Effects of a High-Intensity Functional Exercise Program on Dependence in Activities of Daily Living and Balance in Older Adults with Dementia

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OBJECTIVES: To investigate the effects of a high-intensity functional exercise program on independence in activities of daily living (ADLs) and balance in older people with dementia and whether exercise effects differed between dementia types.

DESIGN: Cluster-randomized controlled trial: Umeå Dementia and Exercise (UMDEX) study.

SETTING: Residential care facilities, Umeå, Sweden.

PARTICIPANTS: Individuals aged 65 and older with a dementia diagnosis, a Mini-Mental State Examination score of 10 or greater, and dependence in ADLs (N = 186).

INTERVENTION: Ninety-three participants each were allocated to the high-intensity functional exercise program, comprising lower limb strength and balance exercises, and 93 to a seated control activity.

MEASUREMENTS: Blinded assessors measured ADL independence using the Functional Independence Measure (FIM) and Barthel Index (BI) and balance using the Berg Balance Scale (BBS) at baseline and 4 (directly after intervention completion) and 7 months.

RESULTS: Linear mixed models showed no between-group effect on ADL independence at 4 (FIM=1.3, 95% confidence interval (CI)=−1.6–4.3; BI=0.6, 95% CI=−0.2–1.4) or 7 (FIM=0.8, 95% CI=−2.2–3.8; BI=0.6, 95% CI=−0.3–1.4) months. A significant between-group effect on balance favoring exercise was observed at 4 months (BBS=4.2, 95% CI=1.8–6.6). In interaction analyses, exercise effects differed significantly between dementia types. Positive between-group exercise effects were found in participants with non-Alzheimer's dementia according to the FIM at 7 months and BI and BBS at 4 and 7 months.

CONCLUSION: In older people with mild to moderate dementia living in residential care facilities, a 4-month high-intensity functional exercise program appears to slow decline in ADL independence and improve balance, albeit only in participants with non-Alzheimer's dementia. **J Am Geriatr Soc 64:55–64, 2016.**

Key words: activities of daily living; exercise; dementia; residential facilities; postural balance

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According to the World Health Organization, dementia is the leading cause of dependence in activities of daily living (ADLs) in older people and should be considered a public health priority.[1] In addition to cognitive decline, dementia is associated with impaired balance; this association may differ according to the type and severity of dementia.[2–4] The ability to maintain balance in a variety of positions is associated with falls, physical activity, and the ability to independently perform ADLs.[5–8] The need for assistance in ADLs affects quality of life and the burden of care.[1,9,10] Thus, postponement of decline in independence in ADLs in older people with dementia is of importance for individuals and society.

In older people without dementia, physical exercise has been shown to improve aspects of physical function such as muscle strength, gait, and balance, as well as cognition and ADL dependence.[11–13] For optimal improvement in physical function, exercise should be performed at high intensity, close to the individual's maximal capacity,[11,12,14] and be task specific (involving the target skill or components thereof).[15–19] Task specificity may be particularly important in people with Alzheimer's disease because of concomitant difficulty in motor skill transfer (ability to use acquired skills in new contexts).[20,21]

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Notwithstanding challenges to exercise that older adults with dementia frequently face, including cognitive and physical impairments, behavioral symptoms, depressive symptoms, and other comorbidities, promising evidence suggests that exercise can benefit independence in ADLs,[22–24] but the majority of previous studies have been conducted with individuals with Alzheimer's disease. Less is known about the effects of exercise in individuals with other types of dementia, and no study has explored differences in exercise effects between those with Alzheimer's disease and other dementia types.[22,23] Furthermore, large studies of high methodological quality in this population,[22,23,25,26] with designs incorporating attention control groups[22] are needed. To explore the effects of exercise as a single intervention, the additional attention that the intervention group receives may need to be matched in the control group,[27] because attention may have an important effect on results in this population, which is characterized generally by limited social interaction.[28,29]

In older adults living in residential care facilities, a large proportion of whom have dementia, physical exercise appears to achieve gains in balance and reduce decline in independence.[30] In the randomized controlled Frail Older People—Activity and Nutrition Study in Umeå (FOPANU), a high-intensity functional exercise program led to improvements in balance that were not moderated by dementia,[31,32] as well as encouraging effects on ADL independence in subgroup analyses of people with dementia.[33] Nevertheless, the effects of this type of exercise per se need to be explored in randomized controlled trials including only individuals with dementia. With the hypothesis that a high-intensity exercise program would improve balance and therefore defer the expected decline in independence in ADLs, the primary aim of this study was to investigate the effects of exercise on independence in ADLs in persons with dementia living in residential care. Secondary aims were to investigate the effects of the intervention on balance and to determine whether the effects of exercise differed according to dementia type or level of cognitive impairment.

METHODS

The Umeå Dementia and Exercise Study (UMDEX), a cluster-randomized controlled trial, was conducted in Umeå, Sweden. The study protocol (ISRCTN31767087) is published on the ISRCTN registry website (http://www.isrctn.com).

Setting and Participants

Eight hundred sixty-four residents of 16 residential care facilities screened by physical therapists and physicians were eligible for inclusion. The facilities comprised nine nursing home units and 10 units for special care of dementia, both with private rooms and staff on hand, as well as seven units with private apartments, access to dining facilities, alarms, and on-site nursing and care. Inclusion criteria were dementia diagnosis according to the *Diagnostics and Statistical Manual of Mental Disorders, Fourth Edition, Text Revision* (DSM-IV-TR) criteria,[34] aged 65 and older, dependence on assistance in one or more personal ADLs according to the Katz Index,[35] ability to stand up from a chair with armrests with assistance from no more than one person, Mini-Mental State Examination (MMSE) score of 10 or greater,[36] approval from a physician, and ability to hear and understand spoken Swedish sufficiently to participate in assessments. All individuals included in the study provided informed oral consent to participate, which their next of kin confirmed. Age (P = .19) and MMSE score (P = .71) did not differ between participants included in the study and those who declined participation (n = 55; Figure 1). A larger proportion of men (34%) than women (18%) declined participation (P = .008). Ethical approval was obtained from the regional ethics review board of Umeå in August 2011 (2011–205–31M).

Randomization

Randomization was performed after completion of the enrollment process and baseline assessment to ensure concealed allocation, thereby avoiding selection bias. To reduce contamination, 36 clusters of three to eight participants each who were inhabitants of the same wing, unit, or floor were formed. Randomization was stratified to ensure that participants of both groups lived in each facility, reducing the risk that associated factors would influence the outcome. Two researchers not involved in the study performed randomization by drawing lots using sealed opaque envelopes; allocation to clusters was performed first, followed by allocation to the intervention and attention control groups.

Intervention

Activities were conducted at the facilities with groups of three to eight participants. The exercise activities were supervised by two physical therapists and control activities by one occupational therapist or occupational therapy assistant, all experienced in working with people with cognitive impairment. Following recommendations for general older populations, five exercise sessions lasting approximately 45 minutes each were held per 2-week period.[11,12] Although most previous interventions have had durations of up to 3 months,[11] the length of the current intervention was 4 months (40 sessions in total) to augment the effects of exercise, considering that people with dementia face difficulties in motor skill learning. When possible, supervised individual sessions were offered when participants were unable to attend a group session. Participation in activities other than those that the study provided was not restricted.

Exercise

The exercise intervention was based on the high-intensity functional exercise (HIFE) program (described in detail elsewhere and available from the authors),[37,38] which aims to improve lower limb strength, balance, and mobility. It comprises 39 exercises performed in functional, weight-bearing positions; similar to those used in everyday situations, such as rising from a chair, stepping up, trunk rotation while standing, and walking. Exercises were selected depending on individuals' degrees of functional deficit. All

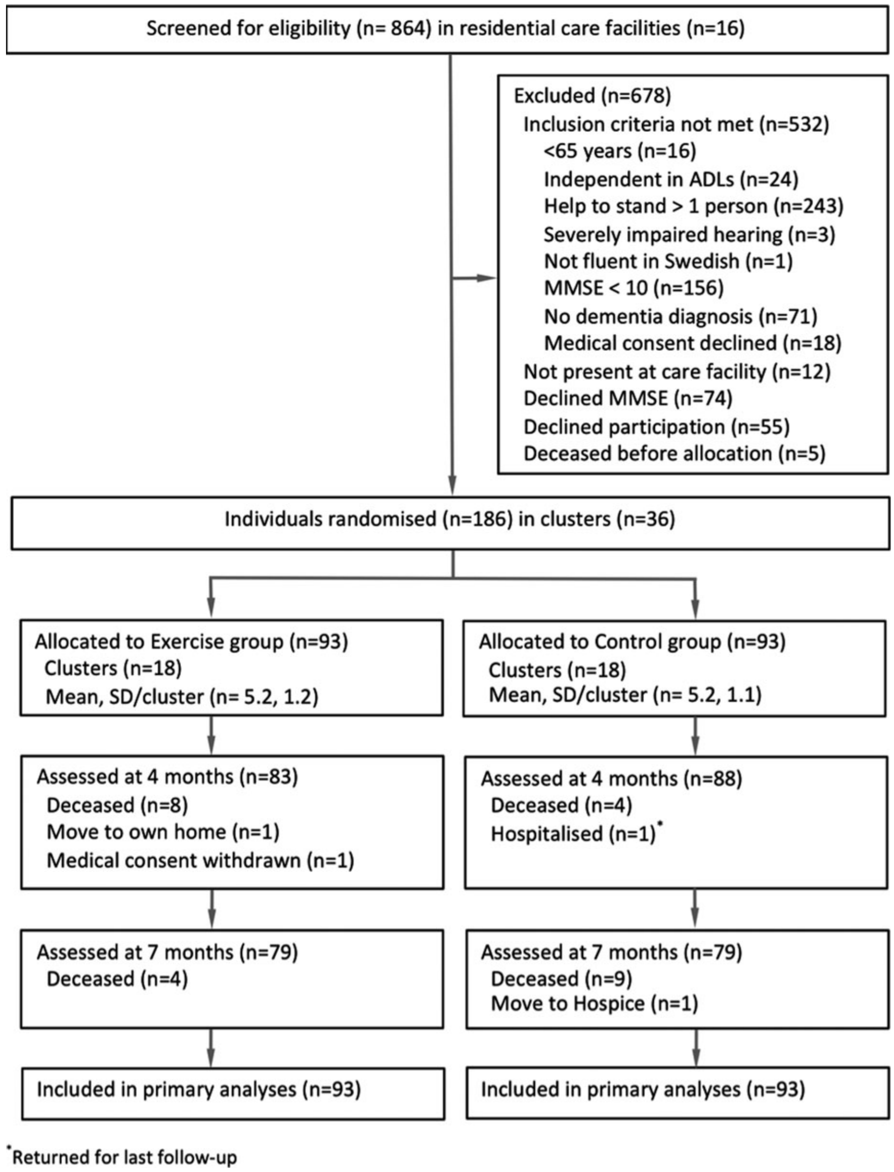

Figure 1. Flow of participants through the study. Recruitment and baseline assessment were performed in August and September 2011, interventions were implemented between October 2011 and February 2012, first follow-up assessments were performed in March–April 2012, and last follow-up assessments were performed in May and June 2012. ADLs = activities of daily living; MMSE = Mini-Mental State Examination; SD=standard deviation.

participants were supervised individually to promote the highest possible exercise intensity while ensuring their safety. By definition, high-intensity strength exercises were performed at 8- to 12-repetition maximum (RM), thus exercises were progressed when participants were able to exceed 12 repetitions.[37–39] The load was increased by, for example, stepping higher, rising from a lower chair, or adding weights to a belt worn around the waist (maximum 12 kg). High-intensity balance exercises aimed to fully challenge postural stability (performed at or near the limit of maintaining an upright position).[37,38] Progression was achieved by, for example, narrowing the base of support or altering the surface. Participants wore belts with handles so that physical therapists could provide support when postural stability was threatened, thereby preventing falls. Participants were encouraged to exercise at moderate intensity (13–15 RM) in the first 2 weeks. Exercises and intensity were adapted throughout the intervention to meet participants' levels of cognition, behavioral and psychological symptoms of dementia, and changes in health and functional status. Activity leaders were encouraged to obtain updates on participants' health status before the activity and were able to contact physicians or nurses when necessary.

Control

The occupational therapists and occupational therapy assistant who took part in the study developed the control activity program. Each session was structured around topics believed to be of interest to older people with dementia, such as wildlife and current seasons and holidays. While sitting together in a group, participants conversed, sang, listened to music or readings, and looked at pictures and objects associated with the topic.

Measurements

Outcome Measures and Blinding

Physical therapists blinded to allocation and previous test results interviewed care staff familiar with participants' need for assistance in ADLs and assessed balance at baseline and 4 and 7 months. All testers took part in theoretical and practical group training in assessments before commencement of the baseline measurement phase. The same tester conducted baseline and consecutive follow-up assessments, except on a few occasions (for primary outcome, n = 9), when assessment by another tester was necessary to preserve blindness. The study hypothesis was not disclosed to participants, their relatives, or staff.

Dependence in ADLs was assessed using the motor domain of the Functional Independence Measure (FIM) and the Barthel Index of ADLs. The FIM has been shown to be valid in people with dementia,[40] with good test–retest and interrater reliability across a variety of disability levels and medical conditions.[41,42] The motor domain of the FIM comprises 13 items rated on a scale ranging from total assistance (1) to complete independence (7), with a total possible summed score of 91. The 10-item Barthel Index (0–20) is a well-established, valid measure of functional independence.[43] Interrater reliability has been found to be fair to very good in people with impaired function.[44] The items cover personal care and mobility, with higher scores reflecting greater independence.[45]

Balance was measured using the Berg Balance Scale (BBS). Participants' ability to maintain an upright posture during 14 functional activities (e.g., sitting, rising from a seated position, transfer between two chairs, reaching while standing) was rated on a scale ranging from 0 to 4, with higher scores reflecting greater balance. Given that the ability to perform functional activities is multifaceted, the BBS also reflects aspects other than balance, such as lower limb strength. The BBS is a valid, reliable instrument for the measurement of function and evaluation of group effects of interventions in older people living in residential care facilities, including people with cognitive impairment.[46,47]

Baseline and Descriptive Measurements

Physical therapists and physicians performed measurements, including gait speed over 4.0 m,[7] the Mini Nutritional Assessment,[48] the first question of the Medical Outcomes Study 36 item Short-Form Health Survey, and the 15-item Geriatric Depression Scale.[49] Nurses at the facilities collected blood samples, which were analyzed using standardized methods at the University Hospital of Umeå. Physicians used electronic records of participants' past medical histories, which included brain imaging in most cases, current pharmaceutical treatment, and assessment results, to record dementia type, depressive disorders, and delirium diagnoses. A specialist in geriatric medicine (YG) reviewed and confirmed these diagnoses according to DSM-IV-TR criteria.[34]

Adherence, Exercise Intensity, and Adverse Events

At the end of each session, activity leaders completed a structured protocol for each participant pertaining to adverse events and intensity achieved in the exercise group. According to a predefined scale,[38] intensity in strength and balance exercises was estimated as high, moderate, or low. Any discomfort brought on or worsened during an activity session was recorded as an adverse event. Two specialists in geriatric medicine (YG, PN) and one physical therapist (HL or ER) rated the severity of each event, first independently and then through consensus.[38] A specialist in geriatric medicine (YG) assessed possible associations between study participation and any death that occurred from the start of the intervention until 1 month after the final follow-up.

Statistical Analysis

Sample size was calculated based on results from the FOPANU Study in Umeå,[33] considering a between-group effect of 1.1 points on the Barthel Index and an intracluster correlation of 0.02. A sample size of 183 participants was required to verify significant intervention effects at a statistical power of 80% at 4-month follow-up, a two-sided significance level of 0.05, and a presumed dropout rate of 10%.

An a priori strategy for selection of adjusting variables was formulated. Significant imbalances between groups[50] and associations (correlation coefficient ≥0.3) with changes in outcome measures at 4 and 7 months[51] were analyzed for all baseline variables listed in Table 1, selected a priori as possible confounders, using the Student *t*-test or the Pearson chi-square test, and Pearson correlation coefficients were calculated. No variable was found to be associated with change in outcome measures above the predefined level. The antidepressant variable differed between groups ($P = .04$) and was adjusted for in analyses.

In agreement with the intention-to-treat principle, available data for each participant were analyzed according to original allocation and regardless of level of attendance. Longitudinal changes in outcome measures from baseline to 4 and 7 months were analyzed using linear mixed-effects models, with interaction terms for activity and time point and adjustment for age, sex, and antidepressant use as fixed effects and individual and cluster allocation as random effects. Baseline measurements were included in the outcome variable to avoid loss of data. The least square mean within-group difference was estimated from these models.

Prespecified subgroup analyses according to dementia type and cognitive level were performed by adding interaction terms to adjusted models. Dementia type was dichotomized as Alzheimer's versus other (non-Alzheimer's) dementia, in part because most previous trials investigating effects on ADLs have included only individuals with Alzheimer's disease, and further by indication of the directional effect in unadjusted within-group analyses of non-Alzheimer's dementia types. Level of cognitive impairment was dichotomized based on the median MMSE score of 15. The difference in effect between the exercise and attention control groups in each subgroup was further investigated using Student *t*-tests and least square mean changes from baseline, with fewer degrees of freedom to obtain conservative *P*-values.

Table 1. Characteristics of the Study Population and Baseline Outcome Measures

Characteristic	Total, N = 186	Exercise, n = 93	Control, n = 93	AD, n = 67	Non-AD, n = 119
Age, mean ± SD	85.1 ± 7.1	84.4 ± 6.2	85.9 ± 7.8	85.5 ± 6.1	88.9 ± 7.6
Female, n (%)	141 (75.8)	70 (75.3)	71 (76.3)	53 (79.1)	88 (73.9)
Dementia type, n (%)					
Vascular	77 (41.4)	36 (38.7)	41 (44.1)		
Alzheimer's disease	67 (36.0)	34 (36.6)	33 (35.5)		
Other	27 (14.5)	15 (16.1)	12 (12.9)		
Mixed Alzheimer's disease and vascular	15 (8.1)	8 (8.6)	7 (7.5)		
Diagnoses and medical conditions, n (%)					
Depressive disorder	107 (57.5)	53 (57.0)	54 (58.1)	40 (59.7)	67 (56.3)
Delirium previous week	102 (54.8)	48 (51.6)	54 (58.1)	37 (55.2)	65 (54.6)
Previous stroke	57 (30.6)	33 (35.5)	24 (25.8)	5 (7.5)	52 (43.7)
Heart failure	56 (30.1)	24 (25.8)	32 (34.4)	15 (22.4)	41 (34.5)
Previous hip fracture	53 (28.5)	28 (30.1)	25 (26.9)	11 (16.4)	42 (35.3)
Angina pectoris	49 (26.3)	21 (22.6)	28 (30.1)	13 (19.4)	36 (30.3)
Diabetes mellitus	29 (15.6)	18 (19.4)	11 (11.8)	9 (13.4)	20 (16.8)
Prescription medication, n (%)					
Analgesics	112 (60.2)	55 (59.1)	57 (61.3)	42 (62.7)	70 (58.8)
Antidepressants	102 (54.8)	58 (62.4)	44 (47.3)	43 (64.2)	59 (49.6)
Diuretics	88 (47.3)	41 (44.1)	47 (50.5)	26 (43.3)	59 (49.6)
Vitamin D–calcium supplement	60 (32.3)	32 (34.4)	28 (30.1)	16 (23.9)	44 (37.0)
Cholinesterase inhibitor	40 (21.5)	25 (26.9)	15 (16.1)	26 (38.3)	14 (11.8)
Benzodiazepine	40 (21.5)	19 (20.4)	21 (22.6)	18 (26.9)	22 (18.5)
Neuroleptic	31 (16.7)	11 (11.8)	20 (21.5)	12 (17.9)	19 (16.0)
Memantine	12 (6.5)	7 (7.5)	5 (5.4)	11 (16.4)	1 (0.8)
Number of medications, mean±SD	8.3 (3.8)	8.4 (4.0)	8.2 (3.7)	7.5 (3.3)	8.8 (4.1)
Blood test results					
Vitamin D ≤ 50 nmol/L, n = 161	83 (51.6)	37 (50.0)	46 (52.9)	33 (49.3)	50 (42.0)
Parathyroid hormone > 6.9 pmol/L, n = 161	42 (26.1)	16 (21.9)	26 (29.5)	14 (20.9)	28 (23.5)
Creatinine clearance ≤30 ml/min, n = 152	17 (11.2)	5 (7.2)	12 (14.5)	3 (4.5)	14 (11.8)
Assessments					
Gait speed over 4 m, m/s, mean±SD (range), n = 185[a]	0.45 ± 0.2 (0.01–1.16)	0.45 ± 0.2 (0.01–1.13)	0.45 ± 0.2 (0.01–0.16)	0.51 ± 0.2 (0.01–1.16)	0.41 ± 0.2 (0.01–0.93)
Pain when walking, n (%), n = 185	35 (18.9)	15 (16.3)	20 (21.5)	15 (22.4)	20 (16.8)
Mini-Mental State Examination score, mean±SD (range 0–30)[b]	14.9 ± 3.5	15.4 ± 3.4	14.4 ± 3.5	14.0 ± 3.1	15.4 ± 3.6
15-item Geriatric Depression Scale score, mean±SD (range 0–15), n = 183[c,d]	3.8 ± 3.2	4.0 ± 3.4	3.6 ± 2.9	3.1 ± 3.1	4.1 ± 3.1
Neuropsychiatric Inventory, mean±SD (range 0–144)[c]	14.8 ± 14.2	15.2 ± 15.8	14.4 ± 12.6	16.7 ± 13.2	13.7 ± 14.7
Mini Nutritional Assessment, mean±SD (range 0–30), n = 185[b]	21.1 ± 2.7	21.3 ± 2.8	20.9 ± 2.6	21.1 ± 2.8	21.1 ± 2.6
Vision impairment[e]	26 (14.0)	10 (10.8)	16 (17.2)	16 (23.9)	10 (8.4)
Self-reported health; good, very good, excellent	119 (64.0)	60 (64.5)	59 (63.4)	43 (64.2)	76 (63.9)
Functional Independence Measure, mean±SD (range 13–91)[b]	52.0 ± 16.9	51.6 ± 17.1	52.5 ± 16.7	53.2 ± 16.7	51.4 ± 17.0
Barthel Index, mean± SD (range 0–20)[b]	10.9 ± 4.4	10.7 ± 4.5	11.0 ± 4.4	11.1 ± 4.3	10.7 ± 4.5
Berg Balance Scale, mean±SD (range 0–56)[b]	28.9 ± 14.5	28.6 ± 14.3	29.3 ± 14.7	33.0 ± 13.7	26.7 ± 14.4

Numbers reported after covariates indicate number of measurements available when values were missing.

[a] Missing data were imputed to 0.01 m/s when participants were unable to complete the gait speed test because of physical impairment.

[b] Higher scores indicate better status.

[c] Lower scores indicate better status.

[d] When at least 10 Geriatric Depression Scale (GDS-15) questions were answered, missing data were imputed using the mean score of questions answered.

[e] Unable to read words printed in 5-mm capital letters, with or without glasses, at a normal reading distance.

AD = Alzheimer's disease; SD = standard deviation; Non-AD = vascular dementia, mixed AD and vascular dementia, and all other types of dementia.

Effect size was estimated for each outcome measure and according to dementia type. It was calculated by dividing the between-group difference in change in linear mixed-effect models by the unadjusted pooled standard deviation of the difference between post- and preintervention values.

The influence of outliers was explored in sensitivity analyses. Adjusted analyses were repeated after the removal of extreme values, defined as more than three times the interquartile range.

All analyses were performed using SPSS version 21.0 (IBM Corp., Armonk, NY) and R version 3.0.1 (R Core Team, Vienna, Austria). All statistical tests were two tailed, and $P < .05$ was considered to be statistically significant.

RESULTS

Baseline Characteristics

One hundred eighty-six participants (141 women, 45 men), 67 (36%) of whom had Alzheimer's disease, were included in the study (Table 1). Non-Alzheimer's dementia types (n = 119 [64%]) included vascular, mixed Alzheimer's and vascular, frontotemporal, Lewy body, and Parkinson dementia. Ninety-eight (82%) participants with non-Alzheimer's dementia had vascular dementia, alone or in combination with other dementia types. Participants with non-Alzheimer's dementia had better cognitive function and were more likely to have medical conditions such as stroke, heart failure, and hip fracture than those with Alzheimer's disease.

Attrition and Adherence

The attrition rate was 8% at 4 months and 16% at 7 months (Figure 1). Over the 4-month intervention period, adherence to the exercise activity was 73% and to the control activity was 70%. Strength exercises were performed at moderate or high intensity at a median of 76% of attended sessions, and balance exercises were performed at high intensity at a median of 75% of attended sessions.

Outcomes

Independence in ADLs deteriorated in both groups, with no significant between-group difference at 4 or 7 months (Table 2, Figure 2A, B). At 4 months, balance had improved in the exercise group and declined in the attention control group; at 7 months, balance had declined in both groups. The difference between groups was significant at 4, but not at 7, months (Table 2, Figure 2C). Effect sizes ranged from −0.003 to 0.52 (Figure 2A–C).

In interaction analyses, the effect of exercise was significant in favor of participants with non-Alzheimer's dementia (vs those with Alzheimer's disease) at 4 and 7 months according to BBS scores (4 months: 5.3, 95% confidence interval (CI) = 0.4–10.2; 7 months: 6.6, 95% CI = 1.4–11.7) but only at 7 months according to FIM and Barthel Index scores (FIM = 7.3, 95% CI = 1.1–13.5; Barthel Index = 2.3, 95% CI = 0.6–4.1; Table 3). The examination of between-group exercise effects in subgroup analyses revealed significant positive effects in participants with non-Alzheimer's dementia according to the FIM at 7 months (Figure 2D) and the Barthel Index (Figure 2E) and BBS (Figure 2F) at 4 and 7 months. FIM and BBS scores reflected negative effects in participants with Alzheimer's disease at 7 months (Figure 2D and E). Effect sizes ranged from −0.34 to 0.89 (Figure 2D–F).

In interaction analyses according to cognitive level, exercise effects benefited participants with higher cognitive levels more than those with lower cognitive levels according to BBS score at 7 months (5.3, 95% CI = 0.3–10.4; Table S1). Analysis of between-group effects revealed a negative effect in participants with lower cognitive function at 7 months (Figure S1C). Interaction analyses according to FIM and Barthel Index scores did not differ significantly between participants with better and worse cognitive function (Table S1).

Sensitivity Analyses

In repeated adjusted analyses after removal of extreme outliers (n = 1–4), intervention effects on ADLs and balance in the total sample remained essentially the same. Subgroup analyses showed no negative effect of exercise in participants with Alzheimer's disease or those with lower cognitive levels.

Adverse Events

All reported adverse events related to exercise sessions were minor or temporary. In the case of one participant's death, an indirect association with exercise could not be excluded with complete certainty; the individual fell ill 1 day after participation in an exercise session and later died from causes attributed to circulatory failure and general atherosclerosis.

DISCUSSION

The effects of a 4-month high-intensity functional exercise program differed between participants living in residential care facilities with Alzheimer's disease and those with other types of dementia. In participants with non-Alzheimer's dementia, the exercise program appeared to postpone decline in ability to perform ADLs and improve balance at 4 and 7 months. No such effect was evident in participants with Alzheimer's disease. The effects of exercise differed according to cognitive level only in terms of balance at 7 months, in favor of participants with better cognitive function.

The two largest randomized controlled trials evaluating the effects of exercise on ADLs in people with dementia have had positive results.[24, 52] Both studies included only people with Alzheimer's disease, and control groups received usual care. The first study, set in nursing homes, found an effect only at 12 months but not at 6 months,[53] suggesting that intervention length is important for achievement of effects in this population and that the 4-month intervention in the present study was too short. Similarly, in the second study, which investigated effects of exercise in community-dwelling older adults, positive effects were evident at 6 and 12 months but not at 3 months.[24] Nevertheless, neither study included an attention control group, limiting the ability to draw conclusive

Table 2. Within- and Between-Group Differences from Baseline in the Functional Independence Measure (FIM), Barthel Index of Activities of Daily Living, and Berg Balance Scale (BBS)

	Within-Group Difference				Between-Group Difference		
Measure	N	Exercise, Mean (SE)[b]	N	Control, Mean (SE)[b]	Mean (95% Confidence Interval)	P-Value	Intracluster Correlation Coefficient[a]
FIM							
4 months	83	−3.10 (1.07)	88	−4.44 (1.04)	1.34 (−1.56–4.25)	.36	0.04
7 months	79	−6.77 (1.09)	79	−7.55 (1.08)	0.78 (−2.21–3.77)	.61	
Barthel Index							
4 months	83	−0.79 (0.31)	88	−1.39 (0.30)	0.60 (−0.24–1.44)	.16	0.05
7 months	79	−1.56 (0.32)	79	−2.12 (0.32)	0.57 (−0.30–1.43)	.20	
BBS							
4 months	81	2.39 (0.88)	86	−1.82 (0.86)	4.20 (1.79–6.61)	<.001	0.07
7 months	74	−2.08 (0.91)	75	−2.05 (0.90)	−0.02 (−2.53–2.49)	.98	

[a]Based on proportion of variation explained by cluster.
[b]From linear mixed-effects models of the complete sample (N = 186) adjusted for age, sex, and antidepressant use.
SE = standard error.

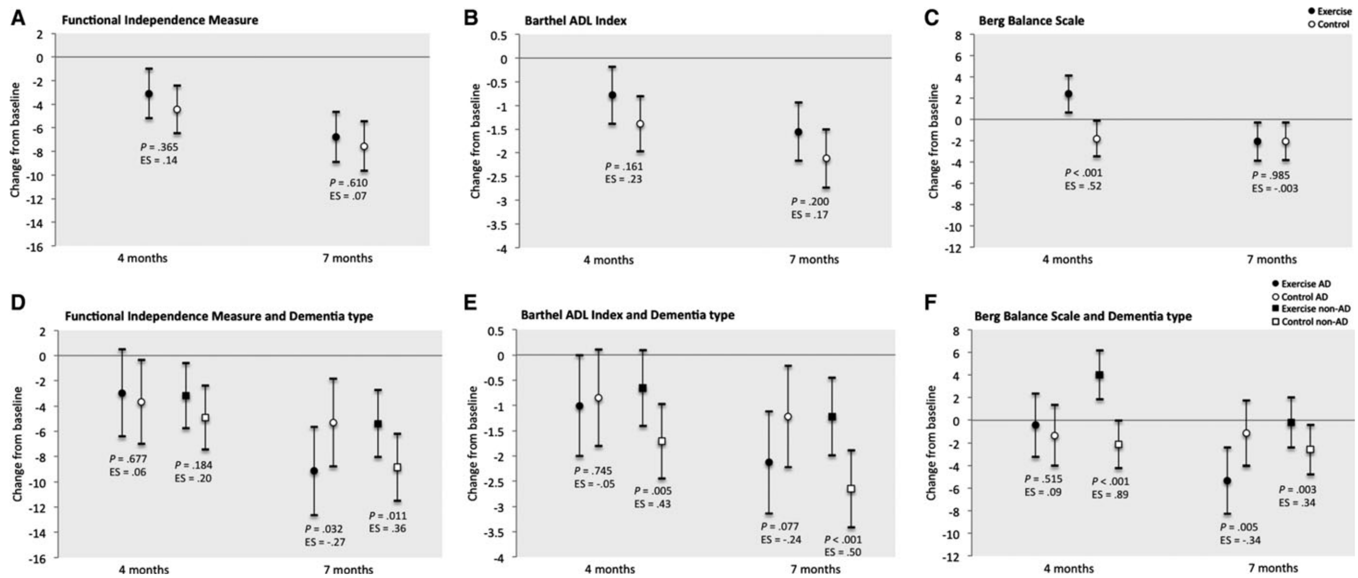

Figure 2. Changes in Functional Independence Measure, Barthel Index of activities of daily living (ADLs), and Berg Balance Scale (A–C) and according to dementia type (D–F). Values are least square means of changes from baseline, with 95% confidence intervals, from linear mixed-effects models of the complete sample (n = 186) adjusted for age, sex, and antidepressant use. Non-AD dementia included vascular dementia, mixed Alzheimer's disease (AD) and vascular dementia, and all other types of non-Alzheimer's dementia. ES = effect size.

inferences regarding exercise effects per se on ADLs and comparisons with the current results in the whole sample and the subgroup of people with Alzheimer's disease.

Functional exercise improved the balance of older people with dementia living in residential care facilities. This result is in accordance with those of previous studies of older populations with various dementia types and comparable cognitive levels in similar settings,[32, 53–55] although the current study results suggest that the improvement in balance and attenuation of decline in ADL independence were exclusive to participants with non-Alzheimer's dementia. The loss of ability to perform ADLs may be due to impaired cognition, but also impaired physical function, and clinical symptoms typical of certain dementia types may influence responses to exercise programs. The absence of a positive exercise response on any outcome measure in participants with Alzheimer's disease may reflect difficulties in motor learning.[20,21,56] Less is known about motor skill learning in people with non-Alzheimer's dementia types, such as vascular dementia, but memory impairment is often less pronounced in people with vascular dementia than in those with Alzheimer's disease,[57] which could indicate greater ability to learn and transfer learned skills. In addition, baseline differences between subtypes may explain the difference in exercise effects between participants with Alzheimer's disease and those with other dementia types; for example, participants with non-Alzheimer's dementia had better cognitive function than did those with Alzheimer's disease. The larger effect of exercise on balance seen in participants with higher cognitive function reinforces the potential moderating effect of cognitive function. Furthermore, considering that 82% of participants with non-Alzheimer's

Table 3. Within-Group Differences from Baseline in the Functional Independence Measure (FIM), Barthel Index of Activities of Daily Living, and Berg Balance Scale (BBS), and Differences in Exercise Effect According to Dementia Type

	Within-Group Difference				Interaction[a]	
Measure	N	Exercise, Mean (SE)[b]	N	Control, Mean (SE)[b]	Mean (95% Confidence Interval)	P-Value
FIM						
4 months						
AD	30	−2.97 (1.77)	33	−3.67 (1.69)	1.04 (−4.98–7.04)	.74
Non-AD	53	−3.18 (1.33)	55	−4.91 (1.30)		
7 months						
AD	29	−9.14 (1.79)	29	−5.33 (1.77)	7.28 (1.10–13.47)	.02
Non-AD	50	−5.40 (1.36)	50	−8.86 (1.35)		
Barthel Index						
4 months						
AD	30	−1.01 (0.51)	33	−0.85 (0.49)	1.21 (−0.53–2.95)	.17
Non-AD	53	−0.66 (0.39)	55	−1.71 (0.38)		
7 months						
AD	29	−2.13 (0.52)	29	−1.22 (0.52)	2.34 (0.55–4.13)	.01
Non-AD	50	−1.23 (0.40)	50	−2.65 (0.39)		
BBS						
4 months						
AD	30	−0.44 (1.44)	33	−1.34 (1.38)	5.26 (0.35–10.18)	.04
Non-AD	51	4.02 (1.10)	53	−2.14 (1.08)		
7 months						
AD	27	−5.33 (1.49)	27	−1.15 (1.48)	6.57 (1.4–11.73)	.01
Non-AD	47	−0.21 (1.13)	48	−2.59 (1.12)		

[a] Difference in exercise effect between participants with Alzheimer's disease (AD) and those with non-AD dementia. A positive mean value indicates a greater effect in favor of participants with non-AD dementia.
[b] From linear mixed effects models of the complete sample (n = 186) adjusted for age, sex, and antidepressant use as fixed effects.
SE = standard error; non-AD = vascular dementia, mixed AD and vascular dementia, and all other types of dementia.

dementia had dementia of vascular origin or dementia with a vascular component, the exercise intervention may have affected vascular risk factors.

The results of this study support the notion that dementia should not be considered a single disease entity but rather constitutes separate disorders with clinical symptoms that may require different strategies to optimize symptom management.[58] The observation of larger effects on balance than on independence in ADLs is consistent with findings from previous studies of older adults with poor cognitive function living in residential care facilities.[31,33,52,54,55] Dependence in ADLs is multifactorial, with various compositions and causes that may not be equally predisposed to change. For example, although better balance may improve ADL performance, the improvement may influence activities such as feeding and bladder control less. In addition, the application of better balance to reduce the level of assistance required in ADLs relies on the responsiveness of care staff, and routines and time constraints may limit it. Furthermore, the observed effects of exercise on FIM (3.5 points) and on Barthel Index (1.4 points), which corresponds to effects sizes of 0.36 and 0.50, respectively, in participants with non-Alzheimer's dementia should be considered to be clinically meaningful. A 1-point difference on the Barthel Index, a scale described as rather crude, can reflect meaningful change in an individual's level of independence. A 1-point improvement in FIM score has been related to timesaving in the care of older adults with stroke.[45,59]

The use of an attention control group to explore exercise effects per se is a strength of this study. The use of a structured exercise program, together with the quantification of exercise intensity, improves the potential to replicate the results of this study clinically or for research purposes.[25,26] The application of inclusion criteria that allowed recruitment of a study population with diverse functional ability, comorbidities, and age improved generalizability. This study has some limitations. In keeping with the intention-to-treat principle, applied to reduce selection bias, the statistical method was chosen to allow inclusion of all available measurements from all participants in analyses, but two participants were inadvertently excluded from follow-up assessments because one participant relocated home for an extended period of the intervention, and the physician of another participant withdrew medical approval to participate in exercise. Sensitivity analyses revealed extreme values for some participants, which influenced the results to some degree; these outliers principally affected the negative effects of exercise in Alzheimer's disease and poorer cognitive function, but because these participants were part of this population, results from analyses of the complete sample are likely to be most accurate. Subgroup analyses may have had limited power, and their results should be interpreted with caution.

CONCLUSION

In older adults with mild to moderate dementia living in residential care facilities, a 4-month high-intensity functional exercise program appeared to defer loss of independence in ADLs and improve balance, albeit only in participants with non-Alzheimer's dementia. In participants with Alzheimer's disease, the intervention seems to have had no such effect. Further research is required to confirm differences in exercise effects between dementia types and to explore possible explanations for these findings, such as the effect of cognitive function.

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Håkan Littbrand and Nina Lindelöf receive royalties on the weighted belt used in the exercise program.

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SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article:

Figure S1. Changes in Functional Independence Measure, Barthel Index of activities of daily living, and Berg Balance Scale according to cognitive function. Values are least square means of changes from baseline, with 95% confidence intervals, from linear mixed-effects models of the complete sample (n = 186) adjusted for age, sex, and antidepressant use. MMSE = Mini-Mental State Examination.

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