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Habitual physical activity as a factor in sustained executive function in Alzheimer-type dementia: A cohort study.

Nicolas Farina, Najj Tabet, Jennifer Rusted

Short Title: PHYSICAL ACTIVITY AND COGNITION IN ALZHEIMER'S DISEASE

PHYSICAL ACTIVITY AND COGNITION IN ALZHEIMER'S DISEASE

Abstract

Evidence from studies on healthy older adults and Mild Cognitive Impairment (MCI) populations suggests that physical activity interventions have a positive effect on executive function. In this study, we consider whether habitual physical activity is positively associated with executive function in Alzheimer's disease (AD). Eighty-two participants with a diagnosis of mild to moderate AD completed six measures of executive function. Objective measures of physical status were taken. In addition, informants completed questionnaires on the participants' habitual physical activity and other lifestyle factors. A composite measure of executive function was the primary outcome. A multistage multiple regression was used to determine how much variance habitual physical activity accounted for. The final model comprised disease severity, cognitive reserve, cognitive activities, neuropsychiatric status and habitual physical activity status. The final model accounted for a total of 57% of the variance of executive performance, of which habitual physical activity itself accounted for 8% of the variance. Habitual physical activity status is associated executive performance in an AD population even after controlling for key covariates. The findings encourage clinicians to recommend habitual physical activity and its cognitive benefits to AD patients and their carers.

Keywords: Alzheimer's Disease; executive function; physical activity; lifestyle; cognition

1. Introduction

Executive function is the cognitive process involved in the planning, initiation and regulation of behaviour (Lezak, 2004). However, executive dysfunction is commonly reported in an Alzheimer's disease (AD) population (Binetti et al., 1996; Collette, Van der Linden, & Salmon, 1999; Sgaramella et al., 2001; Swanberg, Tractenberg, Mohs, Thal, & Cummings, 2004) and this directly affects capacity to sustain activities of daily living (Boyle et al., 2003; Razani et al., 2007). As a result determining methods to combat declining executive skills are vital in maintaining functionality in an AD population.

It has been proposed that physical activity may selectively affect certain cognitive domains in a healthy older adult population. The literature is not easy to interpret, however. "Physical activity" and "physical exercise" are terms that describe different concepts (see Caspersen, Powel & Christenson, 1985) but that have been used relatively interchangeably in the research literature. Physical exercise expressly refers to planned, structured and repetitive physical activity that aims to improve or maintain physical fitness. Physical activity is a more generic term, and is defined as any body movement that results in energy expenditure. Physical activity encompasses routine activities of daily living, but also potentially including physical exercise engaged in by the individual to maintain or improve physical fitness. What differentiates studies in fact is whether they are evaluating the impact on cognition of changes in physical activity levels, or simply the effects of routine, habitual levels.

Kramer and colleagues initially noted that by increasing physical activity that improved cardiorespiratory fitness there were selective benefits on tasks that required greater executive control (Kramer et al., 1999). Since this initial finding there have been several studies in healthy older adults that have explored the effects of physical activity (either routine activities or exercise programmes) primarily on executive function (e.g. Bixby et al., 2007; Hillman et al., 2006; Smiley-Oyen, Lowry, Kohut, & Ekkekakis, 2008). An earlier systematic review confirmed the findings by Kramer and colleagues that any interventions that increased

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physical activity levels have the greatest positive effect on executive function (Colcombe & Kramer, 2003). However, more recent meta-analyses of research in older adult populations have found that other domains such as motor function and auditory attention (Angevaren, Aufdemkampe, Hjj, Aleman, & Vanhees, 2008), memory and attention/processing speed in addition to executive function (Smith et al., 2010), benefit from interventions that increase physical activity levels.

Evidence of domain specific effects of increasing levels of physical activity also has been reported in a Mild Cognitive Impairment (MCI) population. Smith and colleagues in a meta-analysis determined that compared to a healthy older adult population physical activity interventions have a greater positive effect on memory in individuals with MCI (Smith et al., 2010). However whilst physical activity has a positive effect on both executive function and attention and processing speed in MCI, compared to healthy older adults, improvements in executive function were smaller. In a more recent meta-analysis of the MCI literature, Gates and colleagues investigated the effects on a range of cognitive domains of physical activity interventions in randomised controlled trials (RCTs) (Gates, Fiatarone Singh, Sachdev, & Valenzuela, 2013). Unlike previous meta-analyses the study analysed a range of executive tasks separately (Stroop, Trail Making Task (TMT), Verbal Fluency). They reported that physical activity (whether increased routine activities or specific exercise programmes) only had a significant positive effect on verbal fluency, and did not benefit any other domain specific measures of executive function, memory or information processing.

Whilst there are discrepancies on whether executive function is specifically affected by increased physical activity in healthy older adults and MCI patients the studies highlight the importance of measuring domain specific cognitive outcomes. A recent meta-analysis of RCTs in an AD population determined that whilst physical activity interventions designed to increase physical activity levels have a positive effect on global cognitive function, studies tended not to measure a sufficient range of domain specific outcomes to allow conclusions about domain specific effects (Farina, Rusted, & Tabet, 2014). The use of a range of

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measures is particularly important in relation to executive function. Since there is currently no consensus regarding which measure best assesses executive function, it is recommended that multiple measures of executive function are taken (Miyake et al., 2000; Strauss, 2006). Yu and colleagues is one such study, investigating the effects of a physical activity intervention on a range of executive measures in a cohort of mild to moderate AD patients (Mini-mental state examination (MMSE) ≥ 12) (Yu et al., 2013). The study used four measures of executive function: TMT, controlled oral word association (COWAT), the Stroop task, and the executive interview (EXIT-25). These measures were taken at baseline, 3 months and 6 months into the exercise program. None of the measures significantly changed over the 6 months, though three of the four trended toward improvement.

Physical activity interventions have been criticised as changes in behaviour are often small and short lived (Van Der Bij, Laurant, & Wensing, 2002). It is therefore important to establish the effects not only of interventions designed to change levels of either physical activity or physical exercise, but also of habitual physical activity. Habitual physical activity is the physical activity routinely completed by an individual as part of their lifestyle choices, and as such is also reflective of naturalistic behaviour that encompasses the individuals' ability and motivation to be involved in such behaviours. Several studies explored such an association using cardiorespiratory fitness as an objective measure of habitual aerobic physical activity. However, the findings have not been as conclusive as the intervention literature. One study in early stage AD (Clinical Dementia Rating (CDR)= 0.5-1) found that cardiorespiratory fitness was not significantly associated with a range of cognitive measures after controlling for age (Burns et al., 2008), whilst a positive trend was found between baseline cardiorespiratory fitness and global cognitive decline over 2 years in the same AD sample (Vidoni, Honea, Billinger, Swerdlow, & Burns, 2012). Using self-report measures of habitual physical activity, Winchester and colleagues explored the effects of habitual physical activity (based upon walking habits) on cognitive change over a 1-year period in 104 AD patients (MMSE > 18) (Winchester et al., 2013). Participants were split into an active (engaged in more than 2 hours of walking per week) and a sedentary group (did not engage in

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any walking). Those in the active group showed attenuated MMSE decline over 1 year, whilst the MMSE of the sedentary group significantly declined.

It is also important to consider other factors that often covary with physical activity and that may independently influence cognitive performance, particularly in non-intervention studies. Previous non-intervention studies in AD have primarily controlled a limited number of confounding variables, including: age alone (Burns et al., 2008); age, gender and CDR (Vidoni et al., 2012); age, years of education and sex (Winchester et al., 2013). Whilst demographics, cognitive reserve and disease severity are all important factors to control for, other co-varying factors need to be considered. For example, engagement with physical activity has previously been associated with other health behaviours (Pate, Heath, Dowda, & Trost, 1996), and lifestyle behaviours such as socialising and cognitive activity have all been found to influence cognitive performance in an AD population (for a review see Ruthirakuhan et al., 2012).

While there remain no effective pharmacological treatments for AD, it is particularly important to establish the influence of lifestyle factors to influence cognitive capacity of individuals with a diagnosis of AD. To this end, the present study investigates the effects of habitual physical activity on executive function in an AD population. The study develops upon previous AD research in several ways. First, the study measures habitual physical activity using both objective and subjective measures. Second, we consider the effects of habitual physical activity against a composite measure of executive function derived from a range of separate executive measures. Finally, the study considers and controls for a more extensive range of covariates that could affect the relationship between physical activity and executive function. In support of the findings with healthy older adults (Colcombe & Kramer, 2003; Smith et al., 2010), MCI population (Gates, Fiatarone Singh, Sachdev, & Valenzuela, 2013), and preliminary evidence from an AD population (Yu et al., 2013) it is anticipated that habitual physical activity will be positively associated with executive performance, and that this association will be maintained even after controlling for potential confounding variables.

2. Method

2.1. Participants

Ethical approval was obtained from the National Research Ethics Service Committee London – Camberwell St Giles.

Eighty-two community dwelling participants with a clinical diagnosis of typical AD or atypical AD were recruited through Sussex Partnership NHS Trust. Clinical diagnosis was determined using the International Classification of Disease 10 (ICD-10). All participants had an informant (relative or friend), and were either clinically or self-referred. Participants were aged between 65-90, had an English proficiency equivalent to that of a native speaker and had a mild to moderate disease severity (MMSE > 12). Participants were excluded if they had major depressive disorder (Cornell Scale of Depression in Dementia (CSDD)>10), or other severe neuropsychiatric and behavioural symptoms (as determined by the Neuropsychiatric inventory (NPI) > 20). No other exclusions were made based on pre-existing medical conditions. Where participants were under medication, these were stable at the onset of the study.

2.2 Materials

The MMSE (Folstein, Folstein, & McHugh, 1975), derived from the Addenbrooke's Cognitive Examination Revised (ACE-R)(Mioshi, Dawson, Mitchell, Arnold, & Hodges, 2006) was taken to evaluate participants' global cognitive status and severity. The CSDD (Alexopoulos, Abrams, Young, & Shamoian, 1988) was used to screen the presence of major depression. The NPI (Cummings et al., 1994) was used to assess the presence of severe behavioural disturbances.

2.2.1. Measures of Executive Function

A series of measures were selected on the basis of varying executive function required to successfully perform them.

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For the TMT (Army Individual Test Battery, 1944), participants were required (Trails A) to connect numbers distributed on the page in ascending order, and then (Trails B) to connect, alternately, sequential numerical and alphabetical stimuli. Participants were instructed to complete the tasks as quickly and accurately as possible. Both parts of the TMT were scored in time to completion (seconds). Through the subtraction of Trails A from Trails B a measure of executive control is created independent of motor and visual scan speed.

The Controlled Oral Word Association Test (COWAT) (Spreeen & Strauss, 1998) required participants to verbally list words beginning with the letters F, A and S in a fixed time limit of 60 seconds for each letter. Following standard instructions, participants were instructed that they should not list proper nouns or supply the same words but with a different ending. The COWAT was scored as the total number of allowable words generated across the three letters.

The verbal fluency subscale of the ACE-R (Mioshi et al., 2006) composed of two tasks. In the first task participants verbally listed words beginning with the letter P in a fixed time limit of 60 seconds. In the second task participants had to list as many animals possible within 60 seconds.

The Map Search Task (Robertson, Ward, Ridgeway, & Nimmo-Smith, 1994) is a component of the Test of Everyday Attention. Participants were required to identify target symbols (e.g. restaurant) on a city map. Participants have a total of 2 minutes to circle as many target symbols as possible. The Map Search Task is scored on the total number of target symbols accurately identified during the time limit.

The Digit Symbol Substitution Test (DSST) (Wechsler, 1981) is composed of two phases. In the first phase, participants were provided with a sequence of symbols and required to copy as many symbols as possible in 30 seconds. In the second phase, participants were given a

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code table displaying the correspondence between digits (from 1 to 9) and symbols. Participants were required to fill in blank squares with the symbol paired to the digit displayed above the square. The mean time per item was calculated for each phase. Subtracting the DSST copy score from phase two of the DSST provided the time required per symbol for higher mental functions (Glosser, Butters, & Kaplan, 1977; Storandt, 1976).

The computerised card sort task (Rusted, Sawyer, Jones, Trawley, & Marchant, 2009) involves sorting a regular deck of playing cards (52 cards) generated on the computer screen. On each trial, the back of the card is presented for 1000 ms, reversing the show the face of the card for 750 ms. Participants are instructed to sort the cards into 'SPADES' and 'HEARTS' by pressing the designated keys on the keyboard using their right hand. Participants are told to ignore the 'CLUBS' or 'DIAMONDS'. The program automatically advances onto the next card trial. The card sort task score provides mean reaction time taken per sort trial.

2.2.2. Measures of Physical activity and physical status

Physical activity was measured using the Physical Activity Scale for the Elderly (PASE)(Washburn, Smith, Jette, & Janney, 1993). The PASE comprises 12 item questionnaire addressing the leisure, household and work over the past week. The PASE has previously been validated against physiological measures of physical activity including accelerometer (Washburn & Ficker, 1999), mini-logger (Harada, Chiu, King, & Stewart, 2001), peak oxygen uptake and balance score (Washburn, McAuley, Katula, Mihalko, & Boileau, 1999). The questionnaire has previously been completion by carers of dementia patients (Burns et al., 2008; Burns, Johnson, Watts, Swerdlow, & Brooks, 2010; Honea et al., 2009). Previous studies have commented that the PASE (Yasunaga et al., 2008) and physical activity (Pivarnik, Reeves, & Rafferty, 2003; Plasqui & Westerterp, 2004) are affected by seasonal variations and weather (for a review see Tucker & Gilliland, 2007). Consequently the PASE was adapted to measure the physical activity conducted in an average week over

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the past year rather than the past 7 days so that physical habits were not missed due to short term lapses in activity.

Several physiological measures were taken to index physical status. Handgrip strength was measured using a dynamometer. Using their dominant hand participants were instructed to squeeze the dynamometer as hard as they could. Participants repeated this procedure three times with the best score being recorded. In older adults handgrip strength has been found to be positively associated with other muscle groups (Rantanen, Era, & Kauppinen, 1994) as well as measures of physical activity (Bruce, Devine, & Prince, 2002; Rantanen et al., 1994).

Mid-upper arm circumference (MUAC) was measured by placing a plastic tape measure gently but firmly around the relaxed arm, midway between the tip of the acromion (shoulder) and the olecranon process (elbow). Waist circumference was measured at the point of the iliac crest, whilst the calf circumference was measured around the largest point of the calf. In addition, measurements of height and weight were used to calculate BMI (weight [kg] over height squared [m^2]). MUAC, calf circumference, waist circumference and BMI have all previously been associated with nutritional status in an older adult population (Nykänen, Lönnroos, Kautiainen, Sulkava, & Hartikainen, 2013; Ruiz-López et al., 2003)

2.2.3. Other Lifestyle measures

A series of lifestyle measures were completed by each participant's informant.

Cognitive activities were measured using Florida Cognitive Activities Scale (FCAS) (Schinka et al., 2005). The scale consists of 25-items using a 5-point Likert response format based on activity frequency. The FCAS has a reasonably high level of internal consistency ($\alpha = .65$) for an elderly Caucasian sample. The FCAS has also been validated for use with people with AD (Schinka et al., 2010).

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Social network was assessed using the Lubben Social Network Scale – 6 (LSNS-6) (Lubben, 1988). The LSNS-6 is a 6 item scale, 3 items concerning family and 3 concerning friendships. The scale is scored out of 30, with a greater score representing a larger social network. The LSNS-6 has a high internal consistency ($\alpha = .78$) (Lubben & Girona, 2003).

Adherence to a Mediterranean diet was assessed using the EPIC Food Frequency Questionnaire (FFQ) (Bingham et al., 2007). A value of 0 or 1 is assigned for each of 9 indicated categories with the use of the sex-specific median as the cut-off; thus adherence to a Mediterranean diet score ranged from 0 to 9, with a greater score representing a greater adherence to a Mediterranean diet (Cade, Taylor, Burley, & Greenwood, 2011; Trichopoulou, Costacou, Bamia, Trichopoulou, & Trichopoulos, 2003).

2.3. Procedure

Capacity to consent to participation in the study was assessed for all potential participants and those who were deemed to have such capacity were invited to sign the consent form. All informants signed and completed a declaration form that they would act as a personal consultee to participant. The battery of neuropsychology tests, incorporating the tasks reported in this paper and other cognitive measures reported elsewhere, lasted approximately 2-3 hours. Participants were encouraged to take a break when needed. The pen and paper cognitive tasks were conducted in the first part of the battery, and the computerised tasks in the second half.

2.4. Statistical analysis

A principal component analysis (PCA) was conducted using Oblimin rotation ($\delta = 0$) on measures of physical status (PASE, handgrip strength, MUAC, waist circumference, BMI and calf circumference) and executive function (Map search task, Card sort task, TMT B-A, DSST-copy speed, ACE-R fluency subscale and COWAT). Extraction of components were based upon the interpretation of scree plots and moderate loadings on component matrices ($>.40$).

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Three Z score composites were subsequently created, by averaging standardised scores of the variables. Composites were created on the basis of the components identified in the PCA, they were defined as: “habitual physical activity status”, “nutritional status” and “executive performance.”

A series of Spearman's Rho correlations were conducted between the composite measures and all other variables.

A multistage multiple regression approach was used to evaluate the contributions of various factors on executive function so that they could be entered if appropriate into the final regression model. The independent categories were cognitive reserve (premorbid IQ and years of education), cognitive stimulation (FCAS and LSNS-6), diet (nutritional status and adherence to a MeDi), demographic factors (age and gender), neuropsychiatric factors (CSDD and NPI), disease severity (years since diagnosis and MMSE) and habitual physical activity status. The dependent variable was the composite measure of executive function. In the each stage the association between executive function and each independent variable, considered separately, was evaluated. Stages 1-6 involved entering variables that had overlapping variance together into separate models using forced entry (e.g. stage 1 - demographic variables, stage 2 – cognitive reserve). Variables were retained for the final model if they significantly predicted ($p < .05$) executive performance. If there were multiple variables of each category, the best predictor (based on standardised coefficients) was identified and retained. In stage 7 we entered the identified variables into a hierarchical regression model with executive performance as the dependent variable. All previously identified variables (stages 1-6) were entered jointly in the first block and habitual physical activity status being entered into the second block to determine its effect independently.

3. Results

3.1. Demographics

Out of the 82 participants recruited, 33 were male and 49 were female, with a mean age of 80.7 years. On average participants had a dementia rating of mild to moderate severity (mean

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MMSE =23.6), and had received a diagnosis of AD on average 1.2 years prior to participation in the study. See Table 1 for the full summary of demographic and lifestyle data.

3.2 Principal Component Analysis

For measures of physical status two components were identified, component 1 accounted for 31.2% of the variance and was composed of MUAC, waist, BMI and calf circumference (we interpret this as representing nutritional status). Component 2 accounted for 22.8% of the variance and was composed of PASE and handgrip strength (we interpret this as representing habitual physical activity status). The PCA of the executive function measures revealed a single component accounting for 28.4% of the variance and incorporated all executive measures (Map search task, Card sort task, TMT B-A, DSST – copy speed, ACE-R fluency subscale and COWAT); this provided our index of executive performance.

3.3 Spearman's Rho Correlation

A significant correlation was reported between habitual physical activity status and the executive performance composite ($p < .05$; see Table 2). Executive performance also significantly correlated with MMSE ($p < .001$), premorbid IQ ($p < .001$) and NPI ($p < .05$). Executive function did not significantly correlate with any other measure of lifestyle ($p < .05$). Habitual physical activity status was also found to significantly correlate with age ($p < .05$), gender ($p < .01$), years of education ($p < .01$), FCAS ($p < .01$) and CSDD ($p < .01$).

3.4 Multistage Multiple Regression: Stages 1-6

In the initial stages (stages 1-6), significant predictors of executive performance were MMSE (standardised $\beta = .66$, $p < .001$), premorbid IQ (standardised $\beta = .56$, $p < .001$), years of education (standardised $\beta = -.30$, $p < .01$), FCAS (standardised $\beta = .31$, $p = .04$) and NPI (standardised $\beta = -.33$, $p = .04$). As premorbid IQ and years of education were both measures of cognitive reserve, only premorbid IQ, with the greatest standardised coefficient was retained for the final model. No measures of demographics or diet were identified to be significantly associated with executive performance ($p > .05$).

3.5. Multistage Multiple Regression: Stage 7

A final model was created by retaining MMSE, premorbid IQ, FCAS and NPI into the first block and habitual physical activity status into the second block, with executive performance as the dependent variable. Variables in the first block explained 49% of the variance ($\Delta R^2 = .49$, $p < .001$), whilst habitual physical activity status significantly improved the model by 8% ($\Delta R^2 = .08$, $p < .01$). The final model accounted for 57% of the variance ($F(5,47) = 12.51$, $p < .001$). The full details of the hierarchical regression analysis are shown in Table 3.

4. Discussion

Physical activity has previously been found to have a positive effect on cognitive function in healthy older adults, MCI and AD populations. The present study took separate measures of a range of executive measures to create the composite measure of executive function, and explored the effect of habitual physical activity on this composite measure, taking into account a range of other lifestyle and demographic factors in order to isolate more cleanly the relationship between habitual physical activity status and executive function. The present findings support previous evidence that even for individuals with a diagnosis of AD, being physically active is linked to better performance on cognitive tasks that require executive control.

In the present study habitual physical activity status was significantly associated with a composite measure of executive function supporting previous findings in an AD population that habitual physical activity can combat cognitive decline (Vidoni et al., 2012; Winchester et al., 2013). Physical activity has previously been found to be associated with other lifestyle behaviours, neuropsychiatric symptoms, demographic variables and disease severity, which in turn may affect cognition. The present study controlled for a range of these potential covariates that were found to contribute to variance of executive function. Using multistage multiple regression, the data indicated that MMSE, premorbid IQ, cognitive activities and neuropsychiatric symptoms individually contributed to variance of executive function in our

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AD population. When entered together these measures accounted for 49% of the variance of executive function. Even after controlling for these variables, however, the habitual physical activity status composite still accounted for a further (independent) 8% of the variance.

Controlling for co-varying influences allows for firmer conclusions to be made about the relationship between habitual physical activity and executive function in an AD population. Most notably, as the current cognitive activities measure significantly correlated with both habitual physical activity and executive function it was essential to remove the contribution of this factor before asserting an independent effect of physical activity. Cognitive activity levels have been implicated in delaying the onset of AD (Sattler, Toro, Schönknecht, & Schröder, 2012; Wilson, Scherr, Schneider, Tang, & Bennett, 2007).

A potential criticism of previous research is the use of self-report measures of physical activity, as it is susceptible to inaccuracies (Prince et al., 2008). In the present study, we created a composite measure of habitual physical activity status using an objective and a self-report measure. PCA confirmed that the PASE score and handgrip strength loaded onto a single factor. Notably, the PASE score measures all types of physical activity (e.g. aerobic, anaerobic) accounting for frequency and weighted on intensity, whilst handgrip strength provides an objective index of the effect of non-specific physical activities that result in muscle strengthening regardless of exercise type. As a result the composite reflects a more objective proxy of habitual physical activity, taking into account intensity and frequency of the physical activity, though it does not differentiate the types of activity being conducted. Angevaren et al. (2008) in a meta-analysis of healthy older adults found that compared to any other intervention type (including strength, flexibility, and balance activities) aerobic exercise has a significant positive effect on cognitive speed and visual attention. However in a more recent review both aerobic physical activity and strength training interventions were deemed to have a positive effect on cognition, whilst stretching and flexibility activities did not (Clifford, Bandelow, & Hogervorst, 2009).

5. Conclusions

This study has established that, after correcting for differences in disease severity, cognitive reserve, neuropsychiatric symptoms and cognitive leisure activities, habitual physical activity still significantly predicted executive function in a cohort of volunteers with mild-moderate AD dementia. Future research needs to further explore what aspect of physical activity best affects executive function in AD, acknowledging that the current proxy measure encompasses a diverse range of possible activities. In a clinical setting the results encourage the promotion of habitual physical activities to AD patients and their carers in the effort to sustain executive function.

Conflicts of Interest

The authors have no conflict of interest to disclose.

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Table 1. The means (and standard deviations) of demographic and lifestyle variables.

	Total (<i>n</i> = 82)
Age (years)	80.7 (6.1)
Gender	33 male: 49 female
Duration since diagnosis (years)	1.2 (1.5)
MMSE	23.6 (3.9)
Premorbid IQ	113.4 (9.5)
Years of Education	12.2 (2.6)
CSDD	2.9 (2.5)
NPI	4.7 (5.7)
Adherence to a MeDi	3.8 (1.6)
LSNS-6 total	15.8 (5.1)
FCAS total	31.8 (11.5)
PASE total	80.6 (58.8)
Handgrip (kg)	23.1 (8.7)
BMI	27.2 (5.8)
Mid-upper arm circumference (cm)	28.1 (3.2)
Calf circumference (cm)	34.5 (5.1)
Waist circumference (cm)	93.5 (15.2)

Table 2. Spearman's Correlation between Executive function, habitual physical activity, demographic variables and other lifestyle factors. Significance level are indicated

	HPA	Age	Gender	MMSE	Years since diagnosis	YoE	Premorbid IQ	MeDi	Nutritional status	LSNS-6	FCAS	CSDD	NPI
Executive performance	.30*	-.13	.03	.64**	-.21	.10	.35**	-.05	.02	-.10	.25	.01	-.36*
HPA status		-.28*	-.38**	.19	-.19	.28*	.14	.04	-.13	.19	.58**	-.49**	-.34
Age			-.10	-.03	.10	-.25*	.07	.06	.06	-.08	-.23*	.06	.30**
Gender				.04	.15	-.27*	-.33**	.08	.04	.05	-.09	.19	.04
MMSE					-.30**	.20	.44**	-.03	.11	.08	.37**	.05	-.06
Years since diagnosis						-.13	-.31**	-.09	-.20	-.16	-.16	-.07	.09
Years of Education							.65**	-.00	.03	.10	.13	-.21	-.23
Premorbid IQ								-.11	-.04	.05	.13	-.06	-.10
Adherence to a MeDi									.19	.01	.11	-.16	-.05
Nutritional status										.08	.01	.10	.16
LSNS-6											.44**	-.18	-.18
FCAS												-.26*	-.18
CSDD													.49**

HPA: Habitual Physical Activity, MeDi: Mediterranean Diet, LSNS-6: Lubben Social Network Scale-6, FCAS: Florida Cognitive Activities Scale, CSDD: Cornell Scale of Depression in Dementia, NPI: Neuropsychiatric Inventory. * p<.05, ** p <.01

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Table 3. A hierarchical linear regression analysis (Stage 7) between predictor variables and executive performance.

Predictor Variables	Standardised β	R	R ²	ΔR^2	F	ΔF
Block 1		.70	.49	.49	11.67***	11.67***
MMSE	.66***					
Premorbid IQ	.02					
FCAS	-.06					
NPI	-.29*					
Block 2		.76	.57	.08	12.51***	8.52**
MMSE	.67***					
Premorbid IQ	.01					
FCAS	-.20					
NPI	-.20					
HPA	.33**					

HPA: Habitual Physical Activity, FCAS: Florida Cognitive Activities, NPI: Neuropsychiatric Inventory. ***p<.001, **p<.01, *p<.05