The effect of long-term, group-based physical, cognitive and social activities on physical performance in elderly, community-dwelling people with mild to moderate dementia

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The effect of long-term, group-based physical, cognitive and social activities on physical performance in elderly, community-dwelling people with mild to moderate dementia

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Abstract
Background: Elderly people with dementia are known to be less physically active compared with elderly, healthy people, emphasizing the need for interventions in order to maintain a high level of independence in activities of daily living. The aim was to evaluate the effect of long-term, group-based rehabilitation including physical activity on physical performance in elderly, community-dwelling people with mild to moderate dementia.

Methods: A quasi-experimental study of 18 elderly, community-dwelling people, diagnosed with mild to moderate dementia, participated in an ongoing rehabilitation programme based on...
integrated physical, cognitive and social activities. The outcome measure was physical performance: the 30-second sit-to-stand test, Guralnik balance test, 10-metre walking speed test, timed 6-metre walk test and a timed dual task walk test. The repeated measure ANOVA was used to analyse any overall differences between related means.

**Results:** No significant effect of time was found for the five outcome measures during the entire period. The variation in the estimate of most outcome scores was higher within subjects than between subjects during the period. Profile plots illustrated that three of the participants, who experienced severe cognitive deterioration, markedly declined in all physical performance tests.

**Conclusion:** The expected, progressive deterioration in physical performance was delayed in a small group of home-dwelling people with mild to moderate dementia participating in long-term, group-based rehabilitation. Long-term, group-based rehabilitation may have the overall potential to delay deterioration in activities of daily living performance in home-dwelling people with mild to moderate dementia; however, more studies with larger samples are needed to confirm the findings of this study.

**Keywords**
dementia, group based, rehabilitation, physical performance, long term

**Background**
The risk of developing dementia increases with the aging of the population, and the proportion of people with dementia are expected to increase greatly in Denmark during the next few decades (Andersen et al., 1999; Danish Dementia Research Centre, 2017), as in the rest of the world (Burge, Kuhne, Berchtold, Maupetit, & von Gunten, 2012). Currently, 6.6% (55,000) of the Danish population above the age of 65 have been diagnosed with dementia, with an incidence of approximately 7700 new cases each year (Andersen et al., 1999; Danish Dementia Research Centre, 2017).

In Denmark, the government has stated that the impact of dementia must be decreased by rehabilitation programmes in order to maintain a high level of independence in activities of daily living (ADL) in order to achieve highest possible functioning in everyday life as well as quality of life (Sundhedsstyrelsen, 2016). In addition to the degree of independence in ADL and the level of physical performance (Astell, Clark, & Hartley, 2008), other factors known for importance for people with dementia to maintain a high level of independence in ADL are behavioural and psychological in nature (Gruber-Baldini, Boustani, Sloane, & Zimmerman, 2004). Also, social factors are determinants of health, such as social support networks, support and beliefs of the family and community (WHO, 2018).

In elderly, community-dwelling people with dementia, loss of independence in ADL is strongly associated with reduced quality of life (Andersen, Wittrup-Jensen, Lolk, Andersen, & Kragh-Sorensen, 2004), risk of institutionalization (Knopman et al., 1999), premature death (van Dijk et al., 2005) and a greater burden for cohabiting family members and society (Prigerson, 2003). The decline in ADL performance in people with dementia may not only be due to disease progression, but also to physical inactivity associated with dementia-related apathy (Littbrand, Lundin-Olsson, Gustafson, & Rosendahl, 2009). Elderly people with dementia are known to be less physically active compared with elderly, healthy people,
emphasizing the need for physical activity interventions for the former (Fontaine & Haaz, 2006; Hootman et al., 2002). In general, it seems that physical activity and exercise have the potential to slow down the development of dependence in ADL, thereby enhancing the quality of life for people with dementia and their carers (Forbes, Forbes, Blake, Thiessen, & Forbes, 2015).

For people with dementia living in residential facilities, physical activity has been shown to have a positive effect on overall health, physical performance and ADL (Brett, Traynor, & Stapley, 2016), which presumably would have the same effect for community-dwelling people with dementia. When planning physical activity interventions, consideration of content, duration, frequency and intensity must be addressed. In a meta-analysis, it was found that a high-intensity physical activity programme delayed the decline in ADL in people with moderate to severe dementia living in residential facilities (Burge et al., 2012). Similarly, a simple exercise programme of moderate intensity, for 1 hour twice a week, led to a significantly slower decline in ADL score in people with dementia living in residential facilities (Rolland et al., 2007).

Although there seems to be consensus regarding the effect of moderate to high-intensity physical activity on different health parameters in people with dementia living in residential facilities, evidence of content, duration and frequency is inconclusive. This issue was highlighted in a meta-analysis, where a large effect on physical function was seen with physical activity varying from 20 to 60 minutes per session, two to six times per week, lasting from two to six months (Heyn, Abreu, & Ottenbacher, 2004). In another meta-analysis, reviewing the effect of physical activity on ADL performance in people with moderate to severe dementia, an overall delay in the deterioration of ADL performance was seen in interventions lasting from 7 to 52 weeks (Burge et al., 2012). Of the five included studies in this meta-analysis, only one long-term study was included, reporting a significant delay in ADL deterioration only after 12 months of programme duration, with results not being significant at the six-month follow-up (Rolland et al., 2007). Further long-term-based intervention studies are needed in order to highlight the effect of long-term physical activity for people with dementia, including community-dwelling people with dementia, in order to maintain a high level of independence in ADL and to sustain quality of life.

As overall health is the result of an interaction between physical, mental and social components (Wade & Halligan, 2017), physical activity must be seen as a part of a multi-component programme, also including cognitive and social components. Cognitive rehabilitation programmes that include functional tasks are found to be promising for maintaining or improving ADL performance in people with dementia (Wade & Halligan, 2017). The physical and mental status are also related to social participation such as roles and interaction (WHO, 2001).

In order to address multi-component functioning, rehabilitation as a health care process is needed. Rehabilitation is seen as ‘an educational, problem-solving process that focuses on activity limitations and aims to optimize patient social participation and well-being, and so reduce stress on carer and or family’ (Wade, 2005). A broad spectrum of activities containing more than one of the aforementioned three components of physical, cognitive and social activity seems to be more beneficial than to be engaged in only one type of activity (Karp et al., 2006).

In order to meet the multi-faceted needs of people with dementia, also with respect to the dementia-related lack of initiative and motivation, group rehabilitation may have unique advantages beyond those achievable through individual rehabilitation. Group rehabilitation
for dementia is more effective for improving cognitive function and global severity of dementia than personal rehabilitation (Tanaka et al., 2017). In a recent systematic mixed studies review of the effect and importance of physical activity on behavioural and psychological symptoms in people with dementia, the common themes across the qualitative studies were the importance of physical activity being ‘socially rewarding’ (Junge, Ahler, Knudsen, & Kristensen, 2018). Interaction with others in the same situation appears to be essential to people with dementia, as they experience a feeling of belonging (Junge, Ahler et al., 2018). Similarly, the importance of participating in a group during activity such as sports has recently been emphasized in a Danish study of healthy, elderly people, who expressed a higher degree of enjoyment and intrinsic motivation compared to controls; mainly due to the social interaction during the activity, leading to a higher feeling of social connectedness (Pedersen et al., 2017).

Therefore, the aim of this study was to assess the effect of long-term, group-based rehabilitation including physical activity on physical performance in elderly, community-dwelling people with mild to moderate dementia.

**Methods**

**Study design**

This study was a quasi-experimental study, evaluating the effect of a nonrandomized, pre-post intervention in a cohort of people with mild to moderate dementia during nine months in the Municipality of Svendborg, an area in the southern part of Denmark.

All participants were recruited during an ongoing, group-based rehabilitation programme at the local community centre in March 2017. Before joining the programme, all participants were diagnosed with dementia at the local hospital or by their GP. Participants and relatives gave informed written consent to participate before the study started.

The study was approved by the Danish National Committee on Health Research Ethics on 2 February 2017, and by the Danish Data Protection Agency on 14 March 2017. This study conformed with the Declaration of Helsinki (Vollmann & Winau, 1996).

**Participants**

The cohort consisted of 18 elderly, community-dwelling people, diagnosed with mild to moderate dementia. The participants were aged between 65 and 88 years, consisting of 10 men and eight women from the Municipality of Svendborg. The exclusion criteria were moderate to severe dementia or an inability to join a group due to agitation.

The study population was allocated into two similar groups for the programme, with nine participants in each group, as this group size was considered appropriate. All participants had followed the programme for more than half a year at the commencement of this study. Only minor changes in group composition occurred during the intervention period due to acute events, such as illness, behavioural disturbances or significantly decreased physical performance, e.g. due to amputation.

**Purpose and content of the rehabilitation programme**

Health and functioning, as described by the International Classification of Functioning, Disability and Health (ICF) is a complex and dynamic relationship of biological,
psychological and social factors highly affected by contextual factors (Wade & Halligan, 2017; WHO, 2001). Therefore, acknowledging the temporal contextual of the individual and a group, it is crucial to describe the health care setting; the context of the interventions, the organization of the service internally, and the relation to other related services such as resources besides describing the specific actions involved (Wade, 2005).

The rehabilitation programme is a service offered free of charge and delivered by the Municipality of Svendborg to elderly, community-dwelling citizens who have been diagnosed with mild to moderate dementia. Transportation to and from the programme, which took place at the training centre or at an agreed venue, was also free of charge.

All group sessions had a duration of 2 hours, twice a week, separated by at least two days, except during vacation or when the therapists were absent. Between April 2017 and November 2017, a total of 44 sessions were implemented for each participant. Every session was based on an integration of meaningful activities comprising more than one component of physical, cognitive or social character, acknowledging the effect of multi-component and integrated interventions.

The rehabilitation programme often took place outside, at the beach, in the forest, in the garden or at a sports venue during the spring, summer and autumn seasons. During the winter season, the group session was often conducted indoors in a training centre. Some rehabilitation activities were carried out in the whole group, and other activities were performed individually in the group setting, e.g. with predetermined exercises. The physical activities had a duration of at least 45 minutes at each session. Music accompanied most of the indoor sessions.

The combined physical, cognitive and social activities always included one or more elements of cardiovascular exercise, walking, balance, coordination, flexibility, speed, strength, endurance training, cognitive rehabilitation activities for memory, concentration, orientation, social interaction, planning, organizing and co-operation. Examples of the aforementioned activities could be sit-to-stand from a chair, dancing, walking in the forest or at the beach, playing a soccer game, kitchen activities, singing, dancing, playing board games, having quizzes, working on Ipdas and computers, painting, telling life stories and everyday stories.

A physiotherapist and an occupational therapist, with special interest and competence in dementia, were in charge of the programme. The same two therapists conducted all group sessions.

Overall, the content of the rehabilitation programme was based on recommendations from the national Danish guidelines for dementia, the Danish Health Authority and on interventions described in other studies (Blankevoort et al., 2010; Littbrand et al., 2009; Olazaran et al., 2010). The dosage of physical activity was aimed to be of moderate to high intensity.

**Outcome measures**

The physical performance data were collected at three time points: baseline in March 2017, first follow-up in August 2017, and second follow-up in November 2017. A trained team of physiotherapists and an occupational therapist conducted the physical performance testing at the local community training centre.
The primary outcome measure was physical performance, evaluated by via the 30-second sit-to-stand (STS) test, the Guralnik balance test, the 10-metre walking speed test, the timed 6-metre walk test, and a timed dual task walk test.

1. **The 30-second STS test**, a validated test for evaluating lower extremity physical performance in elderly people with functional problems, risk of fall and muscle weakness in the legs (Schoene et al., 2013). Participants performed as many STS cycles as possible, at a self-selected speed, beginning and ending in a sitting position, and were permitted to swing their arms. A standard chair without arm rests was used. The number of repetitions was counted over a 30-second test period.

2. **The Guralnik balance test** is a validated, static balance test designed to test elderly people with balance problems and risk of fall (Rossiter-Fornoff, Wolf, Wolfson, & Buchner, 1995). The participant must be able to stand unassisted without the use of a cane or walker. First, the participant stands with feet side by side, then in semi tandem and then in tandem. All three components are measured over 10 seconds. The number of seconds held, if less than 10 seconds, is noted and the total score is recorded in seconds.

3. **The 10-metre walking speed test** is a reliable and valid test, measuring the walking speed over a distance of 10 meters (Peters, Middleton, Donley, Blanck, & Fritz, 2014). The participant is instructed to walk a 10-metre distance. Time is measured, while the participant walks the distance. The start is from zero in a static position and the participant must walk as fast as possible. The best time of three attempts is recorded and the distance covered is divided by the time took by the participant to walk 10 meters.

4. **The 6-minute walk test** is measuring the walking distance over 6 minutes and is strongly associated with functional capacity in elderly people with moderate to severe impairment. The test is a reliable measurement tool, capable of measuring change over time (Du, Newton, Salamonson, Carrieri-Kohlman, & Davidson, 2009). The test is conducted on a straight 25-metre track. Prior to commencing the walk, the participant is told that the object of the test is to walk ‘as far as possible’ for 6 minutes. The participant is told to walk back and forth along the demonstrated programme. The participants walked in a group of nine people at a time. They were constantly encouraged by the therapists to maintain their speed during the walk, and were told when they were halfway done and again when they had 1 minute to go. At the end, all the participants were told to stop exactly where they were. The total distance walked was recorded.

5. **A dual task walking test** is a reliable and valid test to identify older individuals at high risk of falls (Verghese et al., 2002). Dual task walk testing is recommended for detecting risk of falls in all cognitively impaired older adults, such as people with dementia and Alzheimer’s disease. The dual task walking test evaluates gait speed and stride length, while counting backwards from 100 by serially subtracting sevens (Muir et al., 2012). In the current study, a modified version of the dual task walking test was applied in agreement with the therapists, as the participants were asked to count backwards from 20 while walking a distance of 10 meters. The time taken to walk that distance was recorded.

**Anthropometrics and confounder variables.** Weight was measured to the nearest 0.1 kg on a portable and manual set of scales with the participant wearing light clothes. Height was measured to the nearest 0.5 cm on a portable stadiometer at baseline. Current medication, comorbidities and self-reported physical activity during one week were collected in cooperation with relatives of the participants. Physical activity was self-reported in mean
hours per week, excluding the training sessions. The Mini-Mental State Examination (MMSE) was conducted at baseline and was used to quantitatively assess the severity of cognitive impairment. The MMSE has a satisfactory reliability, although only lower levels of sensitivity for mild degrees of dementia were found (Tombaugh & McIntyre, 1992).

Age, sex, weight and amount of physical activity during one week were registered at baseline and at both follow-ups.

The team was thoroughly instructed and trained in all standardized test procedures before the start of the study.

Statistics

Descriptive statistics (mean and standard deviation) were calculated for all variables.

The repeated measure analysis of variance (ANOVA), or the mixed effects linear regression, was used to detect any overall differences between related means for the physical performance tests, as this model takes into consideration the interdependence between the measurements. Also, the model assesses within-subject and between-subject variation.

The between-subject effect is the five physical performance scores at three time points tested individually, and its error term is the subject nested in the performance score. The within-subject factor is the time points. Its error term is the residual error for the model.

The five assumptions underpinning the one-way repeated measure ANOVA were fulfilled; the dependent variables were measured as continuous variables. The independent variable of time consisted of three categorical and related groups with all participants present at all three time points. Checking the last three assumptions for the mixed effects linear regression model included checking of the residuals, outliers, normal distribution of the dependent variable and equal variances of the differences between all combinations of related tests.

As the repeated measure ANOVA does not allow unequal observations within subjects, profile plots were applied by ID number to visually graph the participant’s mean score for all five performance tests at the three time points. Tracking of each individual’s ID number was performed in order to follow their individual programme.

A multiple linear regression model was applied to assess the overall effect from baseline to second follow-up after nine months. Analyses were performed on each of the five single physical performance tests separately and controlled for the following possible confounders: sex, age, body mass index, mean daily physical activity and MMSE score.

All calculations were performed in the statistical software programme STATA IC 15 (StataCorp, 2017).

Results

Totally, 15 participants completed all three time points of testing. Only one participant dropped out after first follow-up due to severe cognitive decline. Two participants entered the study at the first follow-up.

Descriptive characteristics of the participants are summarized in Table 1. Overall, there were no significant differences between the sexes at baseline in the five outcome measures, except for the Guralnik balance test, where men had a significantly higher mean score than women. In the anthropometric data, age, height and weight were significantly higher in men than women. The MMSE score was significantly higher in women than men.
In the mixed effect linear model, there was no significant effect of time for the five outcome measures during the entire period. The variation in the estimation of most outcome scores was higher within subjects than between subjects during the period, except for the STS test, where within-subject variation was similar to the between-subject variation (Table 2).

The profile plot illustrates the physical performance level of individual participants, exemplified by the STS test, through the study period (Figure 1). Visual inspection of all profile plots for the five physical performance tests revealed that three of the participants declined markedly in physical performance during the last part of the observation period from the first follow-up to the second follow-up. Subjectively, a severe cognitive decline, seen by a change in behaviour, concentration and motivation, was observed in these participants by the therapists and the relatives. These participants were subsequently institutionalized due to their severe cognitive decline and increased dependence on others when performing ADL activities.

With the three participants excluded in the mixed effect linear regression analysis, the within-subject variation was lower between the three time points, except for the Tandem test with the variation being markedly higher. The between-subject variation was lower except for the Tandem test and the 6-minute walk test. There was a slight increase in between-subject variation in the 6-minute walk test (Table 3).

In the multiple linear regression analysis, a small, but significant increase was seen for the STS test (Table 4). Also, there was a slight increase in the 6-minute walk test, the 10-metre

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**Table 1.** Characteristics of participants, presented as mean and standard deviation (SD).

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>All participants (n = 18)</th>
<th>Female (n = 8)</th>
<th>Male (n = 10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>75.9 (6.5)</td>
<td>74.7 (3.7)</td>
<td>76.8 (7.2)*</td>
</tr>
<tr>
<td>Height</td>
<td>171.5 (8.9)</td>
<td>164.8 (7.8)</td>
<td>176.5 (7.2)*</td>
</tr>
<tr>
<td>Weight</td>
<td>80.18 (12.8)</td>
<td>70.8 (8.4)</td>
<td>87.3 (11.0)*</td>
</tr>
<tr>
<td>Mini-Mental State Examination</td>
<td>22.51(4.5)</td>
<td>23.6 (4.2)</td>
<td>21.7 (4.6)*</td>
</tr>
<tr>
<td>Daily physical activity (h)</td>
<td>1.37 (0.9)</td>
<td>1.5 (0.8)</td>
<td>1.3 (1.0)</td>
</tr>
<tr>
<td>Sit to stand</td>
<td>10.27 (2.5)</td>
<td>10.4 (4.0)</td>
<td>10.1 (3.1)</td>
</tr>
<tr>
<td>Guralnik balance</td>
<td>26.64 (3.7)</td>
<td>25.4 (3.8)</td>
<td>27.6 (3.4)*</td>
</tr>
<tr>
<td>10-m walking speed</td>
<td>7.98 (2.8)</td>
<td>8.0 (1.7)</td>
<td>8.0 (3.4)</td>
</tr>
<tr>
<td>6-min walk</td>
<td>359.74 (102.2)</td>
<td>364.0 (71.5)</td>
<td>356.8 (122.4)</td>
</tr>
<tr>
<td>Dual task</td>
<td>9.63 (3.2)</td>
<td>9.0 (1.7)</td>
<td>10.1(3.9)</td>
</tr>
</tbody>
</table>

*Significant difference (p < 0.05) between sexes.

**Table 2.** Within-subject and between-subject variation of the five physical performance outcomes with confidence intervals.

<table>
<thead>
<tr>
<th>Physical performance test</th>
<th>Sit to stand</th>
<th>Guralnik balance</th>
<th>10-m walking speed</th>
<th>6-min walk</th>
<th>Dual task</th>
</tr>
</thead>
<tbody>
<tr>
<td>Within-subject</td>
<td>5.7 (3.5–9.6)</td>
<td>2.0 (0.2–2.1)</td>
<td>0.81 (0.5–1.3)</td>
<td>2837 (1727–4727)</td>
<td>1.8 (1.1–2.9)</td>
</tr>
<tr>
<td>Between-subject</td>
<td>7.0 (2.8–17.6)</td>
<td>12.0 (7.4–19.9)</td>
<td>8.71 (4.3–17.6)</td>
<td>8501 (3365–18,470)</td>
<td>10.4 (5.0–21.6)</td>
</tr>
</tbody>
</table>
walking speed test and in the Dual task test. No change over time was seen for the Tandem test (Table 4). There was no significant effect on the estimate when adjusted for the confounders of sex, age and MMSE score for the five performance tests. The largest effect on the estimate was seen in the 10-metre walking speed test where the effect of the confounders on the estimate increased from 0.3 to 0.01 seconds, equivalent to a difference in mean score walking speed of 0.05 m/s (not shown in tables).

The multiple linear regression model, with the above-mentioned three participants excluded, revealed the overall minimal variations. When adjusted for the confounders of sex, age and MMSE score, the results were the same overall, except for the 6-minute walk and 10-metre walk test.
Discussion

In the current study, the expected progressive deterioration in physical performance was postponed in a small group of home community-dwelling people with mild to moderate dementia who participated in long-term, group-based rehabilitation including physical activity conducted twice a week for 2 hours per session during a nine-month period.

At a group level, the participants of the current study sustained their physical performance level for almost a year. The same positive effect of physical activity on walking speed and ADL was seen in people with dementia living in nursing homes compared with controls, when following a long-term, moderate, multi-component programme including walking, strength, balance, and flexibility training twice a week (Rolland et al., 2007). Moreover, other studies have found that exercise interventions have led to better physical performance, but only with a short-term intervention period (Rolland et al., 2007). As in the study by Rolland et al., the aim of the current study was to assess the effect of an intervention in a natural setting, but with a long-term intervention period.

Comparable to the findings of the current study, combined interventions of physical activity such as walk, strength, balance and flexibility training positively led to a slower decline than usual medical care in nursing home resident people with dementia when exercising 1 hour twice a week during a year (Rolland et al., 2007). Similarly, more short-term multi-component intervention studies, e.g. combining endurance, balance and strength, demonstrated larger improvement in gait speed, functional mobility and balance than strength training alone (Blankevoort et al., 2010). The best results were obtained with the highest training intensity, with a duration of 12 weeks or more and a frequency of three times a week, lasting from 45 to 60 minutes (Blankevoort et al., 2010). The results of the current study identically indicate that intensity, frequency and long-term duration of a rehabilitation programme are of high importance in order to maintain or improve the physical performance evaluation, as described by this ongoing rehabilitation programme carried out two times 2 hours a week, with at least 45 minutes of moderate to high physical activity intensity at every session.

More systematic reviews found no consensus of solely or specific physical activity interventions, when focusing on the positive effects on behavioural and psychological symptoms in people with dementia (Abraha, Trotta, Rimland, & Cherubini, 2017; Barreto Pde, Demougeot, Pillard, Lapeyre-Mestre, & Rolland, 2015; Brett et al., 2016). This may emphasize that an interdisciplinary rehabilitation programme including mental and cognitive components as well as a broad variety of physical activity in various surroundings as in the current study, successfully can meet the multi-faceted needs of people with dementia. Similar results were seen with a multimodal approach combining physical and cognitive rehabilitation, improving individual goal attainment and caregiver burden in individuals and caregivers of persons with mild dementia (Chew, Chong, Fong, & Tay, 2015).

As rehabilitation is holistic, including multi-faceted aspects of physical, cognitive, social and contextual character, the needs of people with dementia concerning a safe and meaningful everyday life can be met to a larger extent than when focusing solely on one aspect. Furthermore, the high compliance of the participants in the current study indicates that long-term, group-based rehabilitation seems meaningful to the participants. As people with dementia may lose social routines, ensuring a stable, externally maintained routine during a longer period can be an important part of rehabilitation treatment (Wade, 2005), as indicated in the current study.
In the mixed effects linear regression analysis, the within-subject variation was larger than the between-subject variation in all five outcome measures. By visual inspection of a profile plot for the entire period, three of the participants had a clear decline in their physical performance level, as well as a subjectively observed severe cognitive decline, which led to all three being institutionalized. Therefore, in a similar analysis as described the three participants were excluded from the statistical analyses, although this did not change the overall result. The finding of severe cognitive decline followed by an acute deterioration in physical performance is similar to the results of another cohort study, concluding that the cognitive decline is strongly associated with the physical decline and loss of independence in ADL (Atkinson et al., 2005).

The STS test seemed to be the most stable test over time with within-subject variation being almost the same as between-subject variation. A significant, but small incline in the STS score was seen during the entire period in the multiple linear regression analysis, including only baseline and end point measurements. The mean STS score was 10.3 in the current study including people with diverse kinds of dementia above the age of 60, comparable to presented Danish reference values of 10 to 15 for healthy, elderly women and 11 to 17 for healthy, elderly men aged 70 to 79 (Beck, Pedersen, & Schroll, 2005). On the contrary, another Danish study found a mean baseline STS score of 12 for people aged 50 to 79 with mild Alzheimer's disease, participating in moderate to high intensity aerobic training three times a week. In a systematic review, it was summarized that people with mild to moderate dementia had a mean STS score of 8.30 (Blankevoort et al., 2010) which is remarkably lower than the mean STS score for the group of the current study during the entire period; supporting that long-term physical activity can maintain and also improve the physical performance over time, also in elderly people with dementia.

Furthermore, very small but significant effects of the 10-metre walking speed test, the 6-minute walk test and the dual task were observed in the multiple linear regression analysis. Excluding the three aforementioned participants, the group performed better in the STS test, the 10-metre walking speed test, the 6-minute walk test and the Dual task test, indicating that it is possible to maintain physical performance levels over time before a severe, cognitive decline is seen.

The strengths of this study are the prospective cohort study design in a natural experimental setting, reflecting usual practice in a Danish municipality. Also, the long-term, rehabilitation programme was developed and implemented by the municipality and experienced therapists, combining components of physical, cognitive as well as social character to meet the needs of people with mild to moderate dementia.

When interpreting the results of the current study, there are some limitations to take into account. As the cohort consisted of only 18 participants, this could have an impact on the results and effect size of the outcomes. Nevertheless, consistent results were found independently in all five outcome measures, underpinning the same overall message of a delay in the progressive deterioration in physical performance over a longer period. Although all the outcome measures were developed and validated in elderly people, to our knowledge, none of the five outcome measures has been assessed for responsiveness, which is why it is uncertain whether these measures are capable of detecting relevant changes at follow-up. Also, outcome measures of ADL and quality of life could have supported the aim of the study.

In the description of the intervention, the complex work of establishing and leading a group is not accounted for. The high level of participant compliance in the group activities
was undoubtedly a result of the interaction between the multi-disciplinary therapists and the participants, as well as between the participants, as described in detail in a qualitative study of the same cohort (Junge, Knudsen, Ulrich, & Hounsgaard, in press). Also, the external validity and the replicability of the study may be affected as the intervention did not follow a standardized protocol, but instead was adapted to the group and the individual participants with dementia; with different activities for every session, tailored to fit the actual requirements of the group.

In summary, the findings of the current small-scaled study add support to an emerging body of evidence that rehabilitation including physical activity is associated with a delay in the decline in physical performance level in people with mild to moderate dementia. Long-term, group-based rehabilitation may have the overall potential to delay deterioration in ADL performance in home-dwelling people with mild to moderate dementia; however, more studies with larger samples are needed to confirm the findings of this study.

**Declaration of Conflicting Interests**
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Biographical notes

Tina Junge’s research focus is on the physical activity and musculoskeletal health across the life span, from children to elderly. With an emphasis on the physical and social benefits of physical activity, the aim is to improve the quality of life for the individual, through epidemiological and participatory action research.

Hans Kromann Knudsen’s research focus is primarily on the musculoskeletal physiotherapy and physical activity in adults with dementia. The aim of the research is to develop health interventions to reduce pain, increase function and enable activity and participation in people’s everyday life.

Hanne Kaae Kristensen focuses in the research fields of cross sectional and interdisciplinary rehabilitation, occupational science and occupational therapy. It concerns implementation science and research generating new knowledge in interdisciplinary and international perspectives stressing user involvement, knowledge sharing and high quality. Her research aims at developing and implementing health service approaches and interventions which enable the activity and participation in meaningful everyday life.