The relation between daily activity and cognitive functioning in nursing home residents with dementia

Master thesis Neuropsychology

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Abstract

Physical activity can have a positive effect on our physical health, mental health and on our brain and cognitive functioning. There are many intervention studies that examined the relation between physical activity and cognitive functioning in patients with dementia, however these studies showed mixed results. Therefore, it is not clear which therapy will be effective and if therapies can be used for specific groups of patients. To explore which specific group(s) of patients profit most from physical therapies, this study examines the relation between daily physical activity and cognitive functioning in nursing home residents with dementia, while controlling for depression, level of education, dementia severity and institutionalization time for different groups. These groups are based on walking ability (1. patients who are able to walk, with and without support, 2. patients who are not able to walk) and cognitive impairment (1. patients with severe cognitive impairment, 2. patients with mild cognitive impairment). Data of sixty-eight participants was used in this study, which was collected within two weeks, by means of cognitive tests (by means of the SIB-NL-Q), interviews and Actiwatches. The results of this study showed no relation between daily physical activity and cognitive functioning, with no differences for the different groups. However, there is found a relation between walking ability and cognitive functioning. While controlling for depression, level of education, dementia severity and institutionalization time, this first explorative study, to the relation of, in particular daily, physical activity and cognitive functioning may provide some handles for further research.

Introduction

Physical activity can positively affect our physical health since it can reduce cardiovascular disease (Sofi et al., 2007) and stress (Sofi et al., 2010). Moreover, it has a positive influence on our cognitive functioning (Blondell, Hamersley-Mather, & Veerman, 2014), also in patients with neurodegenerative diseases as dementia (Groot et al., 2016). Dementia is defined as a neurodegenerative disease in which at least two cognitive domains decline from previous functioning, wherein the patient suffers from these declines in daily life (Blondell, et al., 2014). Many interventions including physical activity are used in patients with dementia to improve cognitive functioning (Harris & Johnson, 2017; Park, & Cohen, 2019). Which interventions have most effect and which patients benefit most from these interventions is however still unclear (Park & Cohen, 2019). Furthermore, as far as known, the amount of daily physical activity that is most effective, is not measured yet. Studying daily physical activity, in nursing home residents with dementia, might reveal insight in what degree of activity is beneficial for cognitive functioning and might also help to find the right patient groups to stimulate with specific interventions.

Physical activity is defined as moving the skeletal muscles which is resulting in expenditure of energy (Blondell et al., 2014). Different studies showed that physical activity can have a positive effect on cognition and also can help to develop the brain. For example, Leisman, Moustafa and Shafir (2016) argue that the development of cognitive and motor processes are related in the brain and therefore increased physical activity will lead to a better cognitive functioning. Physical activity contributes to neuroplasticity and helps to develop new networks (Leisman et al., 2016; McDonnel, Buckley, Opie, Ridding, & Semmler, 2013; Voelcker-Rehage & Niemann, 2013). This effect is independent of age and therefore it is also seen in elderly (Voelcker-Rehage & Niemann, 2013). Since neuroplasticity underlies the strength and the number of the connections between brain regions (Leisman et al., 2016; Voelcker-Rehage & Niemann, 2013) and neuroplasticity is the underlying mechanism to improve cognitive skills as learning and memory (Leisman, 2011; Leisman et al., 2016), it seems reasonable that physical activity contributes to better cognitive functioning. For example, physical activity might lead to a growth of the hippocampus, which might enhance memory functions (Voelcker-Rehage & Niemann, 2013). The study of Colcombe and Kramer (2003) showed a positive effect of physical activity on all cognitive domains, especially in executive functioning in healthy older adults. Other studies showed improvements of declarative memory, motor-skill coordination (McDonnel et al., 2013) and attention (Hillman, Buck, Themanson, Pontifex, & Castelli, 2009). However, due to inconclusive results more research is needed, in particular more research to the relation with age related neurological diseases as dementia and specific cognitive domains. (Prakash, Voss, Erickson, & Kramer, 2015). Moreover, the effect of physical activity can also be observed in the amount of brain atrophy. Research of Gow et al., (2012) showed, while performing a MRI scan on older adults at the age of 70, that physical activity is correlated with less brain atrophy three years later. Brain atrophy is related to loss of neurons, and therefore brain volume, and one of the biomarkers of dementia (Jack et al., 2013). This loss of brain volume is negatively correlated to scores on the Mini Mental State Examination (Fox, Scahill, Crum, & Rossor, 1999), a worldwide used screening instrument of dementia. More physical activity could lead to less loss of brain volume over a longer time and therefore enhances cognitive functioning. The study of Hamer and Chida (2009) confirmed the idea of physical activity leading to a better cognitive functioning and even showed that less physical activity could lead to a higher risk of neurodegenerative diseases as dementia.

Currently, a lot of physical activity therapies, such as walking interventions (Harris & Johnson, 2017), chair yoga (Litchke, Hodges, & Reardon, 2012), strength exercises and aerobic dance (Heyn, Abreu, & Ottenbacher, 2004), are investigated in patients with dementia. Previous studies which have examined the effects of these therapies on cognitive functioning in dementia have reported mixed results (Park & Cohen, 2019). Several meta-analysis (Colcombe & Kramer, 2003; Groot, et al., 2016) have suggested that in particular aerobic exercises show the best results. Aerobic exercises include walking (with and without rollator) (Eggermont, Swaab, Hol, & Scherder, 2009). However, not all dementia patients are able to perform aerobic exercises as a result of impaired motor functions. The study of Yágüez, Shaw, Morris and Matthews (2011) has shown that non-aerobic exercises also can improve cognitive functions in dementia patients, especially on the sustained attention, visual information processing and working memory domains. However, the study of Miu, Szeto and Mak (2008) found that aerobic exercises did improve the physical movement but not cognition. These results are shared by the study of Eggermont et al. (2009) in which walking interventions were studied. No effect of these walking interventions on cognition was found in patients with dementia. Surprisingly, differences in frequency (Groot et al., 2016), time (Eggermont et al., 2009) and the intensity (Varela, Ayán, Cancela, & Martín, 2011) of the exercises do not seem to influence the effects of physical activity on cognition. These mixed results show that it is still unclear which therapies work best and if there are specific patient groups who might benefit more from these therapies.

Remarkable is that the above mentioned studies examined structured physical interventions to study the influence of physical activity on cognitive functioning while the influence of daily physical activity is, as far as known, not studied yet. In nursing homes large differences in the residents' activity level is observed. For example, nursing homes residents might be physical agitated and therefore wandering is frequently observed (Cipriani, Lucetti, Nuti, & Danti, 2014). On the contrary, many nursing home residents with dementia sit in a chair all day which might be due to that nursing home environments might encourage physical inactivity (Tappen, Roach, Buchner, Barry, & Edelstein, 1997). Also, patients with a high risk of falling are often placed in a wheelchair for precaution. Taken this together, the time spent in a nursing home might influence the relation between physical activity and cognitive functioning. Moreover, this inactivity might be caused by depression (Barlow & Durand, 2015) which is present in up to 20% to 37% of the patients with dementia (Kuring, Mathias, & Ward, 2018). Since there is an enormous observed variability in daily physical activity in nursing home residents with dementia and physical activity is associated with better cognitive functioning (Blondell et al., 2014; Hamer & Chida, 2009), it is likely that cognitive functioning differs in nursing home residents with dementia due to daily physical activity.

Besides the effect of depression on physical activity, depression can also affect cognitive functioning. Depression can lead to cognitive dysfunction and make individuals score worse on different cognitive domains (Koenig et al., 2015) and can cause a progression of dementia in patients who are mildly cognitive impaired (Mourao, Mansur, Malloy-Diniz, Costa, & Diniz, 2015). Another factor that can influence the cognitive functioning is the level of premorbid education. Older adults with higher education performed better on cognitive tasks than older adults that had lower education (van Hooren et al., 2007). Furthermore, in contrast to patients with lower educational levels, higher education leads to higher cognitive reserve which can help dementia patients function better for a longer time (Stern, 2012).

Therefore, in this study we investigate the relation between physical activity in daily life and cognitive functioning in nursing home residents with dementia, while adjusting for depression, premorbid education level, dementia severity and institutionalization time. The aim of the current study is to find out more about the relation between daily physical activity and cognitive functioning and to examine if specific groups of patients might benefit more from this daily physical activity. In this way, physical therapies could be adapted and introduced to patients that might truly benefit from these therapies. If a positive relation between daily life activity and cognition is found it is interesting to study if this relation can also be found for the different cognitive domains. Besides, there will be explored if there is a difference in effect of daily life activity on cognition for patients with different stages of cognitive impairment. This information can tell even more about if specific groups of patients with dementia will benefit from more physical activity. For example, when the results show that patients with severe cognitive impairment do not benefit from physical activity, they do not have to be overloaded with physical therapy to increase the cognitive functioning. In the current study, it is first hypothesized that, based on previous studies that examined the effect of physical activity on cognitive functioning (Blondell et al., 2014; Hamer and Chida 2009; Sofi et al., 2010), more physical activity is related to better overall cognitive functioning. It is expected that this relation between daily physical activity still exists while controlling for the effects of depression, level of education, dementia severity and institutionalization time on cognitive functioning. This is expected for the first group; patients who are able to walk, including walking with support, and the second group; patients who are not able to walk. Both groups are able to perform a kind of physical activity, aerobic or non-aerobic, which both have shown to be effective (Groot et al., 2016; Yágüez et al., 2011). However, a stronger effect of daily physical activity on overall cognitive functioning is expected for patients who are able to walk (with and without support), compared with patients who are not able to walk. This is expected since walking, with rollator, is an aerobic exercise (Eggermont et al., 2009) which seems to have the best effects on cognitive functioning (Colcombe & Kramer, 2003; Groot, et al., 2016). Second, the positive relation between daily physical activity and cognitive functioning as described in the first hypothesis, is expected for all separate cognitive domains (Colcombe & Kramer, 2003; Eggermont et al., 2009; Groot, et al., 2016; Yágüez et al., 2011). Third, it is hypothesized that there will be a different relation of daily activity to cognitive functioning for the different stages of cognitive impairment. It is expected that this relation between daily physical activity still exists while controlling for the effects of depression, level of education, dementia severity and institutionalization time on cognitive functioning. Which group will benefit most is not to say yet since this is, as far as known, not investigated before. Still a difference between the groups is expected since the course of dementia shows differences in brain atrophy (Jack et al., 2013). A more affected brain might benefit more from physical activity and the neuroplasticity whereby bigger steps could be made. On the other hand, an intact brain might benefit more from physical activity since it is able to learn more. (Moore, Sandman, McGrady, & Kesslak, 2010; Zarit, Zarit, & Reever, 1982).

Methods

Participants

Current study included 97 participants. The participant group contained residents who used to live at four departments of nursing home '*Atlant*' at Apeldoorn during the period of November 2018 to January 2020. In total 144 participants were invited to participate in the study, 44 contact persons refused participation.

The inclusion criteria was diagnosis of dementia according to ICD-10 and DSM-IV criteria. Exclusion criteria for this study were; a life expectation of less than four weeks according to a doctor and residents or contact persons that did not give verbal and written consent. Participants were (partly) excluded from the research when the participants or the contact persons reported discomfort during the research process. In total 3 participants were excluded from the research due to discomfort or death. The data collection is approved by the Medical Ethics Committee of the '*Vrije Universiteit van Amsterdam'* (VUmc) and by the Science Committee of '*Atlant*'.

Measurement instruments

Cognitive functioning

To measure the cognitive abilities of the participants the Mini Mental State Examination (MMSE) (Folstein et al, 1975) and a shortened Dutch version of the Severe Impairment Battery (SIB-NL-Q) (de Jonghe, Wetzels, Mulders, Zuidema, & Koopmans, 2009) were used. The MMSE measures general cognitive functioning, with 20 questions. The items contain questions as "*In which country are we?*' but also instructions as *'Do you want to think of a sentence and write it down on this paper?'* Most answers are scored by means of a two point scale with options '*Correct*' and '*Incorrect*'. The MMSE can be scored by counting up all points that are obtained (minimum score = 0, maximum score = 30). This scale has a high inter-rater reliability $k_w = 0.97$ and the validity is dependent of premorbid education (Galea & Woodward, 2005). The stage of cognitive impairment was determined by the performance on the MMSE, by using cut-off scores of ≤ 17 which corresponds to severe cognitive impaired and ≥ 18 which corresponds to mild cognitive impaired to normal. (O' Connor et al., 1889).

The SIB(-NL-Q) is developed for patients with severe dementia that cannot complete neuropsychological tests anymore. It contains nine different subscales (cognitive domains); social interaction, memory, orientation, language, attention, praxis, visuospatial ability, construction and orienting to name. The SIB-NL-Q has 26 items and the items contain questions about the different domains as '*Can you read this card and do as it says?*'. Most items are scored on a 3 point scale with 4 answer options; 2 points '*Spontaneous correct*', 1 point '*Correct after encouragement*', 0 points '*Not correct',* 0 points '*No answer'*. The total score can be calculated by counting up all the scores of the sub-scales of the SIB (minimum score = 0, maximum score = 50). The short version of the SIB has a high construct validity (de Jonghe et al., 2009). The SIB-NL-Q and MMSE have a high correlation of $r = 0.97$ which means they measure the same construct (Qazi, et al. 2005).

Daily activity

The daily activity of the participants was measured with wrist worn Actiwatches of type AW4 (Actiwatch, Cambridge Neurotechnology, Cambridge, UK). The Actiwatches were set at one epoch per minute and these were calibrated each half year. Actiwatches were chosen to measure the daily activity in the participants because it can measure the activity for 24 hours a day and are less invasive in comparison with measurement methods that measure brain activity as electroencephalography (EEG). The study of Gironda, Lloyd, Clark and Walker (2007) measured the interunit reliability of Actiwatches, which means the reliability of the Actiwatch when it is at the same body site. Actiwatches, worn at the wrist, have a interunit reliability of $r = .56$ compared to the waist and $r = .58$ compared to the ankle (Gironda et al., 2007). The construct validity of the Actiwatches is high which means that the Actiwatch is a good measure for different kind of movements. During walking an Actiwatch worn on the wrist correlates high to the score as an Actiwatch worn on the ankle (Gironda et al., 2007). Since the participants in our study will wear the Actiwatch on the wrist it will be a reliable and valid measure for daily physical activity.

The 10 consecutive most active hours (M10) will be used to represent the degree of daily physical activity of the participants. M10 contains information about how regular the activity was and how active the participant was during these 10 hours. (Burns, Allen, Tomenson, Duignan, & Byrne, 2009). It measures intensity and frequency of physical activity during the 10 most active hours of the patient within 24 hours over within eight days. Therefore, this variable of activity fits as a measure of daily activity because it gives a mean of the activity pattern during their 10 most active hours of the day.

Ability to walk

Care workers were asked about the ability of the participants to walk using three answer possibilities; able to walk, able to walk with support (unilateral and bilateral) and not able to walk.

Control variables

Depression

The degree of depression was measured with the Dutch version of the Cornell Scale for Depression in Dementia (Dröes, 1993) which was administered with care workers. This scale is a screening for depression in dementia patients and has five subscales which include; mood related characteristics, behavioural disorders, physical characteristics, cyclic features, disorders in thoughts. The Cornell has 19 items which contain questions as '*Do you observe sadness in the patient?'.* All items are scored by means of four answer options; 2 points '*Severe',* 1 point '*Lightly or varying'* 0 points 'A*bsent',* 0 points, '*Not to asses'.* The total score of the Cornell is calculated by counting up all the points that are obtained (minimum score = 0, maximum score = 38). The inter-rater reliability of the Cornell is $k_w = 0.67$ which is high and the validity of measuring depression in nursing homes is rated as good, with a score of $rs = 0.80$. (Alexopoulos, Abrams, Young, and Shamoian, 1988).

Dementia severity

The dementia severity was measured with the Global Deterioration Scale (GDS), which divides dementia in seven stages from '*No cognitive disorder (normal adult)', 'Very mild cognitive disorder', 'Mild cognitive decline', 'Moderate cognitive decline', 'Moderate severe cognitive decline', 'Severe cognitive decline'* to '*Very severe cognitive decline (last stage Alzheimer dementia)'* (Reisberg, Ferris, de Leon, & Crook, 1982). The GDS has a high inter-rater reliability of $k_w = .82$ to $k_w = .92$ (Eisdorfer et al., 1993).

Level of education

To measure the premorbid level of cognitive capacity of the participants, the level of education was measured with the Dutch coding system of Verhage (1964), which divides the level of education in seven different levels from '*Not finished Primary school', 'Finished primary school', 'Finished primary school and less than two years of low level secondary education', 'Finished low level secondary education', 'Finished average level of secondary education', 'Finished high level of secondary education'* to '*Completed university'.*

Institutionalization time

The institutionalization time is defined as the time since the participants were administered to the current psychogeriatric ward of Atlant. This time was rounded down to years.

Design

The data that was used in the current study, is part of the study 'Het effect van verrijkte omgeving op cognitie en kwaliteit van leven van patiënten met dementie' from MSc. Angela Prins and prof. dr. E. J. A. Scherder. This is a cohort study with a prospective nature, since the participants are followed for at least three measurement moments while receiving an intervention. For the current study only data from the baseline measurements, collected between from November 2018 and January 2020, was used. This current study can be described as a qualitative case report study. To enlarge the reliability of the study, all researchers, master students in neuropsychology, were trained to administer the tests in the same way.

Procedure

To include the participants in the study the first contact person of the resident received an information letter and informed consent forms. When the inclusion was not completed in two weeks, an independent secretary who was not directly involved in the research, called the contact person to remind about the inclusion and provided more information when necessary. After inclusion, the data of each participant was collected within two weeks. This data collection contained data from three parts; cognition, physical activity and mood. The SIB-NL-Q, the MMSE and M10 were administered with the participants and the Cornell and GDS were administered by the first responsible care worker. There was not a thigh structure in which the three sorts of data were collected. Prior to the administration of the SIB-NL-Q and the MMSE, the researchers approached care workers and asked them if there were any properties of the participant that had to be taken into account, as hearing, sight or behaviour. This information was used during the tests to approach the participant in the best way. Thereafter the participants themselves were approached to participate with the tests. The test were taken in a quiet place as the bedroom of the participant, so the participant was not distracted by the surrounding. The administration of the SIB-NL-Q took about 15 to 20 minutes and thereafter the MMSE was administered which took about 15 to 20 minutes. To measure the daily activity the Actiwatch was putted on the dominant hand of the participants for eight days and diaries were attached to the bathroom door of the participant at the first day. The Actiwatches were only allowed to take off while showering, the care workers needed to report the time the Actiwatches went off and on again on the diaries. The exact time that the Actiwatch was putted on and taken off was noted. If the participant stated that they did not wanted to wear the Actiwatch anymore or discomfort was observed the Actiwatch was taken of at all times. To measure the ability to walk, degree of depression and dementia severity with the Cornell and GDS the first responsible care worker were interviewed about their observations of the participant in the last two weeks prior to the interview. For this questionnaire the researchers had to pay attention that the concepts of questions were understood and answered correctly by the care workers. This interview took about 15 to 20 minutes. The procedure for administering the Cornell has changed during the data collection. At the start of the study, answers on the questions were based on changes that were seen from earlier to the last two weeks. With this approach, there is a chance that depression symptoms that exist for longer than two weeks will be missed. Therefore, the procedure was changed since July 2019. Answers were now based on observations from the last two weeks. After all data was collected and stored in Castor (Castor EDC, 2019) the data of the participants was separated into two different groups based on the ability to walk; (1) able to walk, which includes walking with support, and (2) not able to walk and the data was analysed.

Data processing steps and data-analyses

Power analysis

According to a power analysis (Faul, Erdfelder, Buchner, & Lang, 2009) 55 participants are needed (power .80, $\alpha = .05$, $F^2 = .15$) to perform multiple regression with five predictors.

Actigraphy

The data that was collected with the Actiwatches was read out using a software computer program Sleep Analysis version 7 (Actiwatch, Cambridge Neurotechnology, Cambridge, UK). The actogram and the diaries were examined to check if the Actiwatches were worn continuously, the times the Actiwatches went off, noted in the diaries, was correct. This was checked by searching for the gaps in the actogram. For gaps in the actogram, from which the cause was unclear, the possible cause was checked by the care workers. For example, these gaps could be explained by a showering moment, in which the Actiwatch was off, that was not written down in the diaries. Gaps that were correctly noted in the diaries and gaps that were seen in the actogram that lasted longer than an hour were noted un a Microsoft Excel template developed by Van Someren (1999). This template was able to cut out the gaps from the data and ran multiple analyses with the data.

Statistical Analyses

The statistical analyses were performed using SPSS Statistics version 25 (IBM Corp., 2017). The assumptions for ‘independence’, ‘normality’, ‘homogeneity of regression slopes’, ‘linearity’ and ‘homogeneity of variance’ were checked before the main analyses were performed. Furthermore, a visual data inspection was performed over the data, which included means, minima and maxima.

To test the first hypothesis, a hierarchical multiple regression analysis for the two groups, able to walk and not able to walk, with dependent variable ‘SIB-NL-Q total score’ was performed. In the first box the predictors ‘Cornell’, ‘Education level’, ‘GDS’ and ‘institutionalization time’ were added to the model and in the second box the independent variable ‘M10’ was added to the model. The main outcome showed how the relation between daily physical activity and cognitive functioning existed and differed for the two groups. When the results showed a significant positive relation between daily physical activity and cognitive functioning, the second hypothesis was tested with several hierarchical multiple regression analysis for the two groups (able to walk and not able to walk), with dependent variable ‘SIB-NL-Q sub-scores’ were performed. In the first box the predictors ‘Cornell’, ‘education level’, ‘GDS’ and ‘institutionalization time’ were added to the model and in the second box the independent variable ‘M10’ was added to the model. In addition, to test the third hypothesis, extra analysis were performed to show the relation between daily activity and cognition for different stages of dementia. First, an ANOVA was performed to see if the SIB-NL-Q scores differed between the four groups. Then, a hierarchical multiple regression analysis for the four groups, able to walk and mild cognitive impaired, able to walk and severe cognitive impaired, not able to walk and mild cognitive impaired and not able to walk and severe cognitive impaired, the same as the first analysis, was performed. Each of the analyses was performed with a *p* value of .05.

Results

Participants

In this study**,** 29 participants (29.9% of the total sample) were excluded from the statistical analyses due to missing data in the main variables (SIB total score and M10). 14% of the total data set was missing. Data of the remaining 68 participants was included in the analyses. The group of participants that was excluded did not differ from the included group with respect to age, gender, walking ability, type of dementia, level of education, SIB-NL-Q scores, MMSE scores and Cornell scores. (all $p > 0.5$). Information about the participant group included into the analyses is presented in table 1.

Table 1

Demographic characteristics of sample included in the analyses

Variables	Total (*n* = 68)	Able to walk (*n* = 55)	Not able to walk (*n* =13)
Age, Mean (SD)	85.52 (7.01)	85,35 (6.93)	86,23 (7.60)
Gender (male/female)	27/41 (40%/60%)	24/31 (44%/56%)	3/10 (23%/77%)
Alzheimer disease	21 (30.9%)	15 (27.3%)	6 (46.2%)
Vascular dementia	10 (14.7%)	9 (16.4%)	1 (7.7%)
Frontotemporal disease	2 (2.9%)	2 (3.6%)	0 (0%)
Lewybody disease	3 (4.4 %)	3 (5.5%)	0 (0%)
Combined dementia	11 (16.2%)	9 16.4%)	2 (15.4%)
Dementia syndrome	21 (30.9 %)	17 (30.9%)	4 (30.8%)
MCI	5 (7.4%)	5 (9.1%)	0 (0%)
SCI	63 (92.6%)	50 (90.9%)	13 (100%)
Vascular disease	55 (80.9%)	46 (83.6%)	9 (69.2%)
SIB-NL-Q, Mean (SD)	33.06 (12.16)	34.82 (10.92)	25.62 (14.66)
MMSE, Mean (SD)	8.72 (5.73)	9.15 (5.87)	6.92 (5.31)
Cornell, Mean (SD)	7.34 (5.54)	6.50 (5.35)	10.69 (5.02)

Note. SCI = Severe cognitive impaired, MCI = Mild cognitive impaired.

Assumptions and data inspection

The assumption of normality was violated for variables SIB total score ($p \leq .001$), MMSE ($p \leq .05$), Cornell ($p \leq .001$). Therefore, a Van der Waerden transformation (van der Waerden, 1952) was performed. All the other assumptions of the hierarchical regression analysis (independence, homogeneity of regression slopes, linearity and homogeneity of variance) were not violated.

Except from the missing data, no particularities were found from the visual data inspection. Correlational analysis yielded a not significant correlation between the Cornell score and SIB total score and between the level of education and the SIB total score (see table 2). Therefore, it was decided that these variables were not included as control variables in the main analyses.

Table 2

Correlations between the different variables.

	1	2	3	4	5	6	7	8
1. SIBtotal	-	.05	-.30*	.84*	-.22	-.52*	-.09	-.31*
2. M10		-	-.05	-.01	.15	-.07	.16	-.17
3. Ability to walk			-	-.16	.32*	.04	-.14	.09
4. MMSE				-	-.19	-.60*	-.09	-.21
5. Cornell					-	-.02	-.00	-.04
6. GDS						-	.10	.15
7. Level of education							-	-.03
8. Institutionalization time								-

*$p \leq .05$

Hypothesis 1

To test the first hypothesis, if there is a positive relation between M10 and the SIB total score when controlling for GDS and institutionalization time for both of the two groups but stronger for the walking group, a hierarchical multiple regression was performed. Within the able to walk group block one of the hierarchical multiple regression, GDS score and institutionalization time accounted for an insignificant proportion of the variance in the SIB total score. In the second block M10 was added to the regression. Independent of the GDS score and institutionalization time, M10 explained no significant proportion of the variance in the SIB total score. The total model including GDS, institutionalization time and M10 explained no significant proportion in SIB total score. More information about the R values, F values and the unstandardized and standardized regression coefficients are reported in table 3.

Within the not able to walk group, block one of the hierarchical multiple regression, GDS score and institutionalization time, did not account for a significant proportion of variance in SIB total score. In the second block M10 was added to the regression. Independent of GDS and institutionalization time, M10 did not explain a significant proportion of variance in SIB total score. The total model including GSD, institutionalization time and M10 explained no significant proportion in SIB total score. More information about the R values, F values and the unstandardized and standardized regression coefficients are reported in table 3**.**

Hypothesis 2

To test the second hypothesis, participants in both groups that show high levels of physical activity will score better on all cognitive domains when controlling for the effects of dementia severity and institutionalization time on cognitive functioning, with higher effects for the patients who are able to walk, there had to be a significant relation between the SIB and M10. Since this relation was not significant (see table 3), the second hypothesis was not tested. Therefore no further statements can be made about the relation between the subscale scores of the SIB and M10 controlled for GDS and institutionalization time.

Hypothesis 3

To test the third hypothesis, if there will be a different relation of daily activity to cognitive functioning for the different stages of cognitive impairment (mild cognitive impairment and severe cognitive impairment) while controlling for dementia severity and institutionalization time, a hierarchical multiple regression was performed. This was performed for the four groups, able to walk and severe cognitive impaired (n = 50), able to walk and mild cognitive impaired (n = 5), not able to walk and mild cognitive impaired (n = 0) and not able to walk and severe cognitive impaired (n = 13). None of the participants accounted to the criteria of the group not able to walk and mild cognitive impaired, therefore the analysis will be performed with only three groups.

First, an ANOVA was performed to check if all the groups the SIB total score indeed differed between the three groups. The ANOVA was statistically significant, indicating that the SIB total score did differ between the groups, F (2, 65) = 11.17, $p \leq$. 001, η^2 = .26. Post hoc analyses with Tukey's HSD revealed that the SIB total score for participants who are able to walk with severe cognitive impairments (M = .01, SD = .81) was significantly lower than participants who are able to walk with mild cognitive impairments (M = 1.71, SD = .43). In addition, the SIB total score for participants who are not able to walk with severe cognitive impairments (M = -.59, SD = 1.07) is significantly lower than the SIB total score for participants who are able to walk with mild cognitive impairments (M = .01, SD = .81). However, the SIB total score did not significantly differ for participants who are able to walk with severe cognitive impairments (M = .01, SD = .81) and for participants who are not able to walk with severe cognitive impairments (M = .01, SD = .81).

Then, the hierarchical multiple regression was performed. Within the first group, able to walk and severe cognitive impaired, block one of the hierarchical multiple regression, GDS score and institutionalization time, accounted for a significant 17.9% of the variance, ($p \leq$. 05). In the second block M10 was added to the regression. Independent of GDS and institutionalization time, M10 did not explain a significant proportion of variance in SIB total score. The total model including GSD, institutionalization time and M10 explained 18.4% of the variance in SIB total score ($p \leq .05$). More information about the R values, F values and the unstandardized and standardized regression coefficients are reported in table 4.

Within the second group, able to walk and mild cognitive impaired, block one of the hierarchical multiple regression, GDS score and institutionalization time, did not explain a significant proportion of variance in SIB total score. In the second block M10 was added to the regression. Independent of GDS and institutionalization time, M10 did not explain a significant proportion of variance in SIB total score. The total model including GDS, and institutionalization time and M10 did not explain a significant proportion of variance in SIB total score. More information about the R values, F values and the unstandardized and standardized regression coefficients are reported in table 4.

Within the third group, not able to walk and severe cognitive impaired, block one of the hierarchical multiple regression, GDS score and institutionalization time, did explain a significant 52.9% the variance in SIB total score ($p \leq .05$). In the second block M10 was added to the regression. Independent of GDS and institutionalization time, M10 did not explain a significant proportion of variance in SIB total score. The total model including GDS, institutionalization time and M10 did not explain a significant proportion of variance in SIB total score. More information about the R values, F values and the unstandardized and standardized regression coefficients are reported in table 4.

Table 3

Unstandardized (B) and Standardized (β) regression coefficients for each variable on each step of a hierarchical multiple regression predicting SIB total score, divided by ability to walk.

Variable	*B* [95% CI]	β	R^2	ΔR^2	*F*
Able to walk				.11	
(*n* = 55)					
Block 1			.11		3.08
GDS	0.69 [-0,12, 1,50]	0.23		.00	
Uptake	-0.10 [-0.22, 0,02]	-0.22			
Block 2					.11
GDS	0.68 [-0.14, 1.51]	0.22			
Time	-0.10 [-0.22, 0.03]	-0.22			
M10	0.00 [-0.02, 0.03]	0.04	.11		
Total					2.05
Not able to walk				.29	
(*n* = 13)			.29		
Block 1					2.00
GDS	0.80 [-0.90, 2.49]	0.28		.00	
Time	-0.17 [-0.43, 0.06]	-0.45			
Block 2					.05
GDS	0.73 [-1,19, 2,65]	0.26			
Time	-0.20 [-0.48, 0.9]	-0.47	.29		
M10	-0.01 [-0.07, 0.09]	-0.07			
Total					1.22

Note. CI = Confidence interval, GDS = Global Deterioration Scale dementia severity*, Time = institutionalization time in years, M10 = Daily physical activity.*
*$p \leq .05$

Table 4

Unstandardized (B) and Standardized (β) regression coefficients for each variable on each step of a hierarchical multiple regression predicting SIB total score, divided by the four groups; Able to walk and severe cognitive impaired (SCI), Able to walk and mild cognitive impaired (MCI), Not able to walk and severe cognitive impaired, Not able to walk and mild cognitive impaired.

Variable	*B* [95% CI]	β	R^2	ΔR^2	*F*
Able to walk,					
SCI (*n* = 48)					
Block 1			.18	.18	4.91*
GDS	-0.43 [-0.73, -0.14]	-0.40			
Time	-0.06 [-0.18, 0.06]	-0.14			
Block 2				.01	.28
GDS	-0.45 [-0.75, -0.15]	-0.41			
Time	-0.06 [-0.18, 0.06]	-0.14			
M10	-0.01 [-0.03, 0,02]	-0.07			
Total			18.4		3.32*
Able to walk,					
MCI (*n* = 4)					
Block 1			1.00	1.00	
GDS	-0.43 [-0.43, -0.43]	-1.00			

Time	0.00 [-0.00, 0.00]	0.00			
Block 2				.00	
GDS	-0.43 [-0.43, -0.43]	-1,00			
Time	0.00 [0.00, 0.00]	0.00			
M10	0.00 [0.00, 0.00]	0.00			
Total			1.00		
Not able to walk, SCI (*n* = 13)					
Block 1			.53	.53	5.61*
GDS	-0.63 [-1.17, -0.09]	-0.61			3.74
Time	-0.10 [-0.31, 0.12]	-0.24			
Block 2				.00	.00
GDS	-0.63 [-1.23, 0.03]	-0.61			
Time	-0.10 [-0.35, 0.15]	-0.24			
M10	0.00 [-0.05, 0.05]	0.01			
Total			.53		3.37

Note. CI = Confidence interval, GDS = Global Deterioration Scale dementia severity, *Time = institutionalization time in years, M10 = Daily physical activity, SCI = Severe cognitive impaired, MCI = Mild cognitive impaired.*

* $p \leq .05$

Discussion

In this study, the relation between daily physical activity and cognitive functioning in nursing home residents with dementia, with different walking abilities, was examined while controlling for depression, education level, dementia severity and institutionalization time. It was hypothesized that a higher daily physical activity would lead to a better cognitive functioning, for both patients who were able to walk and patients who were not able to walk, with a greater effect for patients who were able to walk. Moreover, it was hypothesized that if this relation between daily physical activity and cognitive functioning was found, it would have an influence on all cognitive domains and there would be a difference in the relation between daily physical activity and cognitive functioning for patients with different stages of cognitive impairment. The results of this study showed, contrary to the expectations, that higher daily physical activity was not associated with a higher level of cognitive functioning in both patients who were able to walk and patients who were not able to walk. However, independent of the daily physical activity, patients who were able to walk had a better level of cognitive functioning than the patients who were not able to walk anymore. Since no relation was found between daily physical activity and cognitive functioning, no further statements were made about the relation between daily physical activity and the different cognitive domains. Moreover, when the participants were divided based on their cognitive impairment, no relation between daily physical activity and cognition was found either. Despite depression and level of education are frequently reported predictors for cognitive functioning (van Hooren et al., 2007; Koenig et al., 2015; Mourao et al., 2015; Stern, 2012), in this current study depression and level of education did not relate to cognitive functioning.

That we did not find a relation between daily physical activity and cognitive functioning is not in line with previous research (Colcombe & Kramer, 2003; Hillman et al., 2009**;** McDonnel et al., 2013; Voelcker-Rehage & Niemann, 2013). More specifically, Colcombe and Kramer (2003) found that physical activity has a positive effect on cognition in general. Moreover, other studies found, contrary to the results of the current study, effects of physical activity on specific cognitive domains (Hillman, et al., 2009 McDonnel et al., 2013; Voelcker-Rehage & Niemann, 2013). On the other hand, the finding of the current study does correspond with work of Eggermont et al. (2009). They did not find an effect of walking on cognitive functioning even though walking, even while using a rollator, was categorized as an aerobic exercise, which is the type of exercise that should have the biggest effect on cognitive functioning (Colcombe & Kramer, 2003; Groot et al., 2016). The finding of the current study that walking ability, independent of daily physical activity, is related with cognitive functioning is comparable to previous work of Kikkert, Vuillerme, van Campend, Hortobágyi, & Lamotha, (2016), which found that walking ability might be a biomarker for cognitive decline.

The lack of relation between depression and education level with cognitive functioning does not correspond to the current overall literature (van Hooren et al., 2007; Koenig et al., 2015; Mourao et al., 2015; Stern, 2012). The study of Mourao et al. (2015) found that depression could contribute to progression of dementia in patients that are mildly cognitive impaired. The current study did not find a relation between depression and cognitive functioning in dementia patients. Likewise, the finding that education level had no relation with cognitive functioning is contradictory to the results of the study from Stern (2012) who found that higher education might lead to a better cognitive reserve and to a better cognitive functioning than by patients with a lower education. More specific, regarding to the SIB scores, which are in this study used as a measure of cognitive functioning, did the study of Henskens, Nauta, Drost, Milders, & Scherder (2019) find a relation between SIB score and mood. In that study mood was measured with the Care Dependency Scale (CDS) which measures depression, apathy and agitation. However, the study of Wajman and Bertolucci (2006) shows that there is no relation between level of education and SIB-score, which corresponds to the current study.

The non-existent relation between daily physical activity and cognitive functioning that was found can be explained in multiple ways. As stated in the introduction, the development and networks of cognitive and motor processes are related (Leisman et al., 2016). Since neurodegeneration is one of the biomarkers for dementia and since it can lead to cognitive deficits (Fox et al., 2013; Jack et al., 2013), this could also lead to the loss of motor processes and less daily physical activity. Therefore, it is possible that the differences in cognition and daily physical activity that are seen between nursing home residents with dementia are more due to neurodegeneration and are not caused by the differences in daily physical activity exclusively. Another reason for the absence of the relation between daily physical activity and cognitive functioning might be that in these patients the blood flow during and after the physical activity was reduced (Eggermont et al., 2009). In healthy participants, after physical activity the blood flow will rise, which can decrease the effect of aging (Lucas et al., 2012). This might not be the case in patients with cardiovascular disease, where the cardiac output blood flow, in the brain, is reduced during exercise (Eggermont et al., 2009). The study of Perea et al. (2016) suggested that Alzheimer patients with a higher cardiorespiratory fitness might have better preserved white matter integrity. In this population of nursing home residents with dementia, cardiovascular diseases are very common and in the current study many participants had cardiovascular diseases (80.9%). Therefore, cardiovascular diseases might contribute to a lessened effect of daily physical activity on cognition as it might cause a reduced blood flow in the brain and less preserved white matter integrity (Eggermont et al., 2009; Perea et al., 2016). Moreover, it might be possible that the effect of (daily) physical activity in the younger years also could have influenced the cognitive functioning that the patients show now. The study of Hakala et al. (2019) showed that the physical activity in childhood and young adulthood had an influence of the cognitive functioning in midlife. This effect was independent of the physical activity on other age. This is confirmed by the study of Reas et al. (2019), which found that more physical activity in the teenage years could lead to a better cognitive functioning in the older years. This might be caused by building more cognitive reserve in the younger years. They also found that the effect was stronger when the participants were physical active both at younger age as at older age. This is also confirmed by the meta-analysis of Engeroff, Ingmann and Banzer (2018). More longitudinal research in this area is needed.

Still, in the current study was found that patients who were able to walk had a better cognitive performance than patients who were not able to walk. According to Kikkert et al. (2016) this relation between walking ability and cognitive functioning might be due to age related loss of brain volume. Contrary to the results of Kikkert et al. (2016), the results of the current study showed that lower cognitive functioning in patients who are not able to walk is independent of age and the dementia severity (see table 2). This might mean that this lower cognitive function is not related with general decline associated with aging or dementia severity of the patients. The literature also does not seem to have an explanation for this difference between these groups. Possibly, the relation between walking ability and cognitive functioning could still be explained by physical activity (Blondell et al., 2014; Groot et al., 2016). However, this might be found with another measure for daily physical activity than the M10 since the M10 does not give specific information about the type and intensity of the movements.

No difference was found in the relation between the daily physical activity and cognitive functioning for patients with different levels of cognitive impairment. This might be explained by the scores on the cognitive tests. The scores on the MMSE for all participants were in a small range. 92.7% of the participants scored 17 points or less on the MMSE. This might mean that all participants approximately were on the same cognitive level, which is seen as severe cognitive impaired (O' Connor et al., 1989). An explanation could be that the

MMSE is not as sensitive for the cognitive functioning of severely cognitive impaired individuals as the SIB-NL-Q. The participants of this study show way more variation on the total scores of the SIB-NL-Q (*M* = 33,06; *SD* = 12,16). This might explain why no differences between the groups divided on the level of cognitive functioning were found.

A possible reason for the finding that depression was not related to cognitive functioning might be explained by the research of Vinkers, Gussekloo, Stek, Westendorp and van der Mast (2004). They found that depression might develop when cognitive decline is present in a person and when that person is aware of the cognitive decline. Therefore, depression might not be a risk factor but a consequence of cognitive decline. It is possible that the dementia patients in the nursing home are (as part of their disease) not aware of their cognitive decline (Aalten, Van Valen, Clare, Kenny, & Verhey, 2005) and therefore do not develop a depression or depressive symptoms. The reason why level of education was not related with cognitive functioning in the current study, might be due to the time in which these participants grew up. The mean age of the participants is 85.5 years, which means the time they went to school was during and after war, in a less wealthy society. It is possible that during that time the possibilities for further education were limited. This might mean that the education that the participants received was not presentable for their premorbid level of cognitive capacity (Legdeur et al., 2017). Moreover, in this study cognitive functioning is measured by the SIB total score, as mentioned before, the study of Wajman and Bertolucci (2006) also did not find a relation between education and SIB total score. They state it might be possible that the effect of education might disappear when dementia appears or that differences in premorbid education no longer contribute to the level of the performance on simple SIB tasks which is developed for severe dementia. These might be the reasons why the education level does not correspond to cognitive functioning of the participants.

A strength of this study is that the relation between daily physical activity and cognition including multiple possible confounding variables is extensively studied. Moreover, as far as known this study is the first study that measures the relation between daily physical activity and cognition. Still, the current study has some limitations which should be taken into consideration. Since a lot of the data from the data set was missing (14% of the total data set) many participants had to be excluded from the research (*n* = 29). This data was missing since not all participants wanted or were able to cooperate with the tests. It is important that the wellbeing of the participants was guaranteed and that patients that reported discomfort, or from whom discomfort was observed, were excluded from the study. As well due to the big exclusion rate this study had a small sample size. According to the Power Analysis (Faul et al., 2009), 55 participants were needed to perform the initial analyses. The analyses were done with two groups which means that both groups had to exist of 55 participants. On forehand was unknown how many participants could be included in this study, however it was known that this amount of participants (*n* = 55 per group) was not achievable. Since this study was an explorative study, it was chosen to persevere in this design. However, with a small sample size, caution must be applied, the small sample size caused a lower power (Neuman, 2014) which makes the statements of this study less reliable.

Moreover, during the data-collection the procedure of the Cornell depression scale was changed. More specifically, the procedure was changed from questions about the change in the last two week to questions about the observed behaviour. This has influenced the data, therefore it could be argued that it would have been better to just keep one procedure. Though, it has changed the data in a positive way since with the new procedure more depression symptoms could recorded, this makes the data more valid. With the first procedure depressive symptoms from patients that had these symptoms for longer than two weeks were missed. Therefore it was chosen to continue with the change in procedure.

Furthermore, concerning measuring daily physical activity, it might have been more accurate to analyse the hours of activity only during daytime. In healthy individuals most physical activity is performed during daytime and night time is used for sleep. Therefore, only analysing the hours only during daytime might be more representable for measuring, in particular daily, physical activity. The M10 just measures the 10 most active hours in the 24 hours of a day, which also might have been in the evening or at night time for a lot of participant. Since patients with dementia might show disturbed day and night rhythms (Hooghiemstra, Eggermont, Scheltens, van der Flier, & Scherder 2015; Leng, Musiek, Hu, Cappuccio, & Yaffe, 2019) it also could be argued that physical activity in the evening or at night time is part of activity during their day. It is not known if measuring daily physical activity during daytime only or during the day and night time will make a difference for the relation between daily physical activity and cognitive functioning. This might be an interesting point of focus for further research**.** The M10 seemed to be a very good variable for daily physical activity since these ten hours cover a big part of the day and contained information about how regular the activity was and how active the participant was during these 10 hours (Burns et al., 2009). Therefore, it was chosen to use the M10 as a variable for the daily physical activity.

For further research it would be interesting to improve different aspects of the current study. First of all, it would be interesting to study the relation between daily physical activity and cognition with a bigger sample size, from which more powerful statements could be made (Neuman, 2014). Secondly, it might be helpful to use other tools to measure daily physical activity since the M10 does not seem to be the right variable. It would be interesting to examine if there are more possibilities with the Actiwatch data to split the data into length of activity, intensity of the activity and day- and night time activity. The more specific measurements of daily physical activity might be accomplished by a smart watch rather than an Actiwatch (Xie, 2019). A smart watch could measure length and intensity of the activity, the time and time of the day in which the activity was accomplished and heart rate of the participant. Complementary, observation data could be used to see what movements are made and for how long the activity lasts. Although this is an intensive data collection procedure, this might give a better insight in the activity pattern of the participant. This insight will lead to a better view on the type of activity and specific movements the participant makes, which will give a more controlled representation of the activity pattern of the participant. Besides, with this information the differences for daily physical activity during daytime and during night time could be studied. Lastly, another measure for education level could be chosen to control for the premorbid effects of cognition. According to Legdeur et al. (2017) the Wide Range Achievement Test - Third Edition (WRAT- III) is a reliable test to measure the premorbid cognitive functioning for older participants. Also reading level could be a measure for premorbid cognitive functioning (Miller et al., 2015). This effect is found in different populations. With the adjustments to the current study as described above, it might be possible to study the relation between daily physical activity and cognition in a qualitative higher way.

In conclusion, in this study the relation between daily physical activity and cognition was examined. Which physical activity interventions have most effect on cognitive functioning and which patients benefit most from these interventions is still unclear. Despite the results did not fulfil the expectations, this explorative study could be a good first basis for further research in which tools could be better used to find the relation between daily physical activity and cognition in nursing home residents with dementia. This study provides some handles for new and higher qualitative research which might in the future help to find the interventions that are effective for specific groups of patients.

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