The relationship between physical activity and health-related quality of life in people with dementia: An observational study

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Abstract

Recent research suggests the positive effect of physical activity on health-related quality of life (HRQL) in people with dementia may be mediated through improved activities of daily living (ADL) and reduced depressive symptoms. One hundred and twenty-four people with dementia and their informal carers were recruited from the South East of England for this observational study. A subset of participants wore an accelerometer for 30 days. A series of bivariate analyses were completed, alongside mediation analyses. In people with mild to moderate severity dementia, weak positive associations were widely reported between physical activity indices and HRQL, though only single association reached statistical significance (r_s=0.25, p=0.03). Mediation analysis revealed no significant indirect effects across the models after controlling for cognition. Future research needs to explore such relationships with a greater emphasis on the modality and psychosocial components of physical activity rather than just frequency, duration and intensity.

Keywords: exercise, accelerometer, mediation, depression, activities of daily living

Introduction

There is a growing understanding of the general health benefits of physical activity for people with dementia (Potter et al., 2011); however, the association between physical activity and health-related quality of life (HRQL) in dementia is less clear. HRQL focuses on the overall effects of health and ill health on a person's life. Measuring HRQL enables an overall assessment of impact which is complementary to assessment of specific symptoms or the use of individual health related outcomes.

A systematic review of the literature identified no consistent evidence that physical activity interventions improve the HRQL of people with dementia (Ojagbemi & Akin-Ojagbemi, 2019).[1] However, as the authors note, there were only a limited number of studies identified (k=13; with 6 included in the meta-analysis), many with small sample sizes. In addition, HRQL was not the primary outcome in any of the studies included, and therefore it is unlikely the studies: a) were sufficiently powered to detect HRQL changes, or b) interventions were not tailored to target HRQL. Evidence from the wider older adult literature (without dementia) indicates that physical activity is associated with improved HRQL (Awick et al., 2015; Koolhaas et al., 2018; Kusumaratna, 2016; Scarabottolo et al., 2019; Xu et al., 2018).

There are limited data on HRQL and physical activity of those with dementia in free-living conditions (i.e., normal/naturalistic setting) particularly using quantitative measures. The need for such research is important because observational data can provide better understanding about what activities are achievable and meaningful, whilst providing real-world insights into the implementation of activities with this population. For example, the most frequently cited type of leisure time physical activity reported in people with dementia is gardening (35.3%), which was associated with higher HRQL than those that did not garden (Müller et al., 2021). Another study found physical activity may indirectly improve the HRQL of people with mild to moderate dementia (n=216), mediated through the improvement of function and reduction of depressive symptoms (Huang et al., 2019). However, it is

[1] The authors refer to quality of life more broadly rather than HRQL. Whilst the terms are often used interchangeably in the literature, within the systematic review all studies identified used HRQL outcome measures.

important to recognize that the authors in the study used a single index of physical activity (Physical Activity Scale for the Elderly (PASE)) and HRQL (QoL-AD), which introduces the possibility of measurement error. Notably, the PASE questionnaire has not been validated for use in people with dementia, and preliminary evidence demonstrates that it has poor agreement with objective measures of physical activity (Middleton et al., 2018). The QoL-AD has been critiqued as a measure which is dependent on functional ability (Hall et al., 2011), thus increasing the likelihood that functional ability will mediate the relationship between these outcomes. In addition, we are cautious that the model could partially be explained by variations in cognitive impairment; however, cognitive impairment was not controlled for in the model.

The aim of this study was to better understand the relationship between habitual physical activity and HRQL in people with dementia in free-living conditions. Developing on the work by Huang and colleagues (Huang et al., 2019) we will use multiple indices of physical activity and HRQL, whilst also controlling for underlying cognitive impairment. We hypothesized that physical activity participation is associated with improved HRQL though is not mediated by depression and activities of daily living (ADLs) once cognitive impairment is controlled for.

Methods

Participants

Participants were recruited from South East England as a sub study of the MODEM research programme (Comas-Herrera et al., 2017)). Participants were included if they were diagnosed with dementia (any dementia subtype, with no restriction on other co-morbidities) and had a family carer who was able and willing to report on the physical habits of the person with dementia. Participants were identified through lists of individuals who had previously expressed interest in research, clinical referral from local memory assessment services, self-referral through Join Dementia Research (http://joindementiaresearch.nihr.ac.uk/), or self-referral through community groups. The recruitment strategy encouraged a range of dementia severities (i.e. approached care homes for people with severe dementia).

Procedure

Participants (the person with dementia and carer) were visited in their homes (or another location if requested). Both the person with dementia and their carer were informed about the study and were assessed for eligibility. If the potential participant met the inclusion criteria, they were asked to provide informed consent before participation. Capacity to consent was formally assessed for all people with dementia. To assess capacity, the researcher talked through the study and checked whether the participant, a) understood the purpose of the study, b) was able to retain information long enough to make a decision, c) weigh up the information to make a decision, and c) communicate their decision. If the person lacked capacity to consent, a family member or friend were identified to act as a Personal Consultee. Participants were asked a series of questions about their health, including HRQL. Questions related to HRQL and physical activity were completed by the carer as an informant report. Visits lasted approximately 90 minutes. At the end of the session, participants were asked whether they would be happy to wear an accelerometer (GENEactiv Original) for a period of a month. The device was fitted and guidance was provided about its function. Participants had the option to refuse to wear the device, but still remain in the study. After a month the researcher collected the device.

Measures

- *Demographic information* - age, gender, ethnicity and living arrangement.
- *Standardised Mini-Mental State Examination (sMMSE)*(Molloy et al., 1991) – a measure of severity of cognitive impairment.
- *The Rapid Assessment of Physical Activity (RAPA)*(Topolski et al., 2006) for older adults. A seven-item questionnaire to assess aerobic, and strength and flexibility physical activity. The

RAPA provides examples of types of physical activity that can be done for pleasure, work or transportation. The questionnaire also provides guidance about intensity. We adapted the questionnaire to be informant completed. Two categorical outcomes are derived from this measure: RAPA1 (aerobic activity) and RAPA2 (Strength & Flexibility). For the RAPA1 there are five categories: 1=sedentary, 2=underactive, 3=regular underactive - light activities, 4=regular underactive, and 5=regular active. To provide additional context, a score of "sedentary" is when a participant rarely or never does any physical activity, whilst "regular active" is defined as participating in 30 minutes or more of moderate physical activities (5 or more days a week) or 20 minutes or more of vigorous physical activities (3 or more days a week). The RAPA2 was measured by three categories of 1= participates in strength training, 2= participates in activities to improve flexibility, 3= participates in both, and 0= participates in neither.

- *The Community Healthy Activities Model Program for Seniors (CHAMPS) physical activities questionnaire for older adults* (Stewart et al., 2001). The questionnaire estimates both the frequency and caloric expenditure of physical activity habits. Unlike the RAPA, the CHAMPS asks about each type of activity separately. The questionnaire was scored in line with author guidelines to create the frequency of physical activity per week, and frequency of moderate to vigorous physical activity (MVPA) (≥3 metabolic equivalent of tasks (METs)) per week. In addition, based upon the same categorization, time spent per week were approximated by converting the ranged category responses (on a Likert scale) into a single index of time (e.g. Less than 1 hour = 0.5 hours, 1-2.5 hours = 1.75, 2-4.5 hours = 3.75 hours). Wording of the questionnaire were adapted to be informant completed.
- *DEMQOL* (Smith et al., 2005) - A disease-specific measure of HRQL. Higher scores represent better HRQL. Self-completed by the person with dementia, mild and moderate severity only.
- *DEMQOL-Proxy* (Smith et al., 2005) – A proxy-reported measure of disease-specific HRQL with validity across all severities of dementia.

- *EQ-5D-5L* (EuroQol Group, 1990) – A generic measure of HRQL,. Self-completed by the person with dementia, mild and moderate severity only.
- *Short Form 12 (SF-12)*(Ware Jr et al., 1996) - A generic measure of HRQL with eight domains that generates mental health and physical health component scores. This measure was self-completed by the person with dementia, mild and moderate severity only.
- *Neuropsychiatric inventory (NPI)* (Cummings, 1997) –recording behavioural and psychological symptoms in dementia, completed by the carer. The depressive symptom subscale was calculated for this measure.
- *Bristol Activities of Daily Living (BADL)* (Bucks et al., 1996) – a questionnaire to assess independence in activities of daily living which is validated for people with dementia.
- *The GENEactiv Original* (Activinsights Ltd., Cambridgeshire, UK) is a tri-axial, ±6g seismic, wrist worn acceleration sensor, which is small (36cm x 30 cm x 12cm), lightweight (16g), and waterproof. The device has previously been shown to be a valid measure of physical activity and sedentary time (Pavey et al., 2016; White et al., 2016), and is commonly used in older adult populations (Broekhuizen et al., 2016; Ramires et al., 2017; Rowlands et al., 2014). The GENEActiv Original has been shown to be acceptable and satisfactory to wear for prolonged periods in people with dementia (Farina, Sherlock, et al., 2019). In the present study, the GENEactiv Original was set to have a sampling frequency of 20Hz. Both the person with dementia and the carer were asked to wear the device on their non-dominant wrist for 30 days. Participants were encouraged not to remove or interact with the device. Participants did not have the ability to review their activity habits in real-time. For data to be included in the analysis, a minimum of 7 hours of valid data per day was required, and a minimum of 5 days of valid data were required (spanning both weekday and weekends, across the study). Two indices were extracted: 1) the average daily Euclidean Norm Minus One (ENMO) as a summary measure of acceleration, the value presented is the average ENMO over all the available data normalised per 24 hour cycles, with invalid data imputed by the average at similar time points on different days of the week; and 2) average time spent in MVPA per day

based on 5 second epoch size and a ENMO metric threshold of 100mg setting bout duration of 1 minute and inclusion criterion of more than 80 percent.

Analysis

Processing of accelerometer, described above, was run using GGIR package (version 1.11-0) (Migueles et al., 2019) for R (version 3.6.3) (R. Core Team, 2016).

Descriptive: All data were split by dementia severity (sMMSE total score: 10-30=mild to moderate; 0-9=severe) for several reasons; 1) to reflect differences in recruitment strategies, 2) to ensure there was consistency with the Huang et al. (2019) study, 3) to differentiate between participants who were asked to complete self-report vs proxy-report questionnaires on HRQL, and 4) to minimize the heterogeneity within the population. Where appropriate, means, standard deviations (SDs), frequencies and percentages were reported for key demographic data and outcome measures. For highly skewed data the Median (Mdn) and interquartile range (IQR) were reported. Differences between groups were tested using relevant parametric and non-parametric techniques (i.e., ANOVA, Mann-Whitney U, Pearson's Chi-Square).

Bivariate analysis: A series of correlation analyses (Spearman's Rho) were completed between continuous measures of physical activity and HRQL.

Model creation: A series of parallel mediation analyses were run, in a sample comprised of wholly complete data for those with mild to moderate dementia. For each model we were interested in the relationship between physical activity and HRQL, replicating the mediation model presented elsewhere (Huang et al., 2019). As we were less interested in the variations between HRQL outcomes, a single unweighted composite HRQL outcome measure (Sum of all HRQL indices divided by 5) was entered as dependent variable within the model. Activities of daily living (i.e., BADL) and depressive symptoms (i.e., NPI: Depression subscale) were entered as mediators. Each model used different indices of physical activity as the independent variable (Frequency and time spent of all physical activity per week, Frequency and time spent of MVPA per week, Average acceleration per day (mg), Average MVPA per day (mins)) to understand whether certain physical activity measures better fit the models. Based on evidence that cognitive status is associated with physical activity participation, depressive symptoms and activities of daily living, we recreated the models with the sMMSE entered as a control variable. We report standardized regression coefficients for individual associations, as well as direct and indirect pathways. The model was created using non-parametric bootstrapping analyses (95% CI, 10,000 samples). Analyses were performed by using the PROCESS function V.3.4 in SPSS V.25. Model 4 (model as a parameter in the PROCESS function) was used for the parallel mediation models.

Missing data: We adopted relevant missing data guidelines set out by original creators of the validated outcome measures, when available. For example, we followed the guidelines for the scoring of the DEMQOL and DEMQOL-proxy by inserting an average score for up to 50% missing data (Smith et al., 2005). For the sMMSE, there was no standardized procedure to address missing data. However, in a small number of cases (n=6), there were instances of a few missing items (≤10%), thus preventing a total score from being calculated. As the sMMSE total score was important outcome variable for this study, we made a decision to adopt Hot Deck Imputation (Myers, 2011), rather than excluding the whole case. For each missing item, a value is randomly selected from a list of donor cases, which are chosen based on matching cases on a named variable (i.e. the preceding variable). The benefit of Hot Deck Imputation is that the imputations are realistic since they are based on values observed in other cases, and thus are not outside the theoretical range of responses (Siddique & Belin, 2008). We utilized a SPSS macro developed elsewhere (Levesque, 2012).

Ethics

Ethical approvals were obtained from the National Social Care Research Ethics Committee (17/IEC08/0042).

Results

Participants

One hundred and thirty-four participants were recruited, along with their carers. Ten participants were excluded from the analysis because they lacked basic participant characteristics (e.g., age, gender, sMMSE). Participants were on average 78.1 years old (SD = 9.14), White British (n=117, 94.4%), moderately cognitively impaired (sMMSE; M=15.40, SD=10.08) and male (n=76, 61.3%). Across the cohort, the most frequently reported physical activities on a typical day were leisurely walking (n=73, 58.9%) and light work around the house (n=68, 54.8%). People with mild to moderate dementia participated in significantly more physical activity than those with severe dementia, across all indices (p<0.001). The only exception was participation in strength and flexibility training in which both groups predominantly did not participate in (76.6% vs 75.7%, p=0.73). For full details of participant demographics, split by severity group, see Table 1.

HRQL and physical activity

For those with mild to moderate dementia, weak positive associations were observed between physical activity and HRQL across the majority of outcomes. Only the association between time spent physically active per week (CHAMPs) and EQ-5D index reached statistical significance. See Table 2.

For those with severe dementia, there was a tendency for weak negative associations to be observed between subjective physical activity and HRQL (r_s's=-0.20 to -0.18, p's>0.05), and weak positive associations for accelerometer derived indices (r_s's=0.03 to 0.12, p's > 0.05).

Mediation Analysis

Null mediation models tended to reveal no significant direct or indirect pathways between physical activity and HRQL. However, when the mean daily ENMO acceleration (*mg*) was the independent variable, a significant indirect pathway through improving ADLs was observed (b=0.15, Bootstrapped SE=0.08, Bootstrapped 95%CI=0.02-0.03). See Appendix A for a summary of these null models.

The inclusion of the sMMSE as a covariate did not reveal any significant direct or indirect pathways between physical activity and HRQL across any model. The indirect pathway reported in one of the null models (mean daily ENMO acceleration → ADL → HRQL), was no longer significant (b=0.04, Bootstrapped SE=0.07, Bootstrapped 95% CI=-0.10-0.19). Within these models, depressive symptoms were the only variable to be significantly associated with HRQL. However, physical activity was not significantly associated with depressive symptoms across any of the models. Half of the models demonstrate that physical activity was significantly positively associated with ADLs even after controlling for cognitive impairment. The sMMSE covariate was consistently significantly associated with ADLs across all models.

See Figure 1 and 2 for an overview of individual associations within the models.

Discussion

This study set out to explore the relationship between physical activity and HRQL in people with dementia across a range of severities building upon the model developed by Huang and colleagues (Huang et al., 2019). In a novel component of the study, we used multiple indices of HRQL and physical activity. Our data suggests evidence of a weak positive association between physical activity and HRQL in people with mild to moderate dementia severity. The results were largely consistent across multiple indices of HRQL, though only reached statistical significance on one occasion. Mediation analysis did not reveal any significant indirect pathways via depression or ADLs after controlling for cognitive impairment.

An important observation were the positive associations reported in the mild to moderate severity group appear to become weaker (or negative) in the severe dementia groups. These findings could represent a shift in types of physical activity participation in people with severe dementia. Both apathy (Robert et al., 2005) and physical impairment (Shah et al., 2004) are associated with dementia and worsening severity, which could change the amount and types of physical activity people participate in, particularly during later stages of the condition. Irrespective of physical activity habits, the person with dementia may be less engaged in the activities they participate in, hence limiting some of the psychological benefits.

In this study, we adopted a similar model to that reported by Huang and colleagues (Huang et al., 2019), in which depression and ADLs were investigated as mediators for the effect on HRQL, based upon the Human Capital Model (HCM) (Bailey et al., 2012). Huang and colleagues found a positive relationship between physical activity and HRQL, though with the model there was no significant direct path between physical activity and HRQL, but instead the relationship was mediated by depression and ADLs. Similar to their findings, there was no significant direct pathway between physical activity and HRQL in any of our models. In addition, the majority of regression co-efficients demonstrated the expected direction of effect between physical activity, ADLs and depressive symptoms (some of which reached significance). However, only a single model demonstrated a significant indirect pathway (mean daily ENMO acceleration → ADL → HRQL). This relationship was no longer statistically significant following the addition of sMMSE as a covariate into the model, highlighting the importance of cognitive impairment measurement in understanding the relationship between physical activity and HRQL. Cognitive impairment has previous been shown to be associated with both physical activity (Lu et al., 2018) and ADLs (Bucks et al., 1996).

A strength of this paper is the utilization of multiple indices of physical activity and HRQL. For the former, measures encapsulate objective and subjective outcomes, as well as different components of physical activity (e.g., frequency, intensity, time spent being physically active). The fact that only the EQ-5D was significantly associated with time spent physically active per week (CHAMPS), potentially indicates that there is no effect to be seen (see limitations below). The models also demonstrate that irrespective of physical activity index used, the strength and direction of associations of variables within the model were relatively consistent. It should be noted that a single index measure of physical activity (in terms of frequency, intensity and duration) may not be sufficient to generate an understanding of the relationship between physical activity and HRQL in dementia. Instead the modality of the activity and the psychosocial meaning and experience of activity might be a more pertinent focus for research. For example, whilst overall quality of life tended to benefit those participating in light group exercises, physical components of quality of life benefitted from MVPA (Gillison et al., 2009). The indices of physical activity presented here, irrespective of subjective or objective measures, indirectly capture energy expenditure rather than the motivation for, and psychosocial experiences of, physical activity.

There are a number of important limitations in this study to consider. First, the cross-sectional design of this research prevents us from making conclusions about causality and the direction of effect. Second, although there was a general consistency of direction and strength of effect, differences did lie between models. As the models only differed based on the measure of physical activity, it leads to an important question about how to best measure physical activity in people with dementia, particularly because there is no gold-standard in terms of questionnaires (Farina, Hughes, et al., 2019). Third, the study is limited by a modest sample size, and therefore would benefit from being replicated in a larger sample. Fourth, we did not control for multiple comparisons in the bivariate analysis, and hence the significant association between EQ-5D and CHAMPS (time spent being physically active per week) should be interpreted with caution. Fifth, we exclusively focused on depression and ADLs as mediators within the models, and therefore does not exclude the possibility that there are other potential mediators. Finally, whilst the purpose of the study was not to develop optimum fitting models, the mediation models had generally poor fit.

This study adds usefully to the evidence base on physical activity and HRQL in dementia. These data suggest that the association between physical activity and HRQL is weak at best, indicating that the benefits of physical activity generated from cognitively-intact populations cannot be assumed to apply for those with dementia. Our research did not support the theory that physical activity improves HRQL through reduction of depressive symptoms and improved ADLs and highlights the difficultly in disentangling these relationships cross-sectionally. Future research needs to consider physical activity participation outside of intensity, duration and frequency, whilst also considering the role of a broader set of mediators. Understanding whether certain types of physical activity are particularly beneficial is important in people with dementia where participation is almost non-existent in the most severe cases.

Conflict of interest declaration

None

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Table 1. Participant demographics and key outcome variables (n=124). Statistical comparisons made between groups split by severity.

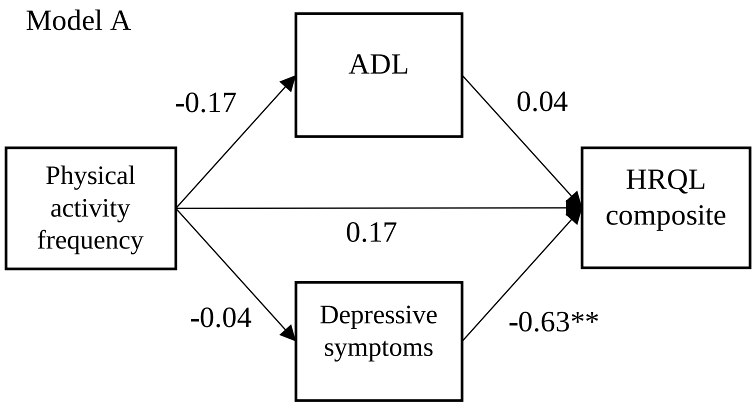
	Mild to moderate (n=87)		**Severe (n=37)**		**Between group comparison**	
	Mean (SD)	**N (%)**	**Mean (SD)**	**N (%)**	**Co-eff**	**p-value**
Age	78.0 (8.59)		78.5 (10.45)		0.29	0.77
Gender: Female		27 (31.0%)		21 (56.8%)	7.24	0.007
Ethnicity: White British		84 (96.6%)		33 (89.2%)	7.65	0.11
Accommodation: Care home		3 (3.4%)		17 (45.9%)	39.69	<0.001
Diagnosis: Alzheimer's Disease		47 (56.0%)		18 (54.5%)	8.63	0.13
sMMSE	21.21 (5.26)		1.8 (2.94)		-21.11	<0.001
BADL	14.81 (12.22)		42.00 (11.66)		10.03	<0.001
NPI: Depression Subscale	1.38 (1.88)		1.31 (2.52)		-0.13	0.90
DEMQOL	94.54 (11.98)		-		-	-
DEMQOL-Proxy	90.59 (13.95)		102.10 (10.90)		4.42	<0.001
SF-12: Physical Health Component	51. 17 (6.43)		-		-	-
SF-12: Mental Health Component	52.60 (7.51)		-		-	-
EQ-5D: Index	0.87 (0.18)		-		-	-
RAPA1: Aerobic activity					15.75	0.003
Sedentary		7 (8.0%)		12 (33.3%)		
Underactive		10 (11.5%)		5 (13.9%)		
Underactive regular-light		28 (32.2%)		9 (25.0%)		
Underactive regular		17 (19.5%)		7 (19.4%)		
Active		25 (28.7%)		3 (8.3%)		
RAPA2: Strength & Flexibility					1.23	0.73
Both		4 (4.7%)		2 (5.4%)		
Strength only		6 (7.0%)		1 (2.7%)		

Flexibility only	10 (11.6%)	6 (16.2%)		
None	66 (76.7%)	28 (75.7%)		
CHAMPS				
Frequency per week for all listed physical activity	Mdn = 14.00 (IQR=13.00)	Mdn = 5.00 (IQR=8.50)	U=657.50	<0.001
Hours per week for all listed physical activity	Mdn=10.00 (IQR=13.25)	Mdn=1.87 (IQR=7.88)	U=593.00	<0.001
Frequency per week in at least moderate intensity physical activities (MET≥ 3.0)	Mdn = 2.00 (IQR=7.00)	Mdn = 0.00 (IQR= 2.00)	U=912.50	0.001
Hours per week in at least moderate intensity physical activities (MET≥ 3.0)	Mdn = 1.75 (IQR=5.50)	Mdn=0.00 (IQR=0.63)	U=824.500	<0.001
Average daily physical activity ENMO (mg)	Mdn = 16.41 (IQR=11.09)	Mdn = 14.35 (IQR=8.05)	U=134.00	0.007
Average daily MVPA (mins)	Mdn = 14.86 (IQR=30.06)	Mdn = 1.37 (IQR=7.18)	U=138.00	0.009

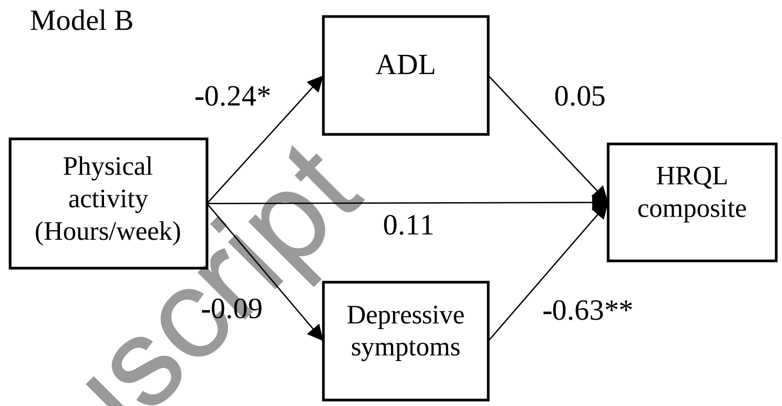
BADL = Bristol Activities of Daily Living, ENMO = Euclidean Norm Minus One, IQR = Interquartile range, Mdn = Median, mg = milli-gravitational units, MVPA = Moderate to Vigorous Physical Activity, MET = metabolic equivalents, NPI = Neuropsychiatric Inventory

Table 2. Spearman's correlation between HRQL outcomes and indices associated with physical activity (derived from the CHAMPS and accelerometer data) in people with mild to moderate severity dementia.

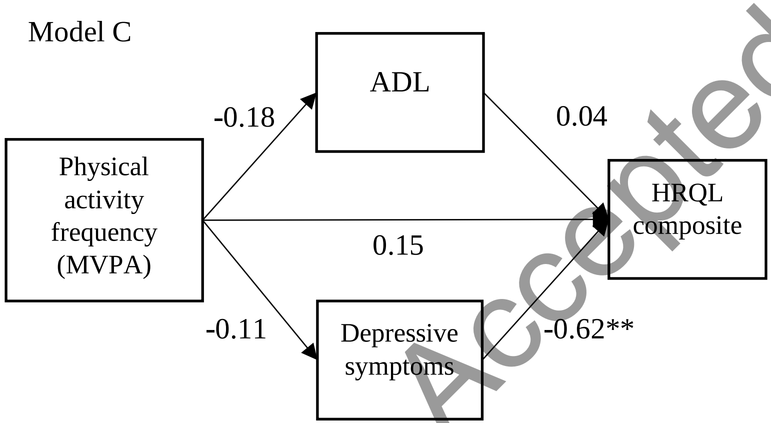
	Frequency of all physical activity per week	Time per week participating in all physical activity (hours)	Frequency of MVPA per week	Time per week participating in MVPA (hours)	Average acceleration per day (mg)	Average MVPA per day (mins)
DEMQOL	0.12 (p=0.30)	0.13 (p=0.22)	0.02 (p=0.84)	-0.01 (p=0.91)	0.19 (p=0.25)	0.06 (p=0.73)
DEMQOL-Proxy	0.19 (p=0.08)	0.18 (p=0.11)	0.16 (p=0.15)	0.19 (p=0.08)	0.24 (p=0.14)	0.22 (p=0.17)
EQ-5D: Index	0.16 (p=0.16)	**0.25 (p=0.03)**	0.17 (p=0.14)	0.19 (p=0.09)	0.14 (p=0.41)	0.08 (p=0.62)
SF-12: Physical Component	0.15 (p=0.21)	0.13 (p=0.29)	0.15 (p=0.22)	0.13 (p=0.27)	0.06 (p=0.74)	-0.04 (p=0.81)
SF-12: Mental Component	0.09 (p=0.44)	0.05 (p=0.71)	0.03 (p=0.78)	-0.002 (p=0.99)	0.25 (p=0.15)	0.23 (p=0.20)
HRQL Composite	0.19 (p=0.25)	0.15 (p=0.22)	0.14 (p=0.25)	0.12 (p=0.31)	0.19 (p=0.30)	0.15 (p=0.41)



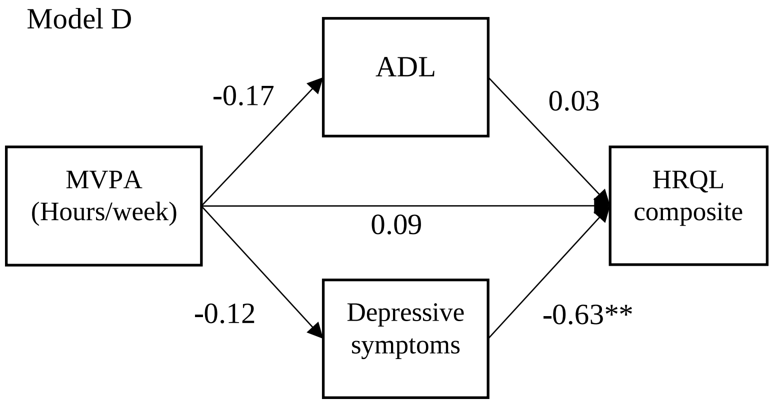
Covariate (sMMSE), standardised regression weights: → ADL = -0.61**, → Depressive symptoms = 0.06, →HRQL composite = 0.02



Covariate (sMMSE), standardised regression weights: → ADL = -0.59**, → Depressive symptoms = 0.07, →HRQL composite = 0.04

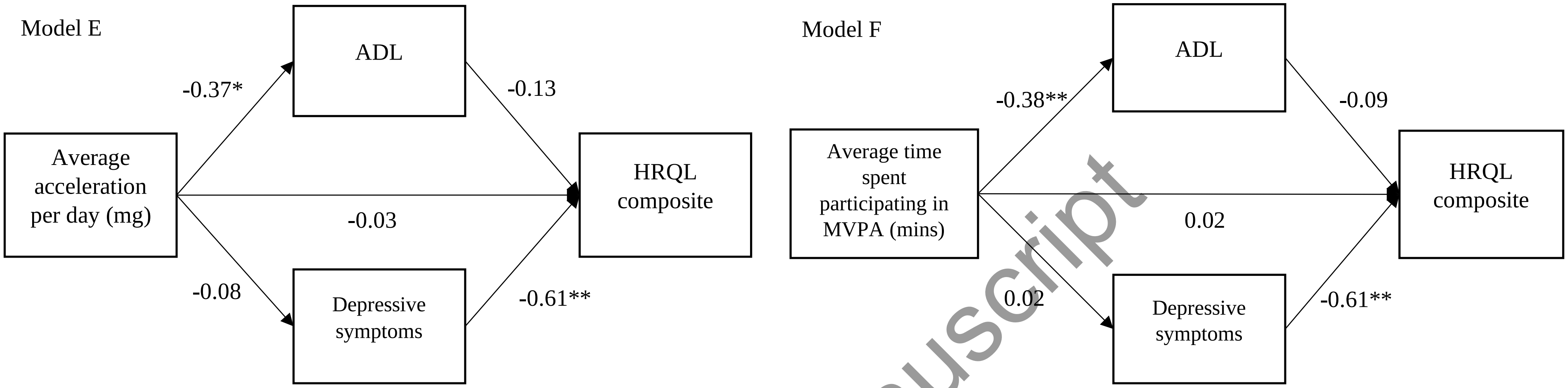


Covariate (sMMSE), standardised regression weights: → ADL = -0.60**, → Depressive symptoms = 0.08, →HRQL composite = 0.02



Covariate (sMMSE), standardised regression weights: → ADL = -0.62**, → Depressive symptoms = 0.08, →HRQL composite = 0.04

Figure 1. A parallel mediation model, standardized regression weights are reported between variables. In all models, sMMSE scores are controlled for. Each model represents different physical activity indices from the CHAMPS. ADL=Activities of Daily Living, HRQL = Health-related Quality of Life. *P<0.05, **p<0.01



Covariate (sMMSE), standardised regression weights: → ADL = -0.53**, → Depressive symptoms = 0.12, →HRQL composite = 0.28

Covariate (sMMSE), standardised regression weights: → ADL = -0.53**, → Depressive symptoms = 0.09, →HRQL composite = 0.30

Figure 2. A parallel mediation model, standardized regression weights are reported between variables. In all models, sMMSE scores are controlled for. Each model represents a different physical activity index from the accelerometer data. ADL=Activities of Daily Living, HRQL = Health-related Quality of Life. *P<0.05, **p<0.01