Increased muscle strength improves managing in activities of daily living in fall-prone community-dwelling older women*

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ABSTRACT. Background and aims: The aim of this longitudinal study was to describe whether an increase in knee extension strength is associated with improvements in managing in activities of daily living (ADL) and in self-perceived physical condition in fall-prone community-dwelling older women. Methods: Subjects (n=417) aged ≥65 years belonged either to intervention or control groups in a 12-month randomized controlled fall prevention trial. Isometric muscle strength of knee extension was measured with an adjustable dynamometer chair. Managing in activities of daily living was measured with structured questions about abilities to climb stairs, walk at least 400 meters, toilet, bath, go to the sauna, do light or heavy housework, and carry heavy loads. A question of self-perceived physical condition was also asked. Results: Positive associations were found between increased knee extension strength and an increase in walking at least 400 meters (p<0.001), carrying heavy loads (p=0.004), and climbing stairs (p=0.007), and in self-perceived physical condition (p=0.005) over a 12-month follow-up. In addition, low age, non-use of a walking aid, low number of prescribed medications, and good functional balance at baseline were associated with an increase in performance of these ADL functions. Conclusions: An increase in knee extension strength during the 12-month follow-up was associated with improvement in some ADL functions and improvement in self-perceived physical condition during the same period in fall-prone community-dwelling women.

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INTRODUCTION

Physical frailty and fall-related injuries are two of the greatest threats to the functioning and quality of life of older people. Reduction in skeletal muscle mass, which is associated with loss of strength and power, is a major factor leading to reduced functional performance and independence among the aged (1-4). Skeletal muscle strength, especially knee extensor strength, plays an important role in the performance of activities of daily living (ADL) (5, 6): for example, in dynamic stability, ability to control the center of gravity within and outside the base of support, during chair rise, walking, and recovery after tripping (7, 8). Aged women are at higher risk than aged men in reaching the threshold of muscle strength, when activities such as standing up from a chair and walking cannot be performed safely (9). Prospective studies (10-12) and a systematic review (13) indicate that muscle weakness may be a contributing factor in balance dysfunction and one of the most important risk factors of falls.

Several earlier articles (14-17) indicated some positive effects of training interventions on physical functioning. The studies reported significant improvements in muscle strength and power, aerobic capacity, balance, mobility, flexibility, rate of falling, and functional performance and/or managing in ADL after training programs. However, some of the studies (16, 18-20) were relatively small, with fewer than 70 participants. Intervention periods were short (four months or less), and lasted over six months only in a few trials. Participants were relatively healthy, young-old persons in several studies (3, 18-20).

The results of the randomized controlled, 12-month, risk-based multifactorial fall prevention trial implemented by our research team in 591 home-dwelling aged persons

*Preliminary results have been presented at a scientific meeting.

Key words: Activities of daily living, aged, muscle strength, physical functioning, women.

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showed that group and home physical exercises increased maximal isometric muscle strength in fall-prone women (21). Using the material of this trial, we decided to answer the question: is an increase in knee extension strength over 12 months associated with an improvement in managing ADL and in self-perceived physical condition during the same period in fall-prone community-dwelling aged women?

**METHODS**

**Subjects and study design**

Participants were women 65 years or older who participated in a multifactorial randomized controlled fall prevention trial in Pori, Finland (registered in ClinicalTrials.gov, ID=NCT00247546). Subjects (n=591) interested in participating in the trial were randomized in two age groups (65-74, and ≥75 yrs) into an intervention group (n=293) and a control group (n=298) (22). After exclusion of men, all 417 women belonging either to the intervention group or the control group and participating in the 12-month follow-up examinations formed the material for this study.

**Training program**

The participants in the 12-month fall intervention program were divided into three exercise groups according to their physical functional abilities (Berg Balance Scale, muscle strength, peak expiratory flow). Details regarding the training and intervention programs and their effects on maximal isometric muscle strength are reported elsewhere (21, 22). Strength exercises were not specially targeted for knee extensors. Group exercises were performed under the guidance of a trained physiotherapist. Exercise was performed in groups twice a month, and circuit training with no extra weights or resistance was used to increase muscle strength. Home exercises were similar to those performed in group sessions, and were performed on average 2.6 times per week. Home exercises were done without any guidance except for the verbal and written information given to participants.

**Measure of muscle strength**

The effects of the intervention on muscle strength were assessed by measuring isometric muscle strength. Maximal isometric knee extension strength was measured in a sitting position in an adjustable dynamometer chair (Good Strength, Metitur, Jyväskylä, Finland) at the knee angle of 60° from full extension and the ankle fastened by a belt to a strain-gauge system. Changes in knee extension strengths were categorized as follows: 1) increased (>10%), 2) unchanged (from ≤10% decrease to ≤10% increase), and 3) decreased (>10%). Details regarding measurement of muscle strength are reported elsewhere (21).

**Measures of physical functioning**

In this report, the abbreviation ADL covers some basic and instrumental activities of daily living (BADL, IADL) but not advanced activities of daily living (AADL). Managing in ADL was measured at the baseline and during the follow-up examination by the following eight questions: Are you able to walk at least 400 meters, climb stairs, use the toilet, take a shower, go to the sauna, do light and heavy housework, and carry heavy loads? The five response categories in every question were: 1) not even with help from another person, 2) if another person helps, 3) yes, alone with aid, 4) yes, with difficulty, but without help or aid, and 5) yes, without difficulty. A question of self-perceived physical condition was also asked: Generally, is your physical condition 1) very poor, 2) poor, 3) neither poor nor good, 4) good, 5) very good? Changes during the 12-month follow-up period in individual items of ADL and in self-perceived physical condition were categorized to 1) improved, 2) remained the same, and 3) became worse.

**Measures of explanatory baseline variables**

Age (1: <75 yrs, 2: ≥75 yrs), marital status (1: single, 2: married or co-habiting, 3: widowed, divorced or legally separated), education (1: less than basic, 2: basic, six years elementary school, 3: more than basic), living partner (1: living alone, 2: living with a spouse or another person), place of living (1: home, 2: sheltered housing), use of walking aid (1: no, 2: yes), and use of prescribed medications (1: <4, 2: ≥4) were explanatory baseline variables. Cognitive abilities measured with the Mini Mental State Examination (23), (1: moderate 17-24, 2: good 25-30), Berg Balance Scale (24) as a measure of functional balance, (1: decreased 0-44, 2: good 45-56), and the number of depressive symptoms measured with the Geriatric Depression Scale (25), (1: a low number of depressive symptoms 0-10, 2: a high number of depressive symptoms 11-30) were additional explanatory baseline variables.

**Ethics**

Permission to conduct this study was issued by the chief physician of Pori Health Center and ethics approval was obtained from the Ethics Committee of Satakunta Hospital District. Participants gave their written informed consent, and the study was conducted in accordance with the guidelines of the Declaration of Helsinki.

**Data analyses**

Of 497 eligible female subjects, 424 were able to perform at least one muscle strength measurement at baseline. Subjects with at least one muscle strength measurement and one ADL measurement at baseline and during follow-up were included in the analyses (n=417). Associations between changes in muscle strength and man-