The Role of Physical Activity and Sedentary Behavior in Predicting Daily Pain and Fatigue in Older Adults: A Diary Study

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Abstract

Background. Little attention has been paid to within-person daily associations amongst light physical activity (PA), moderate-to-vigorous physical activity (MVPA), and sedentary behavior (SB) with subsequent bodily pain and fatigue. Daily reports of pain and fatigue are less likely to be affected by recall bias and to conflate days of high and low pain/fatigue into one overall score.

Purpose. To examine daily within-person associations between pain, fatigue and physical health and ascertain whether such associations are moderated by individual differences in these variables.

Methods. Participants were 63 community-living older adults (female $n = 43$, mean age = 70.98 years). Questionnaires measured typical levels of PA, SB, bodily pain, fatigue and physical health. Subsequently, on a daily basis over a 1-week period, participants' levels of light PA, MVPA and SB were measured using accelerometers. Participants completed a questionnaire rating their pain and fatigue at the end of each day.

Results. Multilevel modelling revealed positive within-person associations between daily light PA, daily MVPA, and pain, as well as negative within-person associations between daily SB and pain. For individuals with higher typical levels of fatigue, there was a negative association between daily light PA, MVPA and fatigue. For individuals with better levels of physical health, there was also a negative association between daily MVPA and fatigue. For those with higher typical levels of fatigue and better levels of physical health, there was a positive association between daily SB and fatigue. No such interaction effects were found between high levels of typical pain and PA or SB.

Conclusions. Our findings indicate that efforts to promote daily PA in older adults might be more effective for those who report high typical levels of fatigue and physical health, compared to those who report high levels of daily physical pain.

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41 According to the United Nations [1], the number of older adults (≥ 60 years) worldwide is

42 expected to increase from 901 million in 2015 to 1.4 billion by 2030. As adults age, they are

43 more likely to experience negative health outcomes (e.g., heart disease, back pain) [2]. For

44 example, evidence shows that many older adults in community settings suffer from bodily

45 pain (63% in men, 91% in women) [3] and fatigue (15% in men, 29% in women) [4]. Bodily

46 pain has been found to be negatively related to walking speed, balance and physical

47 functioning in older women in community settings [5]. With regard to fatigue, positive

48 associations have been reported between this variable and negative health conditions (e.g.,

49 arthritis) in older adults [6].

50   It is well documented that lifestyle factors such as physical activity (PA) and

51 sedentary behavior (SB) can play an important role in determining health-related quality of

52 life in older adults [7]. Evidence shows a positive association between engaging in moderate-

53 to-vigorous PA (MVPA) and improved physical health (e.g., decreased risk of mortality,

54 stroke, type 2 diabetes) [8] and mental health (e.g., fewer depression symptoms) in older

55 adults [9]. In light of recent literature that has identified a high prevalence of light PA in the

56 general public [10], particularly in older adults, research has also examined the role of light

57 PA in improved physical health. Previous studies have reported positive associations between

58 engagement in light PA and the reduction of coronary heart disease in adults and older men

59 [11], as well as fewer depression symptoms in older adults [9].

60   In contrast, spending a large proportion of the day in SB among older adults (age 70-

61 85; men 67.8%, women: 66.3%) [12] can have a negative impact upon health. For example,

62 Stamatakis et al. [13] found that engagement in self-reported SB was associated with a higher

63 cholesterol ratio, BMI, and waist circumference in older adults. Taken together, this evidence

64 indicates that lifestyle factors such as light PA, MVPA and lower SB are important predictors

65 of health. Evidence has also accumulated regarding the role of light PA, MVPA and SB in

66 predicting two important indices of health, namely, bodily pain and fatigue.

67 **Physical Activity, Sedentary Behavior and Bodily Pain**

68 Engagement in self-reported PA has been related to less back pain in older adults [14]. In line

69 with this, PA is recommended as a treatment for chronic pain [15]. Additionally, higher

70 levels of sitting time have been associated with worse bodily pain in community-living older

71 adults [16]. However, the associations between pain and PA are complicated and seem to be

72 influenced by the level at which these associations are investigated. For example, exploration

73 of within-person associations in older adults revealed that daily levels of PA were a

74 significant predictor of higher levels of daily pain in women, even though overall/typical PA

75 was associated with lower levels of pain [17]. In line with this finding, there is also evidence

76 that some older adults who report that activity worsens their pain, also use exercise to manage

77 their pain [18]. Interestingly, the interference of pain with activity was particularly evident in

78 those with severe levels of pain [18], suggesting that typical pain could influence the

79 association between daily pain and daily PA. Within-subject analyses can be used to explore

80 the associations between daily pain and daily PA in more detail, while exploring the

81 moderating influence of typical pain on these associations [17]. In addition, given the

82 negative associations between physical health and pain [19] and between physical health and

83 SB [20], as well as the positive associations between physical health and PA [21], it is also

84 important to examine the moderating influence of physical health in the association between

85 daily PA/SB and daily pain.

86 Daily self-reports are less likely to be affected by recall bias and to conflate days of

87 high and low pain into one overall score of pain. Further, by separating within-person from

88 between-person associations, it is possible to ascertain the degree to which variables correlate

89 with each other within the same individual over time, without such correlations being

influenced by between-person differences in the levels of these variables [22]. As noted by

Curran, Howard, Bainter, Lane, and McGinley [23], virtually all theories in the psychological

sciences postulate joint within- and between-person processes. Omitting either of these two

components results in a disjunction between theory and statistical testing. From an applied

perspective, understanding true within-person associations over time helps to develop more

tailored interventions.

Physical Activity, Sedentary Behavior and Fatigue

Several studies have shown that fatigue is associated with restricted activities [24], lower

levels of PA [25,26], and more dependency in activities of daily living [27]. With regard to

SB, it has been shown that sedentary adults report higher levels of fatigue compared to active

adults [28,29]. There is also evidence that exercise interventions can reduce fatigue in adults

aged 55 and older, and that the improvements in fatigue are related to the improvements in

PA [26]. Similar to the research on pain, however, the relation between fatigue and PA has

been mainly examined at the between-person level. Nevertheless, feelings of fatigue can vary

at the within-person (i.e., daily) level [30], and these within-person changes in fatigue are

negatively related to changes in PA [31]. Interestingly, levels of typical fatigue have also

been negatively related to diurnal PA patterns and physical health (chronic conditions) [32],

suggesting that when exploring the associations between fatigue and PA at within-person

level, typical levels of fatigue and physical health should be taken into account.

Purpose of the Study

Our aim was to examine the relation between daily (over a 7-day period) light PA, MVPA,

and SB, and subsequent bodily pain and fatigue. We also investigated whether such

associations were moderated by individuals' typical levels of bodily pain, fatigue and

physical health. This is the first attempt to examine within-and between person associations

of light PA, MVPA and SB with subsequent bodily pain and fatigue in older adults. It was

115 hypothesized that daily light PA and MVPA would predict lower levels of daily pain,

116 whereas daily SB would predict higher levels of pain, but only for those with low levels of

117 typical pain and high levels of physical health. In addition, it was hypothesized that daily

118 light PA and MVPA would predict lower levels of fatigue, whereas daily SB would predict

119 higher levels of fatigue, but only for those with low levels of typical fatigue and high levels

120 of physical health.

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Method

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Participants

123 Older community-dwelling adults ($n = 67$) in the UK were recruited. Inclusion criteria were

124 that participants did not use a walker or a wheelchair and were above the age of 60 years.

125 Simulation studies (e.g., McNeish & Stapleton; Maas & Hox) [33,34] indicate that $N > 50$ at

126 level 2 (participants in our case) of a multilevel model, provides adequate power for variance,

127 standard error and fixed effects estimates. A list of contacts was provided to the researchers

128 from a database of about 1000 volunteers who were registered with a UK university as

129 potential participants for studies on ageing-related topics. Participants were sent invitation

130 letters and/or emails. In total, 63 participants ($n = 63$, $M_{age} = 70.98$, $SD = 6.92$, female =

131 68.3%) were included in the analysis, after four participants were excluded (not sufficient

132 accelerometer wear time = 2, using a walker = 2) from the analysis. As can be seen in Table 1,

133 the participants had an average body mass index (BMI; kg/m^2) of 25.14 ($SD = 3.47$), were

134 well educated (highest degree obtained = a post-graduate degree; 28.6%), and had a

135 comfortable income (£20,000-£35,000 = 34.9%). The participants were mostly white and

136 British (79.4%) and more than one-third of the participants were co-habitating (65.1%) with

137 their partner. Many participants (57.1%) reported having been diagnosed with a

138 cardiovascular condition.

Procedures

140 Ethical approval for this study was granted by the Ethical Review Committee at a UK

141 university. An introductory session about the study took place in an initial session in a lab or

142 in a convenient place for the participant. The participants signed written consent forms. Their

143 weight and height were then measured to calculate BMI (kg/m^2) using a portable scale

144 (TANITA BC-545N). Two participants refused to be measured, and their self-reported

145 weight and height were recorded. At the beginning of the study, a set of questionnaires was

146 distributed to the participants, to provide pre-diary typical measures of the study variables,

147 including demographics. Further, either a palmtop computer (Scroll Pocket Tablet PC) or a

148 smartphone (ZTE Blade Q Mini Android Smartphone), depending on equipment availability,

149 was given to the participants for the daily assessments. The devices were programmed to

150 prompt a set of daily questions between 4 pm and 9 pm every day on a random basis. The

151 devices had touch-screens which participants had to tap to record an answer. If the

152 participants did not respond to the first alarm, a second alarm was provided 2 minutes later. If

153 there were no answers, the question was treated as missing (n= 45). Answers that were

154 outside of the alarm range due to system errors were treated as missing (n= 1). The answers

155 were stored within each participant's device. At the end of the data collection, research staff

156 downloaded the answers from the devices to a lab-based desktop computer. In addition to the

157 touchscreen devices, an accelerometer was distributed to the participants to wear over seven

158 days during waking hours. Participants were instructed to wear the monitor on their right hip,

159 to avoid wearing the accelerometer during any water activities, and to record in a diary each

160 time point when they started and stopped wearing the accelerometer.

161 **Measures**

162 *Demographics*

163 We asked participants to tick whether they were diagnosed with any cardiovascular disease

164 over the past 12 months. We assessed the occurrence (*have* = 1, *do not have* = 0) of high

165 cholesterol, heart disease, vascular disease, high blood pressure and circulatory problems. In

166 addition, gender (*male = 0, female = 1*) and marital status (*living alone = 0, living with*

167 *someone else = 1*) were coded.

168 ***Typical and daily bodily pain***

169 For typical pain, participants were asked to complete the two pain items from the RAND 36-

170 Item Health Survey [35] [i.e., "How much bodily pain have you had during the past 4 weeks?"

171 ranging from 1 (*none*) to 6 (*very severe*), and "During the past 4 weeks, how much did pain

172 interfere with your normal work (including both work outside the home and housework)?",

173 ranging from 1 (*not at all*) to 5 (*extremely*)]. The coefficient alpha (α) was 0.78 in a previous

174 study [35] and α = 0.79 in the present study. Items were averaged for our analysis. To

175 measure daily bodily pain, we asked one item: "How much bodily pain do you have right

176 now?", and responses were rated on a 1 (*no pain*) to 4 (*severe pain*) scale.

177 ***Typical and daily fatigue***

178 The Multi-Dimensional Fatigue Index (MFI-20) [36] was utilized to assess fatigue over the

179 previous 4 weeks with a total of 20 items. The scale tapped five dimensions of fatigue:

180 general fatigue (e.g., "I feel tired"), physical fatigue (e.g., "Physically, I feel able to only do a

181 little"), reduced activity (e.g., "I think I do very little in a day), mental fatigue (e.g., "My

182 thoughts easily wander"), and reduced motivation (e.g., "I don`t feel like doing anything).

183 Answers were rated on a 5-point scale from 1 (*yes, that is true*) to 5 (*no, that is not true*).

184 Good internal reliability coefficients were found in a previous study (α range: 0.75-0.94) [36]

185 and in the present study (α range: 0.67-0.83). Subscales were summed to calculate a total

186 fatigue score. To assess daily fatigue, one item ("How much fatigue do you feel right now?")

187 was chosen from the MFI and was answered at each beep. Participants provided a rating from

188 1 (*no fatigue*) to 4 (*severe fatigue*).

189 ***Daily physical activity and sedentary behavior***

190 Accelerometers were used to monitor PA and SB levels (model GT3X+ was worn by 47

191 participants and model WGT3X-BT was worn by 16 participants). The two models have been

192 shown to produce very similar results [37], and this was also the case in our study according

193 to the results of one-way MANOVA (Pillai's trace = 0.01, F (3, 59) = 0.19, p = .91, follow-

194 up univariate ANOVAs: SB: F (1, 61) = 0.19, p = .67, light PA: F (1, 61) = 0.00, p = .98, and

195 MVPA: F (1, 61) = 0.1, p = .76). Hence, in our analysis we combined the data from the two

196 types of accelerometers. Participants who wore the accelerometer a minimum of 10 hours a

197 day for 5 days, including 1 weekend day over 7 days, were included in the analysis Data were

198 extracted using the ActiGraph software. The researcher programmed the monitor to

199 accumulate movement data every 60 seconds. Non-wear time was classified as 90 minutes of

200 consecutive non-activity counts (< 100 counts) with 2 minutes of tolerance allowance

201 [38].Based on the diary the participants recorded, we set a time filter to standardize wearing

202 time (7:30 am to 10:30 pm). For the purposes of our analysis, for each day and for each

203 participant, we utilized the movement data accumulated from the morning until the time they

204 answered the daily questions on bodily pain and fatigue. Hence, in our analysis daily PA and

205 SB were used as predictors of daily bodily pain and fatigue.

206 Counts per minute were processed to categorize the thresholds of activities [i.e., SB:

207 0-99 counts per minute (cpm) [12] light PA: 100-2019 cpm, moderate PA: 2,020-5,998 cpm,

208 and vigorous PA: ≥5,999 cpm [39]. Moderate and vigorous intensities were summed to

209 represent MVPA. Finally, each activity category (light PA, MVPA, and SB) was divided by

210 the total wear days and then multiplied by 100 to represent the proportion of each activity

211 category, in order to reduce inter-participant variability [10,40]. These proportion scores were

212 used in the main analysis.

213 *Typical health status*

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214   The RAND 36-Item Health Survey was administered to measure physical health [35].

215   Participants were told: "The following questions are about activities you might do during a

216   typical day. During the past 4 weeks, has your health limited you in these activities? If so,

217   how much?" Rating scales varied depending on items (e.g., carrying groceries). Higher scores

218   on the fours subscales represented better physical health [35]. Good internal consistency

219   coefficients have been found in adults (mean age = 30.54, α = 0.89) [41] , and this was also

220   the case in the current study (α = 0.75).

221   *Typical physical activity*

222   Typical PA was assessed using the Physical Activity Scale for the Elderly (PASE) [42] . In

223   total, 18 items were rated using 4-point scales (hours/week) (e.g., "How much time was spent

224   on the activity over the last 7 days?") and yes/no questions (e.g., "Have you performed 'light

225   housework' over the last 7 days?"). The items captured 7 dimensions of PA (e.g., walking,

226   light sport/recreation). Items were multiplied by the number of hours the participants spent

227   and were weighted and summed to obtain an overall score of PA [43]. People with higher

228   scores were more physically active. Acceptable Cronbach's alpha for reliability was 0.73 in a

229   previous study with older adults [44], but somewhat lower in our study (α = .56).

230   *Typical sedentary behavior*

231   Typical sedentary time was assessed with seven items from the Measure of Older adults`

232   Sedentary Time (MOST) [45]. The survey asked the participants to record their total

233   sedentary time (hours and minutes) over the previous seven days (e.g., watching television).

234   Items were summed with higher scores representing higher levels of SB. Test-retest

235   reliability was found to be acceptable (Intra-class correlation coefficient = 0.52, 95%

236   confidence interval = 0.27-0.70) in older adults [45]. The Cronbach's alpha coefficient is not

237   applicable for this scale.

238   **Data Analysis**

239 Linear mixed models (IBM SPSS, version 22) were tested to examine within- and between-

240 person associations between light PA, MVPA, and SB with bodily pain and fatigue. We ran

241 four models in total. In the first two, light PA and MVPA predicted bodily pain and fatigue

242 respectively, and in the other two models SB predicted pain and fatigue respectively. Within-

243 person predictors (level 1; daily light PA, daily MVPA, and daily SB) were person-mean

244 centered. At level 2, the average of daily light PA, daily MVPA and daily SB over the 7 days

245 were entered as predictors. By including the predictor average scores over the 7-day period at

246 level 2, the level 1 within-person associations were not conflated by between-person

247 differences [22]. In addition, we tested the cross-level interactions between each of the level 1

248 predictors with typical pain (when predicting daily pain), with typical fatigue (when

249 predicting daily fatigue), and with physical health (when predicting daily pain and fatigue).

250 BMI, age, presence/absence of cardiovascular disease, gender and co-habitating were also

251 entered at level 2 as covariates. Level 2 predictors were uncentered [46]. All level 1 and 2

252 predictors, apart from the categorical ones, were converted into Z scores to obtain β

253 coefficients from the analysis. R_1^2 was estimated as an effect size, representing the amount of

254 variance at level 1 explained by the predictors, compared to the variance explained by a

255 model with only the intercept [47].

Results

257 Participants completed 341 (77.3%) out of 441 (over seven days) daily questions on bodily

258 pain and fatigue. The percentage of missing cases for the pre-diary survey was around 3.2%.

259 The skewness scores for the dependent variables of bodily pain (1.89) and fatigue (0.93) were

260 within an acceptable range (skewness ±2) [48]. Daily light PA and SB were highly correlated

261 (r= -0.83, p< 0.01) as is often the case in the literature; hence, separate models for light PA

262 and SB were run.

263   Table 2 shows that the participants wore accelerometers for almost 10 hours (594.13

264   minutes) before they answered the daily questions. The participants spent most of their time

265   in SB (58.58%) and light PA (35.80%), with a lower proportion of MVPA (5.62%).

266   According to R_1^2, models 1 and 2 (Table 3) predicted 52.8% (bodily pain) and 21.0% (fatigue)

267   of the variance at level 1. Also, models 3 and 4 (Table 4) accounted for 54.8% (bodily pain)

268   and 19.1% (fatigue) of the variance.

269   **Daily light PA, MVPA, and daily SB Predicting Bodily Pain**

270   Table 3 shows the standardized coefficients (β) and standard errors for level 1 and level 2

271   predictors of bodily pain. Engagement in daily light PA ($\beta= 0.151$, $p= 0.009$), daily MVPA

272   ($\beta= 0.110$, $p= 0.023$), and higher levels of typical pain ($\beta= 0.543$, $p<0.001$) positively

273   predicted bodily pain experienced at the daily level. No other significant associations were

274   found. Typical bodily pain and physical health did not significantly moderate the associations

275   between daily light PA, MVPA, and bodily pain. Table 4 shows that typical pain ($\beta= 0.515$,

276    $p<0.001$) and daily SB ($\beta= -0.182$, $p= 0.003$) over the 7 days predicted bodily pain at the

277   daily level. No other associations were significant.

278   **Daily light PA, MVPA, and SB Predicting Fatigue**

279   Table 3 depicts that daily light PA and MVPA did not significantly predict fatigue. However,

280   a number of significant interactions emerged. Those interactions were further probed via

281   simple slope analyses, for which we report unstandardized coefficients. Specifically, for

282   individuals with lower levels of typical fatigue, there was a positive association between daily

283   light PA and daily fatigue (B = 3.28, $p< 0.001$), whereas for those with higher levels of

284   typical fatigue, this association was negative (B = -3.22, $p= 0.001$). For those with lower

285   levels of typical fatigue, there was also a positive association between daily MVPA and daily

286   fatigue (B = 3.49, $p< 0.001$), whereas for those with higher levels of typical fatigue, this

287   association was negative (B = -3.41, $p< 0.001$). For individuals with lower typical levels of

288 physical health, there was a positive association between daily MVPA and fatigue (B = 2.93,

289 p= 0.027), whereas for those with higher levels of typical physical health, this association

290 was negative (B = -2.85, p= 0.034). Typical levels of physical health did not significantly

291 interact with light PA to predict daily fatigue. With regard to main effects, typical fatigue (β=

292 0.263, p= 0.031) and cardiovascular disorder (β= 0.483, p= 0.014) were also significantly

293 associated with daily fatigue.

294 Simple slope analyses were also conducted to probe significant interactions in Table 4.

295 Specifically, for individuals with lower typical levels of fatigue, there was a negative

296 association between daily SB and fatigue (B = -4.612, p< 0.000), whereas for those with

297 higher levels of typical fatigue, this association was positive (B = 4.513, p<0.000). For

298 individuals with lower typical levels of physical health, there was a negative association

299 between daily SB and fatigue (B = -3.779, p= 0.019), whereas for those with higher levels of

300 typical physical health, this association was positive (B = 3.680, p= 0.022). With regard to

301 main effects, typical fatigue (β= 0.274, p= 0.026) and the presence of cardiovascular diseases

302 (β= 0.489, p= 0.013) also predicted daily fatigue.

Discussion

304 In this study we examined daily associations between objectively-assessed light PA, MVPA,

305 and SB, and subsequent bodily pain and fatigue in a sample of older adults. Further, we

306 explored whether these within-person associations were moderated by between-person

307 differences in typical bodily pain, fatigue and physical health.

Predictors of Bodily Pain

309 We expected that daily light PA and MVPA (and SB) would be negative (positive) predictors

310 of daily pain, but only for those with low levels of typical pain and better levels of health.

311 Contrary to our hypothesis, the within-person associations of daily light PA and MVPA with

312 daily bodily pain were positive, in that more engagement in daily light PA and MVPA

313   predicted more subsequent bodily pain. However, this finding is in line with a previous study

314   in which a positive within-person association was found between PA and pain in a sample of

315   older adults [17]. With respect to daily SB and bodily pain, the analysis showed that more

316   engagement in daily SB was associated with less subsequent bodily pain in older adults. This

317   finding is aligned with our results pertaining to PA and pain.

318   Even though engagement in PA might predict higher levels of bodily pain in the short

319   term in older adults, it is well established that regular PA can maintain and improve health in

320   older adults [49,50]. In fact, there are studies showing a negative as opposed to a positive

321   association between PA and pain (e.g., Cecchi et al. [14]). Given these apparently

322   inconsistent findings regarding the associations between PA and pain, more research is

323   needed to explore the temporal effects of PA on pain in more detail. Future studies may need

324   to utilize more frequent measurement points (e.g., hourly). Given some reports that feelings

325   of pain can fluctuate throughout the day [50], it is possible that PA/SB might predict pain in

326   different ways depending on the time of the day. It would also be interesting to explore the

327   impact of the type of activity on the associations between PA and pain. For example, lifting

328   heavy objects and gardening could have differential effects on the relationship between pain

329   and PA.

330   Finally, typical physical health did not moderate the associations between pain and

331   PA or SB. It should be acknowledged though that the overall perceived physical health of the

332   participants was good (i.e. 81 out of 100). Therefore, in order to explore this hypothesis in the

333   future it is important to include a sample with a greater variation in perceived physical health.

334   **Predictors of Fatigue**

335   We expected that daily light PA and MVPA (and SB) would be negative (positive) predictors

336   of daily fatigue, but only for those with low levels of typical fatigue and better levels of

337   physical health. The results partially supported our hypotheses. There were no significant

338   within- and between-person associations between light PA, MVPA, SB and subsequent

339   fatigue. Other studies have generally reported modest negative associations between fatigue

340   and PA [25,51]. Such modest and/or non-significant associations could be due to the

341   possibility that the relations between PA, SB and fatigue are dependent on individuals' levels

342   of health and their general levels of fatigue.

343   Better typical levels of physical health moderated the association between daily

344   MVPA and fatigue, and between SB and fatigue. As hypothesized, those who engaged in

345   more MVPA and less SB reported less fatigue, but this was the case only for individuals with

346   better perceived health. In contrast, for those with worse perceived health, engagement in

347   more MVPA and less SB was detrimental as it resulted in more daily fatigue. Interestingly,

348   physical health did not moderate the association between light PA and fatigue. These findings

349   suggest that intensive forms of PA should be reserved for those in better physical health,

350   while those in lower physical health should initially be prescribed light PA. Given that

351   physical health did not influence the associations between light PA and fatigue, perhaps light

352   PA would be the most suitable type of PA to start an intervention to reduce fatigue for older

353   adults. Increasing light PA might not only benefit levels of fatigue and physical health, but it

354   is also a feasible target for older adults who are not active.

355   Contrary to our hypothesis, the expected negative (positive) association between daily

356   light PA (SB) and subsequent daily fatigue were evident only for those individuals with high

357   (as opposed to low) typical fatigue levels. The current findings suggest that those with higher

358   typical levels of fatigue might benefit more in terms of their daily fatigue levels from moving

359   more and sitting less than those with lower levels of typical fatigue. Even though exercise

360   interventions have been shown to reduce the levels of fatigue [52], even in clinical

361   populations with high levels of fatigue such rheumatoid arthritis [53] and multiple sclerosis

362   [54], to our knowledge little attention has been paid to the moderating role of typical levels of

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363 fatigue on these benefits. Therefore, the possibility that those with higher levels of typical

364 fatigue might benefit more from being physically active in terms of their daily fatigue should

365 be investigated in future intervention studies. Our findings also highlight the need to focus

366 PA-promoting interventions in older adults on individuals who report high levels of fatigue

367 and perhaps experience chronic fatigue. Given that higher levels of light PA were associated

368 with lower levels of fatigue in those with higher levels of typical fatigue, perhaps PA-

369 promoting interventions for this particular population should focus on light PA. As

370 mentioned above, this is likely to be a feasible target for people who are not physically active,

371 and such type of activity can help to increased overall health [55,56].

Limitations and Future Research Directions

373 We must acknowledge some limitations of the present study. The standardized coefficients

374 associated with the main effects of daily SB, light PA and MVPA were small. However, such

375 effects are in line with our research in the pain and fatigue literatures utilizing objective

376 assessments of PA [25,51]. Given that our participants were generally inactive, 1 SD

377 increases in daily SB, light PA and MVPA represent substantial deviations from the sample's

378 mean scores on those variables. It should be also considered that objective PA and self-

379 reported pain and fatigue do not share common method variance, as is the case with self-

380 reported PA. Another limitation of the study is that due to its short duration (7 days), we do

381 not know the extent to which our findings would generalize over a longer period of time (e.g.,

382 two or three months). A measurement burst approach [57] in which diaries are administered

383 on multiple occasions (e.g., 3 weeks over a year) would allow for a test of seasonal effects

384 (e.g., due to the weather). Assessing multiple activities and rates of fatigue and pain

385 throughout the same day can also offer a more comprehensive understanding of the dynamic

386 nature of the relations between these two variables, PA and SB. In addition, objectively-

387 assessed PA cannot readily differentiate between different modes of activity (e.g., lifting

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388　heavy objects vs. playing with children) which can predict variations in perceptions of pain

389　and fatigue. Another limitation of the study was that the sample was rather ethnically

390　homogenous, relatively educated, relatively healthy (e.g., low bodily pain and fatigue scores),

391　quite wealthy, and thus not wholly representative of the general population of older adults in

392　the UK. Future studies should aim to recruit older adults from more diverse backgrounds.

393　Further, another limitation was that we used self-reported measures of health. In future

394　investigations, it might be informative to replicate our study using objective assessments of

395　physical health (e.g., field- based tests of gait speed or hand grip strength).

396　Notwithstanding the limitations above, this study has several strengths. This is the first study

397　to examine within-person associations between light PA, MVPA, SB and subsequent daily

398　pain and fatigue in older adults. We were able to establish support for such within-person

399　associations which were not confounded by individual differences in PA and SB. In addition,

400　advancing past research, we specifically measured light PA because in older adults a high

401　proportion of time is spent engaging in this type of PA [10,58]. Indeed, we found that

402　engagement in daily light PA represented 35.80% of the daily activity up to the measurement

403　of pain and fatigue, a much higher percentage than that for MVPA (5.62%). We measured

404　levels of PA and SB both objectively and via self-reports. In contrast, most of the previous

405　studies have only used self-reports of PA and/or SB in predicting bodily pain and fatigue. By

406　using smart devices for EMA, we were able to obtain real-time reports of pain and fatigue.

407　Future studies in this field could build on our findings to develop targeted PA interventions

408　for individuals with varying levels of fatigue and pain. Such interventions could use modern

409　technology (e.g., smartphones) to target beliefs, barriers and benefits of being more

410　physically active and less sedentary.

References

411   **References**

412   1.   United Nations. *World Population Ageing 2015*.; 2015.

413   http://www.un.org/en/development/desa/population/publications/pdf/ageing/WPA2015

414   _Report.pdf.

415   2.   World Health Organization. 10 facts on ageing and health.

416   http://www.who.int/features/factfiles/ageing/en/. Published 2016.

417   3.   Bergh I, Steen G, Waern M, et al. Pain and its relation to cognitive function and

418   depressive symptoms: A Swedish population study of 70-year-old men and women. *J*

419   *Pain Symptom Manage*. 2003;26(4):903-912. doi:10.1016/S0885-3924(03)00329-4.

420   4.   Vestergaard S, Nayfield SG, Patel K V, et al. Fatigue in a Representative Population of

421   Older Persons and Its Association With Functional Impairment, Functional Limitation,

422   and Disability. *Journals Gerontol*. 2009;64A(1):76-82. doi:10.1093/gerona/gln017.

423   5.   Sampaio RAC, Sewo Sampaio PY, Uchida MC, et al. Walking speed and balance

424   performance are associated with Short-Form 8 bodily pain domain in Brazilian older

425   female. *J Clin Gerontol Geriatr*. 2015;6(3):89-94. doi:10.1016/j.jcgg.2015.02.005.

426   6.   Williamson RJ, Purcell S, Sterne A, et al. The relationship of fatigue to mental and

427   physical health in a community sample. *Soc Psychiatry Psychiatr Epidemiol*.

428   2005;40(2):126-132. doi:10.1007/s00127-005-0858-5.

429   7.   Vogel T, Brechat P -h., Leprêtre P -m., et al. Health benefits of physical activity in

430   older patients: a review. *Int J Clin Pract*. 2009;63(2):303-320.

431   doi:http://dx.doi.org/10.1111/j.1742-1241.2008.01957.x.

432   8.   World Health Organization. Global Strategy on Diet, Physical Activity and Health-

433   Physical Activity and Older Adults.

434   http://www.who.int/dietphysicalactivity/factsheet_olderadults/en/. Published 2016.

435   9.   Loprinzi PD. Objectively measured light and moderate-to-vigorous physical activity is

436   associated with lower depression levels among older US adults. *Aging Ment Health*.

437   2013;17(7):801-805. doi:10.1080/13607863.2013.801066.

438   10.   Owen N, Sparling PB, Healy GN, et al. Sedentary Behavior: Emerging Evidence for a

439   New Health Risk. *Mayo Clin Proc*. 2010;85(12):1138-1141.

440   doi:10.4065/mcp.2010.0444.

441   11.   Sesso HD, Paffenbarger RS, Lee I-M. Physical Activity and Coronary Heart Disease in

442   Men : The Harvard Alumni Health Study. *Circulation*. 2000;102(9):975-980.

443   doi:10.1161/01.CIR.102.9.975.

444   12.   Matthews CE, Chen KY, Freedson PS, et al. Amount of time spent in sedentary

445   behaviors in the United States, 2003-2004. *Am J Epidemiol*. 2008;167(7):875-881.

446   doi:http://dx.doi.org/10.1093/aje/kwm390.

447   13.   Stamatakis E, Davis M, Stathi A, Hamer M. Associations between multiple indicators

448   of objectively-measured and self-reported sedentary behaviour and cardiometabolic

449   risk in older adults. *Prev Med (Baltim)*. 2012;54(1):82-87.

450   doi:10.1016/j.ypmed.2011.10.009.

451   14.   Cecchi F, Debolini P, Lova RM, et al. Epidemiology of back pain in a representative

452   cohort of Italian persons 65 years of age and older: the InCHIANTI study. *Spine (Phila*

453   *Pa 1976)*. 2006;31(10):1149-1155. doi:10.1097/01.brs.0000216606.24142.e1.

454   15.   Connelly P. Guidance on the management of pain in older people. *Age Ageing*.

455   2013;42:i1-i57. doi:10.1093/ageing/afs200.

20

456   16.   Balboa-Castillo T, León-Muñoz LM, Graciani A, Rodríguez-Artalejo F, Guallar-

457   Castillón P. Longitudinal association of physical activity and sedentary behavior

458   during leisure time with health-related quality of life in community-dwelling older

459   adults. *Health Qual Life Outcomes*. 2011;9(1):47. doi:10.1186/1477-7525-9-47.

460   17.   Ho A, Ashe MC, DeLongis A, Graf P, Khan KM, Hoppmann CA. Gender Differences

461   in Pain-Physical Activity Linkages among Older Adults: Lessons Learned from Daily

462   Life Approaches. *Pain Res Manag*. 2016:9. doi:10.1155/2016/1931590.

463   18.   Brown ST, Kirkpatrick MK, Swanson MS, McKenzie IL. Pain Experience of the

464   Elderly. *Pain Manag Nurs*. 2011;12(4):190-196. doi:10.1016/j.pmn.2010.05.004.

465   19.   Reyes-Gibby CC, Aday L, Cleeland C. Impact of pain on self-rated health in the

466   community-dwelling older adults. *Pain*. 2002;95(1):75-82. doi:10.1016/S0304-

467   3959(01)00375-X.

468   20.   Rezende LFM de, Rodrigues Lopes M, Rey-López JP, Matsudo VKR, Luiz O do C.

469   Sedentary Behavior and Health Outcomes: An Overview of Systematic Reviews.

470   Lucia A, ed. *PLoS One*. 2014;9(8):e105620. doi:10.1371/journal.pone.0105620.

471   21.   Haider S, Luger E, Kapan A, et al. Associations between daily physical activity,

472   handgrip strength, muscle mass, physical performance and quality of life in prefrail

473   and frail community-dwelling older adults. *Qual Life Res*. 2016;25(12):3129-3138.

474   doi:10.1007/s11136-016-1349-8.

475   22.   Raudenbush SW, Bryk AS. *Hierarchical Linear Models: Applications and Data

476   Analysis Methods*. Vol 2nd.; 2002.

477   23.   Curran PJ, Howard AL, Bainter SA, Lane ST, McGinley JS. The separation of

478   between-person and within-person components of individual change over time: A

479   latent curve model with structured residuals. *J Consult Clin Psychol*. 2014;82(5):879-

480   894. doi:10.1037/a0035297.

481 24. Gill TM, Desai MM, Gahbauer EA, Holford TR, Williams CS. Restricted Activity

482   among Community-Living Older Persons: Incidence, Precipitants, and Health Care

483   Utilization. *Ann Intern Med*. 2001;135(5):313. doi:10.7326/0003-4819-135-5-

484   200109040-00007.

485 25. Egerton T, Chastin SFM, Stensvold D, Helbostad JL. Fatigue May Contribute to

486   Reduced Physical Activity Among Older People: An Observational Study. *Journals*

487   *Gerontol Ser A Biol Sci Med Sci*. 2016;71(5):670-676. doi:10.1093/gerona/glv150.

488 26. Nicklas BJ, Beavers DP, Mihalko SL, Miller GD, Loeser RF, Messier SP. Relationship

489   of Objectively-Measured Habitual Physical Activity to Chronic Inflammation and

490   Fatigue in Middle-Aged and Older Adults. *Journals Gerontol Ser A Biol Sci Med Sci*.

491   2016;71(11):1437-1443. doi:10.1093/gerona/glw131.

492 27. Moreh E, Jacobs JM, Stessman J. Fatigue, function, and mortality in older adults. *J*

493   *Gerontol A Biol Sci Med Sci*. 2010;65(8):887-895. doi:10.1093/gerona/glq064.

494 28. Ellingson LD, Kuffel AE, Vack NJ, Cook DB. Active and sedentary behaviors

495   influence feelings of energy and fatigue in women. *Med Sci Sports Exerc*.

496   2014;46(1):192-200. doi:10.1249/MSS.0b013e3182a036ab.

497 29. Wennberg P, Boraxbekk C-J, Wheeler M, et al. Acute effects of breaking up prolonged

498   sitting on fatigue and cognition: a pilot study. *BMJ Open*. 2016;6(2):e009630.

499   doi:10.1136/bmjopen-2015-009630.

500 30. Ravesloot C, Ward B, Hargrove T, et al. Why stay home? Temporal association of

501   pain, fatigue and depression with being at home. 2016;9(2):218-225.

502   doi:10.1016/j.dhjo.2015.10.010.

503   31.   Murphy SL, Kratz AL, Williams DA, Geisser ME. The association between symptoms,

504   pain coping strategies, and physical activity among people with symptomatic knee and

505   hip osteoarthritis. *Front Psychol*. 2012;3(SEP).

506   32.   Egerton T, Helbostad JL, Stensvold D, Chastin SFM. Fatigue Alters the Pattern of

507   Physical Activity Behavior in Older Adults: Observational Analysis of Data from the

508   Generation 100 Study. *J Aging Phys Act*. 2016;24(4):633-641. doi:10.1123/japa.2015-

509   0237.

510   33.   McNeish DM, Stapleton LM. The Effect of Small Sample Size on Two-Level Model

511   Estimates: A Review and Illustration. *Educ Psychol Rev*. 2016;28(2):295-314.

512   doi:10.1007/s10648-014-9287-x.

513   34.   Maas CJM, Hox JJ. Sufficient Sample Sizes for Multilevel Modeling. *Methodology*.

514   2005;1(3):86-92. doi:10.1027/1614-2241.1.3.86.

515   35.   Hays RD, Sherbourne CD, Mazel RM. The rand 36-item health survey 1.0. *Health*

516   *Econ*. 1993;2(3):217-227. doi:10.1002/hec.4730020305.

517   36.   Smets EMA, Garssen B, Bonke B, De M, Haes JCJ. The multidimensional Fatigue

518   Inventory (MFI) psychometric qualities of an instrument to assess fatigue. *J*

519   *Psychosom Res*. 1995;39(3 SRC):315-325. doi:http://dx.doi.org/10.1016/0022-

520   3999(94)00125-o.

521   37.   Miller J. Cross-Generation Accuracy. 2015. http://actigraphcorp.com/wp-

522   content/uploads/2015/04/cross-generation-accuracy.pdf.

523   38.   Choi L, Ward SC, Schnelle JF, Buchowski MS. Assessment of wear/nonwear time

524   classification algorithms for triaxial accelerometer. *Med Sci Sports Exerc*.

525   2012;44(10):2009-2016. doi:http://dx.doi.org/10.1249/mss.0b013e318258cb36.

526 39. Troiano RP, Berrigan D, Dodd KW, Mâsse LC, Tilert T, McDowell M. Physical

527   activity in the United States measured by accelerometer. *Med Sci Sports Exerc*.

528   2008;40(1):181-188. doi:10.1249/mss.0b013e31815a51b3.

529 40. Bélanger M, Townsend N, Foster C. Age-related differences in physical activity

530   profiles of English adults. *Prev Med (Baltim)*. 2011;52(3):247-249.

531   doi:10.1016/j.ypmed.2011.02.008.

532 41. Padden DL, Connors RA, Agazio JG. Stress, coping, and well-being in military

533   spouses during deployment separation. *West J Nurs Res*. 2011;33(2):247-267.

534   doi:10.1177/0193945910371319.

535 42. Washburn RA, McAuley E, Katula J, Mihalko SL, Boileau RA. The physical activity

536   scale for the elderly (PASE): evidence for validity. *J Clin Epidemiol*. 1999;52(7):643-

537   651. doi:10.1016/S0895-4356(99)00049-9.

538 43. Washburn RA, Smith KW, Jette AM, Janney CA. The physical activity scale for the

539   elderly (PASE): Development and evaluation. *J Clin Epidemiol*. 1993;46(2):153-162.

540   doi:10.1016/0895-4356(93)90053-4.

541 44. Loland N. Reliability of the physical activity scale for the elderly (PASE). *Eur J Sport

542   Sci*. 2002;2(5):1-12. doi:10.1080/17461390200072504.

543 45. Gardiner PA, Clark BK, Healy GN, Eakin EG, Winkler EAH, Owen N. Measuring

544   older adults' sedentary time: reliability, validity, and responsiveness. *Med Sci Sports

545   Exerc*. 2011;43(11):2127-2133. doi:10.1249/MSS.0b013e31821b94f7.

546   46.   Bolger N, Laurenceau J. *Intensive Longitudinal Methods*. New York: Guilford Press;

547   2013.

548   47.   Hox J, Moerbeek M, Schoot R van de. *Multilevel Analysis: Techniques and*

549   *Applications*. 2nd ed. New York: Routledge; 2010.

550   48.   Gravetter F, Wallnau L. *Statistics for the Behavioral Sciences*.; 2016.

551   49.   World Health Organization. *Global Recommendations on Physical Activity for Health*.;

552   2011.

553   50.   Focht B, Ewing V, Gauvin L, Rejeski W. The unique and transient impact of acute

554   exercise on pain perception in older, overweight, or obese adults with knee

555   osteoarthritis. *Ann Behav Med*. 2002;24(3):201-210.

556   51.   Mahieu MA, Ahn GE, Chmiel JS, et al. Fatigue, patient reported outcomes, and

557   objective measurement of physical activity in systemic lupus erythematosus. *Lupus*.

558   2016;25(11):1190-1199. doi:10.1177/0961203316631632.

559   52.   Puetz TW, O'Connor PJ, Dishman RK. Effects of chronic exercise on feelings of

560   energy and fatigue: A quantitative synthesis. *Psychol Bull*. 2006;132(6):866-876.

561   doi:10.1037/0033-2909.132.6.866.

562   53.   Rongen-van Dartel SAA, Repping-Wuts H, Flendrie M, et al. Effect of Aerobic

563   Exercise Training on Fatigue in Rheumatoid Arthritis: A Meta-Analysis. *Arthritis*

564   *Care Res (Hoboken)*. 2015;67(8):1054-1062. doi:10.1002/acr.22561.

565   54.   Pilutti LA, Greenlee TA, Motl RW, Nickrent MS, Petruzzello SJ. Effects of Exercise

566   Training on Fatigue in Multiple Sclerosis. *Psychosom Med*. 2013;75(6):575-580.

567   doi:10.1097/PSY.0b013e31829b4525.

568   55.   Manns PJ, Dunstan DW, Owen N, et al. Addressing the nonexercise part of the activity

569   continuum: a more realistic and achievable approach to activity programming for

570   adults with mobility disability? *Phys Ther*. 2012;92(4):614-625.

571   doi:10.2522/ptj.20110284.

572   56.   Matthews CE, Moore SC, Sampson J, et al. Mortality Benefits for Replacing Sitting

573   Time with Different Physical Activities. *Med Sci Sports Exerc*. 2015;47(9):1833-1840.

574   doi:10.1249/MSS.0000000000000621.

575   57.   Sliwinski MJ. Measurement-Burst Designs for Social Health Research. *Soc Personal*

576   *Psychol Compass*. 2008;2(1):245-261. doi:10.1111/j.1751-9004.2007.00043.x.

577   58.   Gando Y, Yamamoto K, Murakami H, et al. Longer Time Spent in Light Physical

578   Activity Is Associated With Reduced Arterial Stiffness in Older Adults. *Hypertension*.

579   2010;56(3):540-546. doi:10.1161/HYPERTENSIONAHA.110.156331.

580

Table 1

Participant Characteristics

Variable	
Sex, *n* (%)	63; female = 43 (68.3)
Age, mean (SD)	70.98 (6.92)
Education completed, *n* (%)	Missing 4 (6.3)
Primary	7 (11.1)
Secondary	10 (15.9)
Higher	15 (23.8)
Post graduate	18 (28.6)
Other	9 (14.3)
Annual income, *n* (%)	
Below £20,000	22 (34.9)
£20,000 -35,000	22 (34.9)
£35,000 – 45,000	11 (17.5)
Above 45,000	8 (12.7)
Ethnicity, *n* (%)	
White British	50 (79.37)
Other White	2 (3.17)
Black Caribbean	1 (1.59)
Indian	7 (11.11)
Other	3 (4.76)
BMI (kg/m^2), mean (SD)	25.14 (3.47)
Cardiovascular disorder (%)	0 = have (57.1), 1 = do not have (42.9)
Cohabiting with partner (%)	0 = no (34.9), 1 = yes (65.1)

584   Table 2

585   *Descriptive Statistics and Intraclass Correlation Coefficients for Study Variables*

	M	*SD*	ICC	*Min*	*Max*
1. Daily accelerometer wear time (min/day)	594.13	115.27	-	-	-
2. Daily SB (% waking time)	58.58	13.44	0.93	-	-
3. Person-mean SB (%)	59.15	10.70	-	-	-
3. Daily light PA (% waking time)	35.80	11.61	0.90	-	-
4. Person-mean light PA (%)	35.43	8.79	-	-	-
5. Daily MVPA (% waking time)	5.62	5.92	0.78	-	-
6. Person-mean MVPA (%)	5.42	3.72	-	-	-
7. Daily bodily pain (scale range = 1-4)	1.24	0.47	0.87	1	4
8. Daily fatigue (scale range = 1-4)	1.59	0.71	0.87	1	4
9. Typical physical health (scale range = 0-100)	80.95	17.59	-	21.67	100
10. Typical PA	140.57	58.11	-	43.21	330
11. Typical SB (min/day)	470.37	216.20	-	570	8,340
11. Typical pain (scale range = 1-5.5)	1.79	0.83	-	1	4.50
12. Typical fatigue (scale range = 20-100)	39.21	13.57	-	20	81
14. BMI (kg/m^2)	25.14	3.44	-	-	-
15. Age (years)	70.98	6.87	-	-	-

586

587   *Note.* Unstandardized estimates were used to calculate descriptive statistics.

Table 3

Multilevel Modelling Coefficients of Light PA and MVPA Predicting Daily Pain and Fatigue

Predictor Variable	Parameter Estimate (SE)	
	Model 1 bodily pain	Model 2 fatigue
Fixed Effects	β (SE)	β (SE)
Intercept	-0.136 (0.285)	-0.437 (0.309)
Daily light PA	0.151** (0.058)	0.029 (0.061)
Person-mean light PA	-0.064 (0.136)	0.080 (0.144)
Daily MVPA	0.110* (0.048)	0.044 (0.053)
Person-mean MVPA	-0.202 (0.156)	-0.005 (0.171)
Daily light PA x typical bodily pain	0.100 (0.075)	-
Daily MVPA x typical bodily pain	-0.090 (0.051)	-
Daily light PA x typical fatigue	-	-0.240** (0.072)
Daily MVPA x typical fatigue	-	-0.254*** (0.061)
Daily light PA x typical physical health	-0.014 (0.074)	-0.154 (0.084)
Daily MVPA x typical physical health	-0.030 (0.058)	-0.164* (0.076)
Typical PA	0.012 (0.083)	-0.122 (0.091)
Typical pain	0.543*** (0.113)	-
Typical fatigue	-	0.263* (0.119)
Typical physical health	-0.070 (0.105)	0.006 (0.131)
BMI	-0.097 (0.089)	0.151 (0.097)
Age	-0.155 (0.102)	0.132 (0.113)
Cardiovascular disease	0.040 (0.178)	0.483* (0.190)
Gender	0.063 (0.240)	0.308 (0.248)
Cohabiting	0.139 (0.193)	-0.076 (0.211)
Random Effects		

Intercept	0.283*** (0.079)	0.369*** (0.093)
Residual (AR1 diagonal)	0.434*** (0.041)	0.492*** (0.043)
-2 restricted log likelihood	798. 796	857.948
Akaike information criterion	804.796	863.948
R_1^2	0.528	0.210

590

591   *Note. *$p < .05$, ** $p < .01$, *** $p < .000$.*

592   Table 4

593   *Multilevel Modelling Coefficients of SB Predicting Daily Pain and Fatigue*

Predictor Variable	Parameter Estimate (SE)	
Fixed Effects	Model 3 bodily pain	Model 4 fatigue
	β (SE)	β (SE)
Intercept	-0.121 (0.281)	-0.373 (0.315)
Daily SB	-0.182** (0.061)	-0.050 (0.065)
Person-mean SB	0.171 (0.130)	-0.047 (0.143)
Daily SB x typical bodily pain	-0.015 (0.076)	-
Daily SB x typical fatigue	-	0.336*** (0.080)
Daily SB x typical physical health	0.052 (0.077)	0.212* (0.096)
Typical sedentary time	-0.102 (0.086)	-0.035 (0.096)
Typical pain	0.515*** (0.109)	-
Typical fatigue	-	0.274* (0.120)
Typical physical health	-0.063 (0.102)	0.009 (0.133)
BMI	-0.064 (0.084)	0.142 (0.094)
Age	-0.128 (0.095)	0.136 (0.107)
Cardiovascular disease	0.029 (0.174)	0.489* (0.191)
Gender	0.110 (0.229)	0.299 (0.246)
Cohabiting	0.083 (0.196)	-0.174 (0.221)
Random Effects		
Intercept	0.271*** (0.075)	0.378*** (0.093)
Residual (AR1 diagonal)	0.436*** (0.040)	0.494*** (0.043)
-2 restricted log likelihood	789.974	850.538
Akaike information criterion	795.974	856.538
R_1^2	0.548	0.191

594   *Note.* $*p < .05$, $** p < .01$, $*** p < .0$

31