Impact of social restrictions during the COVID-19 pandemic on the physical activity levels of older adults: an analysis of the CHARIOT COVID-19 Rapid Response Study

David Salman*1,2@, Thomas Beaney*2@, and Catherine E. Robb*3, Celeste A. de Jager Loots3, Parthenia Giannakopoulou3, Chi Udeh-Momoh3, Sara Ahmadi-Abhari3, Azeem Majeed2,4, Lefkos T. Middleton3,4, Alison. H. McGregor1

*contributed equally as joint lead authors

Author affiliations:
1MSk lab, Faculty of Medicine, Imperial College London, UK
2Department of Primary Care and Public Health, Imperial College London, UK
3Ageing Epidemiology Research Unit (AGE), School of Public Health, Faculty of Medicine, Imperial College London, UK
4 Public Health Directorate, Imperial College NHS Healthcare Trust, London, UK

@Correspondence to:
David Salman
MSk lab, 2nd Floor, Sir Michael Uren Hub, 86 Wood Lane, London, W12 0BZ
Email: d.salman11@imperial.ac.uk
Phone: 020 7594 2703

Thomas Beaney
Department of Primary Care and Public Health
Charing Cross Campus, The Reynolds Building, St Dunstan's Road, London, W6 8RP
Email: thomas.beaney@imperial.ac.uk
Phone: +44 (0) 207 5943 368

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DS, TB and CR conceived the paper, developed the survey materials, carried out the analysis, wrote the paper equally as joint lead authors and are the guarantors. All authors developed the survey, carried out analysis and contributed to the development and editing of the paper.

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**How patients were involved in the creation of this article**

Older adult volunteers (60-80 years of age) from various social and cultural backgrounds provided feedback on the survey content. This feedback was incorporated into the survey design.

**Conflicts of Interest**

We have read and understood the BMJ Group policy on declaration of interests and declare the following interests: none

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Abstract

Rationale and Objectives:

Physical inactivity is more common in older adults, is associated with social isolation and loneliness, and contributes to increased morbidity and mortality. We examined the effect of social restrictions, implemented to reduce transmission of COVID-19 in the UK (lockdown), on physical activity (PA) levels of older adults, and the demographic, lifestyle and social predictors of this change.

Methods

Cognitively healthy adults aged over 50 years from the Cognitive Health in Ageing Register for Investigational and Observational Trials (CHARIOT) cohort were invited to complete a survey of demographic and lifestyle details, social factors, mood, and frailty. Retrospective (pre-lockdown) and current (post-lockdown) PA were captured by the International Physical Activity Questionnaire (IPAQ) short form.

Results

6,219 adults aged 50 to 92 years completed the survey during the period of April - July 2020. Mean PA significantly reduced following lockdown, from 3,519 Metabolic Equivalent of Task (MET) minutes/week to 3,185 MET minutes/week (p<0.001). Multivariable linear regression models showed that: those who were divorced or single (240 [95% CI: 120, 360] MET minutes/week less); living alone (277 [95% CI: 152, 402] MET minutes/week less); and reported feeling lonely often (306 [95% CI: 60, 552] MET minutes/week less); were doing less PA after lockdown than those married, co-habiting and not reporting loneliness, respectively.

Conclusions and Implications

Markers of social isolation and loneliness were associated with a reduction in PA following lockdown in the UK. Interventions to improve PA in older adults should take account of social and community factors.
1.0 Background and Rationale

Physical inactivity (PA) adversely affects older adults, with 60-70% of those aged over 75 years not sufficiently active for good health\textsuperscript{1,2} as defined by meeting World Health Organization (WHO)\textsuperscript{3} and UK\textsuperscript{4} guidelines. From March until June 2020 in the UK, a national ‘lockdown’ was implemented to reduce exposure to, and transmission of, COVID-19. Although applied to the whole population, adults aged over 70 years and those with underlying health conditions at higher risk of severe COVID-19 disease were asked to follow more stringent social distancing measures. These included: remaining at home where possible; avoiding social mixing in the community; avoiding physically interacting with friends and family; and avoiding public transport.\textsuperscript{5}

Social isolation and loneliness in older adults, possibly exacerbated during lockdowns,\textsuperscript{6} is associated with increases in morbidity and mortality, and also with increases in physical inactivity and sedentary time, as shown from subjective self-reporting and from accelerometer data.\textsuperscript{7,8} Physical inactivity may therefore have a role in mediating the increased morbidity and mortality associated with social isolation.\textsuperscript{9} We set up the CHARIOT COVID-19 Rapid Response study (CCRR) in April 2020 to monitor symptoms and the impact of the COVID-19 pandemic on various health and lifestyle factors, by repeat questionnaire survey of the Cognitive Health in Ageing Register for Investigational and Observational Trials (CHARIOT) members.

We hypothesised that imposed social restrictions would negatively impact on PA levels of older adults, and that change in PA after lockdown would be modified by certain demographic, lifestyle and social factors, with a focus on markers of social isolation and perceived loneliness. An awareness of the extent of, and predictors for, change in PA levels will aid our understanding of the impact of social isolation on the health of older adults, both with respect to pandemic-related lockdowns and social isolation itself.

2.0 Methods

2.1 CCRR survey

Study participants were recruited from the CHARIOT register, a cohort of over 40,000 cognitively healthy adult volunteers aged over 50 years, recruited from 172 GP surgeries.
across West and North London as part of a collaboration between regional GP practices and the School of Public Health, at Imperial College London.

This ongoing study was initiated in April 2020 with repeated questionnaire surveys conducted every six weeks. The CCRR baseline survey consists of questions related to basic demographics, diet, alcohol and smoking status, symptoms of COVID-19, functional activities, physical activity, sleep, frailty and mental health (supplementary file 1). For physical activity, the International Physical Activity Questionnaire (IPAQ) short-form was used, asking respondents to document their weekly vigorous and moderate activity, walking and sitting time from the week prior to completing the survey, and for the week prior to implementation of social restriction measures. For assessing frailty, the 5-point FRAIL scale, and for assessing mental health symptoms, the Hospital Anxiety and Depression (HADS) scale, were used. A question on loneliness was used from the Imperial College Sleep Quality questionnaire, in turn adapted from the Pittsburgh Sleep Quality Index and Centre for Epidemiologic Studies of Depression Scale, for work-free periods.

The survey was sent to 15,000 CHARIOT participants via email, with a subsequent 25,000 contacted by post. 7,320 participants responded and completed the survey. Of these respondents, 6,219 completed IPAQ data both before and after introduction of lockdown measures, and were included in the final analysis. Data used in the present analysis were completed between 30th April and the 22nd July 2020.

2.2 Statistical analysis

All analyses were conducted using Stata version 16.1 (StataCorp 2019) and R. Body Mass Index (BMI) was calculated as weight in kilograms divided by the square of height in metres and categorised according to standard WHO criteria. IPAQ data were cleaned according to the IPAQ data cleaning protocol, and the Metabolic Equivalent of Task (MET) minutes per week, calculated for each activity and total activity (supplementary file 2). Paired t-tests were used to compare the distributions of mean PA levels pre- and post-lockdown.

Measures of association with explanatory variables were explored in univariable linear regression models for two outcomes: i) overall weekly MET minutes after introduction of lockdown and ii) the difference in overall weekly MET minutes before versus after the introduction of lockdown. Multivariable models were constructed for the outcome of MET minutes after lockdown, adjusting a priori each explanatory variable in turn for age, sex and ethnicity. Month of survey completion was also included in the model to account for seasonal
changes, and the finding that physical activity after lockdown varied by month (supplementary file 2: figure 2). Weekly MET minutes before lockdown was also included in the model given its strong association with activity levels after lockdown, which remained significantly associated in all models. Denominators for each model vary according to the levels of missingness in variables included in the models, which was low for most variables, except for BMI (unrecorded in 51.4% of participants).

A causal diagram was constructed using DAGitty\textsuperscript{19} (supplementary file 2: figure 4) to aid adjustment for confounders in order to separate the overall causal effects of marital status, loneliness and living alone on physical activity. Additional multivariable models were then constructed based on the causal diagram for loneliness, adjusting for age, sex, ethnicity, household status, marital status, shielding status and frailty category. No further adjustment was necessary for marital status or household status. Residuals were plotted against fitted values to assess for outlying points and heteroskedasticity; and plots of Cook’s distance and leverage against fitted values were examined to detect the presence of influential points.

3.0 Results
3.1 Participant characteristics

Of the 6,219 participants included in the present study, 55.4% were female, and the majority (55.3%) were aged 65-74 years with a mean age of 70 years. 93.7% of respondents classified themselves as being of white ethnic background, with 2.8% of Asian ethnic background, and only 0.7% of black African or Caribbean background. Approximately half of participants (48.6%) had a recorded height and weight, with a mean BMI of 25.3 kg/m\textsuperscript{2}. The majority of respondents were married (62.2%), co-habiting (72.8%) and retired (69.5%). Most respondents did not smoke (96.9%), drank alcohol (82.6%) and felt they ate a healthy diet (80.3%). 18.0% of respondents were classified as pre-frail, with 0.5% as frail and 26.2% reported that they were shielding at the time of the survey (table 1).

3.2 Physical activity before and after social distancing measures

Mean (SD) PA for participants prior to lockdown was 3,519 (2867) MET minutes/week. There was a significant reduction in mean MET minutes following implementation of lockdown to 3,186 (2673) MET minutes/week (p<0.001; table 2 & figure 1). 3,167 (50.9%) participants decreased their activity during lockdown by a mean (SD) of 1,957 (2025) MET minutes/week, 534 (8.6%) maintained the same level of activity, and 2,518 (40.5%) increased activity by a mean (SD) of 1,636 (1775) MET minutes/week. Mean sitting time increased by 276 MET minutes/week after lockdown (2,680) compared to before (2,404) (table 2).
5,762 (92.7%) participants achieved at least the minimum guidance of 600 MET minutes/week of activity, as defined by WHO, prior to implementation of lockdown measures, slightly reducing to 5,672 (91.2%) following their introduction (p<0.001). 5,039 (81.0%) achieved 1,200 MET minutes/week before lockdown, with 4,904 (78.9%) achieving this after lockdown (p<0.001). Following lockdown, PA levels varied by month of survey completion, with the highest levels in June and lowest levels in July. There was no significant difference between self-reported PA before lockdown by month of survey completion (supplementary file 2: table 1 & figures 2-3).

3.3 Predictors of physical activity after lockdown, and change from before lockdown

3.3.1 Demographic and lifestyle factors

Univariable linear regression models showed statistically significant associations with lower PA after lockdown in older age groups but no evidence of differences in the change from before lockdown between age groups (p<0.001 and p=0.184, respectively; figures 1 & 2). After multivariable adjustment for sex, ethnicity, month of survey completion and pre-lockdown physical activity there was evidence of significantly lower levels of PA with increasing age, with adults aged 85+ doing on average 640 (95% CI: 246, 1034) MET minutes/week less than those aged 50-64 years (figure 3). There was no significant difference in PA after lockdown in males and females (p=0.180), but females on average exhibited a greater decline in PA from before lockdown than males (450 vs 189 MET minutes/week less respectively; p<0.001; figures 1 & 2). After multivariable adjustment, including age, there was only a small and borderline significant difference in PA after lockdown between gender (PA in males on average 108 MET minutes/week more than females; 95% CI: -1, 216; figure 3). No significant associations were seen between PA after lockdown or change in PA according to ethnicity or employment status, before or after adjustment.

Lower levels of PA after lockdown were seen with increasing BMI category, in current smokers and in those reporting an unhealthy or worsening diet before and after adjustment (figure 1). After adjustment, a dose-response relationship was evident between lower PA and increasing BMI (p=0.030), with obese individuals doing 578 (95% CI: 324, 832) MET minutes/week less than those of a healthy weight (figure 3). The denominator included in analyses of BMI was significantly lower than for other models, as BMI was unrecorded for 51.4% of participants. Current alcohol consumption was weakly associated with increased levels of PA in both univariable and multivariable models, with current drinkers reporting 145 MET minutes/week more than non-drinkers after adjustment (95% CI: 1, 289; figures 2 & 3).

3.3.2 Associations with social isolation and loneliness
Participants who were divorced, single or widowed were, on average, less active after lockdown than those married or living with a partner (3,026 vs 3,262 MET minutes/week; p=0.001), and exhibited a greater decline in PA from before lockdown (540 vs 236 MET minutes/week less; p<0.001; figures 1 & 2). The association with PA after lockdown remained after adjustment, with those divorced, single or widowed doing on average 240 (95% CI: 120, 360) MET minutes/week less (figure 3). Participants living alone were also less active than those co-habiting and showed greater reductions in PA from before lockdown. After adjustment for confounders and PA before lockdown, those living alone were doing 277 (95% CI: 152, 402) MET minutes/week less than those co-habiting (figure 3).

Significant associations were seen between PA after lockdown and frequency of loneliness, with those ‘often’ experiencing loneliness achieving 2,938 MET minutes/week compared with 3,284 MET minutes/week in those ‘never’ experiencing loneliness (p=0.024; figure 1). Greater declines in PA from before lockdown were also seen with increasing loneliness (figure 2). After adjustment, PA after lockdown was significantly lower for those with increased frequency of loneliness (figure 3). After full adjustment including, in addition, household status, shielding status and frailty category, those experiencing loneliness ‘often’ reported 306 (95% CI: 60, 552) MET minutes/week less activity than those ‘never’ lonely (supplementary file 2: table 4).

Significantly lower physical activity levels were recorded in those shielding and in participants categorised as pre-frail or frail (both p<0.001; figure 1). Larger declines in PA from before lockdown were seen in those shielding compared to those not shielding (588 vs 243 MET minutes/week less; p<0.001), but there was no significant difference in change in PA according to frailty category (p=0.389; figure 2). After adjustment, frail participants were doing 926 (95% CI: 189, 1,663) MET minutes less on average than those classed as robust (figure 3). Participants who were shielding were doing an average of 290 (95% CI: 163, 417) MET minutes/week less than those not shielding (figure 3).

### 3.3.3 Associations with depression and anxiety

Symptoms of depression were associated with lower levels of PA during lockdown, with those meeting the criteria for depression reporting 2,450 MET minutes/week compared to 3,195 MET minutes/week in those with normal scores (p<0.001; figure 1). There was no strong association with anxiety scores. Mean change in PA from before lockdown was associated with both depression and, in contrast to absolute PA levels, with anxiety scores. Participants with depression reported 1,450 MET minutes/week less on average after lockdown compared with before, while those with normal scores reported 293 MET
minutes/week less (p<0.001). Similarly, in those with anxiety, PA reduced by 836 MET minutes/week compared to 312 MET minutes/week in those with normal scores (p=0.004; figure 2).

After adjustment, those meeting the criteria for depression on the HADS scale had significantly lower PA levels than those with normal scores, doing on average 1,007 (95% CI: 1401, 612) MET minutes/week less (figure 3). There remained no statistically significant association between anxiety score and physical activity after adjustment.

4.0 Discussion

4.1 The effect of lockdown on physical activity

There was a reduction in PA in over half of our participants, and a decrease in mean levels of PA by 333 MET minutes/week following the introduction of lockdown measures in the UK. This was accompanied by an increase in sitting time by 276 minutes per week, an adverse finding given the adverse health impacts associated with increased sedentary and sitting time.20 These findings correlate with other studies from the UK (a decrease in 25% of adults aged over 20 years following lockdown),21 Spain22 and China,23 and from a global survey collected in 8 different languages,24 despite the differences in outdoor exercise permissions between countries. Reductions in PA may impact disproportionately across society. We found that increasing age associated with a reduction in PA after lockdown, corresponding with that seen in Japan, with a 26.5% (65 minutes) decrease in total physical activity in adults aged 65 to 84.25 A self-reported study in the UK found that those with a diagnosis of obesity, hypertension, lung disease, depression or a disability were more likely to reduce PA during lockdown.21

4.2 Social relationships, loneliness, and physical activity

Individuals for whom social engagement was more likely to be restricted, such as those who were shielding, divorced, single, widowed, or living alone, were more likely to have lower levels of PA after lockdown and to have declined to a greater extent. Similarly, those who subjectively reported feeling lonely were more likely to have lower PA levels, and greater declines from before lockdown. These associations remained significant after multivariable adjustment.

Associations between health behaviours, including PA, and social relationships have been noted previously. Data from the English Longitudinal Study of Ageing (ELSA) showed that socially isolated respondents were less likely to report healthy diets, and more likely to
Crucially, they showed reduced activity counts in socially isolated individuals (measured by accelerometer) in a sample of adults older than 50 years, and reduced self-reported moderate to vigorous physical activity. This is particularly important given that isolated and lonely individuals are at an increased risk of morbidity and mortality from cardiovascular events, with the majority of this association mediated by risk factors which include physical inactivity. Fixed effect models from the ELSA cohort show that social disengagement, domestic isolation and loneliness are associated with measures of poorer physical performance, and although they appear to be independent of physical activity, may still be associated along the causal pathway. Studies of spousal pairs found that both men and women in married couples had greater levels of PA than their single counterparts, and changes in PA are positively associated with changes in the PA of a spouse. Increasing PA is associated with larger, more diverse and more heterogenous (in terms of PA) social networks, and having more physically active people in a social network is associated with being more active:

The interaction between social relationships and PA levels may be bi-directional. Levels of PA are influenced by multiple factors at different levels, including: individual (psychological, genetic); interpersonal (social networks); environmental (social, built, natural); and regional or global determinants. Social networks might influence PA through social support for individuals to take up and maintain activity, but also by regulating social norms, and associating PA with social connections or attachments. There may also be increased opportunities for PA when social networks are present.

4.3 Mood, health behaviours and physical activity

In those reporting symptoms of depression, there were significantly lower levels of PA and a significant decrease in activity when compared to before lockdown. These findings correlate with those from around the UK, Australia, Spain, and Brazil which found inverse associations between physical activity levels and poor mental health. The associations between PA and mental health are well known, with positive impacts on wellbeing, and reduced incidence and severity of symptoms of mental ill-health. Therefore, these findings are unsurprising, although the interaction between PA and reduced markers of mental ill-health in older adults may be bi-directional. Moreover, social isolation and loneliness may mediate some of this effect. We found no statistically significant difference in PA during lockdown with anxiety symptoms, at odds with previous studies. However, the trajectory of anxiety symptoms is not known, and it is not clear whether anxiety symptoms pre-dated the introduction of lockdown.

4.2.3 Health behaviours and physical activity
A decrease in PA was associated with other detrimental health behaviours, including unhealthy diet and smoking. A similar tendency of clustering of unhealthy behaviours during the COVID-19 pandemic was noted in a cohort of patients in Spain with type 2 diabetes mellitus. That detrimental health behaviours might coincide in response to lockdown shows the importance of targeted interventions for certain groups. Interestingly, alcohol consumption was seen to be a protective factor in our cohort, and this does not tie with other findings on the negative associations with increased alcohol use during the COVID-19 pandemic. This may be due to the specific demographic features of our cohort, but the possibility of alcohol consumption being associated with social interaction in this group cannot be excluded.

4.4 Limitations

This study has several limitations which may impact the generalisability of our findings. First, the CCRR cohort appear more physically active than the general population. 90% of participants in CCRR achieved minimum UK and WHO guidance, both before and following lockdown. Over 78% achieved double this amount, and mean levels of PA were at least five times greater than the minimum recommendation. In contrast, only 61% of UK adults aged 55-74 years achieve minimum recommended levels. Second, there are differences in demography between the CCRR cohort and the general population of the UK, which may explain the higher levels of PA we observed. 93% of CCRR respondents identify as white/Caucasian ethnicity. The Active Lives Survey demonstrated a difference in those achieving minimum activity levels in White British individuals (65%) and those from Black (58%) and Asian (54%) ethnicities. Third, the CCRR survey relies on self-report, using the short form IPAQ. IPAQ data is well validated across diverse participants up to the age of 65 years and a study of the performance of the IPAQ in older Japanese adults demonstrated adequate validity. However, results from self-reporting tools for PA only weakly correlate with those from objective measures, such as accelerometers and pedometers. Finally, recall bias and seasonal changes in physical activity may also have impacted results. The CCRR survey was collected in April-July 2020, with participants asked to recall PA levels in the week before lockdown, which over time may become less reliable. However, no significant differences were found in the mean PA levels reported before lockdown according to month of survey completion and although there were apparent differences in PA during lockdown by month, we were able to adjust for this in multivariable models.

4.5 Conclusions

Findings from our CCRR study suggest a significant decline in average physical activity levels in older adults following the introduction of lockdown measures during the COVID-19 pandemic.
COVID-19 pandemic. Lower activity levels after lockdown were strongly linked to older age, and to those with objective markers of social isolation, subjective feelings of loneliness and symptoms of depression. Strategies and targeted interventions to increase and sustain PA levels in older adults are needed to mitigate the adverse health impacts not only of COVID-19 related lockdowns, but of social isolation in general, and must consider social relationships in their design and implementation.

5.0 Summary Box

What are the new findings?
- Physical activity decreased in older adults following implementation of lockdown measures in the UK
- Those with factors suggesting increased social isolation were particularly susceptible to decreasing their physical activity following lockdown

How might it impact on clinical practice in the future?
- Interventions designed to increase physical activity in older adults should take account of social relationships in their design and implementation
### 6.0 Tables and Figures

| Participant characteristic | Total | Percent |
|-----------------------------|-------|---------|
| **Gender**                  |       |         |
| Female                      | 3,445 | 55.4%   |
| Male                        | 2,770 | 44.5%   |
| Prefer not to say           | 4     | 0.1%    |
| Mean (SD)                   | 69.9 (7.3) |
| Median (IQR)                | 70 (66-74) |
| Range                       | 50 - 92 |
| **Age (years)**             |       |         |
| 50-64                       | 1,212 | 19.5%   |
| 65-74                       | 3,440 | 55.3%   |
| 75-84                       | 1,394 | 22.4%   |
| 85+                         | 127   | 2.0%    |
| Missing                     | 46    | 0.7%    |
| **White**                   | 5,825 | 93.7%   |
| English/Welsh/Scottish/Northern Irish/British | 5,143 | 82.7% |
| Any other white background  | 536   | 8.6%    |
| Irish                       | 146   | 2.3%    |
| **Mixed/multiple ethnic groups** | 99   | 1.6%    |
| White and Black African     | 10    | 0.2%    |
| White and Asian             | 33    | 0.5%    |
| White and Black Caribbean   | 7     | 0.1%    |
| Any other mixed/multiple ethnic background | 49 | 0.8% |
| **Asian/Asian British**     | 174   | 2.8%    |
| Indian                      | 91    | 1.5%    |
| **Ethnicity**               |       |         |
| Pakistani                   | 12    | 0.2%    |
| Bangladeshi                 | 2     | 0.0%    |
| Chinese                     | 32    | 0.5%    |
| Any other Asian background  | 37    | 0.6%    |
| **Black/African/Caribbean/Black British** | 43 | 0.7% |
| African                     | 13    | 0.2%    |
| Caribbean                   | 21    | 0.3%    |
| Any other Black/African/Caribbean/Black British | 9 | 0.1% |
| **Other ethnic group**      | 64    | 1.0%    |
| Arab                        | 17    | 0.3%    |
| Any other ethnic group      | 47    | 0.8%    |
| Prefer not to say           | 14    | 0.2%    |
| Mean (SD)                   | 25.3 (5.1) |
| Median (IQR)                | 24.4 (22.2-27.1) |
| **Body Mass**               |       |         |
| <18.5 (underweight range)   | 61    | 1.0%    |
| 18.5-24.9 (healthy weight)  | 1,644 | 26.4%   |
| 25.0-29.9 (overweight)      | 962   | 15.5%   |
| >=30.0 (obese range)        | 358   | 5.8%    |
| Missing data                | 3,194 | 51.4%   |
| **Shielding at time of questionnaire** |       |         |
| No                          | 4,591 | 73.8%   |
| Yes                         | 1,628 | 26.2%   |
|    | Married | Single  | Widowed | Divorced | Living with a partner |
|----|---------|---------|---------|----------|-----------------------|
| **Marital status** | 3,869   | 789     | 601     | 595      | 365                   |
| **%** | 62.2%   | 12.7%   | 9.7%    | 9.6%     | 5.9%                   |
|    | Co-habiting | 4,530   | Living alone | 1,689   | Retired | 4,322 |
| **Living arrangements** |          |        |         |          |          |       |
| **%** | 72.8%   | 27.2%   |         |          | 69.5% |
|    | Continuing to work in your usual job | 1,101   | None of the above | 201    | Furloughed | 197 |
| **Employment** |          |        |         |          |          |       |
| **%** | 17.7%   | 3.2%    |         |          | 3.2% |
|    | Continuing to work in your usual job and leave home | 141 |          |          |          |       |
| **%** | 2.3%    |         |          |          |         |
|    | for your job |          | A key worker | 96     |          |       |
| **%** |         | 1.5%    |          |          |         |
|    | Had to close your business due to COVID-19 |    | Lost my job due to the lockdown | 42    |          |       |
| **%** | 1.1%    | 0.7%    |          |          |         |
|    | Unemployed | 36      | A student | 13     |          |       |
| **%** | 0.6%    | 0.2%    |          |          |         |
|    | No change from usual - already had a healthy diet | 4,991   |          |          |          |       |
| **%** | 80.3%   |         |          |          |         |
|    | My diet has become more healthy | 715     |          |          |          |       |
| **%** | 11.5%   |         |          |          |         |
|    | My diet was healthy before but has got worse since lockdown | 312 |          |          |          |       |
| **%** | 5.0%    |         |          |          |         |
|    | No change from usual - my diet isn't very healthy | 201    |          |          |          |       |
| **%** | 3.2%    |         |          |          |         |
|    | Robust | 5,055   |          |          |          |       |
| **%** | 81.3%   |         |          |          |         |
|    | Pre-frail | 1,117   |          |          |          |       |
| **%** | 18.0%   |         |          |          |         |
|    | Missing | 13      |          |          |          |       |
| **%** | 0.2%    |         |          |          |         |
|    | Normal (0-7) | 4,658   |          |          |          |       |
| **%** | 74.9%   |         |          |          |         |
|    | Borderline (8-10) | 312 |          |          |          |       |
| **%** | 5.0%    |         |          |          |         |
|    | Abnormal (11-21) | 116 |          |          |          |       |
| **%** | 1.9%    |         |          |          |         |
|    | Missing | 1,133   |          |          |          |       |
| **%** | 18.2%   |         |          |          |         |
|    | Normal (0-7) | 4,335   |          |          |          |       |
| **%** | 69.7%   |         |          |          |         |
|    | Borderline (8-10) | 486 |          |          |          |       |
| **%** | 7.8%    |         |          |          |         |
|    | Abnormal (11-21) | 265 |          |          |          |       |
| **%** | 4.3%    |         |          |          |         |
|    | Missing | 1,133   |          |          |          |       |
| **%** | 18.2%   |         |          |          |         |

**Total participants**: 6,219

*Table 1: Participant characteristics for 6,219 participants with complete data on physical activity, HADS – Hospital Anxiety and Depression Score*
| Physical activity type       | Before                      | During                     | p value for difference |
|-----------------------------|-----------------------------|----------------------------|------------------------|
| **Vigorous activity**       | Mean (SD) minutes/week      | 145 (276)                 | 135 (253)              | 0.004                  |
|                             | Median (IQR) minutes/week   | 40 (0 - 180)              | 10 (0 - 180)           |                        |
| **Moderate activity**       | Mean (SD) minutes/week      | 292 (430)                 | 245 (374)              | <0.001                 |
| (minutes/week)              | Median (IQR) minutes/week   | 120 (0 - 360)             | 120 (0-360)            |                        |
| **Walking**                 | Mean (SD) minutes/week      | 462 (460)                 | 403 (408)              | <0.001                 |
| (minutes/week)              | Median (IQR) minutes/week   | 360 (150 - 630)           | 315 (150 - 525)        |                        |
| **Sitting (minutes/week)**  | Mean (SD) minutes/week      | 2404 (1137)               | 2680 (1181)            | <0.001                 |
| *                           | Median (IQR) minutes/week   | 2100 (1680 - 2940)        | 2520 (1680 - 3360)     |                        |
| **MET minutes/week**        | Mean (SD) minutes/week      | 3519 (2867)               | 3185 (2673)            | <0.001                 |
|                             | Median (IQR) minutes/week   | 2772 (1386 - 4650)        | 2440 (1386 - 4185)     |                        |

Table 2: Physical activity and sitting time for recipients before and following introduction of lockdown measures. Data presented as minutes per week with both mean (standard deviation) and median (interquartile range) shown. p-values from paired t-test

*denominator 6,023

MET - Metabolic Equivalent of Task
### Predictor vs. PA in lockdown (mean MET minutes/week) (95%CI)

| Predictor                                      | PA in lockdown (mean MET minutes/week) (95%CI) | p-value |
|------------------------------------------------|-----------------------------------------------|---------|
| Mean (whole cohort)                            | 3161 (2923, 3399)                             |         |
| Age (years)                                    |                                               |         |
| 25-34                                          |                                               |         |
| 35-44                                          |                                               |         |
| 45+                                            |                                               |         |
| Sex                                            |                                               |         |
| Male                                           |                                               |         |
| Female                                         |                                               |         |
| Ethnicity                                      |                                               |         |
| White                                          |                                               |         |
| Mixed/multiple ethnic groups                   |                                               |         |
| South Asian or British                         |                                               |         |
| Black African Caribbean/Black British          |                                               |         |
| Other ethnic group                             |                                               |         |
| Body Mass Index category                       |                                               | <0.0001 |
| Underweight                                    |                                               |         |
| Healthy weight                                 |                                               |         |
| Overweight                                     |                                               |         |
| Obese                                          |                                               |         |
| Employment status                              |                                               | 0.1184  |
| Employed                                       |                                               |         |
| Unemployed                                     |                                               |         |
| Retired                                        |                                               |         |
| Marital status                                 |                                               | 0.0012  |
| Divorced/single/widowed                        |                                               |         |
| Living with a partner/married                  |                                               |         |
| Household                                      |                                               | 0.0002  |
| Not living alone                               |                                               |         |
| Living alone                                   |                                               |         |
| Loneliness                                     |                                               | 0.0244  |
| Never                                          |                                               |         |
| Rarely                                         |                                               |         |
| Sometimes                                      |                                               |         |
| Often                                          |                                               |         |
| Smoking                                        |                                               | <0.0001 |
| Not smoking                                    |                                               |         |
| Smoking                                        |                                               |         |
| Alcohol drinker                                |                                               | <0.0001 |
| No                                             |                                               |         |
| Yes                                            |                                               |         |
| Diet                                           |                                               | 0.0093  |
| No change from usual – already had a healthy diet |                                               |         |
| My diet has become more healthy                |                                               |         |
| My diet was healthy before but has got worse since lockdown | | |
| No change from usual – my diet isn’t very healthy |                                               |         |
| HADS (depression score)                        |                                               | 0.0046  |
| Normal (0-10)                                  |                                               |         |
| Borderline (11-21)                             |                                               |         |
| Abnormal (11-21)                               |                                               |         |
| HADS (anxiety score)                           |                                               | 0.1604  |
| Normal (0-7)                                   |                                               |         |
| Borderline (8-10)                              |                                               |         |
| Abnormal (11-21)                               |                                               |         |

**Figure 1:** Forest plot of unadjusted univariable associations with physical activity (PA) during lockdown. Data presented as mean MET minutes/week +/- 95% confidence interval. Heavy dashed line – 600 MET minutes/week (WHO minimal physical activity guideline for adults); light dashed line – mean MET minutes for the whole cohort. See also supplementary file 2: table 2.

HADS – Hospital Anxiety and Depression Score; MET – Metabolic Equivalent of Task; PA – Physical Activity; WHO – World Health Organization
Figure 2: Forest plot of unadjusted mean change in physical activity (PA) for all variables (mean MET minutes/week +/- 95% confidence interval). Negative values indicate a decline in activity after lockdown compared to before lockdown. See also supplementary file 2: table 2

HADS – Hospital Anxiety and Depression Score; MET – Metabolic Equivalent of Task; PA – Physical Activity
Figure 3: Forest plot of multivariable associations with physical activity after lockdown, adjusted for age, sex, ethnicity, month of year of survey completion and baseline physical activity. Data presented as mean MET minutes/week +/- 95% confidence interval, compared to the reference group, with negative values indicating lower physical activity than the reference. See also supplementary file 2: table 3.

HADS – Hospital Anxiety and Depression Score; MET – Metabolic Equivalent of Task; PA – Physical Activity
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### Predictors of Physical Activity during Lockdown (mean MET minutes/week) (95%CI)

| Predictor | PA in lockdown (mean MET minutes/week) (95%CI) | p-value |
|-----------|---------------------------------------------|---------|
| Mean (whole cohort) | 3186 [3120, 3253] |         |
| Age (years) | | | |
| 50–64 | 3341 [3191, 3491] | 0.0003 |
| 65–74 | 3201 [3112, 3290] | 0.0001 |
| 75–84 | 3092 [2952, 3232] | <0.0001 |
| 85+ | 2326 [1863, 2790] | <0.0001 |
| Sex | | | |
| Female | 3227 [3138, 3317] | 0.1801 |
| Male | 3136 [3036, 3235] |         |
| Ethnicity | | | |
| White | 3196 [3127, 3265] | 0.4245 |
| Mixed/multiple ethnic groups | 3346 [2819, 3873] |         |
| Asian/Asian British | 3292 [2530, 3327] |         |
| Black/African/Caribbean/Black British | 3361 [2525, 4151] | <0.0001 |
| Other ethnic group | 2754 [2099, 3410] |         |
| Body Mass Index category | | | |
| Underweight | 3815 [3137, 4493] | <0.0001 |
| Healthy weight | 3568 [3499, 3700] | <0.0001 |
| Overweight | 3130 [2959, 3300] | <0.0001 |
| Obese | 2590 [2309, 2870] | <0.0001 |
| Employment status | | | |
| Employed | 3093 [2950, 3236] | 0.1184 |
| Furloughed | 3406 [3122, 3670] |         |
| Unemployed | 3463 [3031, 3984] |         |
| Retired | 3191 [3111, 3271] |         |
| Marital status | | | |
| Divorced/single/widowed | 3026 [2908, 3143] | 0.0012 |
| Living with a partner/married | 3262 [3181, 3342] |         |
| Household | | | |
| Not living alone | 3262 [3185, 3340] | 0.0002 |
| Living alone | 2983 [2855, 3110] |         |
| Loneliness | | | |
| Not ever | 3284 [3188, 3380] | 0.0244 |
| Rarely | 3087 [2951, 3224] |         |
| Sometimes | 3155 [3010, 3300] |         |
| Often | 2938 [2666, 3210] |         |
| Shielding | | | |
| Not shielding | 3273 [3196, 3350] | <0.0001 |
| Shielding | 2942 [2812, 3072] |         |
| Frailty | | | |
| Robust | 3257 [3183, 3330] | <0.0001 |
| Pre–frail | 2903 [2746, 3069] |         |
| Frail | 1952 [1055, 2849] |         |
| Alcohol drinker | | | |
| No | 3044 [2884, 3203] | 0.0535 |
| Yes | 3217 [3143, 3290] |         |
| Smoker | | | |
| No | 3202 [3135, 3270] | 0.0098 |
| Yes | 2696 [2318, 3074] |         |
| Diet | | | |
| No change from usual – already had a healthy diet | 3257 [3183, 3331] | <0.0001 |
| My diet has become more healthy | 3314 [3119, 3409] |         |
| My diet was healthy before but has got worse since lockdown | 2523 [2227, 2818] |         |
| No change from usual – my diet isn’t very healthy | 2009 [1641, 2377] |         |
| HADS (depression score) | | | |
| Normal (0–7) | 3195 [3119, 3270] | 0.0004 |
| Borderline (8–10) | 2787 [2495, 3079] |         |
| Abnormal (11–21) | 2450 [1971, 2929] |         |
| HADS (anxiety score) | | | |
| Normal (0–7) | 3123 [3044, 3201] | 0.1504 |
| Borderline (8–10) | 3343 [3109, 3577] |         |
| Abnormal (11–21) | 3288 [2971, 3605] |         |
| Predictor                              | Change in PA following lockdown (mean MET minutes/week) (95%CI) | p−value       |
|---------------------------------------|-----------------------------------------------------------------|---------------|
| Mean (whole cohort)                   |                                                                  |               |
| Age (years)                           |                                                                  | 0.1843        |
| 20−64                                 |                                                                  |               |
| 65−74                                 |                                                                  |               |
| 75−84                                 |                                                                  |               |
| 85+                                   |                                                                  |               |
| Sex                                    |                                                                  | <0.0001       |
| Female                                |                                                                  |               |
| Male                                  |                                                                  |               |
| Ethnicity                             |                                                                  | 0.6406        |
| White                                 |                                                                  |               |
| Mixed/multiple ethnic groups          |                                                                  |               |
| Asian/Asian British                   |                                                                  |               |
| Black/African/Caribbean/Black British |                                                                  |               |
| Other ethnic group                    |                                                                  |               |
| Body Mass Index category              |                                                                  | 0.0551        |
| Underweight                           |                                                                  |               |
| Healthy weight                        |                                                                  |               |
| Obese                                 |                                                                  |               |
| Employment status                     |                                                                  | 0.1014        |
| Employed                              |                                                                  |               |
| Furloughed                            |                                                                  |               |
| Unemployed                            |                                                                  |               |
| Retired                               |                                                                  |               |
| Marital status                        |                                                                  | <0.0001       |
| Divorced/single/widowed               |                                                                  |               |
| Living with a partner/married         |                                                                  |               |
| Household                             |                                                                  | <0.0001       |
| Not living alone                      |                                                                  |               |
| Living alone                          |                                                                  |               |
| Loneliness                            |                                                                  | 0.0001        |
| Not ever                              |                                                                  |               |
| Rarely                                |                                                                  |               |
| Sometimes                             |                                                                  |               |
| Often                                 |                                                                  |               |
| Shielding                             |                                                                  | <0.0001       |
| Not shielding                         |                                                                  |               |
| Shielding                             |                                                                  |               |
| Frailty                               |                                                                  | 0.3892        |
| Robust                                |                                                                  |               |
| Pre−frail                             |                                                                  |               |
| Frail                                 |                                                                  |               |
| Alcohol drinker                       |                                                                  | 0.0289        |
| No                                    |                                                                  |               |
| Yes                                   |                                                                  |               |
| Smoker                                |                                                                  | 0.0461        |
| No                                    |                                                                  |               |
| Yes                                   |                                                                  |               |
| Diet                                  |                                                                  | <0.0001       |
| No change from usual – already had a  |                                                                  |               |
| healthy diet                          |                                                                  |               |
| My diet has become more healthy       |                                                                  |               |
| My diet was healthy before but has   |                                                                  |               |
| got worse since lockdown              |                                                                  |               |
| No change from usual – my diet isn’t |                                                                  |               |
| very healthy                          |                                                                  |               |
| HADS (depression score)               |                                                                  | <0.0001       |
| Normal (0−7)                          |                                                                  |               |
| Borderline (8−10)                     |                                                                  |               |
| Abnormal (11−21)                      |                                                                  |               |
| HADS (anxiety score)                  |                                                                  | 0.0041        |
| Normal (0−7)                          |                                                                  |               |
| Borderline (8−10)                     |                                                                  |               |
| Abnormal (11−21)                      |                                                                  |               |

Change in PA following lockdown, unadjusted (MET minutes/week)(95%CI)
| Predictor | PA in lockdown (mean MET minutes/week) (95%CI) | p–value |
|-----------|-----------------------------------------------|---------|
| Age (years) | | <0.001 |
| 50−64 (reference) | | |
| 65−74 | | |
| 75−84 | | |
| 85+ | | |
| Sex | | 0.053 |
| Female (reference) | | |
| Male | | 108 [−1, 216] |
| Ethnicity | | 0.517 |
| White (reference) | | |
| Mixed/multiple ethnic groups | | |
| Asian/Asian British | | |
| Black/African/Caribbean/Black British | | |
| Other ethnic group | | |
| Body Mass Index category | | 0.03 |
| Underweight | | |
| Healthy weight (reference) | | |
| Overweight | | |
| Obese | | |
| Employment status | | 0.905 |
| Employed (reference) | | |
| Furloughed | | |
| Unemployed | | 471 [−278, 372] |
| Retired | | 99 [−48, 246] |
| Marital status | | <0.001 |
| Divorced/single/widowed (reference) | | |
| Living with a partner/married | | |
| Household | | <0.001 |
| Not living alone | | |
| Living alone | | 240 [−1, 289] |
| Loneliness | | <0.001 |
| Not ever | | |
| Rarely | | |
| Sometimes | | |
| Often | | |
| Shielding | | <0.001 |
| Not shielding (reference) | | |
| Shielding | | |
| Frailty | | 0.005 |
| Robust (reference) | | |
| Pre−frail | | |
| Frail | | |
| Alcohol drinker | | 0.049 |
| No | | |
| Yes | | |
| Smoker | | 0.005 |
| No | | |
| Yes | | 145 [1, 289] |
| Diet | | <0.001 |
| No change from usual – already had a healthy diet (reference) | | |
| My diet has become more healthy | | 156 [−13, 326] |
| My diet was healthy before but has got worse since lockdown | | |
| No change from usual – my diet isn’t very healthy | | 160 [−482, −140] |
| HADS (depression score) | | <0.001 |
| Normal (0−7) | | |
| Borderline (8−10) | | |
| Abnormal (11−21) | | |
| HADS (anxiety score) | | 0.478 |
| Normal (0−7) | | |
| Borderline (8−10) | | |
| Abnormal (11−21) | | 94 [−109, 296] |

Multivariable associations with physical activity during lockdown (MET minutes/week)(95%CI)