

1 **Physical activity patterns within dementia care dyads**

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1 **Abstract**

2 Previous research has explored physical activity habits of people with dementia and
3 their family carers separately, with little consideration of how physical habits are
4 associated within dyads. Within this observational study, we sought to explore the
5 relationship between people with dementia and their carers' physical activity, at a group
6 level and at a dyadic level. Twenty-six participant dyads (person with dementia and their
7 carer spouses) were asked to wear an accelerometer for 30 days continuously.
8 Comparisons were made at a group level and a dyadic level. People with dementia did
9 not participate in significantly more moderate to vigorous physical activity (M=15.44
10 mins/day; SD=14.40) compared to carers (M=17.95 mins/day; SD=17.01). Within dyads,
11 there were moderately strong associations between daily moderate to vigorous physical
12 activity ($r=0.48-0.54$), but not with overall activity levels ($r=0.24$). Despite physical
13 activity habits remaining relatively low within people with dementia and caregivers,
14 respectively, moderate to vigorous physical activity levels appear to be correlated within
15 dyads. Understanding mutual influence on physical activity levels within dyads is an
16 important pathway to promote an active lifestyle.

17

18 **Keywords:** physical activity, exercise, dementia, caregiver, dyad, spouse

1 **Introduction**

2 The World Health Organisation (WHO) has prioritized healthy ageing policies to help
3 manage the growing health system costs of an ageing population and to maximise
4 individual health (WHO, 2015). Physical activity is an important contributor to healthy
5 ageing, with well-established health benefits to older adults (Chodzko-Zajko et al., 2009;
6 Cunningham et al., 2020; Taylor et al., 2004). The WHO and UK physical activity
7 guidelines recommend at least 150 minutes of moderate intensity physical activity
8 (MVPA) a week for older adults (65+) (Bull & Expert Working Groups, 2010; World
9 Health Organization, 2010), and suggest that “something is better than nothing” when
10 recommending physical activity for older adults with chronic health conditions, such as
11 dementia (Department of Health & Social Care, 2019).

12 Increased functional and cognitive impairment is associated with lower physical activity
13 participation (Sport England, 2021; Wion et al., 2020) and hence it unsurprising that
14 people with dementia participate in less physical activity than cognitively healthy older
15 adults (Boyle et al., 2015; McArdle et al., 2019; Watts et al., 2016; Zanco et al., 2016).
16 Walking appears to be the most popular form of physical activity in people with
17 dementia (Farina et al., 2021; Winchester et al., 2013), though gardening is also
18 frequently reported as a popular leisure time physical activity (Müller et al., 2021; Watts
19 et al., 2013). Accelerometer data demonstrates that many PwD live largely sedentary
20 lives (van Alphen, Volkers, et al., 2016) with little variability between days (Watts et al.,
21 2016), particularly in non-walking physical activities (Abel et al., 2019).

22 The reduction of physical activity in people with dementia can be attributed to several
23 potential barriers that extend past physical changes associated with old age. Thirty five

1 barriers, 26 motivators and 21 facilitators related to physical activity were identified in a
2 systematic review of literature (van Alphen, Hortobágyi, et al., 2016). Evidence on this
3 topic is however still relatively sparse, being predominantly derived from small samples
4 in qualitative research. One emerging theme is the importance of family carers, herein
5 referred to as carers, in providing support and motivation to facilitate and maximise
6 physical activity in people with dementia (Farina et al., 2020; Hobson, 2017; van
7 Alphen, Hortobágyi, et al., 2016).

8 Carers as a whole appear to participate in a limited amount of physical activity; being
9 more likely to be physically inactive compared to non-carers (Stacey et al., 2019;
10 Tseliou et al., 2019). Increased carer burden is associated with lower physical activity,
11 particularly with leisure based activities (Hirano et al., 2011). This is supported by
12 carers of people with dementia who identified lack of time and their caring role as key
13 barriers to their physical activity (Farina et al., 2020). As highlighted in a recent
14 systematic review, there is a general lack of evidence about physical activity of carers
15 from the UK, including the levels of physical activity in this group (Horne et al., 2021).

16 People with dementia and their carers therefore both represent underactive groups, as
17 a consequence of the condition. However, it is unclear to what extent the physical
18 activity of the person with dementia is associated with carer physical activity and vice
19 versa. One hypothesis is that increased dependence on carers leads to a change in
20 roles, whereby habitual physical activities shift from the person with dementia to the
21 carer (McArdle et al., 2019), such as one partner taking responsibility for all household
22 tasks. As such, we might expect there to be greater low intensity physical activity in the
23 carer to compensate for inactivity in the person with dementia. This may align with

1 evidence from non-cognitively impaired older adults, in which instrumental activities of
2 daily living provide older women with the opportunity to remain active (Sheehan &
3 Tucker-Drob, 2019; Wu et al., 2021). Increased caring responsibilities may however
4 minimise the amount of time available for carers to participate in more purposeful
5 physical activity (Farina et al., 2020; Malthouse & Fox, 2014). In parallel, the reliance on
6 the carer to facilitate and support physical activity for the person with dementia (Farina
7 et al., 2020; Hobson, 2017) may result in greater physical activities participated as a
8 dyad. It is likely that such mechanisms will vary between individuals and over time, but
9 at present there is no research exploring whether there is a quantifiable association of
10 physical activity levels within carer-dementia dyads.

11 In this study, we seek to start to fill this gap in the literature by reporting the relationship
12 between people with dementia and their carers' physical activity, at a group level and at
13 a dyadic level. The study aims were to:

- 14 1. Describe and compare group level differences in physical activity between
15 people with dementia and their spousal carers.
- 16 2. Determine whether there is an association between physical activity participation
17 within carer-dementia dyads.

18 **Materials and Methods**

19 **Design**

20 This is a secondary analysis of observational data collected as part of a study in which
21 we investigated the feasibility and acceptability of using activity monitors in people with
22 dementia (Farina et al., 2019).

1 **Participants**

2 We enrolled community-dwelling, ambulatory, people with dementia (clinically
3 diagnosed, self-reported), aged 65 and above. Whilst there were no criteria based on
4 dementia severity, participants were required to have capacity to consent. There were
5 no other restrictions on comorbidities, health status or dementia type. Participants were
6 also required to have a co-habiting family carer who also participated. Participants were
7 recruited from the geographic area of Sussex (South East England). Health Research
8 Authority ethical approval was obtained by the London - Brighton & Sussex Research
9 Ethics Committee.

10 As an explorative, secondary analysis, there was no formal sample size calculated for
11 this study.

12 **Procedure**

13 Participants were identified either through self-referral or had previously expressed
14 interest in participating in research studies. Informed consent was obtained from both
15 the person with dementia and their carer independently by a trained researcher.
16 Capacity to consent was assessed in all people with dementia. The researcher
17 ascertained whether the person with dementia is able to, a) understand the purpose of
18 the study, b) retain the information long enough to make a decision, c) weigh up the
19 information, and d) communicate their decision. If the person with dementia was unable
20 to do any of these, then they were deemed to lack capacity and excluded from the
21 study. Both the person with dementia and the carer were asked to complete a series of
22 questionnaires (see below) before being given the activity monitor. All participants were

1 provided with a device diary to make notes about when the device was removed,
2 alongside guidance of the device functionality. After one month or withdrawal from
3 wearing the devices (whichever came first), satisfaction with wearing devices was
4 assessed (Farina et al., 2019). The activity monitors were collected at the end of testing
5 and all participants were given a summary of their own physical activity participation
6 after the completion of the study.

7 **Setting**

8 Data collection was conducted during the UK autumn months (September to November
9 2017). In the South East of England during that period, the average temperature was
10 11.3°C, with 30.1 days of rainfall totalling 149.3 mm of rain (Met Office, 2017). Two-
11 thirds of all households in the South East have access to a greenspace of at least 20
12 hectares within two kilometres (McKernan & Grose, 2007).

13

14 **Measures**

15 The measures used in this study can be split into the activity monitor component and
16 questionnaires.

17 **Activity monitor:** The GENEactiv Original (Activinsights Ltd., Cambridgeshire, UK) is a
18 wrist worn acceleration sensor. The device has been shown to be acceptable to wear in
19 community-dwelling people with mild-moderate dementia (Farina et al., 2019). The
20 device has previously been shown to be valid measure of physical activity and
21 sedentary time (Pavey et al., 2016; White et al., 2016) and is commonly used in older
22 adult populations (Broekhuizen et al., 2016; Ramires et al., 2017; Rowlands et al.,

1 2014). In the present study, the GENEactiv Original was set to have a sampling
2 frequency of 20Hz. Both the person with dementia and the carer were asked to wear the
3 device on their non-dominant wrist for the duration of the study. Participants were
4 encouraged not to remove or interact with the device. Participants did not have the
5 ability to review their activity habits in real-time.

6 Three indices were extracted: 1) the average daily Euclidean Norm Minus One (ENMO)
7 as a summary measure of acceleration, the value presented is the average ENMO over
8 all the available data normalised per 24-hour cycles, with invalid data imputed by the
9 average at similar time points on different days of the week. In this study, the average
10 daily ENMO was used as an estimate of unspecified movement, and indirectly
11 represents habitual physical activity; 2) average time spent in MVPA per day based on 5
12 second epoch size and a ENMO metric threshold of 100 milligrams (mg) setting bout
13 duration of 1 minute and inclusion criterion of more than 80 percent, and; 3) average
14 time spent in MVPA per day based on 5 second epoch size and a ENMO metric
15 threshold of 100mg setting bout duration of 10 minutes and inclusion criterion of more
16 than 80 percent. Differentiating between 1-minute and 10-minute bouts allows us to
17 understand the differences between all MVPA instances and more purposeful MVPA
18 (e.g., running, swimming), thus providing us an insight into the types of physical activity
19 being participated in.

20 The data were processed using the GGIR package (version 1.5-12) (Hees et al., 2013)
21 for R (R. Core Team, 2016) on RStudio software v1.2 (RStudio Team, 2020).

1 **Questionnaires:** A short set of questionnaires were administered to the person with
2 dementia and their carer. The full list of measures is reported elsewhere (Farina et al.,
3 2019), but the following were used in the analyses presented here:

- 4 • The Montreal Cognitive Assessment (MoCA) test (Nasreddine et al., 2005) – A
5 short screening instrument of cognitive function. The MoCA was completed by
6 the person with dementia only.
- 7 • The Rapid Assessment of Physical Activity (RAPA) (Topolski et al., 2006) - A
8 short questionnaire used to assess physical activity levels in older adults. The
9 questionnaire captures what older adults “usually do”. The measure provides
10 standardised examples of what light, moderate and vigorous physical activity
11 looks like. The measure was completed by the person with dementia and the
12 carer as a self-report instrument. As per the original guidance, participants were
13 defined as aerobically “regular active” if they reported as spending 30 minutes or
14 more a day of moderate physical activities (5 or more days a week), or 20
15 minutes or more a day of vigorous physical activities (3 or more days a week).

16

17 **Analysis**

18 Data were presented descriptively (e.g., Median, Interquartile Range (IQR), Mean,
19 Standard Deviation (SD)), with the carer and the person with dementia data reported
20 separately.

21 Accelerometer data were initially presented as summary statistics over the duration of
22 the study. Group differences (person with dementia and carer treated as separate

1 groups) were compared through multiple regression, bootstrapped (1,000 samples, Bias
2 Corrected and accelerated (BCa)). To compare the baseline RAPA, a Chi-square test
3 was used to see whether the groups differed in being regularly active or not.

4 We wanted to test whether the physical activity levels of the dyadic pairs were more
5 similar than when compared with data from non-dyads. Dyad comparisons were treated
6 as distinguishable (i.e., the dyads are identifiable by the nature of their role and
7 cognitive status) and only whole cases were used. Pearson product-moment correlation
8 coefficients between dyad indices of physical activity were calculated, whilst using a t-
9 test of the null hypothesis that the sample correlation was 0. We used the SPSS syntax
10 developed elsewhere (Alferes & Kenny, 2009).

11 We also visualised daily data to highlight relationships between groups and within
12 dyads. For the former, this was achieved by creating an average-of-averages of
13 accelerometer indices for each weekday (i.e., Monday to Sunday) and plotting on bar
14 chart. For dyadic data, daily physical activity of both the carer and person with dementia
15 were plotted within a scatter plot. We did not statistically analyse such data as
16 independent observations because it would have violated assumptions of independence
17 of errors and avoids issues with inflated degrees of freedom or pseudoreplication (Lazic,
18 2010; Millar & Anderson, 2004).

19 Analysis was completed in SPSS, version 25 (IBM Corp., 2017).

20

21 **Results**

1 Of the 61 participant dyads contacted, 25 refused. Twenty-six participant dyads were
2 recruited in the study. The average age of people with dementia was 79.8 years old (SD
3 = 5.8) compared with carers who were 76.4 years old (SD= 5.9). The person with
4 dementia had on average a mild severity of cognitive impairment (mean MOCA = 17.7,
5 SD = 3.7). Both the persons with dementia and carer's subjective reported similar
6 physical activity, being classified as "regular active" (n=12 vs n=10, respectively) based
7 on the RAPA ($\chi^2=1.39$, $p=0.41$). Further details are presented in Table 1. One dyad
8 stopped wearing the device after one day and one carer refused to wear the device,
9 thus the remaining 24 dyads had complete data for analysis. Other demographic
10 information and wear time data are reported elsewhere (Farina et al., 2019). The dyads
11 where we were unable to collect sufficient accelerometer data did not significantly differ
12 on key demographics such as age and cognitive status ($p>0.05$).

13

14 ***Group-level differences on daily physical activity***

15 Over the course of the study, carers were on average more active (mean daily ENMO)
16 compared those with dementia ($p=0.02$). There was no statistically significant
17 difference between the two groups for the 1-minute bout MVPA ($p=0.57$) or 10-minute
18 bout MVPA ($p=0.61$). See Table 2.

19 Visualising the data on the average weekday of the study highlights that carers almost
20 always participated in more physical activity than people with dementia. However, error
21 terms were often wide and overlapping between groups. See Figure 1.

22

1 ***Dyadic comparisons***

2 Mean daily ENMO (mg) demonstrated a weak, non-statistically significant, positive
3 association within dyads ($r=0.24$, 95% CI = -0.13 to 0.62, $p=0.17$, $t=1.41$). For daily
4 MVPA time, there was a significant positive association within dyads for greater than 1-
5 minute bouts ($r=0.48$, 95% CI = 0.10 to 0.74, $p=0.01$; $t=2.58$) and 10-minute bouts
6 ($r=0.54$, 95% CI = 0.17 to 0.77, $p=0.006$; $t=3.01$).

7
8 Dyadic comparisons on a daily basis are visualised in Figure 1. All accelerometer
9 indices indicated a positive trend within dyads.

10

11

12 **Discussion**

13 This study set out to understand the relationship between people with dementia and
14 their carer's physical activity. The study highlighted that whilst group-level differences in
15 physical activity were observed, there was also an association within dyads.

16 When visualising data across weekdays, we observed that the carer was nearly always
17 participated in more physical activity across all Actigraph indices on a given day. At a
18 group-level, similar to other studies, physical activity participation is higher in carers
19 than those that they care for (Mattek et al., 2019), based on the average ENMO/day
20 index. Assuming that cognitive impairment does not inherently lead to less physical
21 activity participation (Stubbs et al., 2014), our findings could be explained by increased
22 carer's activity due to their caring role. Such an interpretation might also explain why
23 there was no significant difference between the carers and persons with dementia in

1 terms of MVPA. Namely, the types of physical activity that might increase due to a
2 carer's role, are likely to be considered light (e.g., household chores, walking). However,
3 we cannot rule out potential floor effects in the MVPA data. Contextualising these data
4 within the broader literature is difficult due to differences in populations and
5 accelerometer indices. Both the person with dementia (Mean ENMO/day = 17.02 mg)
6 and carer (Mean ENMO/day = 20.48 mg) were less active compared to a larger cohort
7 (n=785) of European older adults (mean age 68.6) that participated on average 28.1mg
8 per day (SD=19.8)(Felez-Nobrega et al., 2023).

9 At a dyadic level, there was evidence of a linear association between the person with
10 dementia and carer's physical activity, particularly for MVPA indices. This lends support
11 to the notion that the motivation and support of physical activity from the carer (Farina et
12 al., 2020; Hobson, 2017) may lead to increased purposeful physical activity within the
13 dyad. Visualised daily data did not indicate that there is a compensatory mechanism;
14 namely, that as the person with dementia is able to do less, the carer has to do more
15 activity (McArdle et al., 2019). Factoring the role of gender in larger samples would be
16 of value (Wu et al., 2021), as the mechanisms for physical activity might be different for
17 men and women.

18 In both MVPA indices of physical activity, the associations were sufficient to indicate
19 non-independence. In brief, non-independence indicates that the behaviour or
20 characteristic of one is affecting the other's outcome, and can be attributed to
21 compositional effects, mutual influence or common fate (Grawitch & Munz, 2004).

22 Future research should consider adopting an Actor Partner Interdependence Model
23 (APIM) in sufficiently powered dyadic studies (Shamali & Østergaard, 2019) to assesses

1 whether the degree to which the carer's outcome is influenced by their own
2 characteristics (actor effect), or by the characteristics of the person with dementia
3 (partner effect). APIM has been used in other populations (e.g. adolescent-parent,
4 people with multiple-sclerosis-caregiver) to understand the role of salient psychosocial
5 variables and demographic factors on physical activity participation within the dyad
6 (Burns, 2019; Fakolade et al., 2018). The importance of revealing partner effects is that
7 it could provide alternate routes to promoting physical activity through targeting the
8 characteristics associated with the partner. Not framed in terms of the APIM, the
9 Physical Activity Behaviour change Theoretical model in dementia (PHYT-in-dementia)
10 builds upon generic behavioural change models yet recognises the uniqueness of
11 dementia experiences (Di Lorito et al., 2019). Notably, the model highlights the
12 importance of significant others (e.g., carer) in promoting physical activity in people with
13 dementia, though it is proposed that this effect is bidirectional (Di Lorito et al., 2020). As
14 such, there are potential benefits of developing physical activity interventions and public
15 health messages aimed at both the person with dementia and carer. Such dyadic
16 interventions do exist (de Dios-Rodríguez et al., 2023; Lamotte et al., 2017), though just
17 because the intervention targets both carers and people with dementia, it does not
18 necessarily result in a significant increase in physical activity when compared to controls
19 (de Dios-Rodríguez et al., 2023).

20 This study has important limitations. First, we cannot ascertain why the person with
21 dementia or carer were participating in physical activity, and whether the relationship
22 between physical activity habits were causally linked. Second, due to the sample size
23 and recruitment strategy we cannot assume that this population would reflect a larger

1 cohort of people with dementia and carers. Third, the sample size will have limited the
2 statistical power to detect anything but large between group differences, and thus
3 prevented us from controlling for confounding variables (e.g., age, sex, cognitive
4 impairment). Larger studies in representative populations are needed. Fourth, the mean
5 daily ENMO is not the most intuitive metric to interpret, though as it has benefits over
6 applying thresholds to data which may have questionable validity depending on the
7 population (Grimes et al., 2019). In line with this, we adopted a processing threshold to
8 ascertain a metric of time spent participating in MVPA, but there is still debate about the
9 best threshold to use in older adults (Frayse et al., 2021). Fifth, carers were all co-
10 habiting spouses and therefore the findings may not represent other dyadic
11 relationships of care (e.g., child carers). Finally, the present study provides us with
12 certain dimensions of physical activity (e.g., intensity, duration), but does not provide
13 detail about the types of activity that are occurring independently or together, or whether
14 it for leisure or non-leisure purposes.

15 This study provides confirmatory evidence of underactivity in older adults with dementia
16 and carers, over a prolonged observation period. Whilst carers are more physically
17 active than those that they care for, it appears that it is only more purposeful physical
18 activity (MVPA) that is associated within dyads. Our research highlights that efforts to
19 improve spousal carer physical activity may have the added benefit of improving
20 physical activity habits of the person they care for. Future research should seek to
21 better understand why such an association exists and consider whether this non-
22 independence could be adopted as a means to promote activity in both groups.

23

1

2 **Conflicts of Interest**

3 The authors have no conflict of interest to report

References

- 1
- 2 Abel, B., Pomiersky, R., Werner, C., Lacroix, A., Schäufele, M., & Hauer, K. (2019). Day-to-day variability
3 of multiple sensor-based physical activity parameters in older persons with dementia. *Archives*
4 *of Gerontology and Geriatrics*, *85*, 103911. <https://doi.org/10.1016/j.archger.2019.103911>
- 5 Alferes, V. R., & Kenny, D. A. (2009). SPSS programs for the measurement of nonindependence in
6 standard dyadic designs. *Behavior Research Methods*, *41*(1), 47–54.
7 <https://doi.org/10.3758/BRM.41.1.47>
- 8 Boyle, C. P., Raji, C. A., Erickson, K. I., Lopez, O. L., Becker, J. T., Gach, H. M., Longstreth Jr., W. T.,
9 Teverovskiy, L., Kuller, L. H., Carmichael, O. T., & Thompson, P. M. (2015). Physical activity, body
10 mass index, and brain atrophy in Alzheimer’s disease. *Neurobiology of Aging*, *36*, Supplement 1,
11 S194–S202. <https://doi.org/10.1016/j.neurobiolaging.2014.05.036>
- 12 Broekhuizen, K., de Gelder, J., Wijsman, C. A., Wijsman, L. W., Westendorp, R. G., Verhagen, E.,
13 Slagboom, P. E., de Craen, A. J., van Mechelen, W., van Heemst, D., van der Ouderaa, F., &
14 Mooijaart, S. P. (2016). An Internet-Based Physical Activity Intervention to Improve Quality of
15 Life of Inactive Older Adults: A Randomized Controlled Trial. *Journal of Medical Internet*
16 *Research*, *18*(4). <https://doi.org/10.2196/jmir.4335>
- 17 Bull, F. C. & Expert Working Groups. (2010). *Technical Report. Physical Activity Guidelines in the UK:*
18 *Review and Recommendations*. Loughborough University.
19 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/213743/dh_1
20 28255.pdf
- 21 Burns, R. D. (2019). Enjoyment, self-efficacy, and physical activity within parent-adolescent dyads:
22 Application of the Actor-Partner Interdependence Model. *Preventive Medicine*, *126*, 105756.

1 Chodzko-Zajko, W. J., Proctor, D. N., Singh, M. A. F., Minson, C. T., Nigg, C. R., Salem, G. J., & Skinner, J. S.
2 (2009). Exercise and physical activity for older adults. *Medicine & Science in Sports & Exercise*,
3 41(7), 1510–1530.

4 Cunningham, C., O’ Sullivan, R., Caserotti, P., & Tully, M. A. (2020). Consequences of physical inactivity in
5 older adults: A systematic review of reviews and meta-analyses. *Scandinavian Journal of*
6 *Medicine & Science in Sports*, 30(5), 816–827. <https://doi.org/10.1111/sms.13616>

7 de Dios-Rodríguez, E., Patino-Alonso, C., González-Sánchez, S., Tamayo-Morales, O., Ripoll, J., Mora-
8 Simón, S., Unzueta-Arce, J., Gómez-Marcos, M. A., García-Ortiz, L., & Rodríguez-Sánchez, E.
9 (2023). Promoting Physical Activity in a Primary Care Practice in People Living with Dementia
10 and Their Family Caregivers. *Healthcare*, 11(9), Article 9.
11 <https://doi.org/10.3390/healthcare11091255>

12 Department of Health & Social Care. (2019). *UK Chief Medical Officers’ Physical Activity Guidelines*.
13 Department of Health & Social Care.

14 Di Lorito, C., Bosco, A., Pollock, K., H. Harwood, R., das Nair, R., Logan, P., Goldberg, S., Booth, V.,
15 Vedhara, K., Godfrey, M., Dunlop, M., & van der Wardt, V. (2020). External Validation of the
16 ‘PHYT in Dementia’, a Theoretical Model Promoting Physical Activity in People with Dementia.
17 *International Journal of Environmental Research and Public Health*, 17(5), Article 5.
18 <https://doi.org/10.3390/ijerph17051544>

19 Di Lorito, C., Pollock, K., Harwood, R., das Nair, R., Logan, P., Goldberg, S., Booth, V., Vedhara, K., & Van
20 Der Wardt, V. (2019). A scoping review of behaviour change theories in adults without dementia
21 to adapt and develop the ‘PHYT in dementia’, a model promoting physical activity in people
22 with dementia. *Maturitas*, 121, 101–113. <https://doi.org/10.1016/j.maturitas.2019.01.008>

- 1 Fakolade, A., Finlayson, M., Parsons, T., & Latimer-Cheung, A. (2018). Correlating the Physical Activity
2 Patterns of People with Moderate to Severe Multiple Sclerosis Disability and Their Family
3 Caregivers. *Physiotherapy Canada, 70*(4), 373–381. <https://doi.org/10.3138/ptc.2017-36.ep>
- 4 Farina, N., Hughes, L. J., Thomas, S., Lowry, R. G., & Banerjee, S. (2021). The relationship between
5 physical activity and health-related quality of life in people with dementia: An observational
6 study. *Journal of Aging and Physical Activity*.
- 7 Farina, N., Sherlock, G., Thomas, S., Lowry, R. G., & Banerjee, S. (2019). Acceptability and feasibility of
8 wearing activity monitors in community-dwelling older adults with dementia. *International
9 Journal of Geriatric Psychiatry, 34*(4), 617–624. <https://doi.org/10.1002/gps.5064>
- 10 Farina, N., Williams, A., Clarke, K., Hughes, L. J., Thomas, S., Lowry, R. G., & Banerjee, S. (2020). Barriers,
11 motivators and facilitators of physical activity in people with dementia and their family carers in
12 England: Dyadic interviews. *Aging & Mental Health, 1*–10.
13 <https://doi.org/10.1080/13607863.2020.1727852>
- 14 Felez-Nobrega, M., Werneck, A. O., El Fatouhi, D., de Luca, K., Islam, S. M. S., & Franzese, F. (2023).
15 Device-based physical activity and late-life depressive symptoms: An analysis of influential
16 factors using share data. *Journal of Affective Disorders, 322*, 267–272.
17 <https://doi.org/10.1016/j.jad.2022.11.006>
- 18 Fraysse, F., Post, D., Eston, R., Kasai, D., Rowlands, A. V., & Parfitt, G. (2021). Physical Activity Intensity
19 Cut-Points for Wrist-Worn GENEActiv in Older Adults. *Frontiers in Sports and Active Living, 2*.
20 <https://doi.org/10.3389/fspor.2020.579278>
- 21 Grawitch, M. J., & Munz, D. C. (2004). Are Your Data Nonindependent? A Practical Guide to Evaluating
22 Nonindependence and Within-Group Agreement. *Understanding Statistics, 3*(4), 231–257.
23 https://doi.org/10.1207/s15328031us0304_2

1 Grimes, L., Outtrim, J. G., Griffin, S. J., & Ercole, A. (2019). Accelerometry as a measure of modifiable
2 physical activity in high-risk elderly preoperative patients: A prospective observational pilot
3 study. *BMJ Open*, *9*(11), e032346. <https://doi.org/10.1136/bmjopen-2019-032346>

4 Hees, V. T. van, Gorzelniak, L., León, E. C. D., Eder, M., Pias, M., Taherian, S., Ekelund, U., Renström, F.,
5 Franks, P. W., Horsch, A., & Brage, S. (2013). Separating Movement and Gravity Components in
6 an Acceleration Signal and Implications for the Assessment of Human Daily Physical Activity.
7 *PLOS ONE*, *8*(4), e61691. <https://doi.org/10.1371/journal.pone.0061691>

8 Hirano, A., Suzuki, Y., Kuzuya, M., Onishi, J., Hasegawa, J., Ban, N., & Umegaki, H. (2011). Association
9 between the caregiver's burden and physical activity in community-dwelling caregivers of
10 dementia patients. *Archives of Gerontology and Geriatrics*, *52*(3), 295–298. PsycINFO.
11 <https://doi.org/10.1016/j.archger.2010.04.011>

12 Hobson, N. (2017). *Perceived Barriers to Exercise among Older Adults with MCI and Early Dementia*
13 [Master's Thesis]. University of Waterloo.

14 Horne, J., Kentzer, N., Smith, L., Trott, M., & Vseteckova, J. (2021). A Systematic Review on the
15 Prevalence of Physical Activity, and Barriers and Facilitators to Physical Activity, in Informal
16 Carers in the United Kingdom. *Journal of Physical Activity and Health*, *18*(2), 212–218.
17 <https://doi.org/10.1123/jpah.2020-0526>

18 IBM Corp. (2017). *IBM SPSS Statistics for Windows (25.0)* [Computer software].

19 Lamotte, G., Shah, R. C., Lazarov, O., & Corcos, D. M. (2017). Exercise training for persons with
20 Alzheimer's disease and caregivers: A review of dyadic exercise interventions. *Journal of Motor*
21 *Behavior*, *49*(4), 365–377.

22 Lazic, S. E. (2010). The problem of pseudoreplication in neuroscientific studies: Is it affecting your
23 analysis? *BMC Neuroscience*, *11*(1), 5. <https://doi.org/10.1186/1471-2202-11-5>

1 Malthouse, R., & Fox, F. (2014). Exploring experiences of physical activity among people with
2 Alzheimer's disease and their spouse carers: A qualitative study. *Physiotherapy*, *100*(2), 169–
3 175. <https://doi.org/10.1016/j.physio.2013.10.002>

4 Mattek, N., Thomas, N. W., Sharma, N., Beattie, Z., Marcoe, J., Riley, T., Dodge, H. H., & Kaye, J. (2019).
5 HOME-BASED DIGITAL ACTIVITY BIOMARKERS REMOTELY MONITOR RELEVANT ACTIVITIES OF
6 MCI AND ALZHEIMER'S DISEASE PATIENTS AND THEIR CARE PARTNERS. *Alzheimer's & Dementia*,
7 *15*(7, Supplement), P160. <https://doi.org/10.1016/j.jalz.2019.06.4328>

8 McArdle, R., Del Din, S., Donaghy, P., Galna, B., Thomas, A., & Rochester, L. (2019). Factors That
9 Influence Habitual Activity in Mild Cognitive Impairment and Dementia. *Gerontology*, 1–12.
10 <https://doi.org/10.1159/000502288>

11 McKernan, P., & Grose, M. (2007). *An analysis of accessible natural greenspace provision in the South*
12 *East*. Natural England.

13 Met Office. (2017). *Weather and climate change*. Met Office. <https://www.metoffice.gov.uk/>

14 Millar, R. B., & Anderson, M. J. (2004). Remedies for pseudoreplication. *Fisheries Research*, *70*(2), 397–
15 407. <https://doi.org/10.1016/j.fishres.2004.08.016>

16 Müller, B., Kropp, P., Cardona, M. I., Michalowsky, B., van den Berg, N., Teipel, S., Hoffmann, W., &
17 Thyrian, J. R. (2021). Types of leisure time physical activities (LTPA) of community-dwelling
18 persons who have been screened positive for dementia. *BMC Geriatrics*, *21*(1), 270.
19 <https://doi.org/10.1186/s12877-021-02201-1>

20 Nasreddine, Z. S., Phillips, N. A., Bédirian, V., Charbonneau, S., Whitehead, V., Collin, I., Cummings, J. L.,
21 & Chertkow, H. (2005). The Montreal Cognitive Assessment, MoCA: A Brief Screening Tool For
22 Mild Cognitive Impairment. *Journal of the American Geriatrics Society*, *53*(4), 695–699.
23 <https://doi.org/10.1111/j.1532-5415.2005.53221.x>

1 Pavey, T. G., Gomersall, S. R., Clark, B. K., & Brown, W. J. (2016). The validity of the GENEActiv wrist-
2 worn accelerometer for measuring adult sedentary time in free living. *Journal of Science and*
3 *Medicine in Sport, 19*(5), 395–399. <https://doi.org/10.1016/j.jsams.2015.04.007>

4 R. Core Team. (2016). *R: A language and environment for statistical computing*. R Foundation for
5 Statistical Computing.

6 Ramires, V. V., Wehrmeister, F. C., Böhm, A. W., Galliano, L., Ekelund, U., Brage, S., & da Silva, I. C. M.
7 (2017). Physical activity levels objectively measured among older adults: A population-based
8 study in a Southern city of Brazil. *International Journal of Behavioral Nutrition and Physical*
9 *Activity, 14*, 13. <https://doi.org/10.1186/s12966-017-0465-3>

10 Rowlands, A. V., Olds, T. S., Hillsdon, M., Pulsford, R., Hurst, T. L., Eston, R. G., Gomersall, S. R., Johnston,
11 K., & Langford, J. (2014). Assessing Sedentary Behavior with the GENEActiv: Introducing the
12 Sedentary Sphere. *Medicine & Science in Sports & Exercise, 46*(6), 1235–1247.
13 <https://doi.org/10.1249/MSS.0000000000000224>

14 RStudio Team. (2020). *RStudio: Integrated Development for R*. RStudio, PBC.

15 Shamali, M., & Østergaard, B. (2019). Implementing the actor-partner interdependence model for
16 dyadic data analysis: An overview for the nurse researcher. *Nurse Researcher, 27*(4).
17 <https://doi.org/10.7748/nr.2019.e1651>

18 Sheehan, C. M., & Tucker-Drob, E. M. (2019). Gendered Expectations Distort Male–Female Differences in
19 Instrumental Activities of Daily Living in Later Adulthood. *The Journals of Gerontology: Series B,*
20 *74*(4), 715–723. <https://doi.org/10.1093/geronb/gbw209>

21 Sport England. (2021). *Active Lives data tables*. Sport England. [https://www.sportengland.org/know-](https://www.sportengland.org/know-your-audience/data/active-lives/active-lives-data-tables)
22 [your-audience/data/active-lives/active-lives-data-tables](https://www.sportengland.org/know-your-audience/data/active-lives/active-lives-data-tables)

- 1 Stacey, A. F., Gill, T. K., Price, K., & Taylor, A. W. (2019). Biomedical health profiles of unpaid family
2 carers in an urban population in South Australia. *PLOS ONE*, *14*(3), e0208434.
3 <https://doi.org/10.1371/journal.pone.0208434>
- 4 Stubbs, B., Eggermont, L., Soundy, A., Probst, M., Vandenbulcke, M., & Vancampfort, D. (2014). What
5 are the factors associated with physical activity (PA) participation in community dwelling adults
6 with dementia? A systematic review of PA correlates. *Archives of Gerontology and Geriatrics*,
7 *59*(2), 195–203. <https://doi.org/10.1016/j.archger.2014.06.006>
- 8 Taylor, A., Cable, N., Faulkner, G., Hillsdon, M., Narici, M., & Van Der Bij, A. (2004). Physical activity and
9 older adults: A review of health benefits and the effectiveness of interventions. *Journal of Sports
10 Sciences*, *22*(8), 703–725. <https://doi.org/10.1080/02640410410001712421>
- 11 Topolski, T. D., LoGerfo, J., Patrick, D. L., Williams, B., Walwick, J., & Patrick, M. M. B. (2006). The Rapid
12 Assessment of Physical Activity (RAPA) Among Older Adults. *Preventing Chronic Disease*, *3*(4).
13 <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1779282/>
- 14 Tseliou, F., Atkinson, M., Paranjothy, S., & Ashfield-Watt, P. (2019). Do carers care for themselves? A
15 population-based study. *International Journal of Population Data Science*, *4*(3), Article 3.
16 <https://doi.org/10.23889/ijpds.v4i3.1215>
- 17 van Alphen, H. J. M., Hortobágyi, T., & van Heuvelen, M. J. G. (2016). Barriers, motivators, and
18 facilitators of physical activity in dementia patients: A systematic review. *Archives of
19 Gerontology and Geriatrics*, *66*, 109–118. <https://doi.org/10.1016/j.archger.2016.05.008>
- 20 van Alphen, H. J. M., Volkers, K. M., Blankevoort, C. G., Scherder, E. J. A., Hortobágyi, T., & van Heuvelen,
21 M. J. G. (2016). Older Adults with Dementia Are Sedentary for Most of the Day. *PLOS ONE*, *11*(3),
22 e0152457. <https://doi.org/10.1371/journal.pone.0152457>

- 1 Watts, A., Vidoni, E. D., Loskutova, N., Johnson, D. K., & Burns, J. M. (2013). Measuring Physical Activity
2 in Older Adults With and Without Early Stage Alzheimer's Disease. *Clinical Gerontologist*, *36*(4),
3 356–374. <https://doi.org/10.1080/07317115.2013.788116>
- 4 Watts, A., Walters, R. W., Hoffman, L., & Templin, J. (2016). Intra-Individual Variability of Physical
5 Activity in Older Adults With and Without Mild Alzheimer's Disease. *PLoS One; San Francisco*,
6 *11*(4). <http://dx.doi.org.ezproxy.brighton.ac.uk/10.1371/journal.pone.0153898>
- 7 White, T., Westgate, K., Wareham, N. J., & Brage, S. (2016). Estimation of Physical Activity Energy
8 Expenditure during Free-Living from Wrist Accelerometry in UK Adults. *PLoS ONE*, *11*(12).
9 <https://doi.org/10.1371/journal.pone.0167472>
- 10 WHO. (2015). *World Report On Healthy Ageing and Health*. WHO Press.
- 11 Winchester, J., Dick, M. B., Gillen, D., Reed, B., Miller, B., Tinklenberg, J., Mungas, D., Chui, H., Galasko,
12 D., Hewett, L., & Cotman, C. W. (2013). Walking stabilizes cognitive functioning in Alzheimer's
13 disease (AD) across one year. *Archives of Gerontology and Geriatrics*, *56*(1), 96–103.
14 <https://doi.org/10.1016/j.archger.2012.06.016>
- 15 Wion, R. K., Hill, N. L., DePasquale, N., Mogle, J., & Whitaker, E. B. (2020). The Relationship between
16 Subjective Cognitive Impairment and Activity Participation: A Systematic Review. *Activities*,
17 *Adaptation & Aging*, *44*(3), 225–245. <https://doi.org/10.1080/01924788.2019.1651188>
- 18 World Health Organization. (2010). *Global Recommendations on Physical Activity for Health*. World
19 Health Organization.
- 20 Wu, C.-Y., Miller, L. M., Wall, R. N., Beattie, Z. T., Silbert, L. C., & Kaye, J. A. (2021). Prolonged Physical
21 Inactivity in Older Adult Couples: A Dyadic Analysis Using Actigraphy. *Innovation in Aging*, *5*(1),
22 igaa066. <https://doi.org/10.1093/geroni/igaa066>
- 23 Zanco, M. F., Moraes, H., Maranhão Neto, G., Laks, J., Deslandes, A. C., Zanco, M. F., Moraes, H.,
24 Maranhão Neto, G., Laks, J., & Deslandes, A. C. (2016). Assessing cardiorespiratory capacity in

1 older adults with major depression and Alzheimer disease. *Jornal Brasileiro de Psiquiatria*, 65(1),
2 1–8. <https://doi.org/10.1590/0047-2085000000096>
3

Table 1. Participant characteristics of people with dementia (n=26) and their carer (n=26).

	Person with dementia	Carer
Age, mean(SD)	79.8 (5.8)	76.4 (5.9)
Sex: Male, n(%)	16 (31.4%)	7 (26.9%)
Physical complaints: Yes, n(%)	16 (61.5%)	14 (53.8%)
Physical complaints that influence physical activity: Yes, n(%)	8 (30.8%)	6 (23.1%)
More than one fall in the past year: Yes, n(%)	9 (34.6%)	4 (15.4%)
Regularly active (RAPA): Yes, n (%)	12 (46.2%)	10 (38.5%)
<i>Missing</i>	1 (3.8%)	1 (3.8%)

Table 2. Average daily participation in physical activity across the study. Differences are reported between carers and persons with dementia.

	Person with dementia (n=25)				Carer (n=24)				Between-group comparison	
	Mean (SD)	Median (IQR)	Min	Max	Mean (SD)	Median (IQR)	Min	Max	B	BCa 95%
Mean daily ENMO [mg]	17.02 (4.64)	17.25 (7.22)	7.2	27.5	20.48 (5.38)	19.85 (7.31)	11.12	31.94	-3.46	-6.18 to -0.75
MVPA time/day, 1-minute bouts [mins]	15.44 (14.40)	11.04 (23.39)	0.2	46.7	17.95 (17.01)	12.76 (19.53)	2.03	69.02	-2.50	-11.21 to 6.03
MVPA time/day, 10-minute bouts [mins]	4.03 (5.09)	2.54 (5.68)	0.0	18.1	4.92 (7.30)	1.49 (6.42)	0.00	24.20	-0.88	-4.25 to 2.39

BCa = Bias-corrected and accelerated, ENMO = Euclidean Norm Minus One, IQR = Interquartile range, MVPA = Moderate to Vigorous Physical Activity, SD = Standard Deviation

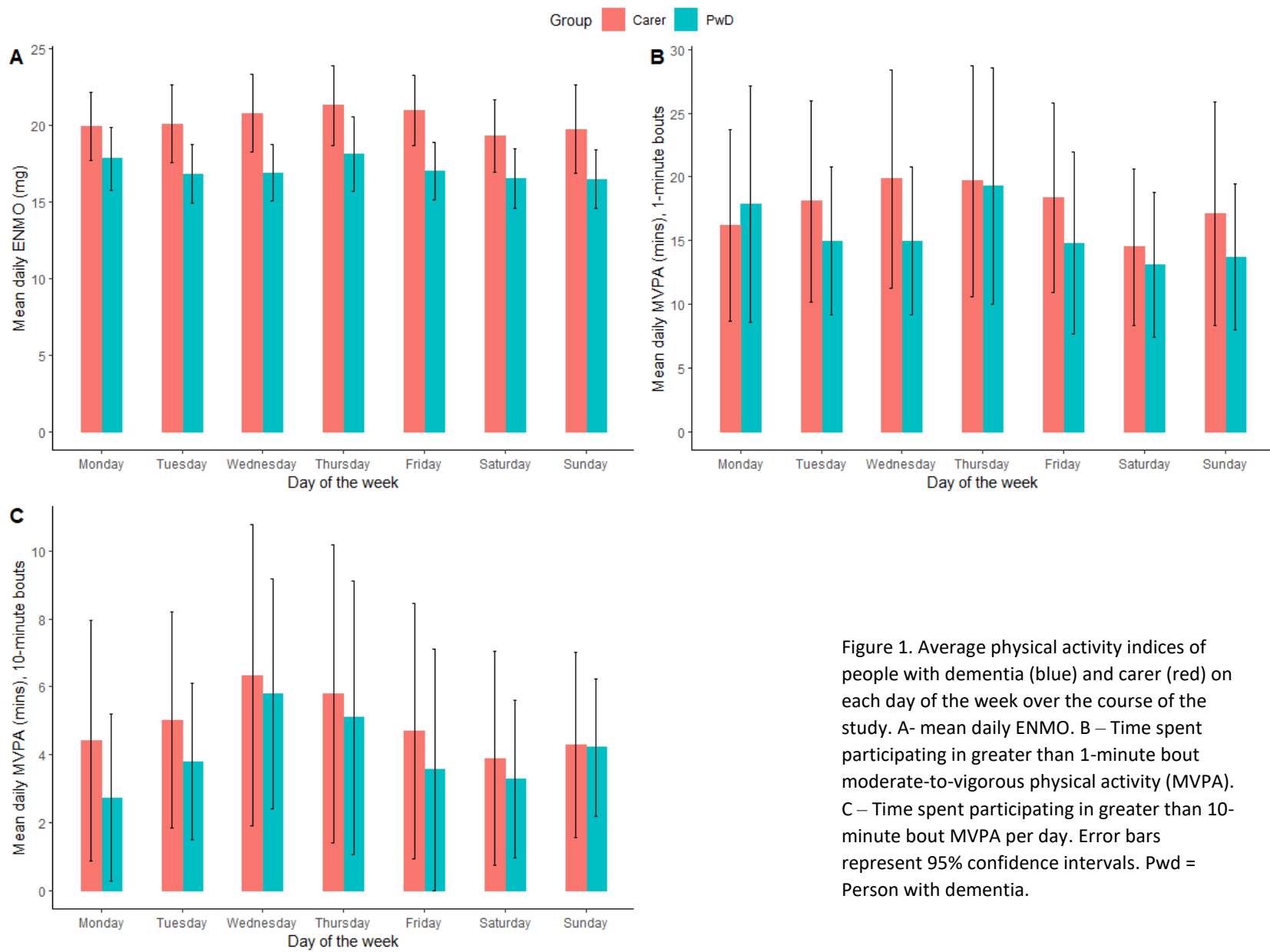


Figure 1. Average physical activity indices of people with dementia (blue) and carer (red) on each day of the week over the course of the study. A- mean daily ENMO. B – Time spent participating in greater than 1-minute bout moderate-to-vigorous physical activity (MVPA). C – Time spent participating in greater than 10-minute bout MVPA per day. Error bars represent 95% confidence intervals. Pwd = Person with dementia.

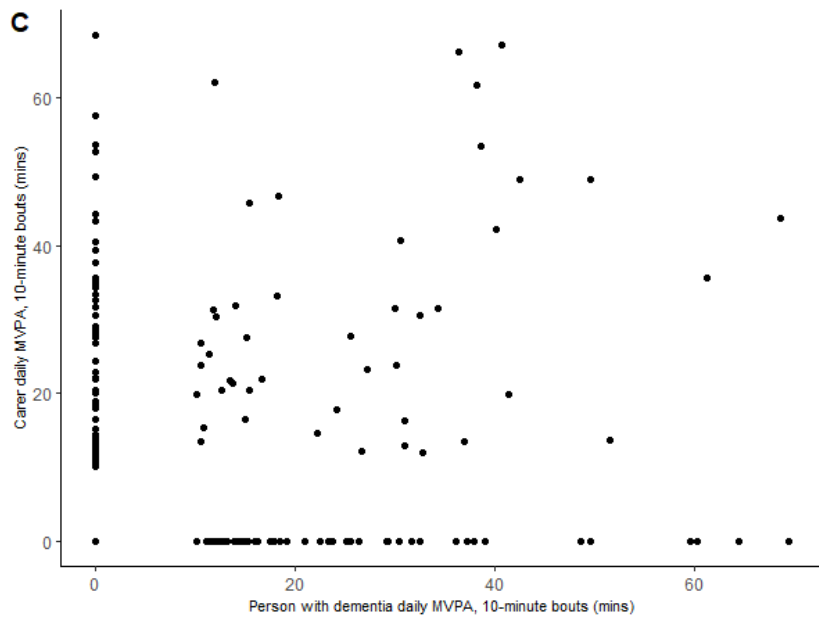
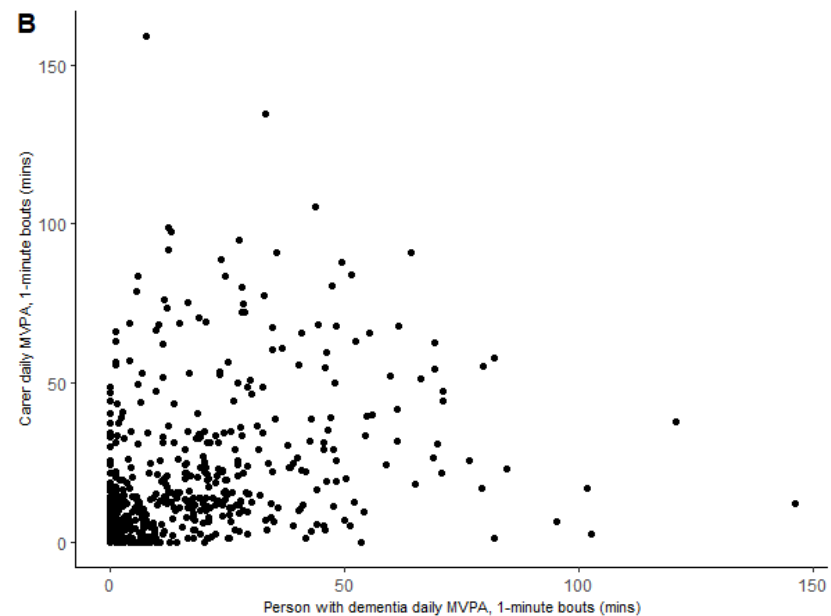
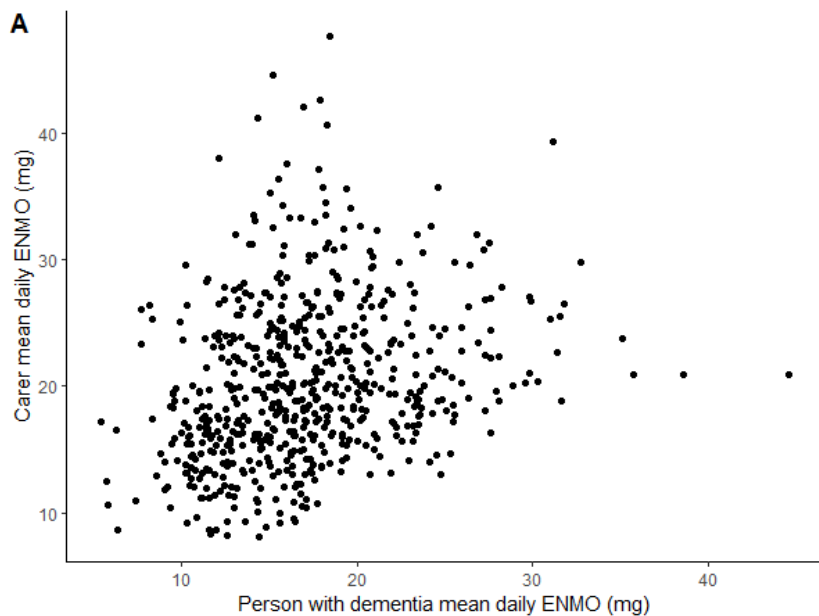


Figure 2. A- mean daily ENMO of the person with dementia vs their carer. B – Time spent participating in greater than 1-minute bout moderate-to-vigorous physical activity (MVPA) of the person with dementia vs their carer. C – Time spent participating in greater than 10-minute bout MVPA per day of the person with dementia vs their carer.