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The impact of COVID-19 restrictions on accelerometer-assessed physical activity and sleep in individuals with type 2 diabetes

Running title: Physical activity in people with type 2 diabetics during COVID-19

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Abstract: 250 words

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Novelty statement (99 words)

- Self-report data suggest COVID-19 restrictions have had a detrimental impact on physical activity.
- Studies in high-risk groups with objective measures of physical activity are lacking.
- We assessed physical activity with accelerometers before and during COVID-19 restrictions in people with type 2 diabetes.
- Although overall physical activity was lower, purposeful moderate-to-vigorous physical activity was maintained and the number of days per week with ≥ 30 -minutes continuous moderate-to-vigorous physical activity was higher.
- Women and individuals who were heavier, older, inactive, and/or from ethnic minority groups, were most at risk of lower physical activity during COVID-19 restrictions and could benefit from targeted support.

Abstract

Aims: Restrictions during the COVID-19 crisis will have impacted on opportunities to be active. We aimed to a) quantify the impact of COVID-19 restrictions on accelerometer-assessed physical activity and sleep in people with type 2 diabetes and b) identify predictors of physical activity during COVID-19 restrictions. **Methods:** Participants were from the UK Chronotype of Patients with type 2 diabetes and Effect on Glycaemic Control (CODEC) observational study. Participants wore an accelerometer on their wrist for 8 days before and during COVID-19 restrictions. Accelerometer outcomes included: overall physical activity, moderate-to-vigorous physical activity (MVPA), time spent inactive, days/week with ≥ 30 -minutes continuous MVPA, sleep. Predictors of change in physical activity taken pre-COVID included: age, sex, ethnicity, body mass index (BMI), socio-economic status, and medical history. **Results:** 165 participants (age (mean \pm S.D.=64.2 \pm 8.3years, BMI=31.4 \pm 5.4kg/m², 45% women) were included. During restrictions, overall physical activity was lower by 1.7 mg (~800 steps/day) and inactive time 21.9 minutes/day higher, but time in MVPA and sleep did not statistically significantly change. In contrast, the percentage of people with ≥ 1 day/week with ≥ 30 -minutes continuous MVPA was higher (34% cf. 24%). Consistent predictors of lower physical activity and/or higher inactive time were higher BMI and/or being a woman. Being older and/or from ethnic

minorities groups was associated with higher inactive time. **Conclusions:** Overall physical activity, but not MVPA, was lower in adults with type 2 diabetes during COVID-19 restrictions. Women and individuals who were heavier, older, inactive, and/or from ethnic minority groups were most at risk of lower physical activity during restrictions.

Key words: lockdown, MVPA, CODEC, accelerometer, activity monitor, coronavirus

Introduction

The severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), which causes coronavirus disease-2019 (COVID-19), has devastated global economies and fundamentally changed patterns of daily life for many. Restrictions put in place to limit the movement and interaction of people during the COVID-19 crisis will have impacted on opportunities to be active, potentially leading to decreases in physical activity and increased sedentary behaviour, which could have negative consequences for cardiometabolic health[1,2]. As people with type 2 diabetes mellitus have impaired cardiometabolic health and are already less active and more sedentary than those without the condition[3], it is important to quantify the impact of the COVID-19 national lockdown on their physical activity.

Evidence is beginning to accumulate documenting a detrimental impact of COVID-19 restrictions on self-reported physical activity levels. For example, declines in total physical activity and in moderate-to-vigorous activity of approximately 35% and 23%, respectively, were reported by 2524 Italian participants completing an online survey[4]. A similar decline in total activity, but 60% decline in moderate-to-vigorous activity was self-reported by 143 physiotherapy professionals and students in an online survey in India[5]. The pattern of decline was similar in a small sample of adults with type 2 diabetes in Spain, with self-reported moderate-to-vigorous activity decreasing by 66% in men and 52% in women[6].

As well as physical activity, restrictions will have disrupted other behaviours, e.g. time spent inactive including sedentary (sitting) behaviours. Self-reported sitting increased by 48% (men) and 21% (women) in adults with type 2 diabetes in Spain[6], and nearly four-fold in physiotherapy students and professionals in India[5].

To date, most research on change in physical activity during the COVID-19 pandemic has relied on self-report, with participants asked to recall their activity during and prior to heightened restrictions,

exacerbating the well-documented limitations of self-report[7]. A small study of 26 heart failure patients that used device-based measures of activity also showed a 16% decrease in steps/day[8]. However, larger studies in high-risk groups with objective measures are lacking, as are studies examining patterns of physical activity which may also be related to health[9].

As well as identifying whether COVID-19 restrictions had a detrimental impact on physical activity, it is important to determine factors that exacerbate or mitigate any decline to inform strategies aiming to prevent further declines in physical activity. This is particularly pertinent given the continued risk of COVID-19[10] and greater likelihood of self-isolating in those with underlying conditions, placing them at increased risk of severe COVID-19[11].

We are in a unique position to quantify the impact of the COVID-19 restrictions on those with type 2 diabetes, through our existing large comprehensively phenotyped cohort[12]. We aimed to quantify the change in device-measured physical activity before and during the major COVID-19 restrictions in the UK. Secondly, we aimed to identify key predictors of change in physical activity levels. Potential predictor variables included demographics, health status and physical function.

Methods

Participants were from the cross-sectional observational study Chronotype of Patients with Type 2 Diabetes and Effect on Glycaemic Control (CODEC, Clinical Trial Registry Number: NCT02973412). Participants were recruited from primary and secondary care in the East Midlands UK, had established type 2 diabetes for >6 months, HbA1c \leq 86 mmol/mol (10%) and were aged 18-75 years. Exclusion criteria were terminal illness, BMI $>$ 45kg/m², HbA1c $>$ 86 mmol/mol (10%), use of sedatives or medications for wakefulness, and those with a known sleep disorder (except obstructive sleep apnoea). All participants provided written informed consent. Ethical approval was obtained from the local NHS research ethics committee (West Midlands-Black Country Research Ethics Committee (16/WM/0457)).

Data were available for 885 CODEC participants in March 2020. A sub-sample of 165 CODEC participants who had \geq 3 days accelerometer data, collected between 2017-2020 provided verbal consent to take part. England was in full nationwide lockdown from 23rd March 2020 with gradual easing of some restrictions on May 10th 2020, but indoor mixing of households still prohibited. The main relaxing of restrictions, including reopening of the hospitality industry, occurred on July 4th 2020. Our data were collected between 17th May and 12th June 2020.

Pre-COVID measures

Pre-COVID measures were taken between 2017-2020. These included: date of birth, date of assessment, sex (men/women), ethnicity (White, Black and minority ethnic), body mass index (kg/m^2), smoking status, alcohol intake, index of multiple deprivation (postcode was used to estimate socio-economic status (SES); lower values indicate more deprived, higher values less deprived), medical history (duration of diabetes and number of diabetes medications), occupation, depressive symptoms (Patient Health Questionnaire 9)), physical function (Short Physical Performance Battery), and HbA1c (glycated haemoglobin). These measures have been described previously[12].

Baseline physical activity outcomes were derived from the GENEActiv accelerometer (ActivInsights Ltd, Cambridgeshire, UK), which participants wore 24 h a day for eight days on their non-dominant wrist. Monitors were initialised to record accelerations at 100 Hz. Season of measurement was categorised as Spring, Summer, Autumn, and Winter.

Measures taken during the major COVID-19 restrictions

Participants were asked a series of COVID-19 related questions over the phone. These included whether they were self-isolating, had been advised to self-isolate, had been tested for COVID-19 and, if so, the result. A GENEActiv was subsequently mailed out to each participant.

To prevent transmission of the SARS-CoV-2 virus, GENEActivs were sterilised prior to posting. Participants were provided with a sterilisation kit to clean the device prior to wearing and were instructed over the phone to leave the accelerometer in the envelope for two days prior to wearing to minimise risk of infection/spread. A pre-paid envelope was provided to return the materials.

Consistent with baseline measures, participants wore the GENEActiv 24 h a day for eight days on their non-dominant wrist.

Accelerometer processing

Accelerometer files were processed with R-package GGIR version 1.11-0 (<http://cran.r-project.org>)[13]. Signal processing in GGIR includes autocalibration using local gravity as a reference[14]; detection of non-wear; calculation of the average magnitude of dynamic acceleration corrected for gravity (Euclidean Norm minus 1 g, ENMO), averaged over 5 s epochs and expressed in milli-gravitational units (mg). Non-wear was imputed using the default setting. Participants were excluded if: post-calibration error $>0.01\text{ g}$ (10 mg), <3 days of valid wear (defined as >16 h per day), or if wear data weren't present for each 15-minute period of the 24 h cycle. Sleep duration was calculated using automated sleep detection[15] excluding any waking periods in the night.

Daily physical activity outcomes included overall physical activity (mg), moderate-to-vigorous activity (minutes) accrued in 1-minute bouts (>100 mg[16]) time spent inactive (<40 mg, excluding sleep[17,18], intensity of the most active continuous 10 minutes/day (mg) and most active continuous 30 minutes/day (mg).

Weekly physical activity outcomes included the number of days/week with 30 minutes continuous moderate-to-vigorous activity, and with 60 minutes continuous moderate-to-vigorous activity. For weekly variables, only participants with seven valid days were included. A continuous 30 (or 60) minute moderate-to-vigorous activity session is evident when the intensity corresponding with the 25th percentile of the distribution for the 30 (or 60) continuous minutes is >100 mg (e.g. walking), i.e. there is an allowance for up to 25% of time to drop below the threshold consistent with standard bout definitions[19].

Statistical analysis

Demographic data, anthropometric data, accelerometer outcomes, and answers to COVID-19 questions are presented as mean (standard deviation) for continuous variables, median (interquartile range) for ordinal variables and n (%) for categorical variables. Demographic and anthropometric data are also presented for the remainder of the CODEC cohort (n=720). Differences between the CODEC cohort and the sub-sample were assessed using independent t-tests for normally distributed variables (parametric), Mann-Whitney U test for non-normally distributed variables (non-parametric), and chi-square independence tests for categorical variables.

Data for the sub-sample were examined using two approaches. Firstly, estimated marginal means, adjusted for age, sex, follow-up time and baseline season of measurement, were derived from general linear models, using a repeated measures design. Pairwise comparisons were used to assess the differences in physical activity outcomes and sleep duration pre- and post-COVID.

Secondly, linear regressions analyses were used to assess associations between each physical activity outcome at follow-up and baseline predictors. Model 1 considered age, sex, baseline physical activity, season of baseline measurement, and follow-up time. In models 2, each of the following predictors was added to model 1 in turn: ethnicity (white, black and minority ethnic), SES, BMI, Patient Health Questionnaire 9, HbA1c, number of diabetes medications, employment status, alcohol intake, smoking status, duration of diabetes, short sleeper (bottom tertile for sleep duration), and physical function. In model 3, predictors from model 1 and significant predictors from models 2 were entered simultaneously.

For daily physical activity outcomes, a normal distribution with an identity link was used. These results are reported as regression coefficients β (95% CI). For weekly outcomes, a Poisson distribution with a log link was used. Data were subsequently back transformed to show the fold change in measures of physical activity per unit change in the predictor. In order to aid interpretability, the weekly analysis was restricted to those with seven days of valid pre- and post-data.

A sensitivity analysis was run, removing all individuals who reported being advised to shield. Data were analysed using SPSS (version 26.0). A p-value of <0.05 was considered statistically significant. Adjustment was not made for multiple comparisons; therefore, data were viewed with caution and in relation to the overall pattern of results.

Results

There were 165 participants (age (mean \pm S.D= 64.2 \pm 8.3years, BMI=31.4 \pm 5.4kg/m², 45% women, 86% white) with valid accelerometer data at both time-points for daily physical activity outcomes (three valid days) and 133 participants for weekly physical activity outcomes (seven valid days). The sub-sample was representative of the wider CODEC cohort except for a larger proportion of women in the sub-sample (45% cf. 32%). Pre-COVID measures were taken a median of 1.2 years (maximum 3 years) prior to follow-up measures (Table 1). Of the 165 participants, 125 (76%) reported self-isolating during COVID-19 restrictions, 31 (19%) had received advice to shield (letter/text from doctor or National Health Service), and two (1%) had been tested for COVID (both negative). Participant characteristics are presented in Table 1.

Difference in physical activity and sleep during COVID-19 restrictions

Differences in physical activity and sleep duration during restrictions are shown in Table 2 (daily and weekly physical outcomes) and Figure 1 (weekly physical activity outcomes). Overall physical activity was significantly lower ($p<0.001$) by 1.7 mg (approximately 800 steps/day[20]), with corresponding higher inactive time (21.9 minutes; $p=0.001$). In contrast, time in moderate-to-vigorous activity, intensity of the most active 10- 30 minutes, and sleep duration were not statistically significantly different. Further, the number of days per week with continuous 30-minute or 60-minute sessions of moderate-to-vigorous activity were 1.5-1.8 times higher, correspondingly the percentage of people with ≥ 1 day per week with a continuous session of moderate-to-vigorous activity was higher (24% to 34%).

Baseline predictors of daily physical activity during COVID-19 restrictions

Baseline predictors of daily physical activity outcomes during COVID-19 restrictions are shown in Table 3 (heatmap) and Supplementary Table 1. In the fully adjusted model, the baseline value was consistently positively associated with all outcomes. Higher BMI was consistently associated with lower physical activity during restrictions, but higher inactive time. For each unit increase in BMI, there were 2.3 minutes more time spent inactive and 0.6 minutes less moderate-to-vigorous activity. In addition, being a woman was associated with lower overall activity (-2.0 mg, approximating 1000 fewer steps/day[20]), \approx 20 minutes more inactive time, and 6 minutes less moderate-to-vigorous activity. Older age was associated with lower intensity activity during the most active 10-30 minutes of the day. Black and minority ethnicity was associated with lower overall activity (-2.3 mg, approximating 1150 fewer steps/day[20]). Finally, each additional unit in physical function (the short physical performance test) was associated with 1.7 minutes more moderate-to-vigorous physical activity.

Baseline predictors of weekly physical activity during COVID-19 restrictions

Baseline predictors of weekly physical activity outcomes during COVID-19 restrictions are shown in Table 3 (heatmap) and Supplementary table 2. Baseline activity and physical function were consistently positively associated, while older age, being a woman, higher BMI, and depressive symptoms were all associated with fewer days per week with 30- and/or 60-minutes continuous moderate-to-vigorous activity.

Associations did not differ when removing participants advised to shield (n = 31).

Discussion

In adults with type 2 diabetes overall physical activity was lower during restrictions imposed due to COVID-19; the difference was greater than the minimum clinically meaningful difference in physical activity for inactive people, approximating a decrease of 800 steps per day[20]. This was accompanied by slightly more (22 minutes or \sim 3%) time spent inactive.

Despite this, sleep and purposeful physical activity, i.e. moderate-to-vigorous activity accumulated in 1-minute bouts and the intensity of the most active 10-30 minutes, was maintained. Notably, the number of days/week where participants undertook a 30-60 minute continuous session of moderate-to-vigorous activity was higher during lockdown. These findings are consistent with data from Garmin activity trackers, showing that whilst total steps/day decreased during the COVID-19 pandemic, purposeful activity (number of workout sessions) increased[21]. It is possible the UK Government's focus on 'permitted' outdoor exercise sessions encouraged people to undertake purposeful bouts of physical activity outside. This is supported by the fact that 62% of adults

surveyed by Sport England reported that being active now was more important than pre-COVID[22]. Google Trends also showed an increase in online searches for 'exercise' and 'fitness training' during the initial periods of restrictions in the UK, Australia and the USA[23].

Whilst there was an overall increase in weekly sessions of moderate-to-vigorous activity, it is worth noting the majority (66%) of participants still recorded zero days per week with 30 minutes continuous moderate-to-vigorous activity. Predictors associated with lower physical activity during lockdown were largely consistent with known correlates of physical activity e.g. being a woman, older, and higher BMI[24,25]. This is not surprising but highlights that people who are already at greatest risk incur further risk when restrictions to daily movement are imposed. Compounding this, there is evidence that BMI, age, ethnicity and pre-existing cardiometabolic disease are also risk factors for testing positive for SARS-CoV-2 and incidence of severe COVID-19[26,27].

The observed decrease of ~8% in overall physical activity is lower than in other samples with chronic disease and apparently similar physical activity levels, i.e. the self-reported 35% decrease in adults with type 2 diabetes in Spain[4] and 16% decrease in steps per day in heart failure patients in the Czech Republic[8]. These differences could reflect geographical location, the nature of the restrictions imposed, and/or government messaging, but may also reflect differing physical activity measurement methods. Further, the maintenance and increase in measures of continuous purposeful moderate-to-vigorous activity may explain the smaller decrease in overall physical activity observed in the current study. These findings highlight the importance of not only using device-based measures of physical activity, but also considering the pattern of accumulation and intensity of physical activity.

Three-quarters of the sample reported self-isolating despite only 31% being specifically advised to. The majority of people self-isolating reported they did so due to Government advice and/or concerns regarding underlying health conditions. The UK is experiencing a further rapid spread in cases of COVID-19 following the emergence of a more transmissible variant; this has led to heightened restrictions and expedited rollout of COVID-19 vaccines [28]. Given this, people with underlying conditions are likely to continue to self-isolate. Our data suggest this is likely to lead to clinically meaningful declines in physical activity[20] with potential consequences for health. Further, lower initial activity levels and/or poorer health both exacerbate the impact of lockdown on physical activity levels; thus, it is important to develop strategies that can be targeted to maintain or increase activity levels in these vulnerable groups.

A strength of our study is device-based measurement of physical activity before and during the COVID-19 restrictions. This gave insight as to how different aspects of physical activity were affected

by the restrictions. Further, as our sample was well phenotyped at baseline we were able to determine predictors of change in physical activity during the restrictions. Together these data inform the strategies needed to maintain or improve physical activity during any future lockdown and identify the people at most need of support. We were unable to assess all CODEC participants during restrictions, but the sub-sample was representative except for a higher proportion of women. We acknowledge the timing of the baseline measures is a limitation as it was up to three years (median 438 days) before COVID-19 and varied between participants. This increases the risk of change in participants' personal, physical, medical, social and professional situations. Further it was taken throughout the year, although we adjusted for seasonality in our models. Additionally, measures taken during restrictions were not taken during maximum lockdown, instead occurring following the first minor easing of restrictions on May 10th. However, the UK remained in partial lockdown for the duration of the study and Leicester, where this study took place, remained under maximum restrictions with over 75% of our sample reporting that they were self-isolating. Further, easing of restrictions will have had little impact on our mostly retired sample, as the focus was on encouraging those who could not work from home to return to work.

In conclusion, our results suggest that strategies to maintain physical activity levels during lockdown should be two pronged. First, encouragement to undertake a physical activity session at least once per day. Second, break up time spent inactive and increase incidental activity, e.g. break up prolonged sitting with light activity. As well as increasing overall activity, breaking up sitting with light movement breaks has beneficial acute metabolic responses, particularly in people at higher metabolic risk[29]. Further, there are existing work-based programmes available to support people in breaking up sitting time [e.g. 30], that may be suitable for adaption for home use. Finally, this study has identified that heavier, older, inactive, ethnic minority individuals, and/or women with type 2 diabetes are most at risk of declining physical activity during COVID-19 restrictions. While acknowledging that some of these sub-groups were small, e.g. 14% (n = 23) of non-white origin, our data suggest these groups could benefit from targeted support.

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Conflicts of Interest

Prof. Kamlesh Khunti is member of the independent SAGE group. No other conflicts of interest.

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Table 1. Participant characteristics for the study sub-sample (n = 165) and the remainder of the CODEC (Chronotype of Patients with Type 2 Diabetes and Effect on Glycaemic Control) cohort (n = 720)

BASELINE			
Demographic variables	<u>Study sub-sample</u>	<u>Remainder of CODEC</u>	<u>p for difference*</u>
	<u>n=165</u>	<u>cohort</u>	
		<u>n=720</u>	
Age	64.2 ± 8.3	64.0 ± 8.4	0.426
Sex (women)	74 [45]	229 [32]	0.026
Ethnicity (white)	142 [86]	599 [83]	0.396
Current smokers	6 [3.6]	44 [6.1]	0.628
Index of multiple deprivation rank	18183 ± 8713	19141 ± 9650	0.794
Employment status			0.315
Employed	56 [34]	245 [34]	
Retired	93 [56]	411 [57]	
Other	16 [10]	64 [8.9]	
Number of diabetes medications			0.057
0	32 [19]	120 [17]	
1	69 [42]	257 [36]	
2	38 [23]	234 [33]	

	3	24 [15]	101 [14]	
	4	2 [1.2]	8 [1.1]	
Duration of diabetes (years)		11.4 ± 7.4	10.9 ± 8.1	0.480
Depressive symptoms (Patient Health Questionnaire 9)		2.5 (0, 7)	2.4 (0, 7)	0.745
Alcohol intake (units/week)		1 (0, 8)	1 (0, 9)	0.747
Short physical performance battery		11 (9, 12)	11 (9, 12)	0.402
Anthropometric variables				
Body mass index (kg/m ²)		31.4 ± 5.4	30.9 ± 5.0	0.391
Cardio-metabolic variables				
HbA1c (mmol/mol)		56 ± 12	54 ± 14	0.139
HbA1c (%)		7.2 ± 1.1	7.0 ± 1.3	
FOLLOW-UP				
Follow-up time (days)†		438 (253, 760)		
Number with 7 days of valid accelerometer data (pre and post)		133 [80.6]		
COVID specific variables				
Self-isolating		125 [76]		
Received specific advice to self-isolate		31 [19]		

Data are presented as mean ± standard deviation for continuous data, median (inter-quartile range) for ordinal data, or n[%] for categorical data

Socio-economic status measured by the index of multiple deprivation (IMD) rank where a rank of 1 indicates the most deprived and a rank of 32,482 the least deprived.

Depressive symptoms (Patient Health questionnaire 9): Depression severity scores of 0-4 indicate none, 5-9 mild, 10-14 moderate, 15-19 moderately severe, and 20-27 severe

*independent t-tests for normally distributed variables (parametric), Mann-Whitney U test for non-normally distributed variables (non-parametric), and chi-square independence test for categorical variables.

†maximum follow-up time = 3 years

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Table 2. Adjusted means (95%CI) of physical activity and sleep duration at baseline and during COVID-19 restrictions, adjusted for age, sex and follow-up time

Predictor		Baseline	During restrictions	Difference	p
Daily physical activity (n = 165)	Overall physical activity (mg)	22.3 (21.3, 23.2)	20.6 (19.5, 21.7)	-1.7 (-2.4, -1.0)	<0.001
	Time spent inactive (min)	734.2 (719.0, 749.5)	756.1 (739.9, 772.3)	21.9 (9.4, 34.3)	0.001
	MVPA (min)	22.4 (18.7, 26.1)	21.7 (18.0, 25.4)	-0.7 (-3.2, 1.9)	0.606
	M30 – continuous (mg)	100.9 (94.6, 107.2)	105.8 (96.6, 114.9)	4.9 (-3.0, 13.4)	0.237
	M10 – continuous (mg)	132.5 (124.2, 140.8)	137.3 (126.1, 148.5)	4.8 (-4.7, 14.8)	0.327
	Sleep duration (min)	452.9 (442.7, 463.2)	459.8 (449.4, 470.3)	6.9 (-2.5, 16.4)	0.150
Weekly physical activity (n = 133)	Days per week with 60 min continuous MVPA	0.24 (0.09, 0.38)	0.44 (0.23, 0.65)	0.20 (0.01, 0.40)	0.036
	Days per week with 30 min continuous MVPA	0.65 (0.41, 0.89)	1.00 (0.72, 1.28)	0.35 (0.10, 0.60)	0.006

mg = milli-gravitational units

min = minutes

MVPA: moderate-to-vigorous physical activity

M30 continuous = intensity of most active continuous 30 minutes

M10 continuous = intensity of most active continuous 10 minutes

CI = confidence interval

p = significance from general linear models using a repeated measures design (significant difference denoted in bold)

Table 3. Heatmap of associations between follow up physical activity value (during COVID-19 restrictions) and baseline predictors

		Daily physical activity (n = 165)				Weekly physical activity (n = 133)		
Predictor		Overall physical activity	Time spent inactive	MVPA	M30 – continuous acceleration	M10 – continuous acceleration	Days per week with 60min continuous MVPA	Days per week with 30min continuous MVPA
Model 1	Age				Yellow	Yellow	Yellow	Red
	Sex (women)	Yellow		Yellow				
	Follow-up time	Yellow	Red					
	Baseline value	Green	Red	Green	Green	Green	Green	Green
	Baseline season (Winter(ref) vs spring)							
Models 2	+Ethnicity (BAME)	Yellow						
	+SES		Light Green				Green	Light Green
	+BMI	Red	Yellow	Yellow	Yellow	Yellow	Red	Red
	+ Depressive symptoms				Yellow	Yellow	Red	Red
	+ HbA1c							
	+ T2DM Medications						Yellow	Red
	+ Employment (retired)							
	+ Alcohol intake							
	+ Smoker							
	+ T2DM duration			Yellow				Yellow
	+ Short sleeper							

	+ Physical function							
Model 3* (multi-variate)	Age							
	Sex (women)							
	Follow-up time							
	Baseline value							
	Baseline season (Winter(ref) vs spring)							
	Ethnicity (BAME)							
	SES							
	BMI							
	Depressive symptoms							
	T2DM Medications							
	T2DM duration							
	Physical function							

	Associated with higher activity or lower time spent inactive (p<0.01)
	Associated with higher activity or lower time spent inactive (p<0.05)
	No association
	Associated with lower activity or more time spent inactive (p<0.05)
	Associated with lower activity or more time spent inactive (p<0.01)

More precise information is available in Supplementary Table 1 (daily physical activity) and Supplementary Table 2 (weekly physical activity)

MVPA: moderate-to-vigorous physical activity

M10 continuous = intensity of most active continuous 10 minutes

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M30 continuous = intensity of most active continuous 30 minutes

BAME: Black and minority ethnic

SES: Socio-economic status measured by the index of multiple deprivation (IMD) rank where lower values indicate more deprived and higher values indicate less deprived.

BMI: Body mass index

T2DM: Type 2 diabetes mellitus

Depressive symptoms measured on the Patient Health questionnaire 9 with higher values indicating more severe symptoms

Physical function assessed on the Short Physical Performance Battery with higher scores representing better physical function

Short sleeper: people in the lowest tertile for sleep duration at baseline (tertile 1 < 375.5 min, tertile 2 = 375.5 min – 427.9 min, tertile 3 > 427.9 min)

*In model 3, all predictors from model 1 and significant predictors from models 2 were entered simultaneously. Boxes are blank (white) where predictors were not significant in model 2.

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Figure Legend

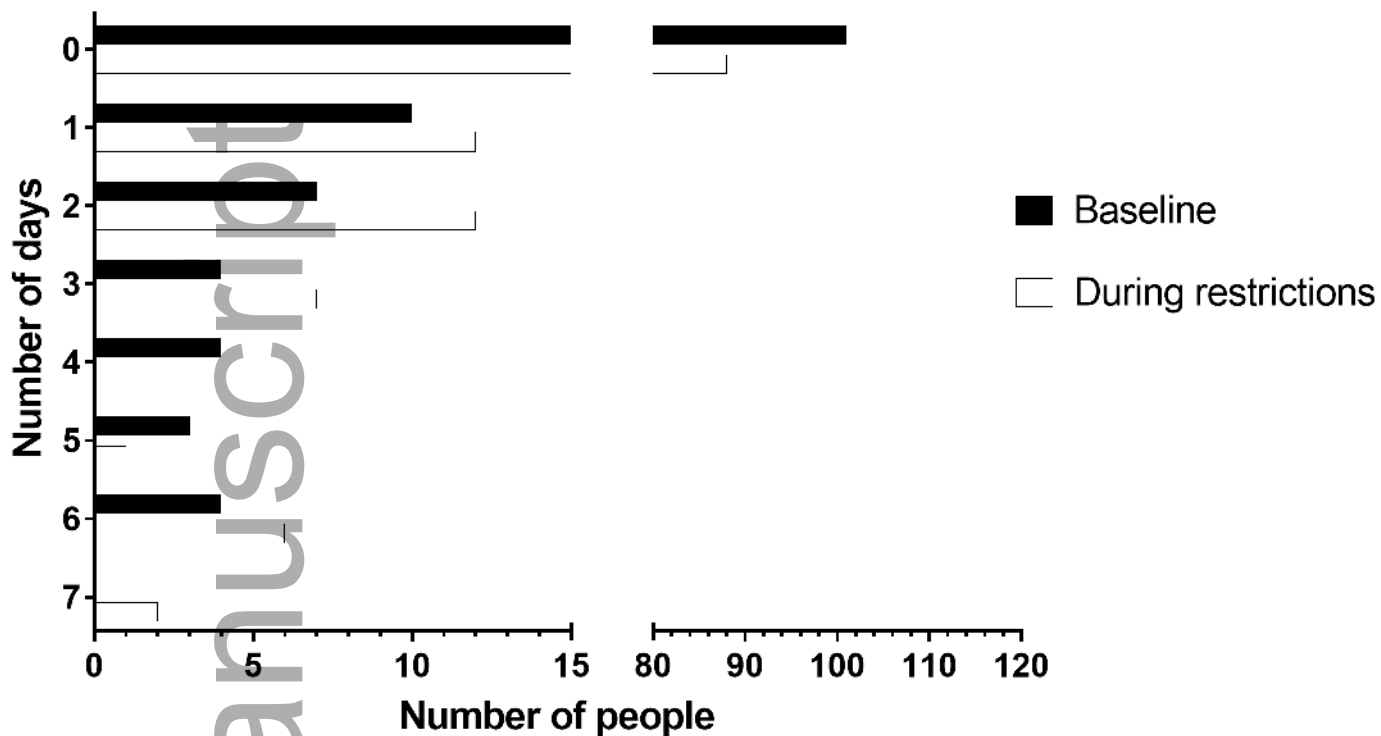
Figure 1. Number of days per week with a continuous 30 min (top) or 60 min (bottom) session of MVPA at baseline (before COVID-19) and during COVID-19 restrictions.

Supplementary information

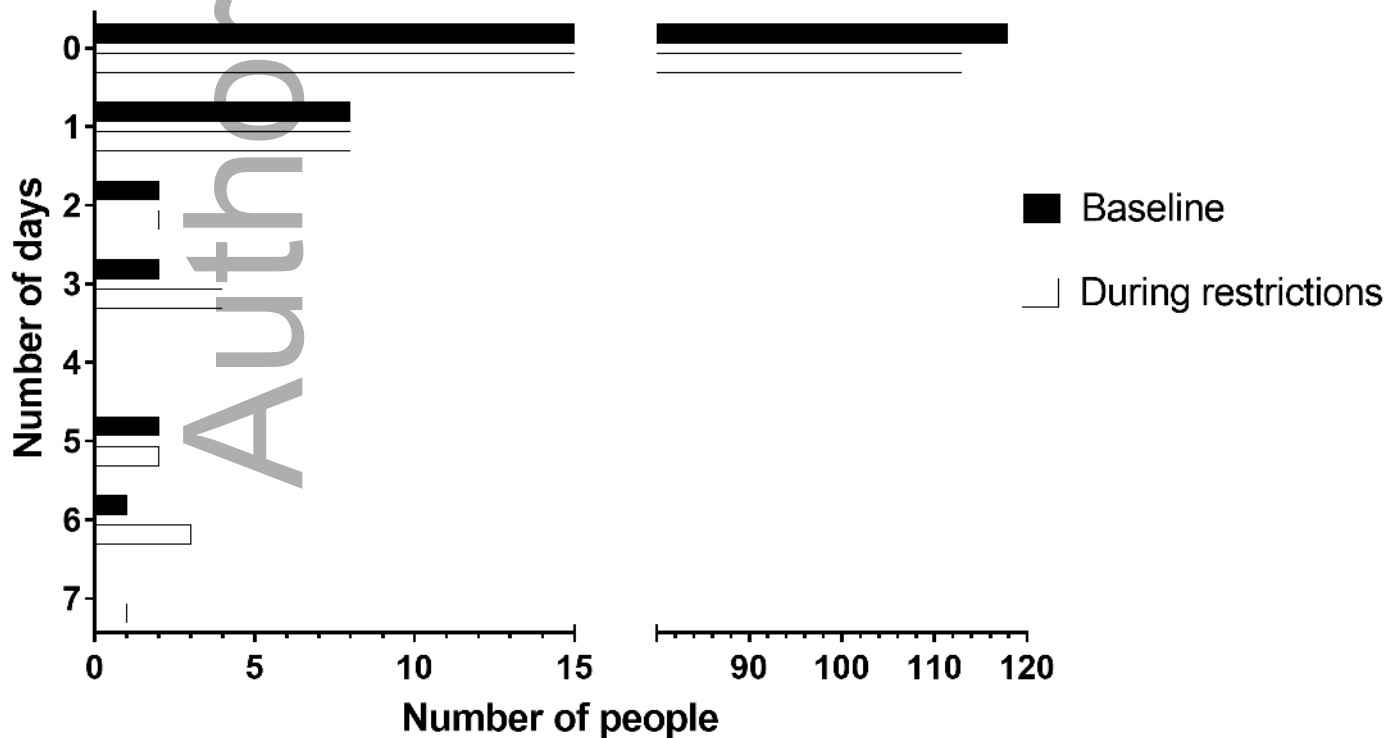
Supplementary Table 1: Associations between follow up daily physical activity value (during COVID-19 restrictions) and baseline predictors

Supplementary Table 2: Associations between follow up weekly physical activity value (during COVID-19 restrictions) and baseline predictors (Poisson distribution (log link))

30 minutes



60 minutes



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