 1.9	-0.3 – 1.4	.90	0.1 ± 3.0	-1.1 – 1.3	.73	.62
Leisure time	-1.6 ± 8.2	-5.2 – 1.9	.34	-3.3 ± 7.4	-6.5 – -0.1	.24	-0.6 ± 7.6	-3.6 – 2.4	.85	.16

Note: SD, standard deviation; CI, confidence interval; PF, physical functioning physical; RP, role limitations physical; BP, bodily pain; GH, general health perceptions; VT, vitality; SF, social functioning; RE, role limitations emotional; MH, mental health; PCS, physical component summary; MCS, mental component summary.

* *T* test mean change between baseline and 3-month scores control group; † Analyses of co-variance (ANCOVA) between exercise group and control group with the baseline values as co-variate and a priori contrast analyses to account for multiple comparisons; ‡ ANCOVA between resistance group and function group with the baseline values as co-variate and a priori contrast analyses to account for multiple comparisons.

DISCUSSION

The primary findings of this study are that (a) exercise has a limited effect on health-related quality of life (HRQOL) and self-reported habitual physical activity in community-living older women; (b) that except for self-reported physical functioning, there is no difference in effect between functional tasks exercise and resistance exercise on HRQOL; (c) 6 months after completion of the intervention, participants reported a decreased HRQOL; and (d) 6 months after completion of the intervention, participants of the resistance group reported decreased physical activity compared with the participants of the function group.

Several studies have reported a limited effect of exercise on HRQOL in relatively healthy older adults.[4,5] Moreover, although the SF-36 is still the most frequently used HRQOL measure, several studies demonstrated that the SF-36 is limited by ceiling effects and thus may be insensitive to clinically relative changes in HRQOL in healthy elderly subjects.[7,25-29]

In the present study, the baseline scores of the participants in the function group and the control group were in the 50th and 75th percentile of US norm scores for women aged 65 and older [19] and above Dutch norm scores, indicating that the participants were in excellent physical and mental health. The high baseline scores make the results more vulnerable to ceiling effects and could explain the lack of change after completion of the 3-month intervention.

Unlike the control group, both exercise groups showed a decrease in HRQOL score after the 6-month follow-up period. The function group even had lower HRQOL scores at 9 months than at baseline. This may be because the participants missed the social and physical benefits of participating in a group exercise programme. In contrast, the control group, the members of which were not obliged to increase their physical activity level, seemed to have increased their HRQOL. These results suggest that, at the end of the intervention, the participants may have changed their internal standards, as a result of participation in the group exercise programme. This phenomenon is known as response shift and is defined as changes in the meaning of one's self-evaluation of quality of life resulting from changes in internal standards, values, or conceptualisation.[30] Several researchers argue that the interpretability of changes in self-evaluated quality of life over time is threatened if people experience a response shift.[31-33] Daltroy and colleagues found that older subjects recalibrated internal standards after recent health changes.[34] Thus the participants in our study may have changed their internal standards after experiencing health, and possibly social, benefits from the intervention and therefore evaluated their HRQOL as being lower 6 months after completion of the intervention. Previously we found that participants who followed the functional exercise programme reported increased motivation during the 3-month intervention, whereas the participants of the resistance group reported decreased motivation.[13]

In an earlier study, we found that the functional tasks exercise programme enhanced the performance of daily activities, in contrast to the resistance exercise programme, and that the resistance programme increased muscle strength after the 3-month intervention, in contrast to the functional tasks exercise programme.[1] Despite these health benefits of the exercise programmes, no change in HRQOL was found in the present study. These findings seem to support the notion of Schwartz and Rapkin [33] that HRQOL scores may remain stable even though performance-based health outcomes improve. Cress and colleagues also found that the SF-36 could not detect significant changes in physical functional performance in community-dwelling older adults who had completed a 6-month exercise programme.[7] Our findings and those of Cress and colleagues support evidence that self-report measurements and performance-based assessments provide information about distinct, although related, domains of physical functioning,[3,35] and that it is possible that social expectations, needs fulfillment, and the person's experience in everyday life affect HRQOL more than physical capacity does.[3]

We hypothesized that participation in an exercise programme might increase habitual physical activity, and that a functional tasks exercise programme might be more effective in this respect than a resistance exercise programme. However, at the end of the 3-month intervention, no difference was seen in either exercise group. These results are consistent with those of Drewnowski and colleagues, who argued that the effect of exercise programmes on the physical activity of elderly subjects was minimal because elderly subjects compensated for exercise training by reducing their spontaneous physical activity.[12] Six months after completion of the intervention, participants of the resistance group reported decreased physical activity compared with the participants of the function group. We previously found that the improved performance of daily tasks was sustained in the function group 6 months after finishing the functional programme,[1] which suggests that the participants may have improved their self-efficacy in managing healthy behaviour. In contrast, in the resistance group the effects of exercise were not sustained during the 6-month follow-up period,[1] and total activity decreased between 3 months and 9 months compared with that of the function and the control groups, although habitual physical activity was not different at 9 months compared to baseline.

The present study had some limitations. First, the recruitment strategy through newspaper advertisements may have recruited a group of older women with a high level of psychological well-being at baseline, thus making it more vulnerable to ceiling effects.[4] Secondly, the exercise interventions were not directly designed to improve HRQOL. The functional tasks exercise programme was designed to improve physical functional performance and the resistance exercise programme was designed to improve muscle strength. Although physical function and muscle strength are related to HRQOL outcomes, evidence indicates that HRQOL measures may be affected more by psychosocial factors.[3] Possibly, an exercise programme that directly addresses psychosocial aspects may have an effect on the HRQOL of community-dwelling older adults. Thirdly, power analyses for this trial were based on the potential effect of the exercise programmes on the performance of daily activities and muscle strength. It may well be possible that the trial was underpowered. However, several other exercise studies in older adults with comparable group sizes demonstrated significant changes in SF-36.[6]

We conclude that exercise has limited effects on HRQOL and self-reported physical activity of community-living, older women. HRQOL is a dynamic concept which is consistently subject to changes in internal standards, values, or conceptualisation, and therefore may be affected by response shift. Furthermore, the SF-36, one of the most frequently used HRQOL measures, may be unsuitable to detect changes in community-living older women because of ceiling effects. Our results suggest that self-report measures and performance-based assessments provide information about distinct domains of physical functioning and should be included together with performance-based measures in studies, to obtain a clear understanding of the effect of exercise interventions in older adults. More research is necessary to completely understand the concept of HRQOL and the response shift phenomena, and to determine whether an exercise programme affects psychosocial factors might be more effective on HRQOL measures. Also, more research is needed to confirm the potential of functional tasks exercise to positively influence the maintenance of habitual physical activity.

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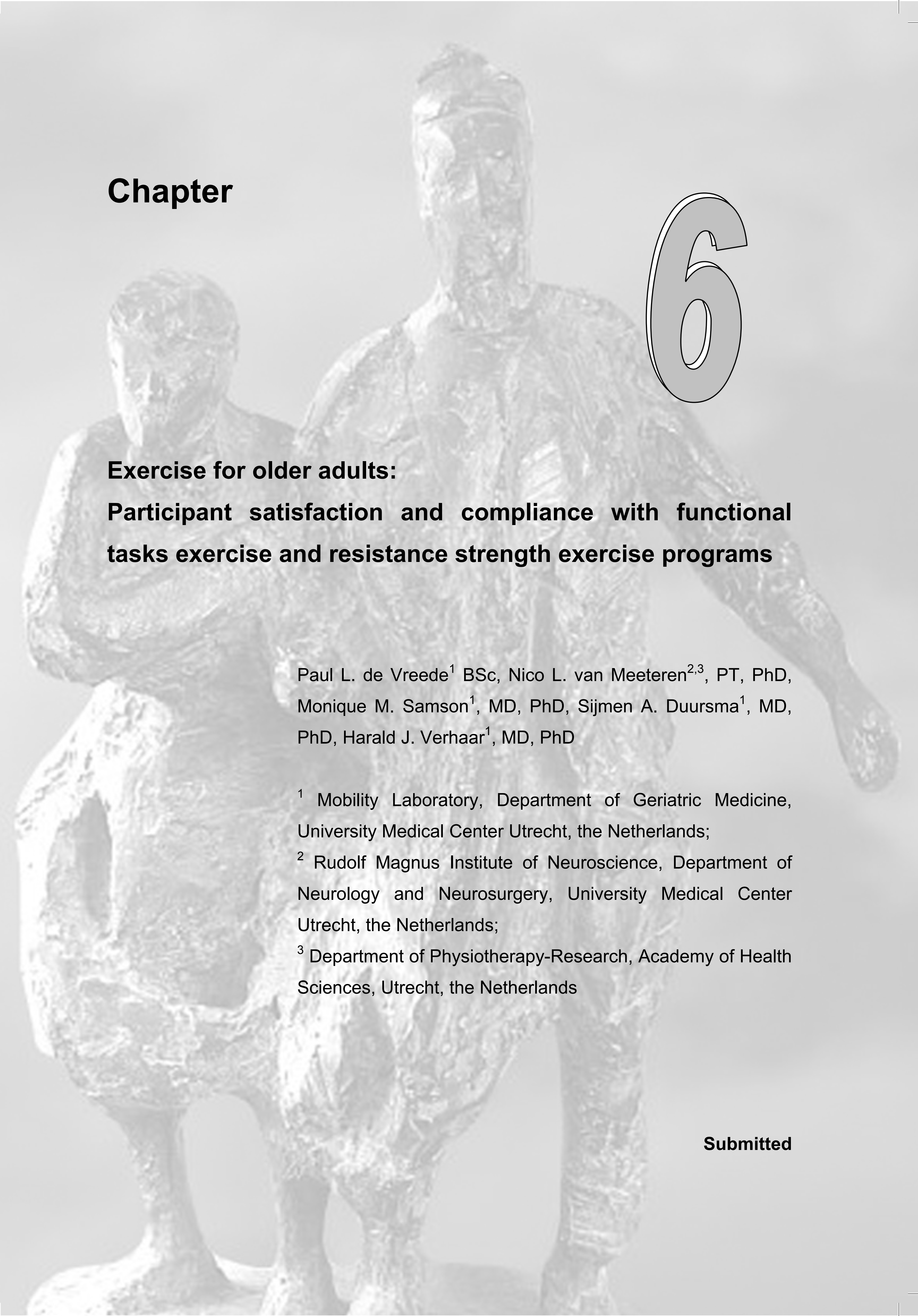


Chapter 6

Exercise for older adults: Participant satisfaction and compliance with functional tasks exercise and resistance strength exercise programs

Paul L. de Vreede[1] BSc, Nico L. van Meeteren[2,3], PT, PhD, Monique M. Samson[1], MD, PhD, Sijmen A. Duursma[1], MD, PhD, Harald J. Verhaar[1], MD, PhD

[1] Mobility Laboratory, Department of Geriatric Medicine, University Medical Center Utrecht, the Netherlands;
[2] Rudolf Magnus Institute of Neuroscience, Department of Neurology and Neurosurgery, University Medical Center Utrecht, the Netherlands;
[3] Department of Physiotherapy-Research, Academy of Health Sciences, Utrecht, the Netherlands

Submitted

ABSTRACT

Background and Purpose: Little is known about the influence of satisfaction and health-status on exercise compliance among older individuals and the effectiveness of exercise programs. This study investigated the impact of these aspects on the effectiveness of a functional tasks exercise program (function group) and a resistance exercise program (resistance group).

Subjects: Sixty-seven healthy women aged 70 and older were randomly assigned to either the function group or the resistance group.

Methods: Exercises were performed 3 times weekly for 12 weeks. Measurements included participants' satisfaction with the exercises, health-status, habitual physical activity, performance-based physical function, and self-reported physical function.

Results: Satisfaction with the exercises (function group 84.8 ± 6.3; resistance group 87.6 ± 6.9) and compliance (function group 90 ± 9.1%; resistance group 90 ± 8.1%) was high in both groups. In the function group, satisfaction with the program was positively associated with sustained physical activity after completion of the exercise program (correlation coefficient [CC] = .46; R^2 = .21). A low initial health status was associated with sustained physical activity after completion of the exercise program (function group, CC = -.45, R^2 = .20; resistance group, CC = -.43, R^2 = .18) and improved performance-based physical functioning in the resistance exercise program (CC = -.47, R^2 = .22).

Discussion and Conclusions: Both exercise programs were well accepted and appreciated. Functional tasks exercises may positively influence daily habits more than resistance training, which means that older individuals may continue exercising and thus maintain the effects of exercise.

INTRODUCTION

In addition to well-documented beneficial physiological effects of regular exercise,[1-3] exercise can also provide a diversion from daily routines and stress, and may induce feelings of enjoyment, companionship, and accomplishment.[4] Despite these benefits of regular exercise, a large percentage of the older Dutch people do not exercise regularly.[5] The decrease in physical activity with age seems to be greater in women than in men, as older women are reported to be the least physically active of all demographic groups.[6] Furthermore, exercise programs for older adults have a high attrition in the early stage and a low adherence and compliance rate.[6-8] Fifty percent of people who start an organized exercise program drop out within 6 months.[9]

The mechanisms that underlie successful initiation and adherence to exercise programs are not well understood.[7,8] Exercise interventions that incorporate co-interventions, stemming from behavioral theories, however, show possibilities to enhance exercise adherence among older adults.[6,10-12] Health status and psychological factors are considered to be the most important factors determining older adults' adherence to and compliance with exercise programmes.[6,13] A low health status is associated with decreased exercise participation, a low exercise self-efficacy, and high barriers to exercise.[6,12-15] Psychological factors that predict positive exercise behavior include participants' satisfaction with and enjoyment of the programme.[6,12-15]

While satisfaction and health status seem to play a role in the exercise compliance of older individuals and hence in the effectiveness of exercise programs, it is not clear whether the influence of these factors differs according to the type of exercise. We reported previously that functional tasks exercises were more effective than resistance exercises on the performance of daily tasks by older women, and that the effects of functional tasks exercises were preserved for longer than the gain in strength achieved with resistance exercises.[16] In the present paper, we discuss the differences in participants' satisfaction with a functional tasks exercise program and a resistance exercise program, and we investigate the impact of participants' satisfaction and health status on exercise compliance and the effectiveness of the two programs.

METHODS

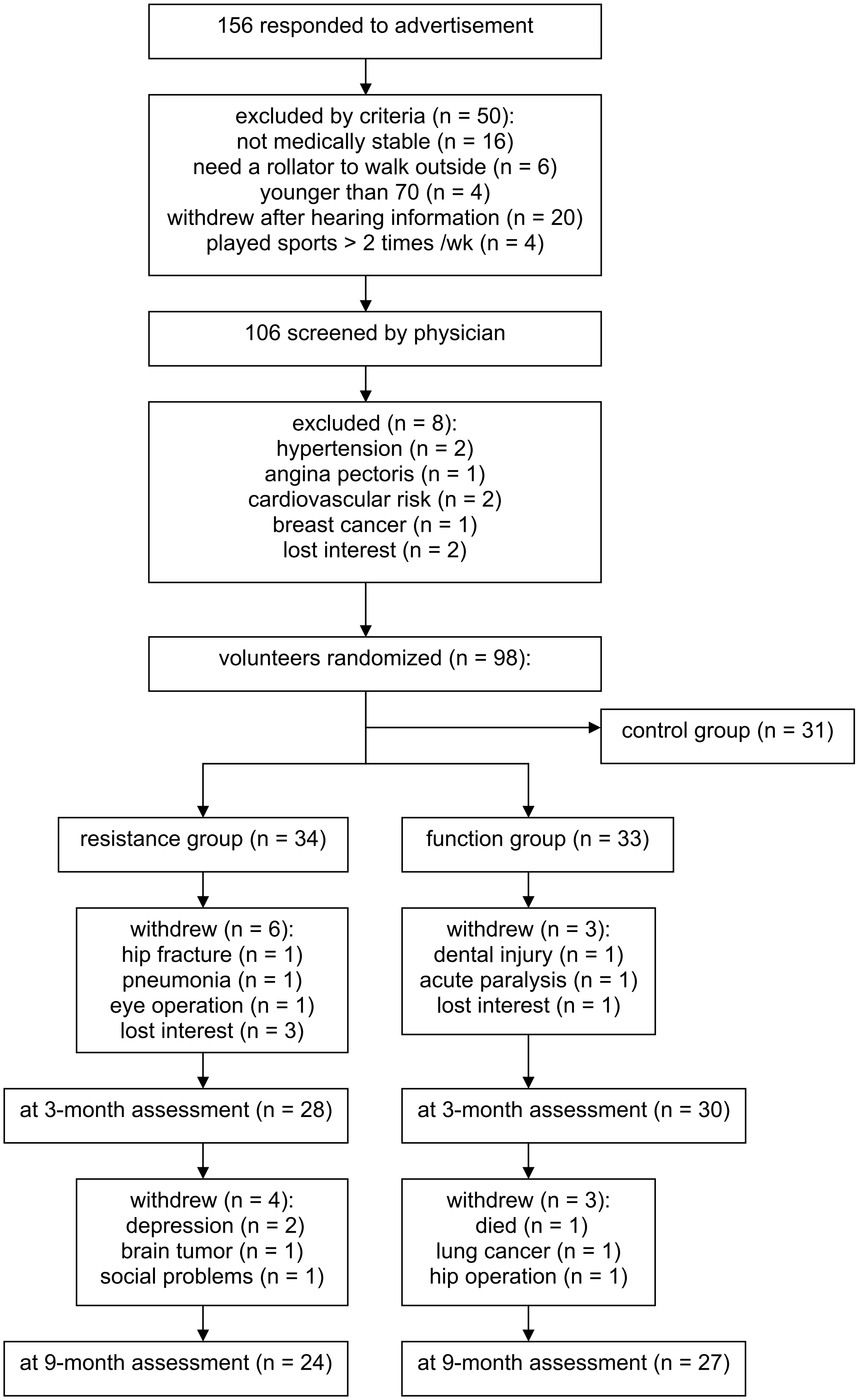
Design and participants

The present study was part of a single-blinded, randomized controlled trial, in which the effectiveness of progressive resistance exercise and functional tasks exercise programs was investigated in older, community-living women. The Medical Ethics Board of the University Medical Center Utrecht in the Netherlands approved the study. Ninety-eight women gave written informed consent and were allocated randomly by computer, using a random numbers table, to a functional tasks exercise program (function group, n = 33), a resistance exercise program (resistance group, n = 34), or a control group (n = 31). The data of the control group are not included in this article (Figure 1). Exclusion criteria included recent fractures; unstable cardiovascular or metabolic diseases; musculoskeletal condition or other chronic illnesses that might limit training or testing; severe airflow obstruction; recent depression or emotional distress; or loss of mobility for more than 1 week during the previous 2 months. Respondents who exercised at a sports club three times a week or more were also excluded. Potential participants were screened for medical history and underwent a physical examination. The flow of these subjects through the main trial is described elsewhere.[16] Data for 67 participants from both the function group and the resistance group were used in the present study.

Interventions

The exercise interventions had a social cognitive approach to changing behavior to maintain exercise participation. Social Cognitive Theory (SCT) postulates that self-efficacy, a person’s confidence in his/her ability to perform a certain behavior, and the expectation regarding the outcome resulting from performing that behavior, are important constructs of behavior motivation.[17] Research has demonstrated self-efficacy to be implicated in exercise adherence.[6] The exercise interventions of the present study incorporated the tenets of SCT: performance accomplishment; verbal persuasion or encouragement from others; social modeling or vicarious experiences; and physiological states or cues.[6,17,18]

Figure 1. Trial profile



The exercise programs were given three times a week in 1-hour sessions for 12 weeks at a local leisure center in the Utrecht region, with sessions separated by 1 day of rest. Group size varied from 6 to 12 participants per session for both exercise programs. Training sessions were supervised by at least two experienced instructors (physiotherapist and sports instructor). Exercise intensity in both exercise programs was set at 7 to 8 on a 10-point rated perceived exertion (RPE) scale (1 = very, very light; 10 = very, very hard).[19-21]

Functional tasks exercise program (FUNTEX)

The exercises of the functional tasks exercise program, FUNTEX program, are described elsewhere.[16,22] The aim of the 40-minute core exercises is to improve the ability to perform daily tasks in the domains first affected in older people,[5] namely, moving with a vertical component, moving with a horizontal component, carrying an object, and changing position between lying, sitting and standing. During each exercise class, participants performed tasks in at least two of these domains in three sessions of 5–10 repetitions. The 12-week program was divided into a practice phase (2 weeks), a variation phase (4 weeks), and a daily tasks phase (6 weeks). In a randomized controlled trial, the FUNTEX program improved the performance of daily tasks, as measured with the Assessment of Daily Activity Performance (ADAP) test.[16]

Resistance strength exercise program

The core resistance exercises were designed according to the American College of Sports Medicine recommendations for exercise and physical activity for older adults [21] and based on the exercises of the Fit For Your Life resistance training programme.[23] The aim of the exercises was to strengthen the muscle groups used to perform daily tasks: elbow flexors and extensors; shoulder abductors, adductors, and rotators; trunk flexors and extensors; hip flexors, extensors, abductors, and adductors; knee flexors and extensors; and ankle dorsal and plantar flexors. In a progressive resistance protocol, three to four muscle groups were trained in three sets of 10 repetitions. In a randomized controlled trial, this resistance exercise program improved the strength of the muscles of the arms and legs in older women.[16]

Measurements

Participants' satisfaction with the functional tasks exercise program and the resistance exercise program was determined with a 17-item questionnaire, based on a satisfaction questionnaire described elsewhere.[22] Given the second aim of this study was to investigate the impact of participants' satisfaction and initial health status on the effect of the two exercise programs on physical functioning, physical functioning was assessed with performance-based and self-reported measures. Performance-based measures included the Assessment of Daily Activity Performance (ADAP) test[16,22] and muscle function tests. Self-reported measures included the physical functional scale of the SF-36 Health Survey [24,25] and a physical activity questionnaire.[26] The ADAP test, muscle function tests, SF-36, physical activity questionnaires, and health status assessments were completed before randomization, at the end of the training period, and after 6 months, at the Mobility Laboratory of the Department of Geriatric Medicine at the University Medical Center Utrecht.

Exercise compliance

Attendance and adverse events were monitored by the instructors, by means of program diaries. Training compliance was defined as the number of exercise classes attended as a percentage of the total number of classes.

Participant satisfaction with the programs

Participant satisfaction was determined with a 17-item questionnaire that was completed anonymously.[22] Questionnaire items were selected on the basis of their importance for exercise compliance and adherence in older adults.[6] Participants were asked not to record their name on the questionnaire to keep the responses confidential. Information from participants was obtained regarding general satisfaction with the program, experienced intensity and pace of the exercises, location of exercise program, supervision during the exercises, motivation during the training period, and planned continuation of an exercise program. The motivation to attend classes during the first, second, and third months was asked retrospectively. Participants rated most items on a 5-point Likert-type scale ranging from "very bad" to "very good", except for the motivation item (4-point scale ranging from "very motivated" to "considered quitting"), the location accessibility item (3-point scale ranging from “not accessible” to “good accessibility”), and continuation of exercises (“yes” or “no”). In addition, the participants were asked to rate the exercise program on a scale from 1 to 10 (1 = very bad; 10 = excellent). All item scores were transformed to a range from 0 to 100, using the formula:

(actual raw score - lowest possible raw score) / possible raw score range x 100

Higher scores indicated greater satisfaction. To identify subscales a factor analysis was performed using a standard principal analysis and a varimax rotation procedure. Cronbach’s alpha was calculated to determine the internal consistency of the factors.

Performance-based physical function

Assessment of Daily Activity Performance (ADAP)

Physical functional performance was quantitatively assessed using the Assessment of Daily Activity Performance (ADAP) test.[16,22] This method allows the participant to perform at his or her maximal ability, by maximizing the weight carried and working at the fastest speed possible or reaching the greatest distance. The method is based on the Continuous-scale Physical Functional Performance (CS-PFP) test, a reliable, valid and sensitive test to measure changes in physical function.[27,28] The CS-PFP test was modified to account for the size of Dutch beds (190 cm x 200 cm; height 60 cm), height of the kitchen counter (114 cm), and height of the washing machine (88.5 cm). Vertical reach was replaced by the functional reach test.[29] Like the CS-PFP test, the ADAP test includes 16 common tasks, such as transferring laundry and boarding a bus, performed at maximal effort. A more detailed description of the ADAP test has been published elsewhere.[22]

Muscle function

Isometric knee extensor strength (IKES) was measured in both legs with a fixed strain gauge (AFG-Advanced Force Gauge, Mecmesin Inc, Santa Rosa, California, USA).[22,30,31] The highest score of five attempts was recorded in newtons (N). Isometric elbow flexor strength (IEFS) was measured in both arms with a hand-held dynamometer (microFET, Hoggan Health Industries, Draper, Utah, USA).[22,32,33] The highest score of three attempts was recorded in newtons (N).

Self-reported physical function

Self-reported physical function was assessed with the physical functioning scale and physical component summary score of the Dutch language version of the SF-36 Health Survey.[24,25] The SF-36 is a 36-item questionnaire designed to obtain a person's assessment of his or her physical functioning, well-being and general health. The physical component summary (PCS) score was calculated as described in the manual guide,[24] using the norm scores for Dutch people older than 70 years.[25] Scales were scored from 0 (poor health) to 100 (excellent health).[24] The Dutch language version SF-36 has proven to be practical, reliable, and valid,[25,34] and has been used extensively in exercise studies and in older people.[28,35-38]

Habitual physical activity was assessed with a questionnaire developed for older adults by Voorrips et al.[26] The questionnaire scores household activities, sporting activities, and other physically leisure-time activities, to generate a single activity score. Respondents were asked to report habitual physical activities. Household activities were scored from 'very active' to 'inactive' (4 or 5 ratings). Participants were asked about the type of activities, the hours per week spent on them, and the period of the year in which they usually undertook these activities. All activities were classified according to work posture and movements: intensity was based on the net energetic cost of activities. The questionnaire is reliable and valid for use in older people.[26]

Initial health status

Health status was assessed in two ways: 1) with the baseline Physical Component Summary score (PCS) of the Dutch language version of the SF-36 Health Survey [24,25]; 2) during the screening procedure, the physician administered the Specific Activity Scale (SAS) score, an ordinal scaled, 4-class physical functioning instrument (class 1 = highest level of physical functioning, class 4 = lowest level of physical functioning) based on the metabolic expenditures of various personal care, housework, occupational, and recreational activities (e.g., carrying heavy objects, mopping floors).[39,40]

Statistics

Statistical analyses were performed with SPSS software (SPSS Inc. SPSS reference guide. Chicago: SPSS Inc, 1990). To identify different subscales of the participants' satisfaction questionnaire, a factor analysis was performed using a standard principal analysis and a varimax rotation procedure. The results of the factor analysis were interpreted using both the Kaiser-Guttman rule and examination of the scree plots of eigenvalues. Subscales were identified when the factors had eigenvalues greater than 1.0 and by examining the scree plot. Factor scores were constructed by summing the respective scores for items with a factor loading greater than 0.50. Cronbach's alpha was calculated to determine the internal consistency of the factors.
Participants' satisfaction was compared for the two groups by non-parametric Kruskal-Wallis tests. Linear regression analysis was used to explore the impact of participants' satisfaction and health status on exercise compliance and effectiveness of the functional tasks exercise program and the resistance exercise program.

RESULTS

Participants and compliance

The baseline characteristics of the participants and the difference in effect between the functional tasks exercise program and the resistance exercise program are shown in Table 1. The methods and statistical procedures to determine the difference in effect between the two exercise interventions are published elsewhere.[16] Mean age was similar in the two groups. Between the baseline and 3-month assessments three participants in the function group and six in the resistance group withdrew. The reasons for withdrawal were loss of interest (four), dental injury after a fall at home (one), acute paralysis in a leg (one), hip fracture after a fall at home (one), pneumonia (one), and eye operation (one) (Figure 1). After the 9-month follow-up, three participants in the function group and two in the resistance group had dropped out because of death due to a brain tumor (one), hospitalization (lung cancer, one; brain tumor, one), hip operation (one), depression (two), and social problems (one). The baseline data for participants that withdrew did not differ from those for the participants who completed the study.

Table 1. Baseline characteristics and change at 3 months and 9 months in physical function measures

Characteristics	*Resistance group (n = 34)*	*Function group (n = 33)*
Age, mean ± SD	74.8 ± 4.0	74.7 ± 3.5
Marital status, %		
Married	50	36
Single	6	6
Widowed	44	58
Disease status, %		
Hypertension	28	33
Arthritis	28	23
Prosthetic hip/knee	13	20
Diabetes	0	3
Medication 3 or more	16	23
Osteoporosis	16	10
Height meters, mean ± SD	1.62 ± 0.08	1.63 ± 0.06
Weight kg, mean ± SD	70.7 ± 12.1	69.4 ± 9.0
Specific activity scale class, n (%)		
1	14 (41)	14 (42)
2	19 (56)	18 (55)
3	1 (3)	1 (3)
4	0	0
ADAP Total score, mean ± SD	45.7 ± 8.1	47.4 ± 9.9
Change at 3 month	3.2 ± 4.8	6.8 ± 4.3* †
Change at 9 month	3.0 ± 4.7	6.1 ± 5.0*
Isometric knee extensor strength, N mean ± SD	282.5 ± 90.5	307.3 ± 79.5
Change at 3 month	23.7 ± 30.1* †	-7.0 ± 25.2
Change at 9 month	0.4 ± 42.1	-10.7 ± 20.6
Isometric elbow flexor strength, N mean ± SD	158.6 ± 34.6	166.2 ± 29.1
Change at 3 month	10.6 ± 16.0 †	-1.0 ± 17.4
Change at 9 month	4.8 ± 27.5	4.3 ± 23.5
SF-36 Health Survey		
Physical Functioning, mean ± SD	72.9 ± 18.0	82.7 ± 15.6

Change at 3 month	7.7 ± 12.4* †	0.2 ± 8.1
Change at 9 month	-7.0 ± 15.2	-10.8 ± 19.3*
Physical Component Summary, mean ± SD	47.9 ± 8.3	51.8 ± 7.3
Change at 3 month	2.1 ± 7.1	-1.1 ± 4.6
Change at 9 month	-2.3 ± 8.7	-3.7 ± 7.7*
Physical activity, mean ± SD	12.8 ± 7.3	14.6 ± 5.6
Change at 3 month	1.3 ± 7.4	-1.3 ± 5.8
Change at 9 month	-3.7 ± 8.1	0.9 ± 6.1†

Note: SD, standard deviation; N, newtons; ADAP, assessment of daily activity performance. Analysis of variance with Bonferroni correction *P* < .05 * compared to control group, † function group compared to resistance group.

Training compliance, expressed as the proportion of exercise classes attended relative to the total number of classes, was 90 ± 9.1% (range, 66% to 100%) in the function group and 90 ± 8.1% (range, 71% to 100%) in the resistance group. The compliance rate in the function group did not influence the change in performance-based and self-reported measures. In the resistance group, the participants with a high compliance increased more on the ADAP tests at 3 months (correlation coefficient [CC] = .44; R^2 = .19), but decreased more in IKES scores at 9 months (CC = -.49; R^2 = .24).

Participants' satisfaction with the exercise programs

Table 2 presents the results of the factor analysis to identify subscales of the 17-item participants' satisfaction questionnaire. The principal component analysis identified 4 factors, which accounted for 53.3% of the total variance. The items loading on the first factor (general satisfaction with exercise program) included evaluation of the supervision provided during the exercises, general opinion of the program, motivation of the participants during the second and third months, overall grade of the exercise program, and general organization of the program. The items loading on the second factor (intensity of core exercises) included pace of the exercises, whether or not the participant wanted to continue with the exercises, and intensity of the overall program. The items loading on the third factor included the intensity of exercises during the warm-up and cool-down periods.

Table 2. Factor analysis satisfaction questionnaire

	Factor 1	*Factor 2*	*Factor 3*	*Factor 4*
Eigenvalue	3.088	2.608	1.958	1.411
% Variance	16.046	14.844	11.283	11.150
Cumulative %	16.046	30.889	42.173	53.322
Cronbach's alpha	.73	.70	.67	.65
Items				
Supervision	**.761**	.167	.187	.121
Overall judgement	**.682**	-.341	-.012	.136
Motivation month 1	.477	.168	.107	-.174
Motivation month 2	**.658**	.093	-.409	-.283
Motivation month 3	**.622**	.236	-.381	.021
Overall grade	**.569**	-.197	-.024	.125
Organization	**.559**	-.202	-.065	.435
Pace exercises	.063	**.787**	.040	-.089
Continue exercise?	-.039	**.685**	.042	.201
Overall intensity	-.022	**.574**	.426	-.188
Duration program	.010	-.445	-.049	.037
Intensity warm-up	-.007	.025	**.785**	.018
Intensity cool-down	.025	.075	**.706**	-.114
Intensity core exercises	-.093	.337	.433	-.360
Location	-.154	-.045	-.049	**.762**
Accessibility location	.200	.169	-.055	**.693**
Travel time	.064	.408	-.242	**.663**

Scores >.50 are printed bold

Items had a significantly higher correlation with their own scale than with competing scales, which supports the discriminant validity of the items. Cronbach's alpha for the 4 factors ranged from .65 (Factor 4) to .73 (Factor 1), which supports the internal consistency of the items.

Table 3 shows that the participants' satisfaction was high and similar for both exercise programs. According to the satisfaction questionnaire, most participants wanted to continue exercising (function group 93%; resistance group 89%), and the perceived intensity of the core exercises was higher in the function group than in the resistance group (*P* = .05). Regression analysis demonstrated that participants of the functional tasks exercise group with a high health status (as measured with the SAS questionnaire) had relatively low satisfaction scores (CC = -.48; R^2 = .23), whereas no such association was found in the resistance group.

Table 3. Participant satisfaction with the exercise programs

Satisfaction Scales	*Function group (n = 30)*	*Resistance group (n = 28)*	*P-value*
Total score, mean ± SD	84.8 ± 6.3	87.6 ± 6.9	.06
(95% Confidence Interval)	(82.5 – 87.2)	(84.9 – 90.3)	
General satisfaction	85.5 ± 10.3	84.3 ± 10.3	.77
	(81.7 – 89.4)	(80.3 – 88.3)	
Core exercises	85.8 ± 20.2	90.5 ± 17.8	.18
	(78.3 – 93.4)	(83.6 – 97.4)	
Warm-up / Cool-down	80.0 ± 22.2	89.3 ± 17.3	.10
	(71.7 – 88.3)	(82.6 – 96.0)	
Exercise location	87.1 ± 11.4	81.5 ± 17.7	.23
	(82.8 – 91.3)	(74.5 – 88.5)	

Note: SD, standard deviation

Association between participants' satisfaction and exercise effect.

For both exercise programs, participants' satisfaction with the exercises was not associated with the compliance to the programs. The associations between participants' satisfaction and the effect of the exercise programs on physical function are presented in Table 4.

In the function group, satisfaction with the functional tasks exercise program was not associated with change in performance-based physical functioning measures, except for change in IEFS. Participants who reported a high satisfaction with the functional tasks program had a greater increase in IEFS score at 3 months (CC = .36; R^2 = .13) and maintained higher IEFS scores (CC = .44; R^2 = .19) at 9 months. A high satisfaction with the functional tasks exercise program was also associated with improved self-reported physical functioning, as measured with the SF-36. Also, satisfied participants of the function group had higher self-reported habitual physical activity scores (CC = .46; R^2 = .21) at 9 months.

In the resistance group, satisfaction with the resistance program was not associated with change in performance-based physical functioning or change in self-reported physical functioning.

Association between participants' initial health-status and exercise effect*.*

For both exercise programs, the health status of the participants did not influence compliance with the programs. In the function group, the initial health status of the participants was not associated with change in performance-based physical function (Table 4). A low baseline SAS score in the function group was associated with an increased SF-36 Physical Component Summary score (CC = -.38; R^2 = .14) at 3 months, an increased SF-36 Physical Functioning score (CC = -.41; R^2 = .17) at 9 months, and a positive change in habitual physical activity score (CC = -.57; R^2 = .33) at 9 months.

In the resistance group, a low baseline SF-36 PCS score was associated with an increased performance-based physical functioning score at 3 months (CC = -.47; R^2 = .22) and a positive change in performance-based physical functioning score at 9 months (CC = -.63; R^2 = .40). A low initial SF-36 PCS score was also associated with an increase in self-reported SF-36 PCS (CC = -.34; R^2 = .12) at 3 months and with a positive change in SF-36 PCS (CC = -.42; R^2 = .17) at 9 months. A low baseline SAS score in the resistance group was associated with a positive change in habitual physical activity score (CC = -.43; R^2 = .18) at 9 months.

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Table 4. Association between participant satisfaction, baseline health status and performance-based physical functioning and self-reported physical functioning

Measure	*Function group*			*Resistance group*		
	Satisfaction	Health status (SF36 PCS)	Health status (SAS)	Satisfaction	Health status (SF36 PCS)	Health status (SAS)
Performance-based Physical functioning						
Assessment of daily activity performance						
Total 3 month	-.002 (.50)	.079 (.34)	-.179 (.17)	.227 (.13)	-.472 (.006)	-.031 (.44)
Total 9 month	.044 (.42)	-.100 (.33)	.069 (.38)	-.215 (.17)	-.632 (.001)	-.016 (.47)
Isometric knee extensor strength 3 month	-.071 (.36)	.101 (.30)	.098 (.30)	-.286 (.08)	-.258 (.10)	.098 (.31)
Isometric knee extensor strength 9 month	.244 (.14)	-.147 (.26)	.123 (.29)	-.570 (.003)	-.025 (.46)	-.308 (.08)
Isometric elbow flexor strength 3 month	.362 (.03)	.162 (.20)	-.190 (.16)	-.078 (.35)	-.180 (.19)	.122 (.27)
Isometric elbow flexor strength 9 month	.445 (.02)	.269 (.10)	-.244 (.13)	-.073 (.37)	.010 (.48)	-.028 (.45)
Self-reported Physical functioning						
SF-36 Health Survey						
Physical functioning 3 month	.313 (.05)	-.090 (.32)	-.181 (.17)	.257 (.10)	.153 (.22)	.087 (.33)
Physical functioning 9 month	.039 (.42)	-.087 (.34)	-.410 (.02)	.026 (.45)	-.146 (.25)	-.322 (.07)
Physical component summary 3 month	.344 (.03)	-.125 (.26)	-.376 (.02)	.082 (.34)	-.340 (.04)	-.122 (.27)
Physical component summary 9 month	-.093 (.32)	-.264 (.09)	-.161 (.21)	-.240 (.14)	-.064 (.39)	-.138 (.27)
Physical activity						
Total score 3 month	.260 (.09)	.376 (.02)	-.063 (.37)	.036 (.43)	-.100 (.31)	-.076 (.35)
Total score 9 month	.463 (.01)	.358 (.03)	-.445 (.01)	.052 (.41)	.033 (.44)	-.426 (.02)

Note: Values are linear regression correlation coefficients (*P*-values).

DISCUSSION

Previously, we reported that functional tasks exercises were more effective than resistance exercises in improving the performance of daily tasks, and that the effects of functional tasks exercises were preserved for longer than the gain in strength achieved with resistance exercises.[16] In the present study we investigated whether these two exercise programs also differed from the participants' perspective and whether the initial health status of the participants could predict compliance with and the effectiveness of the two programs.

Both the functional tasks exercises and the resistance exercises were well accepted and highly appreciated by older, community-dwelling women. Satisfaction with the exercise programs did not differ between the exercise programs and was not associated with the compliance with the exercise programs. Participants who were highly satisfied with the functional tasks exercises reported an improved physical functioning and had higher habitual physical activity scores 6 months after completion of the exercise program. A low initial health status was associated with improved self-reported physical functioning in both exercise groups and with improved performance-based physical functioning in the resistance exercise group.

The high compliance rates found in the present study are not consistent with those reported in other exercise studies involving older adults.[6-8] The high compliance was consistent with the high scores on the satisfaction questionnaire. Other studies reported the attitude towards exercise and the enjoyment of participants to be motivational factors in maintaining participation in an exercise programme.[6,12-15] Several review studies suggest a high exercise adherence rate among older adults when interventions are based on behavioral theories, such as the social cognitive theory, the transtheoretical model and the theory of planned behaviour.[6,10-12] These theories and the findings of other researchers [15,41,42] emphasize the importance of psychosocial factors, such as class cohesion, joint participation with friends or a partner, to continued exercise participation, especially in older women.[6] The exercise programs used in our study incorporated several psychosocial aspects, which may have contributed to the high attendance and the high participant satisfaction. First, the exercises were given in classes, which increases social support.[41] Second, contact between participants was stimulated by the opportunity to have a social drink after each session and by the introduction of training pairs (dyad training), which emphasizes interaction and enjoyment.[43] Third, participants were called at home if they repeatedly did not come to the session. Fourth, participants registered their performance in a personal file, which provided feedback about their progress. Knowledge about exercises is associated with participation and adherence to exercise programs among older adults.[6]

The importance of a person's attitude towards and enjoyment of the exercises is consistent with our observation of a high satisfaction with the functional tasks exercise program and with the intention to continue exercising after completion of the program. The effects of functional tasks exercises lasted longer than the gain in strength achieved with resistance exercises, as we reported previously.[16] We showed (unpublished results de Vreede et al, 2004) that habitual physical activity was also sustained for longer in the function group than in the resistance group. Functional tasks exercise programs, mimicking daily activities, seem to influence daily habits more than do resistance training programs. In both exercise groups, a low baseline health status was associated with improved habitual physical activity after completion of the 12-week exercise intervention. Older people with a low health status might spend less time on physical activity and are more likely to benefit from stimulation to maintain regular physical activity [6,13] They may be more motivated to continue to be physically active than the participants with a higher health status. However, several other studies found a low health status to be a barrier to taking up and continuing exercise and to be a predictor of decreased physical activity.[6,12-15,44] The incorporation of psychosocial factors in the exercise programs probably contributed to the high compliance among the less healthy participants. Further, exercise intensity and complexity were adjusted to the individual's health status, which might have contributed to a higher attendance among the less healthy participants. The participants with a low initial health status also showed a greater improvement in performance-based and self-reported physical functioning. Less healthy participants may have a greater therapeutic window and may derive more benefit from the intervention. This is in agreement with the observations of other researchers.[45-47]

The present study had some limitations. The participants were in a moderate-to-good health, as measured by the ADAP test and IKES, and results suggest that less healthy participants may benefit more from exercise interventions. The apparently high participant satisfaction with the programs has to be considered with caution because the data were collected retrospectively, which may have introduced bias.

However, the high compliance and adherence found in our study makes it plausible that satisfaction was truly high and not biased. Participants who are not satisfied with the program would probably not complete a time-consuming intensive exercise programme.[42] The generalizability of the results should be handled with caution, because compliance and satisfaction were studied within a trial setting, and investigators encouraged the participants, to prevent drop-out, which may have increased compliance and satisfaction.

In conclusion, the functional tasks exercise program and the resistance exercise program, which incorporate the tenets of social cognitive theory, appear to be well accepted and appreciated by older, community-dwelling women. As reported earlier, functional tasks exercises are more effective than resistance exercises in improving the performance of daily tasks. Mimicking daily activities in an exercise setting may effect a change in daily habits more than resistance training does, enabling older people to sustain the effects of exercises, especially when participants are satisfied with the exercises. Less healthy, older participants may benefit more from an exercise intervention than their healthier counterparts. The results of the present study improve our understanding of exercise-related behavior in older populations. A greater emphasis on satisfaction and enjoyment will make older adults more likely to either adapt or continue a regular exercise regimen. More research is needed to understand the factors influencing older adults' compliance and continuation of exercise interventions.

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Chapter 7

General discussion

7.1 GENERAL DISCUSSION

The aim of the studies described in this thesis was to examine differences in effect between functional tasks exercise and resistance strength exercise on the physical function and quality of life of older community-dwelling women. In this last chapter, the main conclusions of the thesis are discussed. The main results are first evaluated and compared with the results of recent studies, and the possible mechanisms underlying the exercise effects are discussed. Secondly, methodological considerations are addressed. Thirdly, the answers to the research questions presented in the foregoing chapters are critically reviewed. Finally, implications for clinical practice and recommendations for future research are considered, followed by the overall conclusions.

7.2 MAIN RESULTS

7.2.1 Assessment of Daily Activity Performance

Chapter 3 describes the development of the quantitative Assessment of Daily Activity Performance (ADAP) test. This test was based on the Continuous-scale Physical Functional Performance (CS-PFP) test and allows the participant to perform at maximal capacity by maximizing the weight carried and working at the fastest speed possible or reaching the greatest distance. Like the CS-PFP test, the ADAP includes 16 common tasks, such as transferring laundry and boarding a bus, performed at maximal effort. The Assessment of Daily Activity Performance (ADAP) proved to be a reliable and valid instrument for measuring the performance of daily activities by community-dwelling older women, provided an experienced tester administered the test (*Chapter 3*).

Functional tasks exercises improved the ADAP total and subscales scores of healthy, community-living older women, whereas resistance strength exercises did not. The participants of the functional tasks exercise programme increased their total ADAP score by 6.8 units (14%), with an effect size of 1.25, and this improvement was still present 6 months after completion of the exercise programme (*Chapter 4*). Functional tasks exercises may positively influence daily habits more than resistance training does, thereby enabling older people to sustain a higher level of physical activity and the benefits thereof. Cress and colleagues expressed a similar change on the CS-PFP test as the capacity to carry 14% more weight, while moving 10% more quickly.[1]

In a recent review, Barry and Carson concluded that resistance training improved both strength and power in older adults; however, resistance training-induced adaptations were not sustained beyond the training period.[2] In another review by Latham et al, resistance training alone did not have an effect on physical disability. The authors suggested that resistance training should be combined with other forms of exercise.[3] The findings of the present study support the evidence to incorporate task-specific functional exercises in the intervention programmes to improve physical functional performance of older adults.

7.2.2 Timed Up and Go test

The Timed Up and Go (TUG) test was used to assess functional mobility. Neither functional tasks exercises nor resistance strength exercises affected the TUG scores. Nine months after baseline measurements, the control group took 0.6 seconds longer to complete the TUG test. Ceiling effects may affect these results. In a cross-sectional study of 413 community-dwelling and 78 institutionalised older women, Bischoff and colleagues[4] identified completion of the TUG test within 12 seconds as the cut-off point for normal mobility. The mean baseline TUG score in our study was 5.2 ± 1.0 seconds (range, 3.2 seconds – 8.9 seconds), indicating good mobility and suggesting a ceiling effect, which may have affected the results. Recently, Latham et al affirmed in a Cochrane review that resistance strength training had little or no effect on TUG test performance.[5]

7.2.3. Muscle strength

Isometric knee extensor strength (IKES), isometric elbow flexor strength (IEFS), and handgrip strength (HGS) were measured, to provide information about the strength of the major muscle groups of the legs, arms and hands. Twelve weeks of resistance strength training improved IKES and IEFS in older, community-dwelling women, whereas functional tasks exercise had no effect on muscle strength. This finding is consistent with the principles of training specificity. According to this principle, the nature of the stimulus determines the nature of the physical change. Neither exercise programme had an effect on the HGS, probably because the hand muscles were not directly trained. This might be considered as a shortcoming of the programmes, because many older people suffer from an impaired hand function. Six months after the exercise period, the gain in exercise-induced muscle strength in the resistance group was lost (*Chapter 4*), which is consistent with the principle of training reversibility, by which the effects of training regress after completion of the training.

The increase in IKES and IEFS immediately after completion of the resistance exercise training is consistent with earlier results obtained with comparable resistance exercise programmes.[3,6,7] In a recent review, Hunter et al reported that there was sufficient evidence for a beneficial effect of strength training on older adults' muscle mass, strength and power.[8] Although the authors did not find consensus about an optimal training programme, Hunter and colleagues recommended a loading intensity of about 60-80% of 1-repetition maximum (1RM), with a volume ranging from 2-4 sets of 8-15 repetitions per exercise, to improve muscle strength. Resistance strength exercise seems appropriate for improving muscle strength of older adults.

7.2.4. Muscle power

Explosive leg extension power (LEP) was measured with the Nottingham power rig.[9] Functional tasks exercises as well as resistance strength exercises increased LEP directly after the 3-month exercise period. The increased LEP scores were sustained for 6 months after completion of the exercise programmes. The increase in LEP in the function group was unexpected because IKES did not change in this group. LEP seems to be affected by neuromuscular events, rather than by isometric strength. In our opinion muscle power is a better functional measure than muscle strength. This idea is supported by the findings of other researchers.[10,11] Several investigators proposed power training is to be preferred to resistance strength training for improving physical function.[8,10] In future research it would be of interest to compare the effects of functional tasks exercises with power training.

7.2.5. Health-related quality of life

Health-related quality of life (HRQOL) was assessed with the Dutch language version of the SF-36 Health Survey,[12,13] a frequently used HRQOL instrument. At the end of the 3-month intervention, no exercise effect on HRQOL was found, except for an increase in the SF-36 Physical Functioning score in the resistance group (*Chapter 5*).

Several studies have reported a limited effect of exercise on HRQOL in healthy older adults.[3,14] The high baseline SF-36 scores of the participants in the present study make the results more vulnerable to ceiling effects, which could explain the lack of change after completion of the 3-month intervention. This is in agreement with the findings of others, who also observed a ceiling effect in a healthy population.[1,15-17] In their review, Spirduso and Cronin concluded that there was a weak evidence for an effect of exercise on well-being and quality of life.[18] In a Cochrane review Latham et al found no effect of resistance strength training on HRQOL in older people.[5]
Remarkably, in our study, the participants of both exercise groups had lower HRQOL scores, some even lower than at baseline, 6 months after completion of the exercise programmes, whereas the control group still had a high score (*Chapter 5*). This suggests that participants' internal standard and self-evaluation had changed at the end of the intervention period, as a result of their experiences during the exercise programme. This phenomenon is known as 'response shift'.[19] After completion of the exercise programmes, the participants may have missed the social and physical benefits of the programme. These findings are consistent with the idea that self-reported HRQOL is a dynamic concept and subject to changes in internal standards, values or conceptualisation, resulting in a 'response shift'.

7.2.6. Habitual physical activity

Habitual physical activity was assessed with a questionnaire developed for older adults by Voorrips et al.[20] After completion of the exercise programmes, neither group had changed their habitual physical activity (*Chapter 5*). These results are consistent with those of Drewnowski and colleagues,[21] who explained the absence of an effect on physical activity as being due to a decrease in spontaneous physical activity to compensate for exercise training. In our study, physical activity 6 months after completion of the exercise programme was diminished in the resistance group but sustained in the function group (*Chapter 5*). Participants of the function group who reported high satisfaction with the exercises were more likely to have greater increases in habitual physical activity scores 6 months after completion of the exercise programme (*Chapter 6*). These findings indicate a positive change in daily habits after a functional tasks exercise programme, which mimics daily activities, whereas resistance training has no effect. The improvement of habitual physical activity together with the increased ADAP scores in the function group 6 months after the exercise period suggests a change in a trigger mechanism: The increase in physical capacity at the end of the training period may have enabled people to be more physically active and triggered the mechanism to maintain this regained capacity.

7.2.7. Participant satisfaction

An 18-item questionnaire was developed to assess participants' satisfaction with the exercise programmes. A factor analysis identified four subscales: 1) evaluation of the total programme, 2) evaluation of the core exercises of the programme, 3) evaluation of the warm-up and cool-down periods, and 4) evaluation of the exercise location (*Chapter 6*).

The participants of both exercise groups reported a high satisfaction with the programmes. In the function group, this high satisfaction was associated with a positive change in self-reported physical functioning and habitual physical activity 6 months after completion of the programme (*Chapter 6*). In the feasibility study (*Chapter 2*), the resistance exercise programme had a higher participant acceptation than the functional tasks programme, probably because the functional tasks exercises did not meet participants' expectations. As a consequence of the feasibility study, we changed the information on the functional tasks exercises prior to the start of the programme and during the practice phase to increase participants' knowledge and understanding of the programme. This might explain the equally high satisfaction with the two programmes. Information about and understanding of an exercise programme are important motivational factors.[22,23]

Besides knowledge about the programme and the exercises, we incorporated psychosocial aspects, such as social support, interaction between participants, feedback about exercise progress and emphasis on enjoyment, which may have contributed to the high satisfaction reported by both groups. Several researchers mention that class cohesion is important for continued participation by older adults.[24,25] Recently, Stiggelbout and colleagues [26] found the perceived quality of an exercise programme and the baseline attitude to be predictors of continued exercise participation. To encourage continued participation in organised exercise programmes for older adults, we suggest an active promotion of a positive attitude towards exercise at baseline and to evaluate and eventually adjust the programme, by means of a participant satisfaction questionnaire.

7.3 POTENTIAL MECHANISM

The main finding of the present study is that functional tasks exercises are better than resistance exercises in improving the performance of daily tasks by healthy, community-living older women. Moreover, this improvement lasts longer than the gain in muscle strength achieved with resistance exercises (*Chapter 4*). Which mechanism is responsible for the observed differences between functional tasks exercises and resistance strength exercises? And why does resistance strength training fail to improve the functional performance of older, community-dwelling adults? To get a desired physiological effect, a training programme must be consistent with the principles of training: individuality; overload; reversibility and specificity.[27]

Individuality: A general training programme is likely to be unsuitable for some group members, because the physical abilities of these individuals may differ considerably. Ideally, a training programme should be tailored to an individual's physical status and requirements.

Overload: The overload principle indicates that the intensity of exercises should be just above the 'normal' capacity in order to facilitate physiological adaptations to training, such as neural recruitment or muscle hypertrophy. To gain maximum benefit from training, the workload should gradually be adjusted upwards as adaptations occur.

Reversibility: Reversibility means the loss of adaptations after training. Some effects of training regress more rapidly than others.

Specificity: Specificity concerns metabolic and physiological adaptations, depending on the type of overload imposed on the system, i.e. the predominant energy system or the movement pattern and specific muscle groups exercised. Adaptations to exercise training are specific to the manner and mode of exercises used during training. Specificity indicates specific adaptations of a training programme to the physiological level required at a particular time.

Training programmes for older adults are usually consistent with the overload and reversibility principles. However, none of the studies reported in the literature described exercise programmes for community-dwelling, older adults that followed the principles of individuality and specificity. The consistency of the functional tasks exercises in our study with all the principles of training might explain why this programme was successful in improving the functional performance, unlike the resistance strength exercises. In rehabilitation medicine and sports science, exercise training with an individual, tailored approach has proven beneficial.[27-30] The work of Jette and Keysor [31] supports our suggestion regarding the lack of consistency with the principle of specificity. Another reason for the lack of effect of resistance strength exercises could be a limitation of neural plasticity in older adults. Recently, Barry and Carson proposed neural adaptation to be the main mechanism to enhance muscle strength and power.[2] Progressive degradation of the neuromuscular system, in particular degeneration of spinal motor neurons, loss of corticospinal fibres, and cerebellar degeneration, will influence the capacity for neural adaptation in response to resistance training in older adults. If limitations of neural adaptation restrict the response to resistance training in older adults, then there will be a restricted transfer to functional movement tasks.[2]

7.4 METHODOLOGICAL CONSIDERATIONS

Randomised controlled trials (RCTs) of non-pharmacological interventions, such as exercise studies, include several components, e.g. psychosocial, cognitive and physiological components, and are often individualised (interaction, intensity, effort of participant). As a consequence, the quality of non-pharmacological RCTs is often lower than that of pharmacological RCTs.[32] Therefore, the methodological quality of non-pharmacological studies should be critically evaluated. This section addresses the internal and external validity of the RCT presented in this thesis, to determine whether the effects of the exercise interventions are accurately portrayed and whether results can be generalised.

7.4.1 Internal validity

Internal validity is the degree to which a study establishes the cause-and-effect relationship between treatment and observed outcome. The central issue in demonstrating internal validity and establishing the effects of treatment is to ensure equality between the groups to be compared for all relevant variables, except the independent treatment variable. Specific threats to establishing a cause-and-effect relationship are associated with research design and how the study procedures are executed.[33]

7.4.1.1 Study design

The primary aim of the study, to determine differences in effect between functional tasks exercise and resistance strength exercise on the physical functional performance measures and self-reported HRQOL of older community-dwelling women, was addressed in a randomised, controlled, single-blind trial *(Chapters 4 and 5)*. RCTs are accepted as a reliable method for determining the effectiveness of a specific intervention.[32,34] The RCT uses random assignment to control and treatment groups, thereby avoiding selection bias. The participants included in our study were randomly assigned to the functional tasks exercise programme (the function group), the resistance exercise programme (the resistance group) or the control group. The exercise programmes were followed three times a week in 1-hour with sessions separated by 1 day of rest. The programmes were held at a local leisure centre in the Utrecht region for three periods of 12 weeks. The control group was run concurrently with the exercise groups.

Part of the internal validity of a study depends on the drop-out rate, which should be similar for all groups investigated. During the intervention period, 14% of the included participants withdrew from the study (resistance group 18%; function group 9%; control group 16%). Six months after completion of the intervention, 25% of the included participants had withdrawn (resistance group 29%; function group 18%; control group 26%). Although the function group seemed to have a lower attrition rate than the resistance group and the control group, the attrition did not lead to a change in group composition and baseline data of the drop-outs and the participants who completed the study were not different.

7.4.1.2 Study procedures

The lower quality of published non-pharmacological RCTs compared with pharmacological RCTs is also influenced by a poor implementation of study procedures.[32] Schulz and colleagues[35,36] reported that the effects of treatment are 30% greater in studies with inadequate allocation concealment than in studies with adequate concealment. Similar results have been reported in studies lacking appropriate blinding. Less bias is attributed to drop-outs.[33] This paragraph addresses the implementation of several study procedures, to determine internal validity of the study.

7.4.1.2.1 Randomisation

Randomisation is a method to set up study groups, that are equivalent with respect to known and unknown variables. The randomisation procedure should not introduce bias. In the present study, random assignment was carried out by computer, using a random numbers table.

7.4.1.2.2 Allocation

Allocation concealment is essential to prevent foreknowledge of group assignment and prevents bias during the process of determining participant eligibility and assignment. Concealment in the present study was achieved by having the randomisation process administered by someone who was not responsible for recruiting participants and was carried out by computer using a random numbers table.[33-36]

7.4.1.2.3 Blinding

Ascertainment bias (systematic differences in outcome assessment) and performance bias (systematic differences in care provided apart from the intervention being evaluated) can occur when a study is not blinded.[37] Blinding participants and care providers is usually problematic in exercise studies, because participants are taking part in the intervention and know what treatment they have. For this reason, it is important to try to blind outcome assessors.

In line with the revised CONSORT (Consolidated Standards Of Reporting Trials) statements, with recommendations about reporting ‘how the success of blinding was evaluated’, we evaluated the success of blinding of the outcome assessor of the present study (chapter 4). This is not straightforward because participants easily reveal the intervention type they followed.[38] At the beginning of the assessments of the present study, we specifically instructed participants not to discuss the type of exercise programme they had followed with the person who collected the data. Although 18% of the participants did reveal which type of programme they followed, the data collector guessed the intervention correctly in only 37% of the cases, as opposed to 33% expected by chance, indicating successful blinding of the data

collector. Moreover, the effects of exercise are often assessed with self-reported questionnaires, and if participants cannot be blinded, conscious or unconscious prejudice may influence this type of measurement.[32]
Exercise trainers are an integral part of the exercise intervention and the success of the intervention may depend on the trainers' skills, experience, and enthusiasm.[32,40] To minimise performance bias, we used the same trainers for both exercise programmes. Further, we carefully instructed the trainers to follow the exercise protocols regarding the level of attention and encouragement given to participants.

7.4.1.2.4 Control group

It is often technically difficult to make a control intervention that is indistinguishable from the exercise intervention. Several exercise studies have used as control group participants who followed a non-physical activity programme, to ensure that the participants in the control group received the same amount of attention as the participants in the exercise group.[10,41-44] However, it is difficult to ensure that exercise and control groups receive a similar amount of attention. In the present study the control did not receive additional attention, other than the scheduled physical assessments and subsequent health screening reports, because we wanted to compare the exercise programmes with a "pragmatic right" control group that mimicked a real life situation. Control group participants were asked to maintain their normal pattern of activities during the 3-month intervention period. Recently, Latham et al observed no differences in the measured effects of resistance exercises with or without an attention control group.[3] Also, health screening of older adults alone does not produce any effect on physical functional outcomes and health-status outcomes.[45,46] Control group participants of the present study also did not change in primary outcomes at the end of the intervention period.

7.4.1.2.5 Compliance with the protocol

Compliance was defined as the number of exercise classes attended, expressed as a percentage of the total number of classes. Illness, limited mobility, and reluctance to leave home are limiting factors in the exercise compliance of older individuals.[23,47,48,49] The compliance rate reported in other exercise studies with older adults ranges from poor (43%) to high (100%).[23] The compliance rate in the present study was 90% ± 9.1 (range 66 to 100%) in the function group and 90% ± 8.1 (range

71 to 100%) in the resistance group. The exercise programmes used in the present study incorporated several psychosocial aspects, to stimulate participant attendance and satisfaction. Firstly, exercise was given in classes, which increases social support.[24] Secondly, contact between participants was stimulated by the opportunity to have a drink after each session and by training in pairs (dyad training) with emphasis on interaction and enjoyment.[50] Thirdly, participants were called at home if they repeatedly did not come to the session. Fourthly, participants registered their exercise performance in a personal file, to provide feedback about their progress.[23]

Exercise interventions incorporating psychosocial aspects based on behavioural theories, such as social cognitive theory (SCT), the transtheoretical model (TM), and theory of planned behaviour (TPB), have a higher compliance rate among older adults than programmes not incorporating these psychosocial aspects.[23] The theories and findings of other researchers [24,25,51] emphasize the importance of psychosocial factors, such as class cohesion, joint participation with friends or a partner in exercise class participation, especially in older women.[23]

7.4.1.2.6 Drop-outs

Although participants were encouraged to arrange their own transportation to the leisure centre, free transportation was provided if needed. To keep them interested, participants were sent a monthly newsletter with updates on the study's progress and health topics. The drop-out rate of 14% during the intervention period was comparable to that reported in other exercise studies involving older community-living individuals.[7,26,52] Exercise interventions in older persons have a drop-out rate of 6% to 34%, with the highest number of drop-outs occurring in the first 3 months.[47,53-58]

Reasons for drop-out in the present study included illness and loss of interest. The drop-outs of the control group were more likely to withdraw because of a loss of interest. This is a common problem with intervention trials in older people in whom the control group cannot be blinded.[42,47] Older persons often enrol to improve their functioning or slow its deterioration and may be disappointed if they are assigned to a control group, which may result in drop-out. Tables 1 and 2 show the composition of the groups and the baseline scores of the drop-outs. People dropping out did not affect the composition of the groups and drop-outs did not differ between the groups. It is acceptable to exclude influence of the drop-out on the results of the rest of the groups.

Table 1. Comparison of baseline values of all participants, the participants who completed the 3-month measurements, and the participants who completed the 9-month measurements.

	Control group				*Resistance group*				*Function group*						
Measure	*Total (n = 31)*	*3 months (n = 26)*	*9 months (n = 23)*	*P*-value*	*Total (n = 34)*	*3 months (n = 28)*	*9 months (n = 24)*	*P*-value*	*Total (n = 33)*	*3 months (n = 30)*	*9 months (n = 27)*	*P*-value*	*P†-value*	*P‡-value*	*P#-value*
Age	73.0 ± 3.2	73.0 ± 3.4	72.9 ± 3.6	.99	74.8 ± 4.0	74.9 ± 4.0	75.1 ± 4.1	.96	74.7 ± 3.5	74.4 ± 3.4	74.1 ± 3.2	.80	.10	.16	.13
ADAP total	47.7 ± 9.0	48.7 ± 8.3	48.9 ± 8.6	.85	45.9 ± 7.8	45.1 ±7.3	45.4 ±7.5	.92	47.4 ± 9.8	48.0 ± 9.6	48.0 ± 9.7	.96	.68	.24	.36
TUG, seconds	5.1 ± 0.9	5.1 ± 1.0	5.1 ± 1.0	.99	5.4 ± 1.0	5.4 ± 0.9	5.3 ± 0.9	.95	5.1 ±1.1	5.1 ± 0.9	5.0 ± 0.9	.94	.40	.32	.50
IKES, newtons	304.0 ± 73.2	312.6 ± 73.4	314.3 ± 75.1	.86	283.7 ± 86.4	282.6 ± 92.0	291.4 ± 91.8	.93	306.9 ± 78.3	310.0 ± 81.5	307.3 ± 80.0	.99	.43	.33	.62
Physical Activity	16.5 ± 9.4	16.7 ± 9.7	17.6 ± 9.9	.91	12.8 ± 7.3	12.8 ± 7.8	13.6 ± 7.9	.89	14.6 ± 5.6	14.6 ± 5.9	14.5 ± 5.7	1.00	.17	.19	.21
SF-36 PCS	49.4 ±7.5	50.3 ± 7.0	50.3 ± 7.4	.87	47.9 ± 8.3	49.0 ± 8.7	47.8 ± 8.7	.91	51.8 ± 7.3	52.4 ± 6.6	52.5 ± 6.8	.92	.11	.13	.10

Note: Values are means ± standard deviation; ADAP, assessment of daily activity performance test; TUG, timed up and go test; IKES, isometric knee extensor strength; SF-36 PCS, short form 36-item Health Survey physical component summary score.
* Within group Analyses of variance (ANOVA) between baseline values of all participants, the participants who completed the 3-month measurements, and the participants who completed the 9-month measurements; † Between group ANOVA between baseline values of all included participants;‡ Between group ANOVA between baseline values of the participants who completed the 3-month measurements;
# Between group ANOVA between baseline values of the participants who completed the 9-month measurements

Table 2. Between group comparison of baseline values of the drop-outs

	Drop-outs at 3-month measures				*Drop-outs at between 3 and 9-month measures*			
Measure	*Control group (n = 5)*	*Resistance group (n = 6)*	*Function group (n = 3)*	*P*-value*	*Control group (n = 3)*	*Resistance group (n = 4)*	*Function group (n = 3)*	*P*-value*
Age	73.0 ± 2.2	74.3 ± 4.1	76.7 ± 3.5	.27	74.0 ± 1.7	73.5 ± 3.4	76.0 ± 4.6	.44
ADAP total	42.1 ± 11.7	49.6 ± 9.7	41.4 ± 11.7	.44	47.5 ± 5.5	43.2 ± 6.3	48. 3 ± 9.8	.62
TUG, seconds	5.3 ± 0.5	5.5 ± 1.5	5.7 ± 2.9	.94	5.2 ± 0.3	5.8 ± 0.5	5.3 ± 0.8	.36
IKES, newtons	259.6 ± 59.9	288.9 ± 59.9	275.5 ± 16.4	.69	298.9 ± 70.0	239.6 ± 84.6	324.8 ± 109.4	.38
Physical Activity	15.0 ± 8.9	13.1 ± 5.0	14.5 ± 1.7	.88	10.1 ± 5.4	7.3 ± 4.3	15.5 ± 8.9	.29
SF-36 PCS	44.7 ± 9.2	52.0 ± 4.5	46.0 ± 13.3	.36	50.9 ± 3.7	42.3 ± 7.4	51.8 ± 5.1	.12

Note: Values are means ± standard deviation; ADAP, assessment of daily activity performance test; TUG, timed up and go test; IKES, isometric knee extensor strength; SF-36 PCS, short form 36-item Health Survey physical component summary score.
*Analyses of variance between baseline values of all participants, the participants who completed the 3-month measurements, and the participants who completed the 9-month measurements

7.4.1.2.7 Adverse events

Schmidt and colleagues reported that older participants who experienced an adverse event in the first 3 months of an exercise programme were nearly four times more likely to drop-out than those who did not have adverse effects.[47] Although adverse events should be monitored, they are often not reported.[5] In the present study, the following adverse events were reported by the exercise instructors and required adaptation of the personal training programme: in the function group; muscle pain (8), osteoarthritic joint pain (5), prosthetic joint pain (4), low back pain (4); in the resistance group, muscle pain (10), osteoarthritic joint pain (5), prosthetic joint pain (3), low back pain (4).One participant in the resistance group strained a hamstring muscle, as a result of which two exercise classes were missed and the personal training programme was adapted. Despite these reported complaints, all participants completed the exercise programmes. The reported adverse events of other exercise studies include muscle pain[6,59], stiffness[7], joint pain[60-62], falls[41,57], and back or leg pain.[63]

7.4.2 External validity

External validity is addressed by delineating inclusion and exclusion criteria and assessing the generalisability of findings.[33]

7.4.2.1 Inclusion criteria

The inclusion criteria of the present study were female sex, living in the community, medically stable health, aged 70 years or older, and being willing and able to comply with the protocol for the duration of the study period after written informed consent. During telephone interviews we determined, using a validated questionnaire, whether participants were medically fit enough to participate in the exercise programme.[64]

7.4.2.2 Exclusion criteria

The exclusion criteria were recent fractures; unstable cardiovascular or metabolic diseases; musculoskeletal disease or other chronic illnesses that might limit training or testing; severe airflow obstruction; history of cerebrovascular disease; major systemic disease active within the previous two years (e.g. cancer, rheumatoid arthritis); on daily analgesia; recent depression or emotional distress; or loss of mobility for more than one week in the previous two months. Furthermore, to obtain a more representative group of participants, very active respondents, respondents who exercised at a sports club more than two times a week, were also excluded.

7.4.2.3 Generalisability

We targeted community-living, medically stable women aged 70 and older because older women are the least physically active of all demographic groups [23] and because older women have less physical reserve than older men.[65-67]

In exercise studies with healthy community-living participants, it often is difficult to randomly select participants. The participants of the present study were recruited through local newspaper advertisements. It is possible that a relatively healthy population was selected, because people who volunteer to participate in a time-consuming exercise study are likely to be healthy, to be interested in health-related topics, to be more physically active, and to be more positive about the benefits of exercise. By excluding the most active respondents, we assumed we would have a more representative group of participants. The physical functioning and HRQOL scores at baseline showed that the participants were in moderate-to-good health, which may influence the generalisability of the study results to the general population. However, the baseline characteristics in terms of marital status, height, weight, and disease status of the sample population were comparable with those of the overall Dutch population of community-living women aged 70 years or older.[68] It remains a question whether functional tasks exercises and resistance exercises would have induced greater improvements among less healthy participants (*Chapter 6*). Functional tasks exercises may be beneficial to participants with a lower capacity and with more limitations than the participants in this study.

7.5 QUESTIONS AND ANSWERS

Our specific questions concerning the difference in effect between functional tasks exercises and resistance strength exercises on the physical functional performance and health-related quality of life of older community-dwelling women, as formulated in *Chapter 1*, can be answered as follows:

1. *To evaluate the feasibility of a new functional tasks exercise programme, designed to improve functional performance of community-dwelling older women, by comparing it with a resistance exercise programme (chapter 2).*

   The newly developed functional tasks exercise programme is feasible and well tolerated by women older than 70 years living in the community.

2. *To determine the intra-examiner reliability and construct validity of the Assessment of Daily Activity Performance (ADAP) test in a community-living older population, and to identify the importance of tester experience (chapter 3).*

   The Assessment of Daily Activity Performance (ADAP) is a reliable and valid instrument for measuring physical function in community-dwelling older women; however, testers should be trained in its use to improve reliability.

3. *To determine whether a functional tasks exercise programme and a resistance exercise programme have different effects on the ability of community-living older people to perform daily tasks (chapter 4).*

   Functional tasks exercises are more effective than resistance exercises in improving functional task performance in community-dwelling older women, and the effects of the functional tasks exercises are preserved for longer than the gain in strength achieved with resistance exercises.

4. *To determine whether a functional tasks exercise programme and a resistance exercise programme have a different effect on the health-related quality of life (HRQOL) of community-dwelling older women (chapter 5).*

   Both functional tasks exercise and resistance strength exercise have a limited effect on the HRQOL of community-living, older women; the HRQOL outcomes are probably affected by ceiling effects and response shift.

5. *To discuss the differences in participants' satisfaction between a functional task exercise programme and a resistance exercise programmes, and to explore the impact of participants' satisfaction and health-status on exercise compliance and effectiveness of the two programmes (chapter 6).*
   Both exercise programmes are well accepted and appreciated; functional tasks exercises may positively influence daily habits more than resistance training, especially when participants are satisfied with the exercises. This enables older people to keep physically active and to sustain the positive effects of exercise.

7.6 IMPLICATIONS FOR PUBLIC HEALTH AND CLINICAL PRACTICE

Functional tasks exercises are more effective in improving physical functional performance than resistance strength exercises and the effects last longer than the gain in strength achieved with resistance exercises. Usually, after completion of an exercise programme, effects decline and finally disappear. The results of this study suggest that functional tasks exercises, which mimic daily activities, bring about a positive change in daily habits more than does resistance training. Therefore, we recommend that task-specific functional exercises are incorporated in exercise interventions to enhance the physical functional performance and independence of older adults.

To prevent early attrition, Stiggelbout et al. recently recommended evaluating the perceived quality of exercise programmes by means of satisfaction questionnaires.[26] Our study showed that both the functional task exercises and the resistance strength exercises were accepted and appreciated by the participants. Also, the compliance rates for both programmes were higher than those reported in many other exercise studies involving older adults. The inclusion of psychosocial aspects (such as knowledge about the exercises) and social support (such as interaction between exercisers), information on the exercises and feedback about exercise progress, may have contributed to the high satisfaction and compliance with the programmes. We therefore recommend the incorporation of psychosocial aspects when designing exercise interventions.

The Assessment of Daily Activity Performance (ADAP) test proved to be appropriate, reliable and sensitive to changes after training in older adults. Since exercise effects are specific, the tests used to measure the effects of an exercise programme should also be specific to the mode of the exercises to reflect the pursued effects.

The results of *chapter 5* are consistent with the idea of regarding HRQOL as a dynamic concept, which is consistently subject to changes in internal standards, values, or conceptualisation, resulting in a response shift. To obtain a clear understanding of the effects of exercise interventions in older adults, studies should include performance-based tests in addition to self-report HRQOL measures.

7.7 CONSIDERATIONS FOR FUTURE RESEARCH

This study sought to determine the differences in effect between functional tasks exercises and resistance strength exercises on the performance of daily activities by older women. In the current literature, the diversity of exercise interventions for older adults makes it difficult to determine which type of exercise is the most effective one for daily tasks. We tested the effect of the exercise programmes in a group of older women, because women constitute the majority of the older population, they are the least physically active of all demographic groups,[23] they have higher prevalence rates of disability than men of the same age,[66,67] and they have a smaller physical reserve than older men.[65-67] It would be of interest to determine the effects of functional tasks exercises in comparison to resistance exercises in older men. Although we anticipate older men to accept functional tasks exercises, a feasibility study would first be necessary to determine so.

The population of the present study consisted of healthy older women. The results of chapter 6 suggest that the exercise programmes may have a beneficial effect in less healthy participants. More research is needed to determine the effects of functional tasks exercises in a group of frail older adults.

Although the functional tasks exercise programme proved to be highly appreciated and effective in improving the physical functional performance of older women, the programme still needs further development. For instance, the exercises do not specifically train hand function, whereas many older people suffer from an impaired hand function.[71]

Lastly, more research is needed to obtain an understanding of HRQOL and the response shift phenomena in intervention studies in older adults.

7.8 MAIN CONCLUSIONS

The main conclusions of our study indicate that functional tasks exercises are more effective in improving physical functional performance than resistance strength exercises and that the effects of functional task exercises last longer than the gain in strength achieved with resistance exercises. Furthermore, functional tasks exercises cause a greater positive change in daily habits than does resistance training.

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Summary

SUMMARY

The introduction, the background and aims of this thesis have been described in *chapter 1*. As in other countries, the population of the Netherlands is ageing. Ageing is characterised by a reduction in physical reserve, the physiological capacity in excess of that needed for daily activities, that provides a margin of safety that absorbs age- or disease-related changes without a loss in function. When physical capacity falls below the ability required for the performance of daily tasks, functional limitations and a loss of independence may occur. Approximately 20% of people between 65 and 75 years of age report problems with activities of daily living (ADLs), a proportion which increases to 48% in people older than 85. The loss of independence results in a decreased quality of life and is the most distressing aspect of ageing for many older adults. Limitations in physical function of a growing segment of the population herald an increased expenditure for health care and long-term care systems.

Exercise studies and exercise promotion for older adults offer the potential for improving the performance of daily activities and quality of life. However, the results of current exercise programmes are limited and inconsistent. The performance of functional tasks is complex and involves an interplay of cognitive, perceptual and motor functions, and is closely linked to the individual's dynamic environment. None of the studied reported in the literature investigated the effect of functional tasks exercises on the performance of daily activities and the quality of life of older adults. Further, there is a need for comparative studies, to determine which type of exercise is most effective in terms of performance of daily activities. Also, the mechanisms that underlie successful initiation and adherence to exercise programmes are not well understood.

The aim of the studies described in this thesis was to study the difference in effect between functional tasks exercises and resistance strength exercises on the physical functional performance and health-related quality of life of older community-dwelling women.

In *Chapter 2*, the feasibility of a newly developed functional tasks exercise programme was studied compared with a resistance strength exercise programme. Feasibility was determined by information on participants' satisfaction, drop-out, and

attendance, as well as occurrence of adverse events. Twenty-four community-dwelling, medically stable women (mean age 74.6 ±4.8) were randomly assigned to 12 weeks of functional tasks exercises (function group) or resistance exercises (resistance group). Three participants (two in the function group) withdrew from the study. Exercise adherence was 81% in the function group and 90% in the resistance group. Participants reported a greater satisfaction with the resistance exercises than with the functional exercises. Both exercise programmes appeared feasible and well tolerated by women over the age of 70 years and living in the community.

Chapter 3 addresses the reliability and validity of the newly designed assessment of daily activity performance (ADAP) test. The ADAP test was based on the Continuous-scale Physical Functional Performance (CS-PFP) test and provides a quantitative assessment of older adults' physical functional performance. The ADAP includes 16 common tasks, such as transferring laundry and boarding a bus, performed at maximal effort. Construct validity was assessed by comparing the baseline ADAP scores of 24 community-living older women with self-perceived SF-36 Health Survey physical function, muscle function tests, and the Timed Up and Go (TUG) test. Intra-examiner reliability was determined by comparing test and retest scores of 19 community-dwelling, medically stable women aged 70 or older by an experienced and an inexperienced tester. The experienced tester had good consistency and reliability scores, whereas the inexperienced tester had lower reliability scores, with a systematic difference between test and retest scores for the ADAP domain lower body strength. ADAP total scores correlated highly with the TUG test ($r = -.91$), isometric knee extensor strength ($r = .80$) and SF-36 Physical Functioning scale ($r = .67$). The ADAP test proved to be reliable and valid for measuring the performance of daily activities by community-dwelling older women. However, testers should be trained in its use to improve reliability.

In *Chapter 4* the central research question of this study: "To determine whether a functional tasks exercise programme and a resistance exercise programme have different effects on the ability of community-living older people to perform daily tasks." was addressed. Ninety-eight healthy women aged 70 and older were randomly assigned to either the function group ($n = 33$), the resistance group ($n = 34$) or a control group ($n = 31$). Participants attended exercise classes three times a week for

12 weeks. Functional task performance (ADAP test), isometric knee extensor strength (IKES), handgrip strength, isometric elbow flexor strength (IEFS) and leg extension power were measured at baseline, at the end of training (at 3 months) and 6 months after the end of training (at 9 months). The ADAP total score increased more in the function group than in the resistance group or the control group. The ADAP total score of the resistance group did not change compared with the control group. In contrast, IKES and IEFS increased significantly in the resistance group compared with the function group and the control group. Six months after the end of training, the increase in ADAP scores were sustained in the function group, whereas the strength gains of the resistance group had disappeared. Functional tasks exercises are more effective in improving physical functional performance than common resistance strength exercises and the effects are preserved for longer than the gain in muscle strength achieved with resistance exercises.

Chapter 5 presents the effects of functional tasks exercises and resistance strength exercises on the health-related quality of life (HRQOL) and free-time physical activity of the 98 community-living older women of chapter 4. The SF-36 Health Survey questionnaire and self-reported physical activity were assessed at baseline, directly after completion of the intervention (3 months), and 6 months later (9 months). At 3 months, no exercise effect on the HRQOL and physical activity scores was seen found, except for an increase in SF-36 physical functioning score in the resistance group compared with that in the control group and the function group. The participants of both exercise groups had lower SF-36 physical functioning scores, some even lower than at baseline, 6 months after completion of the exercise programmes. Exercise has a limited effect on the HRQOL of community-living older women. The HRQOL outcomes are probably affected by ceiling effect and response shift. After completion of the exercise programmes, neither group had changed their habitual physical activity. Physical activity 6 months after completion of the exercise programme was diminished in the resistance group but sustained in the function group. Functional tasks exercises may positively influence habitual physical activity more than resistance training does.

Chapter 6 investigated the differences in participants' satisfaction with functional tasks exercises and resistance strength exercises, and the influence of participants' satisfaction and health status on exercise compliance and the effectiveness of the two programmes are discussed. Data for 67 participants from both the function group and the resistance group were used. An 17-item questionnaire on the satisfaction with the exercise programmes was developed and evaluated. A factor analysis identified four subscales: 1) general satisfaction with the programme, 2) intensity of core exercises of the programme, 3) intensity of the warm-up and cool-down periods, 4) exercise location. Satisfaction with the programmes (function group 84.8 ±6.3; resistance group 87.6 ±6.9) and compliance (function group 90 ±9.1%; resistance group 90 ±8.1%) was high in both groups. In the function group, satisfaction with the programme was positively associated with an increase of physical activity after completion of the exercise programme. A low initial health status was associated with sustained physical activity after completion of the exercise programme and improved performance-based physical functioning in the resistance exercise programme. Both exercise programmes were well accepted and appreciated. Functional tasks exercises may positively influence daily habits more than resistance training, which means that older individuals may continue exercising and thus maintain the effects of exercise.

Chapter 7 is a retrospective view on the findings of this study, and discusses methodological issues and implications for clinical practice and future research. We recommend that task-specific functional exercises are incorporated in exercise interventions to enhance the physical performance and independence of older adults. Functional tasks exercises are more effective in improving physical functional performance than resistance strength exercises and the effects are preserved for longer than the gain in strength achieved with resistance exercises. More research is needed to confirm the potential of functional tasks exercise to positively change free-time physical activity. Other considerations for future research are studies to provide insight into the effect of task-specific exercises on the physical functional performance of older men and frail older persons.

Samenvatting

SAMENVATTING

De inleiding, de achtergronden en de doelstellingen van dit proefschrift worden beschreven in *hoofdstuk 1*. Evenals in andere landen neemt het aantal ouderen ook in Nederland sterk toe. Veroudering gaat samen met een vermindering van de fysieke reservecapaciteit, dat is de beschikbare fysiologische capaciteit boven de capaciteit die nodig is voor het verrichten van dagelijkse activiteiten. De fysieke reservecapaciteit is een veiligheidsmarge tijdens leeftijdgerelateerde of ziektegerelateerde negatieve invloeden. Bij een fysieke capaciteit onder het niveau dat nodig is voor het verrichten van dagelijkse taken, ontstaan functiebeperkingen en verlies in de zelfredzaamheid. Ongeveer 20% van de ouderen in de leeftijd van 65 tot 75 jaar ondervinden problemen bij het verrichten van activiteiten van het dagelijks leven (ADL). Boven de 85 jaar loopt dit op tot 48%. Een vermindering van het zelfstandig functioneren leidt tot een vermindering van de kwaliteit van leven en vormt voor veel ouderen het meest bedreigende aspect van het oud worden. Daarnaast zorgen de beperkingen in het lichamelijk functioneren bij een snel groeiend deel van de bevolking voor een hoge financiële druk op de gezondheidszorg. Trainingsstudies en de promotie van lichaamsbeweging voor ouderen beogen het verrichten van dagelijkse activiteiten en de kwaliteit van leven te verbeteren. De resultaten van recente onderzoeken naar de effecten van training zijn echter beperkt en tegenstrijdig. ADLs bestaan uit complexe handelingen, waarbij een samenspel bestaat tussen cognitieve, waarnemings- en motorische functies in nauwe samenhang met de dynamische omgeving van het individu. Tot op heden zijn geen onderzoeken beschikbaar naar het effect van het direct trainen van functionele taken op het verrichten van dagelijkse activiteiten en de kwaliteit van leven van ouderen. Daarnaast is onderzoek nodig naar een eventueel verschil in effect van verschillende trainingsinterventies, om te kunnen bepalen welk type training het meeste effect heeft voor het verbeteren van het verrichten van de dagelijkse activiteiten bij ouderen. Daaraan kan nog worden toegevoegd dat de mechanismen voor een succesvolle initiatie en voor het volbrengen van een trainingsprogramma onvoldoende bekend zijn. Het doel van het onderzoek in dit proefschrift is het bepalen van eventuele verschillen in het effect tussen het trainen van functionele taken en spierkrachtversterkende weerstandstraining op het verrichten van de dagelijkse activiteiten en de kwaliteit van leven bij zelfstandig wonende, oudere vrouwen.

In hoofdstuk 2 wordt de uitvoerbaarheid van het nieuwe ‘functionele taken’ trainingsprogramma onderzocht in vergelijking met een spierversterkend weerstandtrainingsprogramma. De uitvoerbaarheid van de trainingsprogramma’s werd bepaald aan de hand van de tevredenheid van de deelneemsters, het aantal uitvallers, het percentage gevolgde trainingssessies en de eventuele bijwerkingen. Vierentwintig zelfstandig wonende, ‘medisch stabiele’ vrouwen, met een gemiddelde leeftijd van 74.6 ± 4.8jaar werden gerandomiseerd over een groep die gedurende 12 weken functionele taken trainde (functiegroep) of een groep die 12 weken spierversterkende weerstandstraining (weerstandgroep) volgde. Drie deelneemsters (twee uit de functiegroep) trokken zich terug uit de studie. De functiegroep bezocht gemiddeld 81% van de trainingssessies en de weerstandgroep bezocht gemiddeld 90% van de trainingssessies. De deelneemsters in de weerstandgroep waren meer tevreden over het gevolgde trainingsprogramma dan de deelneemsters in functiegroep. Beide trainingsprogramma’s bleken goed uitvoerbaar en werden gewaardeerd door de deelneemsters van 70 jaar en ouder.

Hoofdstuk 3 onderzoekt de betrouwbaarheid en de validiteit van de nieuwe “assessment of daily activity performance” (ADAP) test. Deze kwantitatieve ADAP test is gebaseerd op de “Continous-scale Physical Functional Performance” (CS-PFP) test en geeft een kwantitatieve meting van het lichamelijk functioneren. De ADAP test bestaat uit 16 dagelijkse taken, die naar maximaal vermogen worden uitgevoerd, zoals het doen van de was en het in en uit een bus stappen. De validiteit werd getest door de baseline ADAP uitslagen van 24 zelfstandig wonende oudere vrouwen te vergelijken met de resultaten van de Timed Up and Go (TUG) test, het zelf ervaren van het lichamelijk functioneren (SF-36 Health Survey) en de spierfunctie tests. De intra-onderzoeker betrouwbaarheid van een ervaren en een onervaren tester werd bepaald door bij een test en hertest de ADAP uitslagen te vergelijken van 19 zelfstandig wonende, medisch stabiele vrouwen van boven de 70 jaar. De ervaren tester toonde een goede consistentie en betrouwbaarheidsscores, de onervaren tester had lagere betrouwbaarheidsscores met een systematisch verschil tussen test en hertest voor de ADAP domeinscore “kracht van het onderlichaam”. De ADAP totaal score toonde een hoge correlatie met de TUG test (r = -.91), de isometrische kniestrekkracht (r = .80) en de meting op de SF-36 fysiek functioneren schaal (r = .67). De ADAP test blijkt betrouwbaar en valide voor het meten van het uitvoeren van dagelijkse activiteiten van zelfstandig wonende, oudere vrouwen. Voordat de ADAP wordt gebruikt in wetenschappelijke studies wordt aangeraden de tester ervaring te laten opdoen met het afnemen en scoren van de test.

Hoofdstuk 4 beantwoordt de centrale vraag van dit proefschrift: “Heeft het trainen van functionele taken een verschillend effect op de het uitvoeren van dagelijkse activiteiten van zelfstandig wonende oudere vrouwen dan spierversterkende weerstandtraining?”. Achtennegentig gezonde, zelfstandig wonende vrouwen van 70 jaar en ouder werden gerandomiseerd over een groep die functionele taken trainde (functie groep n = 33), een groep die spierversterkende weerstandtraining volgde (weerstandgroep n = 34) of een controlegroep (n = 31). De trainingssessies werden gedurende 12 weken 3 keer per week gevolgd. Aan het begin van de trainingsperiode (baseline meting), direct na afloop van de trainingsperiode (3 maanden meting) en 6 maanden na beëindiging van de trainingsperiode (9 maanden meting) werden de verrichtingen van de functionele activiteiten (ADAP test), de isometrische kniestrekkracht (IKES), de handgreepkracht (HGS), de isometrische elleboogbuigkracht (IEFS) en het explosief strekvermogen van de benen (LEP) gemeten. Aan het eind van de trainingsperiode was de ADAP totaal score significant meer gestegen in de functiegroep dan in de weerstandgroep en in de controlegroep. Bovendien was de ADAP totaal score van de weerstandgroep niet veranderd ten opzichte van de controlegroep. Daar tegenover staat dat de kracht van de benen (IKES) en van de armen (IEFS) van de weerstandgroep significant verbeterde in vergelijking met de functiegroep en de controlegroep. Zes maanden na het beëindigen van de trainingen waren de verbeterde ADAP scores van de functiegroep behouden, terwijl de verbeterde spierkracht van de weerstandgroep was verdwenen. Het trainen van functionele taken is effectiever voor het verbeteren van het verrichten van dagelijkse activiteiten dan spierversterkende weerstandtraining. Bovendien blijven de effecten van het trainen van functionele taken langer behouden dan de winst aan spierkracht naar aanleiding van weerstandtraining.

In *hoofdstuk 5* worden de effecten weergegeven van het trainen van functionele taken en van spierversterkende weerstandtraining op de kwaliteit van leven (HRQOL) en de lichamelijke activiteit van de 98 zelfstandig wonende oudere vrouwen van hoofdstuk 4. Bij de baseline en de metingen direct na afloop van de trainingsperiode (3 maanden meting) en 6 maanden na beëindiging van de trainingsperiode (9 maanden meting) werden de SF-36 Health Survey vragenlijst (HRQOL) en een lichamelijke activiteiten vragenlijst door de deelneemsters ingevuld. Bij de 3 maanden meting werd geen verandering waargenomen in de HRQOL en de lichamelijke activiteiten vragenlijst, behoudens een verhoogde SF-36 score voor het lichamelijk functioneren in de weerstandgroep bij vergelijking met de controlegroep en de functiegroep. Tussen de 3 maanden meting en 9 maanden meting nam de eigen waardering af voor het ervaren van het lichamelijk functioneren bij de functiegroep tot onder het niveau van de baseline meting. In de weerstandgroep werd een vermindering gezien van de lichamelijke activiteit bij vergelijking met de functiegroep. Het volgen van training blijkt een beperkt effect te hebben op de HRQOL van zelfstandig wonende, oudere vrouwen. Mogelijk zijn de uitkomstmaten bij deze groep gezonde, oudere vrouwen onderhevig aan het zogenaamde 'plafondeffect' en de 'response shift'. Het trainen van functionele taken blijkt een positiever effect te hebben op de lichamelijke activiteit van oudere vrouwen dan weerstandtraining.

In hoofdstuk 6 is de tevredenheid van de deelneemsters over de trainingsprogramma's bepaald en zijn de invloed van die tevredenheid en van het ervaren van de eigen gezondheid op het volbrengen van de programma's en de effecten van de programma's onderzocht. Voor dit onderzoek werd gebruik gemaakt van de gegevens van de 67 deelneemsters aan de trainingsprogramma's. Een 18-delige vragenlijst ter bepaling van de tevredenheid over de trainingsprogramma's werd ontwikkeld en beoordeeld. Een factor analyse identificeerde vier onderdelen: 1) de algemene beoordeling van het programma, 2) de beoordeling van de kernoefeningen van het programma, 3) de beoordeling van de warming-up en cooling-down, 4) de beoordeling van de trainingslocatie. Beide groepen toonden een hoge tevredenheid over de gevolgde trainingen (functiegroep 84.8 ± 6.3; weerstandgroep 87.6 ± 6.9) en een hoge opkomst (functiegroep 90% ± 9.1%; weerstandgroep 90% ± 8.1%). Een hoge tevredenheid in de functiegroep was geassocieerd met een hoge lichamelijke activiteit 6 maanden na het beëindigen van de trainingsperiode. Een lage gezondheidsstatus bij de baseline meting was geassocieerd met het behoud van lichamelijke activiteit na het beëindigen van de trainingsperiode en dit was in de weerstandgroep tevens geassocieerd met een verhoogde ADAP score. Beide trainingsprogramma's werden positief beoordeeld en gewaardeerd door de deelneemsters. Wanneer deelneemsters tevreden zijn met de trainingen, is het mogelijk dat het trainen van de functionele taken meer invloed heeft op dagelijkse gewoonten dan de weerstandtraining. Bij de functionele taken wordt de lichamelijke activiteit mogelijk meer bevorderd en blijven de trainingseffecten langer behouden.

In hoofdstuk 7 worden de resultaten van het onderzoek en methodologische vraagstukken besproken en worden aanbevelingen gedaan voor de praktijk en toekomstig onderzoek. Voor trainingsinterventies, die tot doel hebben het verbeteren van het dagelijks functioneren van ouderen, wordt geadviseerd om het trainen van functionele taken in de trainingen op te nemen. Het trainen van functionele taken verbetert bij oudere vrouwen niet alleen het lichamelijk functioneren meer dan spierkrachtversterkende weerstandtraining, de effecten van het trainen van functionele taken blijven ook langer behouden. Meer onderzoek is nodig om te bepalen of het trainen van functionele taken een gunstig effect heeft op de lichamelijke activiteit van ouderen. Andere mogelijkheden voor toekomstig onderzoek zijn het bepalen van het effect van het trainen van functionele taken op het lichamelijk functioneren van mannen en van de zogenoemde kwetsbare ouderen.

Dankwoord

Curriculum vitae

List of abbreviations

List of publications

DANKWOORD

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CURRICULUM VITAE

Paulus Leonardus de Vreede was born in Pijnacker, the Netherlands, on December 30, 1971. After graduating the secondary school (atheneum) at the “St. Stanislascollege” in Delft in 1992, he studied Geodesy for one year at the Technical University of Delft. In 1993 he started to study Human Movement Technology at the Haagse Hogeschool in The Hague. He graduated in June 1998 on the development of a new concept for the football shoe. In September 1998 he started to work as a research assistant at the Mobility Laboratory of the Department of Geriatric Medicine of the University Medical Center Utrecht. In 2000 he started as a PhD student on the studies described in this thesis at the Department of Geriatric Medicine of the University Medical Center Utrecht under supervision of prof. dr. S.A. Duursma, prof. dr. E. van der Wall, dr. HJJ Verhaar and dr MM Samson.
Currently, he is working on an application for a grant for a project that aims to investigate the national implementation of the functional tasks exercise (FUNTEX) programme.
He is living with Nicole van Winden on the Nienke van Hichtumstraat in Pijnacker.

LIST OF ABBREVIATIONS

ADAP	assessment of daily activity performance
ADLs	activities of daily living
ANCOVA	analysis of co-variance
ANOVA	analyses of variance
BP	bodily pain
CC	correlation coefficient
CI	confidence interval
CS-PFP	continuous-scale physical functional performance
FTP	functional task exercise programme
FUNTEX	functional tasks exercise
GH	general health perceptions
HGS	handgrip strength
HRQOL	health-related quality of life
ICC	intraclass correlation coefficient
IEFS	isometric elbow flexor strength
IKES	isometric knee extensor strength
kgF	kilogram force
LEP	leg extensor power
LoA	limits of agreement
MCS	mental component summary
MH	mental health
N	newtons
PCS	physical component summary
PF	physical functioning
RCTs	randomised controlled trials
RE	role limitations due to emotional problems
REP	resistance exercise programme
RP	role limitations due to physical health problems
RPE	rating of perceived exertion
SAS	specific activity scale
SCT	social cognitive theory
SD	standard deviation

SF	social functioning
SF-36	Short Form Health Survey
TM	transtheoretical model
TPB	theory of planned behaviour
TUG	timed up & go
U	units
VT	vitality
W	Watts

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