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## The Applicability of a High-Intensity Functional Exercise Program Among Older People With Dementia Living in Nursing Homes

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### ABSTRACT

**Background and Purpose:** Exercise programs for people with dementia need to be optimized. We therefore evaluated the applicability of a high-intensity functional exercise program among people with dementia in nursing homes with regard to attendance, achieved exercise intensity, adverse events, a focus on dementia type, and whether symptoms of dementia or other medical conditions common in this population were associated with program applicability.

**Methods:** The Umeå Dementia and Exercise study, a cluster-randomized controlled trial set in 16 nursing homes in Umeå,

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H.L. and N.L. developed and have received royalties on the weighted belt used in the exercise program. All other authors declare no conflicts of interest.

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Sweden. Ninety-three people with dementia (mean [SD] Mini-Mental State Examination score of 15.4 [3.4]) were randomized to the exercise intervention. Thirty-four participants had Alzheimer's disease (AD) and 59 non-Alzheimer's dementia (non-AD). High-Intensity Functional Exercise (HIFE) program was conducted in groups of 3 to 8 participants. Two physiotherapists led 5 sessions (45 minutes each) per fortnight for 4 months (total 40 sessions).

**Results:** Median attendance rate was 82.5%. Lower limb strength exercises were performed at high or medium intensity at a median interquartile range of 94.7% (77.8%-100%) of attended sessions. Participants with non-AD performed more sessions with high intensity in strength exercises than participants with AD (median interquartile range, 53.8% [25.7%-80%] vs 34.9% [2.02%-62.9%];  $P = .035$ ). Balance exercises were performed at high intensity at a median interquartile range of 75% (33.3%-88.6%). Adverse events (all minor and temporary, mostly musculoskeletal) occurred during the exercise sessions in 16% of attended sessions. Low motivation was the most common barrier for attendance. Buildup period, low motivation, and pain were common barriers for achieving high intensity in balance and strength exercises, and fear was a barrier in balance exercises. Of medical conditions, only behavioral and psychological symptoms of dementia, including apathy, were negatively associated with applicability.

**Conclusion:** A group-based, supervised, and individualized high-intensity functional exercise program seems to be applicable with regard to attendance, achieved intensity, and adverse events during the exercise sessions, in people with mild to moderate dementia in nursing homes. Effective strategies to enhance motivation to participate in exercise, as well as prevention and treatment of pain and behavioral and psychological symptoms of dementia, are important when promoting exercise participation in this population.

**Key Words:** dementia, exercise, long-term care, mobility limitation, rehabilitation

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### INTRODUCTION

Dementia is common, progressive, and the leading cause of dependency in activities of daily living (ADLs) in older adults, leading many to reside in nursing homes.<sup>1</sup> Gradually, it reduces cognitive function and impairs walking and balance,<sup>2</sup> increasing the risks of falls, fractures,<sup>3</sup> physical inactivity,<sup>4</sup> and dependency in ADLs.<sup>5</sup> Physical exercise may postpone or prevent these consequences in people with

dementia,<sup>6-10</sup> and thus may be an important way to maintain independence and quality of life.

To improve functional ability in older adults with mobility problems, resistance<sup>11,12</sup> and balance<sup>13</sup> training is recommended. To obtain optimal effects, exercise should be task specific<sup>14,15</sup> and performed with high intensity,<sup>11,15</sup> that is, performed near the individual's maximum capacity and with sufficient frequency and duration.<sup>12,16</sup> However, these recommendations may be challenging for some people with dementia due to complicating symptoms of the disease.<sup>6</sup> Cognitive deficits (eg, impaired memory, impaired executive function, aphasia, and apraxia), and behavioral and psychological symptoms of dementia (BPSD) may impede participation in high-intensity exercise programs, especially with increasing dementia severity. Furthermore, common comorbidities and medical conditions, such as pain, vision or hearing impairment,<sup>1,17</sup> and an unstable health status,<sup>18,19</sup> may impact attendance, reduce the ability to achieve high exercise intensity, and increase the risk of adverse events. In addition, symptom patterns and comorbidities differ among dementia types,<sup>1,20</sup> which could affect exercise program applicability.

Studies exploring applicability of exercise programs have been requested with the aim of optimizing exercise programs for people with dementia.<sup>6,9</sup> Furthermore, it is also important to evaluate whether different dementia types, dementia symptoms, and other medical conditions are associated with applicability of exercise programs. The Umeå Dementia and Exercise (UMDEX) study evaluated the effects of a high-intensity functional exercise program in people with dementia living in nursing homes. The exercise program affected ADLs and balance positively, but only in participants with other types of dementia than Alzheimer's disease (non-AD).<sup>21</sup> The primary aim of the current study was to evaluate the applicability of this high-intensity functional exercise program among people with dementia in nursing homes with regard to attendance, achieved exercise intensity, and adverse event occurrence, with a focus on dementia type. The secondary aim was to evaluate whether symptoms of dementia or other medical conditions common in this population were associated with program applicability.

## METHODS

This study was part of the UMDEX study, a cluster-randomized controlled trial conducted in 16 nursing homes in Umeå, Sweden, including general and dementia units all with private rooms and staff on hand, as well as units with private apartments with access to on-site nursing and care. A group of 864 residents were screened by physiotherapists (PTs) and physicians. The UMDEX study is described in detail elsewhere.<sup>21</sup> Those randomized to participate in the exercise intervention were included in this study. The study protocol (ISRCTN31767087) is published on the ISRCTN registry. Ethical approval was obtained from the Regional Ethical Review Board in Umeå in August 2011 (2011-205-31M).

## Participants

Participants had dementia according to the *Diagnostic and Statistical Manual of Mental Disorders* (Fourth Edition, Text Revision) (*DSM-IV-TR*),<sup>22</sup> aged 65 years and older, had Mini-Mental State Examination (MMSE) scores of 10 or more,<sup>23</sup> had dependence in personal ADLs according to the Katz Index (score > A) administered in an interview by health care staff,<sup>24</sup> had the ability to rise from a chair with an armrest with assistance from 1 person or less, had the ability to hear and understand spoken Swedish, and had their physicians' approval. All participants provided informed oral consent, affirmed by next of kin.

## Exercise Intervention

The intervention was based on the High-Intensity Functional Exercise (HIFE) program developed by research team members. The HIFE program, designed to improve lower limb strength, balance, and mobility, is available as a booklet<sup>25</sup> and on a Web page.<sup>26</sup> Exercise sessions were conducted at participating nursing homes in small groups (N = 3-8), each supervised by 2 PTs. The sessions were mediated by a total of 7 PTs (clinical experience range, 1-11 years), who had experience working with geriatric patients diagnosed with dementia. Before intervention, all of the administering PTs participated in a 1-day education session held by the developers (H.L., N.L., and E.R.) for training to deliver the exercise program, during which they were also taught about the signs and symptoms of heart disease by a geriatric medicine and internal medicine specialist (Y.G.) on the research team. Five sessions (~45 minutes each) were held per fortnight at set times for 4 months (total, 40 sessions). Before starting each exercise session, the PTs or nursing home staff gave verbal reminders or aided transfer to the exercise sessions, and also when needed, motivated the participants to join the sessions. When possible, supervised individual sessions were provided for participants unable to attend group sessions. Physiotherapists were encouraged to obtain updates on participants' health status before sessions and could contact physicians or nurses when necessary. Based on the patients health status, PTs were able to adjust attendance arrangements (fewer exercises, individual sessions, or nonattendance) and modify exercise intensity.

Each group session started with group warm-up exercises for all participants. Participants were then supervised individually to safely promote the highest possible exercise intensity. Participants took turns exercising and resting during each session. The high-intensity functional exercise program comprises 39 exercises performed in functional weight-bearing positions, similar to those used in everyday situations (eg, rising from a chair, trunk rotation, walking, climbing stairs).<sup>25,27</sup> The exercises are distributed over 5 categories: A, static and dynamic balance exercises in combination with lower limb strength exercises; B, dynamic balance exercises in walking; C, static and dynamic balance exercises in standing; D, lower limb strength exercises with continuous balance support; and E, walking with continuous balance support. Exercises were planned

depending on each individual's degree of functional deficit and according to a hierarchical model based on level of support required while walking a short distance (5-10 m). We recommended performance of at least 2 lower limb strength exercises and 2 balance exercises in 2 sets each session. High intensity was the aim, with adaptation through progressive adjustment of load (performance adjustment or weighted waist belt [maximum 12 kg] use) and support (eg, by narrowing base of support or surface alteration), while considering participants' symptoms and changes in health and functional status. Physiotherapists defined the intensity of each strength exercise set relative to the repetition maximum (RM), that is, "the maximum number of times a load can be lifted before fatigue using good form and technique,"<sup>28</sup> (high, 8-12 RM; medium, 13-15 RM; low, >15 RM). Balance exercise intensity, estimated by the supervising PT through observation, was defined according to the level of postural stability challenge exhibited: high, fully challenged (ie, balance exercises performed near limits of maintaining an upright position); medium, not fully challenged or fully challenged in a minority of exercises; low, not challenged. Participants wore belts with handles so that PTs could provide support when needed, thereby preventing falls. Participants conducted moderate-intensity strength exercises for the first 2 weeks (buildup period).

### Outcome Variables

Attendance, intensity of lower limb strength and balance exercises, and adverse events were the outcome variables. At the end of each exercise session, activity leaders completed a structured protocol for each participant, including exercise intensity,<sup>25</sup> reasons for not achieving high intensity, effective workout time without rest, reasons for nonattendance, and adverse event occurrence, that is, development or worsening of discomfort during the exercise session (observed by a leader or expressed by a participant spontaneously or upon questioning). Leaders assessed whether moderate- to high-intensity strength exercises primarily strained either peripheral (muscular) or central (cardiorespiratory) systems. They assessed by observation or upon questioning whether the reason for stopping exercise primarily was muscle fatigue in the lower limb or shortness of breath in chest. Two geriatric medicine specialists (including Y.G.) and 1 PT (E.R. or H.L.) assessed adverse event severity in consensus as (1) minor or temporary (incurred or worsened by exercise), (2) serious symptoms (potential risk of severe injury or life threatening), (3) manifest injury or disease, and (4) death. During adverse event assessment, they had access to medical records to follow up the course and severity of the symptoms. Two geriatric medicine specialists assessed whether deaths occurring during the intervention period were related to the exercise.

### Baseline Assessment

Physiotherapists and physicians performed baseline assessments before randomization, evaluating functional balance capacity (Berg Balance Scale),<sup>29</sup> usual gait speed over

4 m with a walking aid, pain while walking (self-reported pain directly after gait speed test), depressive symptoms (15-item Geriatric Depression Scale administered by interviewing the participant),<sup>30</sup> global cognitive function (MMSE),<sup>23</sup> BPSD (Neuropsychiatric Inventory) (proxy reported by nursing home staff),<sup>31</sup> and nutritional status (Mini Nutritional Assessment).<sup>32</sup> Diagnoses were based on information gathered from assessments, medical records, and medication prescriptions. Physicians specialized in geriatric medicine diagnosed dementia type according to the *DSM-IV-TR*.<sup>22</sup>

### Data Analysis

Individual attendance rate was calculated as the number of sessions attended divided by the total number of sessions offered (n = 40), regardless of study completion. Intensity and adverse event rates were calculated as the number of sessions attended, with specific intensity and with adverse event occurrence, respectively, divided by the number of attended sessions. Baseline characteristics of participants with AD and non-AD were compared using Student *t* test or the  $\chi^2$  test. Attendance, high intensity, and adverse event rates and effective workout time were compared using the Mann-Whitney *U* test (due to skewed distribution). Spearman rank correlations between outcome variables and medical conditions (Table 1) were examined. Analyses were performed using SPSS software (version 23; IBM Corporation, Armonk, New York), with a 2-tailed significance level of  $P < .05$ .

## RESULTS

Ninety-three participants (70 women, 23 men) were included in the study (Figure 1). Thirty-four (36.6%) participants had AD and 59 (63.4%) had non-AD, including vascular, mixed Alzheimer's and vascular, Lewy body, frontotemporal, and Parkinson's dementia (Table 2). Fifty-three (57.0%) participants had depressive disorders, 48 (51.6%) had delirium in the past week, and 21 (22.6%) had apathy symptoms according to the Neuropsychiatric Inventory. Relative to those with AD, participants with non-AD had better global cognitive function (MMSE score of 16.0 vs 14.4), a greater occurrence of previous stroke (50.8% vs 8.8%), more mobility device use (93.2% vs 61.8%), more prescribed medications (9.1 vs 7.3), and worse balance (Berg Balance Scale score of 25.9 vs 33.2) (Table 2).

### Attendance

The overall attendance rate was in mean (SD): 73.4% (28.5) (2729/3720 sessions, including 247 [9.1%] individual sessions). The median (interquartile range) individual attendance rate and effective workout time per session were 82.5% (70.0%-92.5%) and 17.0 (15.0-19.5) minutes, respectively, with no significant differences between the AD and non-AD groups ( $P = .308$ ), ( $P = .64$ ), respectively (Figure 2). The most common reasons for session nonattendance were lack of motivation (9.7%

**Table 1. Correlations Between Outcome Variables and Medical Conditions<sup>a</sup>**

Variable	Attendance Rate	High-Intensity Strength Rate	High-Intensity Balance Rate	Adverse Event Rate
MMSE	-0.016	0.182	0.153	0.027
GDS-15	0.009	0.014	0.163	0.057
NPI, total	-0.217 <sup>b</sup>	-0.150	-0.295 <sup>c</sup>	0.063
NPI, apathy	-0.216 <sup>b</sup>	0.067	0.055	-0.082
BBS	0.055	-0.001	0.093	-0.085
MNA	-0.026	0.028	-0.048	-0.061
Pain while walking	0.016	-0.119	0.013	0.215 <sup>b</sup>
Analgesic use	-0.064	-0.183	-0.041	0.238 <sup>b</sup>
Neuroleptic use	0.185 <sup>b</sup>	0.107	0.185	0.036
Heart failure	-0.025	0.175	0.040	-0.006
Angina pectoris	-0.107	0.223 <sup>b</sup>	0.034	0.049
Chronic lung disease	-0.193	0.043	-0.094	0.091
Vision impairment	0.166	-0.070	-0.178	0.053
Hearing impairment	0.077	0.074	-0.164	0.026
Sex (female)	0.043	-0.097	-0.016	0.148

Abbreviations: BBS, Berg Balance Scale; GDS-15, 15-item Geriatric Depression Scale; MMSE, Mini-Mental State Examination; MNA, Mini Nutritional Assessment; NPI, Neuropsychiatric Inventory.  
<sup>a</sup>Spearman rank correlations used in analyses.  
<sup>b</sup> $P < .05$ .  
<sup>c</sup> $P < .01$ .

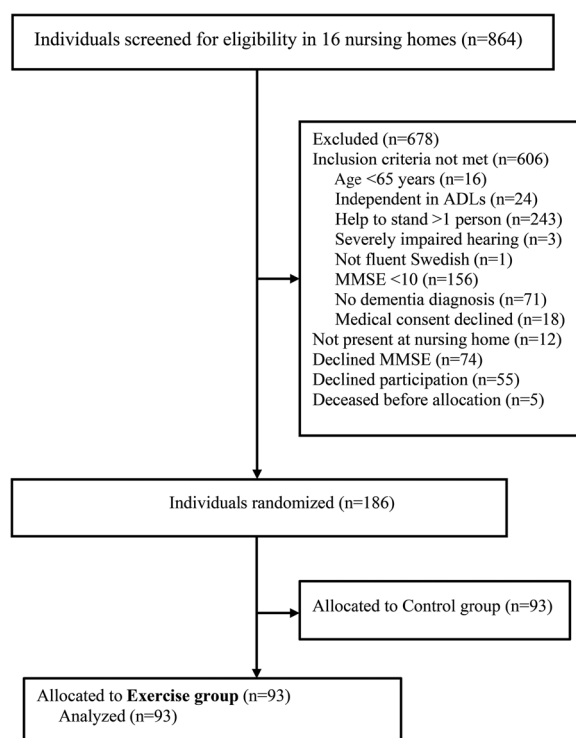
of all sessions), illness (4.0%), tiredness (3.6%), and deceased status (2.6%; Figure 3).

### Exercise Intensity

In total, lower limb strength exercises were performed at high intensity in 49.4% of the attended sessions, moderate intensity in 39.7%, and low intensity in 10.8% (1349, 1084, and 296 out of 2729 sessions, respectively). Corresponding figures for balance intensity were 67.6%, 26.5%, and 5.9% (1845, 722, and 162 sessions, respectively). The median (interquartile range) individual lower limb strength exercises rate for high intensity was 47.2% (12.5%-77.8%) of attended sessions, and the rate for high or medium intensity at 94.7% (77.8%-100%). Balance exercises were performed at high intensity at 75% (33.3%-88.6%) of attended sessions and at high or medium intensity at 100% (91.2%-100%). High-intensity strength and balance exercises were performed in the same session at 28.6% (9.1%-40.5%). A significant difference was observed between the AD and non-AD groups in the high-intensity strength rate (34.9% [2.0%-62.9%] vs 53.8% [25.7%-80.0%]  $P = .035$ ) but not in the high-intensity balance rate ( $P = .771$ ) (Figure 2).

Strength exercises resulted in primary straining of peripheral (muscular) and central (cardiorespiratory) systems in 82.9% and 17.1% of attended sessions, respectively. The most common reasons for not achieving high-intensity performance in lower limb strength exercises were buildup training in the beginning of the exercise period or after a period of absence due to, for example, illness (14.5% of attended sessions), low motivation (11.4%), and pain (11.0%; 9.8% in the lower extremities; Figure 4). Corresponding figures divided in participants with AD and

non-AD, respectively, are shown in Figure 5. The most common reasons for not achieving high intensity in balance exercises were buildup training (10.3% of attended sessions), low motivation (9.3%), fear (8.7%), and pain (6.1%; Figure 4).



**Figure 1.** Flowchart of the study. ADLs indicates activities of daily living; MMSE, Mini-Mental State Examination.

**Table 2. Baseline Characteristics of Participants<sup>a</sup>**

Characteristic	Total (n = 93)	AD (n = 34)	Non-AD (n = 59)
Age, y	84.4 (6.2)	84.9 (6.6)	84.1 (6.0)
Sex, female	70 (75.3)	27 (79.4)	43 (72.9)
Dementia type			
Alzheimer's	34 (36.6)		
Vascular	36 (38.7)		
Mixed AD/vascular	8 (8.6)		
Other	15 (16.1)		
Diagnoses and medical conditions			
Depressive disorders	53 (57.0)	18 (52.9)	35 (59.3)
Delirium, previous week <sup>b</sup>	48 (51.6)	15 (44.1)	33 (55.9)
Previous stroke	33 (35.5)	3 (8.8)	30 (50.8) <sup>c</sup>
Heart failure	24 (25.8)	6 (17.6)	18 (30.5)
Angina pectoris	21 (22.6)	5 (14.7)	16 (27.1)
Previous hip fracture	28 (30.1)	7 (20.6)	21 (35.6)
Diabetes mellitus	18 (19.4)	6 (17.6)	12 (20.3)
Rheumatic disease	14 (15.1)	4 (11.8)	10 (16.9)
Chronic lung disease	20 (21.5)	6 (17.6)	14 (23.7)
Osteoarthritis	35 (37.6)	12 (35.3)	23 (39.0)
Hearing impairment <sup>d</sup>	20 (21.5)	9 (26.5)	11 (18.6)
Vision impairment	10 (10.8)	6 (17.6)	4 (6.8)
Pain while walking, n = 90	15 (16.1)	7 (20.6)	8 (13.6)
Prescription medications			
Analgesics	55 (59.1)	19 (55.9)	36 (61.0)
Antidepressants	58 (62.4)	22 (64.7)	36 (61.0)
Benzodiazepine	19 (20.4)	8 (23.5)	11 (18.6)
Diuretics	41 (44.1)	13 (38.2)	28 (47.5)
Cholinesterase inhibitor	25 (26.9)	13 (38.2)	12 (20.3)
Neuroleptics	11 (11.8)	5 (14.7)	6 (10.2)
Number of medications	8.4 (4.0)	7.3 (3.6)	9.1 (4.1) <sup>e</sup>
Assessments			
Barthel ADL Index (0-20) <sup>f</sup>	10.7 (4.5)	11.0 (4.5)	10.6 (4.5)
MMSE (range: 0-30) <sup>f</sup>	15.4 (3.4)	14.4 (3.0)	16.0 (3.6) <sup>e</sup>
Berg Balance Scale (range: 0-56) <sup>f</sup>	28.6 (14.3)	33.2 (12.9)	25.9 (14.5) <sup>e</sup>
Gait speed: 4 m, m/s, n = 88	0.45 (0.2)	0.5 (0.2)	0.45 (0.2)
NPI (range: 0-144) <sup>g</sup>	15.2 (15.8)	15.7 (12.9)	15.0 (17.4)
NPI apathy (range: 0-12) <sup>g</sup>	0.97 (2.2)	0.47 (1.4)	1.3 (2.5)
GDS-15 (range: 0-15) <sup>g</sup> , n = 92	4.0 (3.4)	3.2 (3.0)	4.4 (3.5)
MNA (range: 0-30) <sup>f</sup>	21.3 (2.8)	21.1 (2.9)	21.3 (2.7)
Use of mobility device	76 (81.7)	21 (61.8)	55 (93.2) <sup>c</sup>
Self-reported health, good	60 (62.5)	21 (61.8)	39 (66.1)

Abbreviations: ADL, activities of daily living; GDS-15, 15-item Geriatric Depression Scale; MMSE, Mini-Mental State Examination; MNA, Mini Nutritional Assessment; NPI, Neuropsychiatric Inventory.

<sup>a</sup>Values are expressed as mean (SD) or as n (%). Numbers reported after covariates indicate numbers of measures available when values are missing.

<sup>b</sup>Reported by staff based on the confusion subscales of the Organic Brain Syndrome Scale.

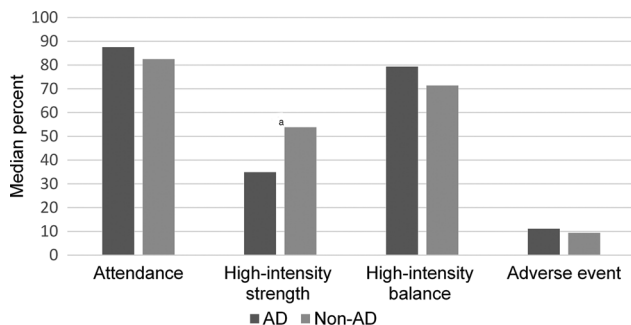
<sup>c</sup> $P < .01$ .

<sup>d</sup>Unable to hear conversation from 1-m distance with or without hearing aid.

<sup>e</sup> $P < .05$ .

<sup>f</sup>Higher scores indicate better status.

<sup>g</sup>Lower scores indicate better status.

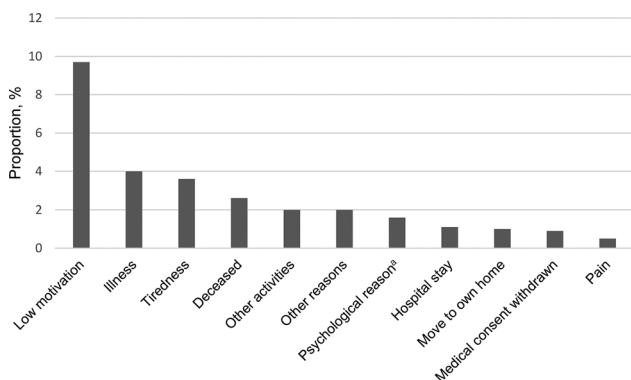


**Figure 2.** Attendance, high-intensity strength, high-intensity balance, and adverse event rates in participants with AD and non-AD dementia. <sup>a</sup> $P < .05$ , AD versus non-AD. AD indicates Alzheimer's disease.

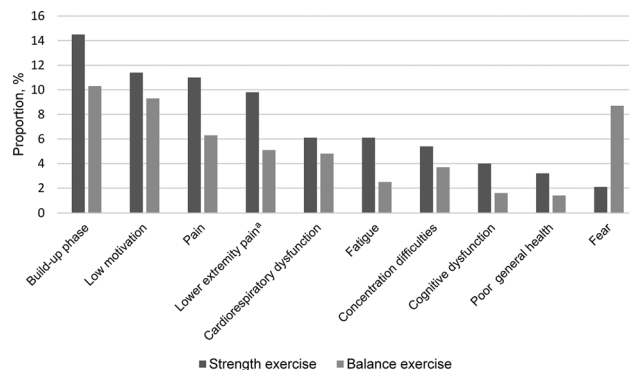
### Adverse Events

In total, adverse events were recorded in 446/2729 (16.3%) attended sessions among 72 (77.4%) participants. All adverse events ( $N = 455$ ) were minor or temporary. The median (interquartile range) individual adverse event rate was 10.0% (2.6%-27.3%) of attended sessions, with no significant difference between participants with AD and non-AD ( $P = .821$ ) (Figure 2). Adverse events were musculoskeletal (pain, soreness; 64.0%), general/unspecified (eg, fatigue, headache, stomach pain, nausea; 13.6%), psychological (eg, anxiety, restlessness, anger; 13.3%), dizziness (5.2%), and cardiorespiratory (eg, breathlessness, chest discomfort; 3.9%).

Among the deaths that occurred during the intervention period, there was 1 case in which an indirect association with exercise could not be excluded with complete certainty. The individual fell ill 1 day after participating in an exercise session and later died from causes attributed to circulatory failure and general atherosclerosis.<sup>21</sup> The participant suffered from multimorbidity, including poststroke, heart failure, atrial fibrillation, and general atherosclerosis. During the last 3 exercise sessions, the participant experienced some reduced endurance but without any discomfort. The participant's responsible physician at the nursing home was



**Figure 3.** Reasons for not attending exercise sessions, as percentage of total sessions. <sup>a</sup>Includes anxiety, restlessness, and delirium.



**Figure 4.** Reasons for not achieving high intensity, as percentage of all attended sessions. More than 1 reason per participant could be recorded. <sup>a</sup>Included in the pain category.

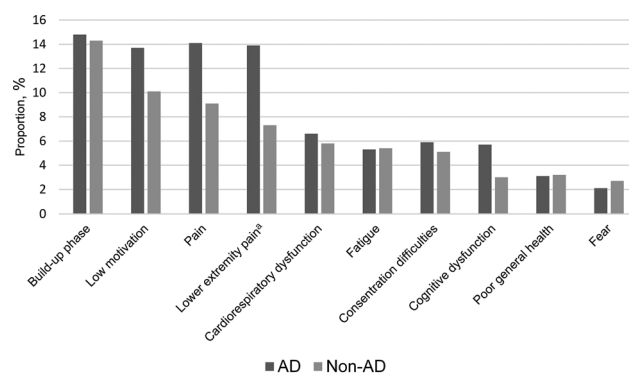
consulted after the 2nd of these 3 sessions and approved further exercise, which was adjusted according to the program instructions.

### Correlation Between Outcome Variables and Medical Conditions

The occurrence of more BPSD symptoms, according to the Neuropsychiatric Inventory, was correlated with lower attendance ( $P = .037$ ) and lower balance intensity ( $P = .005$ ), and apathy was correlated with lower attendance ( $P = .037$ ; Table 1). Neuroleptic use was correlated with higher attendance ( $P = .012$ ). Angina pectoris diagnosis was correlated with higher strength intensity ( $P = .034$ ). Use of analgesics ( $P = .023$ ) and pain while walking ( $P = .041$ ) were correlated with the occurrence of more adverse events.

### DISCUSSION

This study showed that in a group-based, supervised, and individualized high-intensity functional exercise program, among older people with mild to moderate dementia living in nursing homes, a majority of the participants had high



**Figure 5.** Reasons for not achieving high intensity in strength exercises in participants with AD and non-AD dementia, as percentage of all attended sessions. More than 1 reason per participant could be recorded. <sup>a</sup>Included in the pain category. AD indicates Alzheimer's disease.

attendance rate and could exercise with moderate to high lower limb strength intensity and high balance intensity. The exercise program led to only minor and temporary (mostly musculoskeletal) adverse events during the exercise sessions. Participants with non-AD performed more sessions with a high intensity in strength exercises than participants with AD. The most common barriers for not attending exercise sessions were low motivation, illness, and tiredness. While fear was a common reason for not achieving high intensity in balance exercises, buildup period, low motivation, and pain were all common barriers in both balance and strength exercises. Of the medical conditions and symptoms of dementia analyzed in our study, only BPSD, including apathy, was negatively associated with the applicability of the program.

The attendance rate in this study was similar to those reported in other evaluations of high-intensity functional exercises among people with dementia living in nursing homes<sup>9,33</sup> and only slightly lower than that reported in community-dwelling sedentary older adults participating in various exercise regimes,<sup>34</sup> despite participants' significant cognitive and mobility impairment and the high prevalence of medical conditions.<sup>35,36</sup> Exercise studies reporting higher attendance in people with dementia living in nursing homes included participants with greater mobility<sup>37,40</sup> and cognitive capacity,<sup>40</sup> only completing participants,<sup>37-39</sup> and exercises of seemingly lower intensity.<sup>37,40</sup> The high intensity of the present intervention may have negatively impacted motivation to attend, as participants with cognitive impairment have been found to prefer simple, light, and safe exercises.<sup>41</sup> However, UMDEX participants reported that the exercise was challenging, but achievable, gave them moments of pleasure, and improved their mental and physical strength.<sup>42</sup> In addition, no serious adverse event occurred during exercise, which may have increased motivation to attend. Other factors contributing to attendance in this study were the possibility of individual sessions and help with transfer to sessions, as shown previously.<sup>43</sup> The latter factor may have contributed to the similarity of attendance rates of participants with AD and non-AD, despite differences in cognitive and balance capacity.<sup>35,36</sup> Although the median attendance rate was 82.5%, only half of participants fulfilled the recommendation to exercise at least 2 times per week.<sup>12,44</sup> To increase this proportion, the provision of additional weekly exercise sessions and individualization of session times according to participants' daily routines and needs may be necessary.

Although many participants did not reach high intensity, especially in strength exercises, participants achieved moderate to high intensity in strength and balance exercises in almost all attended sessions, in accordance with exercise recommendations<sup>12,44</sup> and findings of similar studies in this population.<sup>27,33</sup> Factors potentially contributing to this result are that the program's functional exercises are easy to follow for people with cognitive impairment and were adapted individually. As lower limb strength is important for functional performance, the greater intensity with which participants with non-AD were able to perform strength exercises may have contributed to the superior

effects on ADLs and balance compared with those with AD, as shown previously.<sup>21</sup> Despite comorbidity, including cardiorespiratory diseases, strength exercises strained mostly peripheral lower extremity muscles in this study. This straining is a positive result because exercising to muscle fatigue is a prerequisite to increasing muscle strength.

The incidence of recorded adverse events during exercise sessions in the study was higher than previously reported incidences in people with dementia.<sup>27,45</sup> This difference could be explained by a relatively high prevalence of medical conditions such as osteoarthritis, stroke, depression, and delirium in our cohort. The participants were also more dependent in ADLs and more cognitively impaired than prior study groups, indicating that our population had progressed further in the course of their diseases, making them more sensitive to internal and external disturbances.<sup>18</sup> The high prevalence of osteoarthritis (37.6%) in our cohort may explain, at least in part, why the majority of adverse events were musculoskeletal (pain and soreness; 64.0%). Muscle-strengthening physical activity to reduce pain and improve function is recommended for people with osteoarthritis, with no contraindication for minor or temporary pain during exercise.<sup>46-48</sup> Although all discomforts experienced by the participants during the exercise sessions were minor or temporary, there was 1 death for which an indirect association with exercise could not be excluded with complete certainty. The participant, who had multimorbidity, fell ill a day after an exercise intervention. The patient experienced no discomfort during the preceding exercise session, which suggests that the death was probably unrelated to the exercise intervention. This inference is supported by other studies of exercise in people with dementia in nursing homes in which no exercise-related deaths were reported.<sup>33,40,49,50</sup> Factors important for the safe achievement of moderate to high intensity were participants' use of waist belts with handles and PTs' ability to modify exercise according to participants' health status. This was based on PTs' close attention to participants' nonverbal communication<sup>51</sup> and PTs' ability to obtain updates on participants' health status by communication with nursing home staff and to contact physicians or nurses when needed.

Low motivation, illness, and tiredness were the most common barriers to session attendance, as in other studies of people with dementia living in nursing homes.<sup>38,49</sup> Despite individual exercise adaptation and the leader's effort to get to know participants and interpret their needs,<sup>51</sup> low motivation was a common barrier to exercise attendance and intensity. Future studies should explore reasons for low motivation in this population, in which apathy is common, to develop more effective strategies, including ways to deliver exercise programs, to enhance the applicability of high-intensity functional exercise programs. Pain was a common barrier to the achievement of high-intensity performance, especially in strength exercises and among participants with AD. Pain while walking and analgesic use were also associated with adverse events. Thus, pain reduction and exercise individualization are needed in this population. Fear was a

common barrier to the achievement of high intensity in balance exercises, perhaps due to difficulties in understanding the purpose of the exercises because of cognitive impairment and/or fear of falling when challenging postural stability; addressing these issues might be important.

Behavioral and psychological symptoms of dementia, including apathy, but not depression, functional balance capacity, or cognitive level, affected program applicability negatively in this study. Similarly, depression and dementia severity did not affect attendance,<sup>33</sup> and cognitive function did not affect the applicability of high-intensity exercise,<sup>9</sup> in previous studies. Unexpectedly, neuroleptic use, which was present in approximately one-tenth of the participants, had a positive association with attendance. This result might be due to a positive medication effect (eg, on BPSD) or random significance. This might also be the reasons for the positive association between angina pectoris and high intensity in balance exercises. In summary, these results support the provision of high-intensity exercise functional programs to individuals with dementia living in nursing homes.

Some limitations of this study should be considered. Although the inclusion criteria were broad, the exclusion of people with MMSE scores of less than 10 and need of assistance from 2 or more to rise from a chair with an armrest diminishes the generalizability of the findings. Strength, in the present study, is the attempt to estimate the exercise intensity in an adequate manner, that is, quantify the challenge of a task to the capability of that individual.<sup>52</sup> A limitation is that the reliability of the rating scales was not tested, which makes the assessment more uncertain. However, the standardized rating system was predefined and all PTs were familiar with its application. There was no monitoring of new adverse events between exercise sessions, which might have led to missing potential adverse events. However, when assessing the course and severity of adverse events present during exercise sessions, it was possible to follow up them between sessions by reviewing medical records. In addition, it is possible that participants experienced delayed-onset muscle soreness or other pain between sessions and which is not known to the research team. However, pain was not a common reason for not attending exercise session (0.5% of total sessions, shown in Figure 3). Furthermore, the non-AD group was heterogeneous, as it included participants with several dementia subtypes. Further subdivision was not possible due to power issues in this analysis. Future studies of high-intensity functional exercise program applicability in participants with various dementia subtypes, as well as studies recording adverse events between sessions are needed.

## CONCLUSION

A group-based, supervised, and individualized high-intensity functional exercise program seems to be applicable with regard to attendance, achieved intensity, and adverse events during the exercise sessions, in people with mild to moderate dementia in nursing homes. People with non-AD might be able to exercise with higher intensity

in strength exercises than people with AD. To fulfill the recommendations to exercise at least twice per week for a majority of people in this population, the provision of additional weekly exercise sessions and individualization of exercise time may be needed. Since low motivation was a common barrier for attendance as well as for achieving high intensity, effective strategies to enhance motivation to participate in exercise are of importance. Furthermore, it is also important to prevent and treat pain and BPSD when promoting an high-intensity functional exercise program in this population. Although medical conditions are common in people with dementia in nursing homes, the results from our study support the inclusion of this population in high-intensity functional exercise programs.

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