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### What are the factors associated with physical activity (PA) participation in community dwelling adults with dementia? A systematic review of PA correlates

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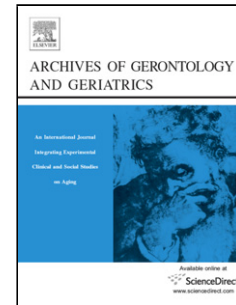
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# What are the factors associated with physical activity participation in community dwelling adults with dementia? A systematic review of physical activity correlates

## Submission to Archives of Gerontology and Geriatrics

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**Abstract**

Physical activity shows promise as a modifiable lifestyle intervention to benefit pathological symptoms of dementia. However, little is known about the factors associated with participation in physical activity in community dwelling adults with dementia. A systematic review was undertaken to identify physical activity correlates. Two independent reviewers searched major electronic databases and extracted data on studies reporting quantitative correlates of physical activity participation in community dwelling adults with dementia. Physical activity correlates were analysed using the summary code approach within the socio-ecological model. Out of a potential of 118 articles, 12 met the eligibility criteria encompassing 752 participants. We conducted secondary analysis on 9 data sets. Increased energy intake, resting metabolic rate, fat free mass, gait speed, global motor function, overall health related quality of life (HRQOL), physical HRQOL, higher levels of social functioning and reduced apathy were positively associated with physical activity. Taking  $\geq$  four medications, dizziness, lower ADL function, a history of falls, less waking hours in the day, more autonomic problems and delirium were negatively associated with physical activity. Increasing age and lower global cognition were not consistently associated with physical activity participation. It is surprising that increasing age and lower global cognition do not appear to influence physical activity participation. All significant correlates should be confirmed in prospective studies with particular focus on the relationship of physical activity and gait speed, ADL function, falls history and dietary intake and the progression of frailty and nursing home admission as a priority.

**Key words:** physical activity, dementia, exercise, Alzheimer's disease,

## 1. Introduction

The ageing population and the number of people affected by dementia are reaching epidemic levels (Prince *et al* 2013). The inherent cognitive decline observed in dementia is associated with profound loss of independence, increased falls risk, a reduction in capacity to undertake activities of daily living (ADL), nursing home admission and increased mortality (Prince *et al* 2013, Butler and Radhakrishnan 2012, Smith *et al* 2013, Pitkala *et al* 2013). Unsurprisingly, the prevention and management of dementia is an International political and health priority (Prince *et al* 2013).

Within recent years interest has risen in physical activity as an effective non-pharmacological intervention in the prevention and management of dementia (Ahlskog *et al* 2011). For instance, Erikson *et al* (2012) recently concluded that there is convincing evidence that physical activity reduces the risk of Alzheimer's disease (AD), improves brain health and decreases the risk of pathological symptoms associated with AD. Other recent reviews (Potter *et al* 2011, Pitkala *et al* 2013, Blankevoort *et al* 2010) have established that physical activity interventions can improve mobility and functional limitations in people with dementia. This is exemplified in a recent randomised control trial (Hauer *et al* 2012) involving physical activity which resulted in significant improvements in strength ( $p < 0.001$ ) and functional performance ( $p < 0.001$ ) in community dwelling adults with mild and moderate dementia. In a recent updated Cochrane review, Forbes *et al* (2013) concluded that structured physical activity (exercise) can have a positive influence on cognition and a person with dementia's ability to undertake their ADL. In addition, a recent RCT (Lowry *et al* 2013) demonstrated that physical activity programme for people with dementia resulted in

a reduction of caregiver burden from 23% to 17% ( $p=0.01$ ) whilst the burden doubled in the control arm.

Despite these positive findings, there remain concerns that community-dwelling adults with dementia are physically inactive (James *et al* 2012). A recent randomised control trial found that only 30.7% achieved the prescribed frequency of the physical activity intervention and the authors concluded that it is essential research is undertaken to identify factors influencing participation in physical activity in community dwelling adults with dementia (Lowry *et al* 2013). A systematic review of quantitative research would identify potential factors associated with physical activity and this information can be used to target future physical activity interventions for persons with dementia. One approach that is potentially useful to understand the factors associated with physical activity uptake is the socio-ecological model (Sallis *et al* 2006). This model posits that multiple levels may impact upon an individual's participation in physical activity, including intrapersonal factors (e.g. socio-demographic or psychological) factors, interpersonal factors (e.g. social support); environment factors (e.g. access to facilities) and policy factors (e.g. regulations) (Sallis *et al* 2006, Bauman *et al* 2010). The socio-ecological model has been successfully used to identify influential factors in the uptake of physical activity within the general population (Sallis *et al* 2006, Bauman *et al* 2010), persons with mental illness (Vancampfort *et al* 2014). Given the promising benefits associated with physical activity for community dwelling adults with dementia, it is important to understand the multiple levels over which physical activity participation may be affected.

To our knowledge, no author has systematically reviewed the literature to establish the factors associated with physical activity participation in community dwelling adults with

dementia. This information would provide essential information that can be utilised by clinicians, researchers and policy makers. With this in mind we conducted a systematic review to establish quantitative correlates of physical activity participation in community dwelling adults with dementia utilising the socio-ecological approach.

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## 2.1 Methods

### 2.2 Data Sources and Searches

Two independent reviewers conducted an electronic search of PsycINFO, CINAHL, PubMed and Embase from the inception of these databases until October 2013. The medical subject headings used were 'physical activity' or 'exercise' or 'physical inactivity' or 'sedentary' and 'dementia', or 'Alzheimer's disease' or 'vascular dementia' or 'frontotemporal dementia' or 'Lewy Body dementia' in the title, abstract or index term fields. We also conducted manual searches of the reference lists of identified articles.

### 2.3 Eligibility Criteria

Inclusion criteria were: (a) studies published in a peer review journal providing quantitative data, (b) including community dwelling adults with a confirmed diagnosis of dementia (assessed with a structured clinical diagnostic interview, or the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV; APA 1995), or the National Institute of Neurological and Communicative Disorders and Stroke and the Alzheimer's Disease and Related Disorders Association criteria (NINCDS-ADRDA, McKhann 1984) and (c) the dependent variable was a measure of physical activity participation. We did not place a restriction on the selection of the outcome measure or the language of manuscripts that were considered within the review. When we encountered cohort or interventional studies, we utilized the physical activity outcome measurement and correlates from the baseline data. Authors of all potential and included studies were contacted up to three times in order to obtain correlates if this information not given and in order to identify any potential additional correlates not reported in the paper.



Articles were excluded if the dependent variable was aerobic fitness, physical activity intention, motivation, self-efficacy or other non-behavioral measures because we aimed for variables that were a direct indicator of actual participation in physical activity. In addition, we excluded case reports, conference abstracts, qualitative research, reviews and expert opinion pieces. If studies were encountered that included a population with multiple diagnoses (for example mild cognitive impairment and dementia) or participants residing in mixed settings (e.g. nursing home residents and community dwelling participants) we contacted the primary author in order to provide us with the dementia specific information. If we did not receive a response after three requests and it was not possible to extract the information from the paper, we subsequently excluded the paper.

#### *2.4 Data Collection*

Two reviewers independently extracted data from the included studies using a predetermined form. The data extracted included socio-demographic information (mean age, % male), details of dementia diagnosis (including information on Mini Mental State scores if available) and the type and quality of the physical activity measure.

In accordance with previous reviews (Vancampfort *et al* 2014) we coded the quality of the self-reported physical activity measures as follows: (a) self-report with poor, unknown or not reported reliability/validity in dementia, (b) self-report with reported and acceptable reliability/validity in dementia, and (c) acceptable objective measurements for dementia. The categorization of the quality of physical activity measure was conducted by two reviewers and a third reviewer was available for guidance. We did not utilize a code for acceptability of objective based measures, rather we identified objective measures as motion sensors such as accelerometers, pedometers, actigraphs and the doubly labeled

water method (Warren *et al* 2010). In order to establish if the quality of physical activity measure had any effect upon the proportion of significant correlates in each study, we conducted a Chi squared test.

We classified all variables as 'related' or 'not related' to physical activity based upon statistical significance and the direction of the association for each related variable was coded. The data was summarized for each variable to provide an overview of the literature on each different variable (see table 1).

### *2.5 Selection and Categorization of Variables.*

When we encountered studies based upon the same sample examining the same correlates, we included the most recent data and/ or those with the largest sample size. This approach enables the identification of domains which have been explored in the literature and to elucidate the multidimensional perspective of potential influencing factors upon physical activity participation in older adults with dementia (Bauman *et al* 2010). In accordance with previous reviews (Vancampfort *et al* 2014) and following the socio-ecological model, we examined and grouped physical activity correlates within the following categories: (a) demographic, (b) biological, (c) psychological / cognitive / emotional, (d) behavioral attributes/skills, (e) social/cultural factors, (f) physical environment, and (g) policy factors.

### *2.6 Coding Associations with Physical Activity*

Within the published papers we encountered a variety of statistical techniques to evaluate correlates of physical activity, including uni-/ bivariate analyses such as correlations, t-tests, and ANOVA. Sometimes, only multivariate analyses were reported,

including linear regression or logistic regression. In order to gain consistency whenever possible we used the uni/ bivariate analysis available in the paper or those authors had provided us in response to our request for additional data. We contacted the corresponding author of all included studies requesting either (a) uni / bivariate correlation with physical activity as the dependent variable or (b) the raw data so that we could conduct the analysis. If the author did not respond after three requests we included the variables available in the paper. If these were not available in the paper or if authors did not respond to our email requests, we excluded the paper.

The information regarding the correlates of physical activity were collated and grouped under the socio-ecological themes in table 2. Within table 2 the column 'related to physical activity' denotes that there was a significant association with physical activity participation and the column 'unrelated to physical activity' denotes that there was a non-significant correlation to physical activity participation. For those correlates identified as being significantly associated with physical activity we employed the symbol '+' or '-' based upon whether or not it was positively or negatively associated with physical activity participation.

### 2.7 Summary Codes

A summary code for each correlate was calculated and presented in accordance with the established method of Sallis *et al* (2006). This summary code (see table 2) provides an overall reflection of the findings from the literature for the association of that variable with physical activity participation. We calculated total percentage of studies supporting or negating each correlate by dividing the number supporting an association by the overall number investigating each correlate. In accordance with previous reviews (Vancampfort *et*

*al* 2014) associations were coded with: '0' (0-33% of studies supporting association); '?' (34%-59% of studies supporting an association); or '+' or '-' (60%-100% of studies supporting an association). When we encountered four or more studies supporting or refuting an association, we coded the summary as '00', '--', or '++'. The '??' code indicated a variable that was studied four (or more) times but that there was a lack of consistency in the findings.

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### 3.1 Results

#### 3.2 Study Selection

We identified 2,603 articles from the searches and following screening of these we obtained the full text of 118 articles to assess their eligibility. At this stage, we contacted 19 research groups requesting additional information on the correlates with physical activity and nine provided us with additional analysis and/ or provided their data set so we could conduct secondary analysis of their data set (See acknowledgements). Seven groups were not contactable or able/ willing to provide additional data and were subsequently excluded as there was not any information on the correlates with physical activity in the published paper. Three papers were still included as there was at least one correlate of physical activity reported in the published paper. In total, 106 articles were excluded with reasons and the complete search strategy is outlined in Figure 1. Twelve articles met the eligibility criteria and were included in the review.

Insert figure 1 about here

#### 3.3 Participant and Study Characteristics

In total 752 unique adults with dementia were included within our analysis and most (n=671, 89%) had a diagnosis of Alzheimer's disease. It was possible to establish the percentage of males in 11 of the 12 studies and on average 48% of the samples were male ( $\pm 13\%$ ). The largest sample was the Allen *et al* (2006) study (n=156) whilst the smallest (n=24) was Cedervall *et al* (2012). All of the studies confirmed a diagnosis of dementia with the NINCDS-ADRDA criteria and/ or the DSM-IV. Seven studies adopted a cross sectional design (Allan *et al* 2006, Christofletti *et al* 2011, David *et al* 2011, Dvorak & Poehlman 1998, Erickson *et al* 2013, Vital *et al* 2012, Watts *et al* 2013), four were cohort studies (Auyeung *et*

*al* 2008, Cedervall *et al* 2012, James *et al* 2012, Winchester *et al* 2013) and one was a randomized controlled trial (McCurry *et al* 2010). However all studies adopted cross sectional measurement of physical activity and the subsequent correlates. Four studies (33%; David *et al* 2011, Dvorak & Poehlman 1998, Erickson *et al* 2013, James *et al* 2012) captured physical activity with an objective measure, whilst the remaining 8 studies (66%) used a range of self-report measures to capture physical activity. None of the self-report physical activity measures were validated for use in community dwelling adults with dementia. Table 1 presents the characteristics of the included participants, the quality of physical activity assessment and statistical analysis undertaken.

Insert Table 1 about here

We conducted a two tailed Chi squared test and found there was no statistical significant difference between the proportion of related correlates reported in studies utilizing objective or self-report physical activity measures ( $p=0.203$ ).

#### *3.4 Correlates of Physical Activity in community dwelling adults with Dementia*

In total 38 correlates were examined within the literature across five of the domains of the socio-ecological model. A summary of the correlates with physical activity are presented in Table 2 and these will be considered below.

[Insert Table 2 about here]

#### *3.5 Demographic correlates*

In total 6 demographic correlates were examined. The most commonly assessed correlate was the influence of age upon physical activity. Increasing age was not consistently associated with physical activity with only 2/8; (25%, James *et al* 2012, Erickson *et al* 2013)

finding a negative association between increasing age and physical activity. Education was examined in four studies and the results were inconsistent (2/4, 50%, Christofolletti *et al* 2011, Vital *et al* 2012 found a positive association). Evidence from three studies suggest that the duration of dementia does not appear to be associated with physical activity participation (1/3, 33% Vital *et al* 2012, found a positive association). Only one study investigated socioeconomic status, gender and ethnicity and none found any association with physical activity.

### 3.6 Biological correlates

In total 14 biological correlates were investigated. We did not identify any consistent correlates (reported in four or more studies), but there is evidence from two studies (100%, Auyeung *et al* 2008, Watts *et al* 2013) that faster gait speed/ better walking capacity is positively associated with participation in physical activity. There is inconsistent evidence that body mass index (BMI) is related to physical activity with 40% (2/5 studies, Auyeung *et al* 2008, Erikson *et al* 2013) finding an increased BMI was negatively associated with physical activity participation. There is an indication from the findings of single studies that global motor function, lower fat free mass, resting metabolic rate and higher energy intake are all positively associated with physical activity participation. One study (Allen *et al* 2006) found that dizziness was negatively associated with physical activity. Surprisingly, other biological correlates including lower limb strength, VO<sub>2</sub> peak and balance were not related to physical activity although investigation of these were limited to one study.

### 3.7 Behavioural attributes and skills

Two correlates were studied within this category and the most commonly investigated variable was how a participant's difficulty completing their activities of daily living (ADL) affected physical activity participation. This analysis established that 3 out of 5 studies (60%, Auyeung *et al* 2008, James *et al* 2012, Allan *et al* 2006) found that difficulties engaging in ADL was negatively associated with physical activity. There is some evidence from another study (Allen *et al* 2006) that a history of falls is negatively associated with physical activity.

### *3.8 Psychological, cognitive and emotional correlates*

In total 15 correlates were analysed within this domain. We found consistent evidence from ten studies that lower global cognition is not related to physical activity participation with 90% (9/10, Dvorak & Poehlman 1998, McCurry *et al* 2011, Auyeung *et al* 2008, James *et al* 2012, Vital *et al* 2012, David *et al* 2011, Christofolletti *et al* 2011, Allan *et al* 2006, Cedervall *et al* 2012) finding no significant association. There is some evidence from two studies (Auyeung *et al* 2008, Allen *et al* 2006) that higher physical health related quality of life (QOL) is positively associated with physical activity. There were inconsistent findings regarding the influence of mental health related QOL whilst sleep and depression were not related to physical activity participation. There was some evidence from investigations limited to a single study that overall health related QOL and reduced apathy were positively associated with physical activity, whilst waking hours in the day and delirium were negatively associated with physical activity.

### *3.9 Social and cultural factors*



Only one study (Allen *et al* 2006) investigated a correlate within this domain and this study found that higher social functioning was positively associated with physical activity participation.

### *3.10 Physical environment and policy factor correlates*

Within this systematic review we did not identify any study that investigated the influence of the physical environment or policy factors upon physical activity participation.

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#### 4.1 Discussion

To the authors' knowledge this review is the first to detail the quantitative correlates of physical activity participation in community dwelling adults with dementia. We were able to identify significant correlates in four of the five domains across the socio-ecological model. Increased dietary (energy) intake, resting metabolic rate, fat free mass, gait speed, global motor function, overall HRQOL, physical HRQOL, higher levels of social functioning and reduced apathy were all positively associated with physical activity. In addition, taking four or more medications, dizziness, lower ADL function, a history of falls, less waking hours in the day, more autonomic problems and delirium were negatively associated with physical activity participation. However, most of these associations were only supported by findings in one or two studies and we did not find any consistently reported (in four or more studies) statistically significant correlates.

It is of interest that we found that increasing age, education and global cognition were not consistently associated with lower participation in physical activity. The finding from 8 studies that increasing age is not negatively associated with physical activity participation suggests that regardless of age community-dwelling adults with dementia can still engage in physical activity and therefore potentially obtain the multiple benefits associated with participation in it (Potter *et al* 2011, Pitkala *et al* 2013). Similarly, nine out of ten studies showed that lower global cognition is not associated with lower levels of physical activity in community dwelling adults with dementia. This is a somewhat surprising finding and a possible explanation could be that caregivers compensate with additional assistance to engage the person with dementia to be more active. A recent qualitative study of people with Alzheimer's disease and their caregivers gave an insight into this

phenomenon and stressed the importance of dual involvement of the caregiver in order for physical activity participation to be successfully increased (Malthouse and Fox 2013). Clearly as the dementia advances the promotion of physical activity becomes more complex and it is imperative that caregivers are involved in order for physical activity uptake to be successful but this has also been demonstrated to result in reductions in burden (Lowry *et al* 2013). From this review, it appears that within dementia, other factors such as polypharmacy, difficulties in ADL and functional decline are more pertinent factors negatively associated with physical activity than cognition.

It is also of interest that HRQOL and in particular physical HRQOL are positively associated with physical activity but the results are limited to one and two studies respectively. A randomised controlled trial (Teri *et al* 2003) including community dwelling adults with Alzheimer's disease established that a structured physical activity program improved physical HRQOL in the intervention group compared to the control group. The group undertaking the physical activity program also had lower levels of depression and improved physical function. The findings from our review are backed up by this RCT that physical HRQOL is a key factor associated with physical activity participation in dementia. Somewhat surprisingly, we found inconsistent results regarding the association between depression and physical activity.

Perhaps the most interesting biological correlate we identified is that higher gait speed and walking capacity were positively associated with physical activity (two studies). Whilst this may not be surprising, it is important, since variations in gait speed and in particular slow gait are associated with an elevated risk of falls (Callisaya *et al* 2010, Barak *et al* 2006) and it should be noted that falls are a travesty in community dwelling adults with

dementia (Wesson *et al* 2013). We also found evidence from one study that a history of falls was negatively associated with physical activity participation (Allan *et al* 2006). This highlights the challenge that clinicians face when older adults with dementia start to develop slow walking speed, their falls risk increases and they actually start falling. Within the general older adult setting, targeted physical activity programs are the most effective interventions to prevent falls (Sherrington *et al* 2008) yet their role of physical activity programs in preventing falls in community dwelling adults with dementia is unclear and warrants exploration (Wesson *et al* 2013).

Within the behavioural attributes domain of the socio-ecological model we found that older adults with dementia who experienced difficulty undertaking their ADL were significantly less active. The relationship between physical activity and ADL is well established in the general older population with a recent review establishing that increasing physical activity is effective in slowing the progression of ADL disability, frailty and ultimately dependency (Tak *et al* 2013). A recent Cochrane review established that physical activity can have a positive influence upon people with dementias ability to undertake their ADL (Forbes *et al* 2013). Whilst increasing difficulty participating in ADL is a key feature of the progression of dementia, it remains unclear if physical activity can prevent this progression. The current review demonstrates that difficulties with ADL and a history of falls were negatively associated with physical activity whilst a higher gait speed is positively associated with physical activity participation. Whilst it is not possible to make any claims regarding causation, current results do suggest the importance of maintaining physical activity in older adults with dementia particularly when the wider well established benefits of physical activity are considered.

Within the literature (Bilota *et al* 2012, Gray *et al* 2013) there has been an increased discussion regarding the importance of preventing the development of frailty. Frailty is related with a number of factors that we found were associated with physical activity including weight loss (energy intake), exhaustion, muscle weakness, slow walking and physical inactivity (Kulmala *et al* 2013). Preventing the development of frailty in community dwelling adults with dementia is vitally important since this is considered an independent predictor of death in outpatients with Alzheimer's disease (Bilota *et al* 2012). In addition frailty and dependence in ADL are associated with nursing home admission (Gaugler *et al* 2009). Physical activity is an important component to prevent sarcopenia and frailty (Cooper *et al* 2012, Landi *et al* 2010) and so maintaining physical activity is clearly important. Whether increasing physical activity levels may actually prevent the development of frailty in community dwelling adults with dementia and postpone nursing home admission is purely speculative at this stage but warrants exploration in prospective longitudinal studies.

#### **4.2 Strengths and limitations**

We conducted a comprehensive systematic review to identify the multiple layers of factors over which physical activity participation is influenced. In order to reduce heterogeneity we only included participants only with a confirmed diagnosis with dementia according to recognised criteria and excluded those with mild cognitive impairment. In addition, nine research groups (out of 12) sent us their raw data and/ or conducted additional analysis on our behalf, thus our results go considerably beyond what is available in the published literature. However, it is important that the results of this review are interpreted with caution in view of a number of limitations. First, all of the studies collected physical activity and the accompanying correlates with a cross sectional measurement, thus

it is not possible to identify causal relationships but only refer to association. On the other hand, others (Bauman *et al* 2010) have argued that this is also a strength enabling potential mediators to be established for planning interventions and to enable the prioritisation of target population groups. Secondly, two thirds of the studies within this review measured physical activity with self-report outcomes that are of unknown reliability and validity in dementia. Clearly there are concerns about the accuracy of the physical activity measurement obtained from self-report in this population, but we did not find any statistical difference in the proportion of correlates found in studies with studies using self-report or objective measures. Third, dementia is a very heterogeneous group and most within our review had a diagnosis of Alzheimer's disease (89%), but one study (Allan *et al* 2006) included participants with other known types of dementia and it is unclear how this may have impacted the results of our review. Fourth, as previous authors have noted (Bauman *et al* 2010, Vancampfort *et al* 2014) this approach to studying correlates only enables the consistency of associations to be established and not the magnitude, thus meta-analysis is rarely possible. Meta-analysis is also very difficult due to the heterogeneity in the use of outcome measures, assessments tools and statistical procedures. Finally, most of the included studies had relatively small sample sizes and included a limited number of correlates.

#### *4.3 Clinical overview and implications*

This review offers relevant information for the stimulation of physical activity participation in clinical practice and in clinical trials within community settings. It has highlighted that participation in physical activity is complex and affected by multiple factors. Future research endeavours should explore in RCTs whether the identified variables

associated with physical activity, in particular ADL, gait speed and dietary intake could reduce the onset of frailty, progression of dementia, functional dependence, and ultimately nursing home admission (Kulmala *et al* 2013). At this stage, this link is purely speculative and theoretical but warrants investigation. We did not find any correlates within the domains of physical environment and policy factors of the socio-ecological model. This is not uncommon since these factors have been understudied in other populations; however their importance on physical activity levels cannot be underestimated (Bauman *et al* 2010). It may be interesting to determine differences in physical activity participation between urban and rural settings or whether level of physical activity participation depends on coverage of physiotherapy programs by health care insurance. When conducting future correlate investigations of physical activity authors should seek to use appropriate measures to calculate physical activity and prioritise the use of objective measures.

It is known that carers and in particular family members are faced with many challenges including difficulty in encouraging people with dementia to engage in physical activity. Future research should investigate the influence of carers upon participation as this is likely to be essential but this was not established in our review. However, there is promising research that engaging in physical activity can reduce carer burden (Orgeta and Claudia Miranda-Castillo 2014). Future research should therefore seek to determine the amount and type of social support required to initiate or maintain physical activity in community dwelling adults with dementia. Previous research (Teri *et al* 2003) has established the importance of social support from caregivers in engaging people with dementia in physical activity and this is likely to be influential in its uptake. Other professionals such as physiotherapists are likely to be able to provide advice on the

appropriate forms of physical activity that can be matched to the individual. This may be particularly useful when a person's functional abilities decline, balance deteriorates and falls risk increases and it becomes important to encourage the participation in physical activity that is safe for the individual.

#### **4.4 Conclusion**

There are indications that difficulty in undertaking ADL, gait speed, dietary intake and physical HRQOL are important factors associated with physical activity participation. From the review we were able to determine that increasing age and lower global cognition do not appear to be negatively associated with participation in physical activity. However, we found no consistent correlates (reported in >4 studies) of factors associated with physical activity in community dwelling adults with dementia. With the mounting political and health interest in physical activity in dementia, it is integral that future research is required to investigate these and other correlates further with objective measurement of physical activity and prospective measurement being a priority.

#### **Conflict of Interest**

All authors report that they do not have any conflicts of interest to declare.

#### **Description of authors roles**

All authors formulated the research question and designed the study. BS, LH and DV undertook the searches and decided on the final list of included articles. BS and LH undertook data extraction. BS, LH and DV analysed the data and all authors contributed to



the interpretation of the data analysis and writing of the manuscript. All authors have approved the final version of the manuscript.

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## References

Ahlskog JE, Geda YE, Graff-Radford NR, Petersen RC. (2011). Physical exercise as a preventive or disease-modifying treatment of dementia and brain aging. *Mayo Clinic Proceedings*. Sep;86(9):876-84. doi: 10.4065/mcp.2011.0252

Allan L, McKeith I, Ballard C, Kenny RA. (2006) The prevalence of autonomic symptoms in dementia and their association with physical activity, activities of daily living and quality of life. *Dementia Geriatric and Cognitive Disorders*. 2006;22(3):230-7. Epub 2006 Aug 10.

American Psychiatric Association. (1994). Diagnostic and Statistical Manual of Mental Disorders (4th edn) (DSM-IV).

Auyeung TW, Kwok T, Lee J, Leung PC, Leung J, Woo J. (2008) Functional decline in cognitive impairment--the relationship between physical and cognitive function. *Neuroepidemiology* ;31(3):167-73

Barak Y, Wagenaar RC, Holt KG. (2006). Gait characteristics of elderly people with a history of falls: a dynamic approach. *Physical therapy*, Nov;86(11):1501-10.

Bauman AE, Reis RS, Sallis JF, Wells JC, Loos RJ, Martin BW; (2012). Lancet Physical Activity Series Working Group. Correlates of physical activity: why are some people physically active and others not? *Lancet*. Jul 21;380(9838):258-71

Bilotta C, Bergamaschini L, Nicolini P, Casè A, Pina G, Rossi SV, *et al.* (2012) Frailty syndrome diagnosed according to the Study of Osteoporotic Fractures criteria and mortality in older outpatients suffering from Alzheimer's disease: a one-year prospective cohort study. *Aging Mental Health*.;16(3):273-80.

Blankevoort CG, van Heuvelen MJ, Boersma F, Luning H, de Jong J, Scherder EJ. (2010). Review of effects of physical activity on strength, balance, mobility and ADL performance in elderly subjects

with dementia. *Dementia and Geriatric and Cognitive Disorders*;30(5):392-402. doi: 10.1159/000321357.

Butler R, Radhakrishnan R. (2012) Dementia. *Clinical evidence*; Sep 10; doi:pii: 1001.

Callisaya ML, Blizzard L, Schmidt MD, McGinley JL, Srikanth VK. (2010). Ageing and gait variability--a population-based study of older people. *Age Ageing*; Mar;39(2):191-7.

Cedervall Y, Kilander L, Aberg AC. (2012). Declining physical capacity but maintained aerobic activity in early Alzheimer's disease. *American journal of Alzheimer's Disease and Other Dementia*; May;27(3):180-7.

Christofolletti G, Oliani MM, Bucken-Gobbi LT, Gobbi S, Beinotti F, Stella F. (2011) Physical activity attenuates neuropsychiatric disturbances and caregiver burden in patients with dementia. *Clinics*;66(4):613-8.

Cooper C, Dere W, Evans W, Kanis JA, Rizzoli R, Sayer AA *et al.* (2012). Frailty and sarcopenia: definitions and outcome parameters. *Osteoporosis International*; Jul;23(7):1839-48

David R, Mulin E, Friedman L, Le Duff F, Cygankiewicz E, Deschaux O, *et al.* (2012). Decreased daytime motor activity associated with apathy in Alzheimer disease: an actigraphic study. *American Journal of Geriatric Psychiatry*; Sep;20(9):806-14

Dvorak RV, Poehlman ET. (1998). Appendicular skeletal muscle mass, physical activity, and cognitive status in patients with Alzheimer's disease. *Neurology*;Nov;51(5):1386-90.

Erickson KI, Barr LL, Weinstein AM, Banducci SE, Akl SL, Santo NM, *et al.* (2013). Measuring physical activity using accelerometry in a community sample with dementia. *Journal of American Geriatrics Society*; Jan;61(1):158-9.

Erickson KI, Weinstein AM, Lopez OL. (2012). Physical activity, brain plasticity, and Alzheimer's disease. *Archives Medical Research*; Nov;43(8):615-21. doi: 10.1016/j.arcmed.2012.09.008. Epub 2012 Oct 16

Forbes D, Thiessen EJ, Blake CM, Forbes SC, Forbes S. (2013). Exercise programs for people with dementia. *Cochrane Database Systematic Reviews*; Dec 4;12:CD006489

Gaugler JE, Yu F, Krichbaum K, Wyman JF. (2009). Predictors of nursing home admission for persons with dementia. *Medical Care*.;Feb;47(2):191-8.

Gray SL, Anderson ML, Hubbard RA, LaCroix A, Crane PK, McCormick W *et al.* (2013). Frailty and incident dementia. *The Journals of Gerontology, Series A: Biological Sciences*; Sep;68(9):1083-90

Hauer K, Schwenk M, Zieschang T, Essig M, Becker C, Oster P. (2012). Physical training improves motor performance in people with dementia: a randomized controlled trial. *Journal of American Geriatrics Society*; Jan;60(1):8-15. doi: 10.1111/j.1532-5415.2011.03778.x.

James BD, Boyle PA, Bennett DA, Buchman AS. (2012). Total daily activity measured with actigraphy and motor function in community-dwelling older persons with and without dementia. *Alzheimer Disease and Associate Disorders*; Jul-Sep;26(3):238-45

Kulmala J, Nykänen I, Mänty M, Hartikainen S. (2013). Association between Frailty and Dementia: A Population-Based Study. *Gerontology*; Aug 17. [Epub ahead of print]

Lowery D, Cerga-Pashoja A, Iliffe S, Thuné-Boyle I, Griffin M, Lee J, *et al.* (2013). The effect of exercise on behavioural and psychological symptoms of dementia: the EVIDEM-E randomised controlled clinical trial. *International Journal of Geriatric Psychiatry*; Dec 11. doi: 10.1002/gps.4062.

Malthouse, R, Fox, F. (2013) Exploring experiences of physical activity among people with Alzheimer's disease and their spouse carers: a qualitative study. In press in *Physiotherapy*.

McCurry SM, Pike KC, Logsdon RG, Vitiello MV, Larson EB, Teri L. (2010). Predictors of short- and long-term adherence to a daily walking program in persons with Alzheimer's disease. *American Journal of Alzheimer's Disease and Other Dementia*; Sep;25(6):505-12.

McKhann G, Drachman D, Folstein M, Katzman R, Price D, Stadlan EM. (1984). Clinical diagnosis of Alzheimer's disease: report of the NINCDS-ADRDA Work Group under the auspices of Department of Health and Human Services Task Force on Alzheimer's Disease. *Neurology*; Jul;34(7):939-44.

Pitkälä K, Savikko N, Poysti M, Strandberg T, Laakkonen ML. (2013). Efficacy of physical exercise intervention on mobility and physical functioning in older people with dementia: a systematic review. *Experimental Gerontology*; Jan;48(1):85-93. doi: 10.1016/j.exger.2012.08.008.

Prince M, Bryce R, Albanese E, Wimo A, Ribeiro W, Ferri CP. (2013). The global prevalence of dementia: a systematic review and meta-analysis. *Alzheimers and Dementia*; Jan;9(1):63-75.e2. doi: 10.1016/j.jalz.2012.11.007.

Potter R, Ellard D, Rees K, Thorogood M. (2011). A systematic review of the effects of physical activity on physical functioning, quality of life and depression in older people with dementia. *International Journal of Geriatric Psychiatry*; Oct;26(10):1000-11. doi: 10.1002/gps.2641.

Sallis, J.F., Cervero, R.B., Adcher, W., Henderson, K.A., Kraft, M.K., Kerr, J. (2006). An ecological approach to creating active living communities. *Annual Review of Public Health*; 27, 297–322.

Schwenk M, Zieschang T, Oster P, Hauer K. (2010). Dual-task performances can be improved in patients with dementia: a randomized controlled trial. *Neurology*; Jun 15;74(24):1961-8.

Sherrington C, Whitney JC, Lord SR, Herbert RD, Cumming RG, Close JC. (2008). Effective exercise for the prevention of falls: a systematic review and meta-analysis. *Journal of American Geriatrics Society*; Dec;56(12):2234-43.

Smith, JC ,. Nielson, KA.,Woodard, JL, Seidenberg, M., Rao, SM. (2013). Physical Activity and Brain Function in Older Adults at Increased Risk for Alzheimer's Disease. *Brain Sciences*; 3, 54-83; doi:10.3390/brainsci301005

Tak E, Kuiper R, Chorus A, Hopman-Rock M.(2013). Prevention of onset and progression of basic ADL disability by physical activity in community dwelling older adults: a meta-analysis. *Ageing Research Reviews*; Jan;12(1):329-38

Teri L, Gibbons LE, McCurry SM, Logsdon RG, Buchner DM, Barlow WE *et al* (2003). .Exercise plus behavioral management in patients with Alzheimer disease: a randomized controlled trial. *Journal of American Medical Association*; Oct 15;290(15):2015-22.

Vancampfort D, Vanderlinden J, Stubbs B, Soundy A, Pieters G, Hert MD *et al*. (2013). Physical Activity Correlates in Persons with Binge Eating Disorder: A Systematic Review. *European Eating Disorders Review*; Sep 9. doi: 10.1002/erv.2255

Verdelho A, Madureira S, Ferro JM, Baezner H, Blahak C, Poggesi A, *et al* (2012). Physical activity prevents progression for cognitive impairment and vascular dementia: results from the LADIS (Leukoaraiosis and Disability) study. *Stroke*; Dec;43(12):3331-5

Vital TM, Hernandez SS, Stein AM, Garuffi M, Corazza DI, de Andrade LP *et al*. (2012). Depressive symptoms and level of physical activity in patients with Alzheimer's disease. *Geriatric and Gerontology International*; Oct;12(4):637-42

Warren JM, Ekkelund U, Besson H, Mezzani A, Geladas N, Vanhees L. (2010). Assessment of physical activity – a review of methodologies with reference to epidemiological research: a report of the exercise physiology section of the European Association of Cardiovascular Prevention and Rehabilitation. *European Journal of Cardiovascular Prevention and Rehabilitation*;17:127–139.

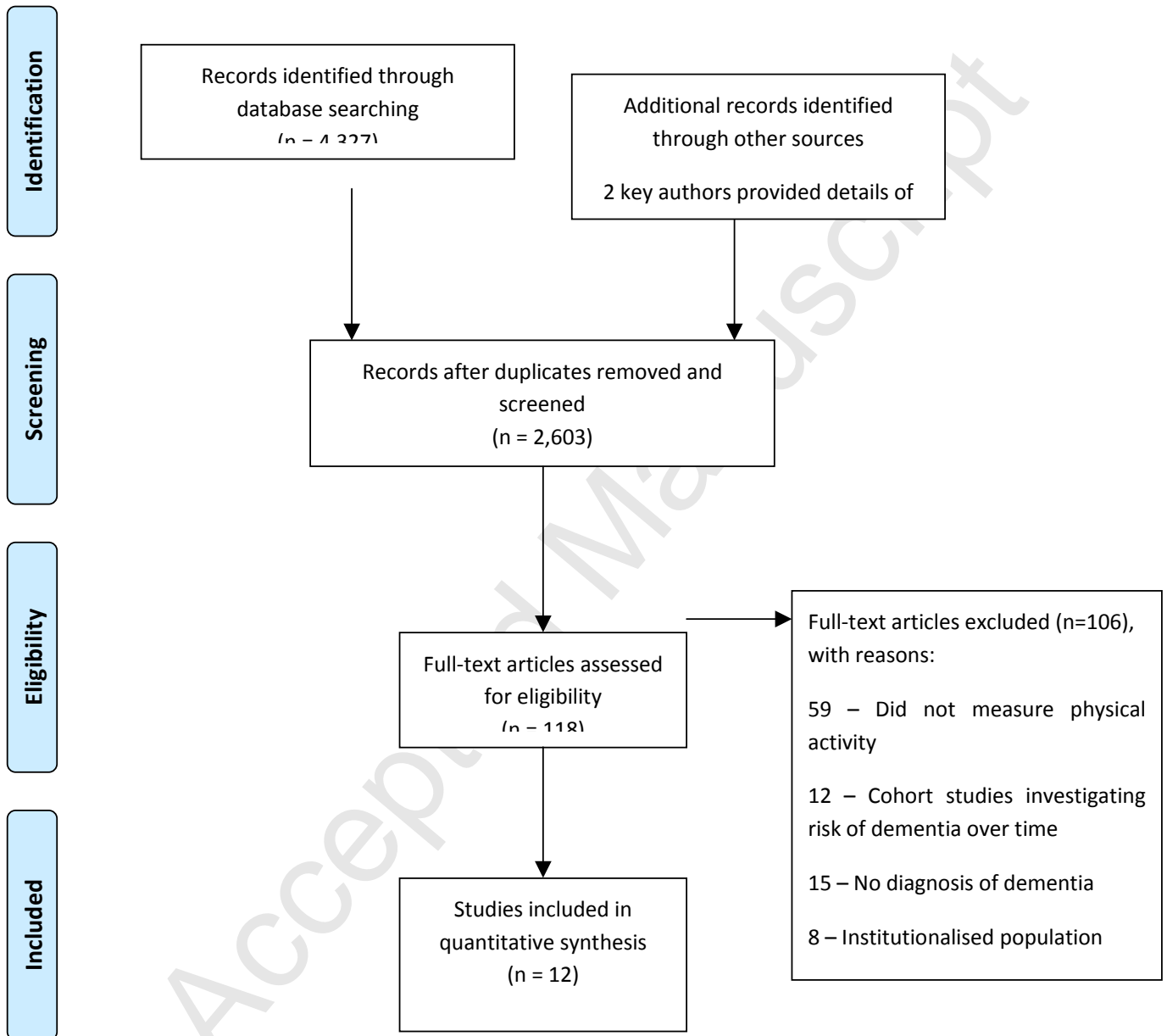
Watts, A., Vidoni, E., Loskutova, N., Johnson, D. K., & Burns, J. (2013). Measuring physical activity in older adults with and without Alzheimer's disease. *Clinical Gerontologist*, 36(4), 1-20.

Ware JE, Sherbourne CD. (1992). The MOS 36-item short-form health survey (SF-36). I. Conceptual framework and item selection. *Medical Care*; Jun;30(6):473-83

Wesson J, Clemson L, Brodaty H, Lord S, Taylor M, Gitlin L, *et al.* (2013). A feasibility study and pilot randomised trial of a tailored prevention program to reduce falls in older people with mild dementia. *BMC Geriatrics*; Sep 3;13(1):89.

Winchester J, Dick MB, Gillen D, Reed B, Miller B, Tinklenberg J, *et al.* (2013). Walking stabilizes cognitive functioning in Alzheimer's disease (AD) across one year. *Archives Gerontology and Geriatrics*; Jan-Feb;56(1):96-103.

Figure 1. PRISMA (2009) flow diagram for search strategy





**Highlights**

- We investigated all factors associated with PA in people with dementia.
- Faster gait speed and improved function are positively associated with PA.
- Higher HRQOL & social functioning & reduced apathy are positively associated with PA.
- Polypharmacy, falls and lower ADL function are negatively associated with PA.
- However, we were unable to identify any consistent correlates (reported >4 studies).

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Table 1. Characteristics of included studies

Study [Ref nr]	Participants				Quality of PA	Statistical tests
	N	Diagnosis	Age (mean±SD)	% Male	Measurement	
Allan et al 2006	156	- 46 PDD - 32 DLB 40 AD - 38 VAD Diagnosis confirmed by 2, or if necessary, 3 clinicians	76.2±6.5 y	59	A	Pearson product moment correlation coefficient
Auyeung et al 2008	28	Diagnosed by psychiatrist in accordance to DSM-IV	All > 70 y	54	A	Pearson product moment correlation coefficient
Cedervall et al 2012	24	AD MMSE 25 (21-30) Diagnosis according to DSM-IV and NINCDS-ADRDA	73 years (55-79 range)	56	A	Spearman rank correlation coefficient

Table 1. Characteristics of included studies

Study [Ref nr]	Participants			Quality of PA	Statistics
	N	Diagnosis	Age (mean±SD)	% Male	
Christofolletti et al 2011	59	23 AD 17 mixed dementia 19 VAD DSM-IV and according to NINCDS- ADRDA / NINCDS-AIREN criteria	76 y	NA	A Kruskal-Wallis tests and Mann Whitney U test. Stepwise linear regression.
David et al 2011	80	AD* NINCDS-ADRDA criteria MMSE 21.4±4.6	77.5±6.7 y	53	C Pearson product moment correlation coefficient
Dvorak & Poehlman 1998	30	AD NINCDS-ADRDA criteria MMSE 17±8	74±8 y	43	C Pearson product moment correlation coefficient

Table 1. Characteristics of included studies

Study [Ref nr]	Participants			Quality of PA	Statistical tests	
	N	Diagnosis	Age (mean±SD)	% Male		Measurement
Erickson et al 2013	26	AD NINCDS-ADRDA criteria	76.8±9.3 y	69	C	Pearson product moment correlation coefficient
James et al 2012	70	Clinical diagnosis with 3 stage process, NINCDS-ADRDA	85.6±6.5 y	36	C	Pearson product moment correlation coefficient
McCurry et al 2010	66	AD NINCDS-ADRDA criteria MMSE 19.2±6.7	81.2±8.3 y	46	A	Bivariate correlations
Vital et al 2012	37	AD DSM-IV and CDR MMSE 17±4.4	78.8±7 y	22	A	Spearman correlation coefficient

Table 1. Characteristics of included studies

Study [Ref nr]	Participants			Quality of PA	Statistical tests	
	N	Diagnosis	Age (mean±SD)	% Male		Measurement
Watts et al 2013	72	Early stage AD NINCDS-ADRDA criteria	74.9±6.4 y	37	A	Bivariate correlations
Winchester et al 2013	104	AD NINCDS-ADRDA criteria	81±6.54 y	56	A	ANCOVA

Key: Physical Activity measurement grading: A=self-report of poor or unknown reliability/validity in people with dementia, B=self-report with acceptable reliability/validity in people with dementia, C= objective measure of physical activity

AD= Alzheimer's disease, ANOVA=analysis of variance, ANCOVA analysis of covariance. BMI=body mass index , CDR= clinical dementia rating scale, DLB= dementia with Lewy bodies, DSM-IV= Diagnostic Statistical Manual American Psychiatric Association 4th edition, MDT= multidisciplinary team, MMSE mini mental state examination, NA = not available, NINCDS-ADRDA= National Institute for Neurological and Communicative Disorders and Stroke-Alzheimer's Disease and Related Disorder Association, PA=physical activity, PDD = Parkinson's disease dementia , , y= years, VAD= vascular dementia

Table 2. Summary of determinants of physical activity in patients with dementia

Determinant variable	Related to PA		Unrelated to PA		Summary code	
	Study	Assoc.	Study	Assoc.	% studies reporting assoc.	
<b>Demographic</b>						
Age (higher)	James et al 2012, Erikson et al 2013	-	Christofolletti et al 2011, McCurry et al 2011, Auyeung et al 2008, Allan et al 2006, Vital et al 2012, David et al 2011	00	25% (2/8)	
Education (higher)	Christofolletti et al 2011, Vital et al 2012	+	James et al 2012, Erikson et al 2012	?	50% (2/4)	
Duration of dementia (longer)	Vital et al 2012	+	Christofolletti et al 2011, Allan et al 2006	0	33% (1/3)	
Socioeconomic status			Auyeung et al 2008	0	0% (0/1)	
Gender			Erikson et al 2013,	0	0% (0/2)	
Ethnicity			Erikson et al 2013	0	0% (0/1)	
<b>Biological</b>						
BMI (higher)	Auyeung et al 2008, Erikson et al 2013	-	James et al 2012, Allan et al 2006, Watts et al 2013	?	40% (2/5)	
Comorbidity (higher nr. of conditions)			McCurry et al 2011	0	0% (0/1)	
Fat free mass (lower)	Dvorak & Poehlman 1998	+		+	100% (1/1)	
Body fat % (lower)			Dvorak & Poehlman 1998, James et al 2012, Watts et al 2013	0	0% (3/3)	
Resting metabolic rate (higher)	Dvorak & Poehlman 1998	+		+	100% (1/1)	
Energy intake (higher)	Dvorak & Poehlman 1998	+		+	100% (1/1)	

Table 2. Summary of determinants of physical activity in patients with dementia

Grip strength (higher)			Auyeung et al 2008	0	0% (0/1)
Gait speed & walking capacity (faster)	Auyeung et al 2008, Watts et al 2013	+		+	100% (2/2)
Global motor function (higher)	James et al 2012	+		+	100% (1/1)
Dizziness	Allan et al 2006	-		-	100% (1/1)
Lower limb strength			Watts et al 2013	0	100% (1/1)
VO2 peak			Watts et al 2013	0	100% (1/1)
Balance			Watts et al 2013	0	100% (1/1)
Medications (>4)	Allan et al 2006	-		-	100% (1/1)
<b>Behavioural attributes/ skills</b>					
ADL function (lower)	Auyeung et al 2008, James et al 2012, Allan et al 2006	-	Winchester et al 2013, Cedervall et al 2012	-	60% (3/5)
History of falls	Allan et al 2006	-		-	100% (1/1)
<b>Psychological, cognitive, emotional</b>					
Global cognition	Winchester et al 2013	+	Dvorak & Poehlman 1998, McCurry et al 2011, Auyeung et al 2008, James et al 2012, Vital et al 2012, David et al 2011, Christofolletti et al 2011, Allan et al 2006, Cedervall et al 2012	00	10% (1/10)
HRQOL overall (higher)	Allan et al 2006	+		+	100 (1/1)
Physical HRQOL (higher)	Auyeung et al 2008, Allan et al	+		+	100% (2/2)

Table 2. Summary of determinants of physical activity in patients with dementia

		2006				
Mental HRQOL(higher)	Allan et al 2006		+	Auyeung et al 2008	?	50% (1/2)
Dementia severity (higher)				Christofolletti et al 2011	0	0% (0/1)
NPI patient (lower scores)	Christofolletti et al		+	Allan et al 2006	?	50% (1/2)
		2011				
NPI caregiver (lower scores)				Allan et al 2006, Christofolletti et al 2011	0	0% (0/2)
Sleep (better)	Christofolletti et al		+	McCurry et al 2011, David et al 2011	0	33% (1/3)
Depression (higher)	Allan et al 2006		-	McCurry et al 2011, David et al 2011, James et al 2012	0	33% (1/3)
Waking hours in day (less)	McCurry et al		-		-	100% (1/1)
		2011				
Revised Memory and Behavior Problem Checklist - Disruption scale				McCurry et al 2011	0	100% (1/1)
Autonomic symptom scale (higher=more problems)	Allan et al 2006		-		-	100% (1/1)
Delirium	Allan et al 2006		-		-	100% (1/1)
Apathy (lower)	David et al 2011		+		+	100% (1/1)
<b>Social and cultural</b>						
Social functioning	Allan et al 2006		+		+	100% (1/1)
<b>Physical environment</b>						
-						
<b>Policy factors</b>						
-						

**Key:**

Assoc=association; - = negative, + =positive; 0= no relation; ?= indeterminate, ++, --, 00 and ?? = four or more studies investigating a correlate.



Table 2. Summary of determinants of physical activity in patients with dementia

ADL function = activities of daily living functioning, BMI= body mass index, CAMCOG = The Cambridge Examination for Mental Disorders of the Elderly (Cognitive Section), CDR = clinical dementia rating scale , DLB= dementia with Lewy bodies, HRQOL = health related quality of life, NPI patient = neuropsychiatric inventory patient, NPI caregiver = neuropsychiatric inventory caregiver, PA= physical activity; PDD = Parkinson's disease dementia, ,