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Correlates of and changes in aerobic physical activity and strength training before and after the onset of COVID-19 pandemic in the UK: findings from the HEBECO study

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ABSTRACT

Objectives Understanding changes in moderate to vigorous aerobic physical activity (MVPA) and muscle-strengthening activity (MSA) at the start of the COVID-19 pandemic and their correlates (socio-demographics, health characteristics, living and exercise conditions and pre-pandemic MVPA/MSA) can inform interventions.

Design A cross-sectional analysis of retrospective and concurrent data on MVPA/MSA.

Setting An online survey in the UK.

Participants 2657 adults (weighted n=2442, 53.6% women) participating in the baseline survey (29 April 2020–14 June 2020) of the HEalth BEhaviours during the COVID-19 pandemic (HEBECO) study.

Primary and secondary outcome measures Meeting WHO-recommended levels for MVPA/MSA/both (vs meeting neither) during the first lockdown and changes in MVPA/MSA from before to since the COVID-19 pandemic following stratification for pre-pandemic MVPA/MSA.

Results A third of adults maintained (30.4%), decreased (36.2%) or increased (33.4%) MVPA. For MSA, the percentages were 61.6%, 18.2% and 20.2%, respectively. MVPA increased or decreased by an average of 150 min/week and 219 min/week, respectively, and MSA by 2 days/week. Meeting both MSA+MVPA recommendations since COVID-19 (vs meeting neither) was positively associated with meeting MVPA+MSA before COVID-19 (adjusted OR (aOR)=16.11, 95% CI 11.24 to 23.07) and education: post-16 years of age (aOR=1.57, 95% CI 1.14 to 2.17), and negatively associated with having obesity (aOR=0.49, 95% CI 0.33 to 0.73), older age (65+ years vs ≤34 years; aOR=0.53, 95% CI 0.32 to 0.87) and annual household income of <50 000 GBP (aOR=0.65, 95% CI 0.46 to 0.91). The odds for decreasing MVPA were lower for white ethnicity (aOR=0.62, 95% CI 0.44 to 0.86), education: post-16 years of age (aOR=0.73, 95% CI 0.58 to 0.91) and access to garden/balcony (aOR=0.75, 95% CI 0.60 to 0.94), and were higher for those living in total isolation (aOR=3.81, 95% CI 2.33 to 6.23), with deteriorated psychological well-being (aOR=1.40, 95% CI 1.15 to 1.71) and conditions limiting physical activity (aOR=1.74, 95% CI 1.27 to 2.39). The odds for decreasing MSA were higher for having overweight (aOR=1.88, 95% CI 1.39 to 2.55), obesity (aOR=23.38, 95% CI 2.23 to 5.14) and being employed (aOR=1.81, 95% CI 1.34 to 2.46).

Conclusion Aerobic and strength training were differently impacted during the first UK lockdown, with poorer outcomes associated with older age, lower education and higher body mass index. Targeted interventions may be required to avoid pandemic-related inequities in physical activity.

Strengths and limitations of this study

- ⇒ The study presents novel data on the unique correlates of increases and decreases in WHO recommended levels of physical activity at the onset of the COVID-19 pandemic.
- ⇒ Two types of physical activity, moderate-to-vigorous aerobic physical activity and muscle strength training are assessed in the study.
- ⇒ It was a cross-sectional and self-reported study among a convenience sample.
- ⇒ Biases were minimised by weighing data using UK Census data.
- ⇒ We tested robustness of findings in sensitivity analyses.

INTRODUCTION

Physical activity has been negatively affected by the COVID-19 pandemic, which could have major implications for general health and COVID-19 outcomes.[1–3] As the COVID-19 pandemic continues and new restrictions may be introduced with new waves of the pandemic, it is paramount to understand how physical activity, and especially aerobic and muscle-strength training, were affected during the early stages of the pandemic, and which groups may require most support.

Adults who engage in less than 30 min of moderate physical activity per week are considered to be inactive.[4 5] In the UK[6] and other

countries (eg, the US[7] guidelines for physical activity), frequency and duration are complex, and often vary by age or clinical profile of the target population. However, a consensus exists that for the best health outcomes adults are recommended to engage in moderate-to-vigorous intensity aerobic physical activity (MVPA; ie, activities that increase heart rate and make one feel warmer) for at least 150 min/week, as well as in muscle-strengthening activity (MSA; eg, strength/resistance training) for at least 2 days/week.[8] MVPA and MSA lower morbidity and mortality both independently and combined.[9–14] Importantly, improving MVPA or MSA requires different strategies and interventions at both population and individual level, thus both are important outcomes to research.[15]

The COVID-19 pandemic[15] and social distancing measures introduced in the UK and other countries limited many opportunities to engage in physical activity.[15 16] The first national lockdown in the UK was introduced on 23 March 2020. As part of the lockdown measures, sports centres and gyms were temporarily closed and team sports banned, while access to outdoors spaces (eg, remote national parks) was greatly reduced (ie, some parks were closed or were only available to local visitors). By contrast, certain lockdown measures introduced in the UK could enable exercising, including the introduction of remote working that offered greater flexibility in scheduling and engaging in exercising at home or in local parks.[15] Furthermore, exercising outdoors was listed as one of the few activities that were still permitted even during the strictest lockdown in the UK, alongside shopping for essential items or medicine and going to work.

A large systematic review[17] showed that the majority of studies published by October 2020 reported declines in different measures of physical activity and increases in sedentary behaviour during the initial stages of COVID-19 pandemic.[17 18] However, some studies found that a small minority of adults increased their activity,[19] suggesting it is important to identify factors associated with both the detrimental and beneficial changes to activity levels. Female gender, lower income, older age, health conditions, perceived risks, poorer mental health and non-white ethnicity[19–25] were all associated with lower physical activity levels. However, few studies accounted for other factors that could be relevant during the pandemic, such as having access to indoor and outdoor exercising space or household makeup.[19]

Furthermore, research on how the COVID-19 pandemic has affected physical activity to date has often focused on moderate-to-vigorous physical activity (MVPA), without consideration of MSA, or failed to distinguish between MVPA and MSA,[17 19 26 27] or assessed only perceived, qualitative changes to physical activity levels with respect to pre-pandemic levels (eg, participants were asked to report if they exercised 'more' or 'less' since before the pandemic started rather than providing detailed information about MVPA and MSA responses).[28 29] Moreover, few studies that assessed and reported declines in MVPA and MSA, for example, among adults in Russia[30] and in Italy,[31] did not report on factors associated with these specific changes.

In order to identify groups in the population that may require targeted physical activity interventions during future periods of lockdowns or restrictions to physical activity, it is important to research the patterns and factors associated with changes in levels of both MVPA and MSA that are recommended by the WHO.

Aims

We characterised separately and combined MVPA and MSA levels during the periods before and since the COVID-19 pandemic had started in the UK, with the latter covering the period of the first strictest UK lockdown up until 14 June 2020. The research questions (RQs) were:

1. RQ1: what were the levels and changes in MVPA and MSA among UK adults from before to since COVID-19?
2. What socio-demographic, environmental and health factors were associated with:
   - RQ2: meeting WHO recommendations for MVPA and MSA since COVID-19?
   - RQ3: (1) decrease in MVPA among those who were active and (2) increase in MVPA among those who were inactive from before to since COVID-19?
   - RQ4: (1) decrease in MSA among those who were active and (2) increase in MSA among those who were inactive, from before to since COVID-19?

METHODS

Study design

The study involved cross-sectional data analysis from the baseline online survey of the HEalth BEhaviours during the COVID-19 pandemic (HEBECO) study (https://osf.io/sbgru/). Data were collected using REDCap software[32] at UCL. The protocol for the present data analysis was preregistered (https://osf.io/ejghs/). Departures from the protocol are explained in online supplemental materials 1. The results from all the preregistered analyses not reported here are available elsewhere (https://osfio/2ujxq/). The reporting follows the Strengthening the Reporting of Observational Studies in Epidemiology guidelines.[33]

Participants and procedures

Recruitment involved a UK-wide campaign, including paid and unpaid posts, on social media and information shared through the networks of Cancer Research UK, Public Health England, other charities, sports clubs, universities and local authorities. Interested participants were directed to the study website where they were shown a participant information sheet, provided informed consent and then completed the online survey. Participants with complete data on the measures of interest for this study, and who enrolled between 5 May 2020 (start of the data collection for all study variables, during the first UK lockdown) until 14 June 2020 (the last day prior

to easing of restrictions of the first UK lockdown) were included in the analytical sample.

Patient and public involvement

Patients or members of the public were not involved in the HEBECO baseline design, but the survey was shared with researchers at CRUK and Public Health England's behavioural insights function in order to collect their feedback and suggestions for questions and answers wording, where relevant (eg, when questions were not validated). Participants in the HEBECO study were encouraged to leave comments about specific behaviours and the survey itself, and these were incorporated into subsequent follow-up surveys (not the present study), where possible and relevant.

Measures

For the wording of all measures, see https://osf.io/bja7g/ and online supplemental materials 2. At baseline, participants indicated the time when their lives started to be affected by the COVID-19 pandemic in any way, which was used as an anchor to assess before/since the COVID-19 pandemic onset MVPA and MSA. Almost half (44.0%, weighted) of adults selected the second half of March, followed by 26.9% who selected the first half of March.

Meeting WHO recommendations for MVPA and MSA

The before/since COVID-19 MVPA and MSA were measured using the following questions.[14 34] For MVPA, participants were first asked, 'In the month before/since COVID-19, on average, how many times per week did you do at least 15 min or more of MVPA? Examples: brisk walk, jogging, dancing, cycling for recreation or commute, swimming, team or racket sports'. The answers were capped at 14+ "times" per week (ie, sessions), equivalent to at least two times (or sessions) of MVPA per day. The "15-minute or more" for the MVPA period was selected as it corresponds to the minimum amount of time of PA needed for mortality reduction and extending lifespan.[35] Those who engaged in at least one such session were asked, 'In the month before/since COVID-19, how long (in minutes) was your average session of MVPA? Do not include strength training'. Total weekly MVPA was computed by multiplying the session number by the minutes.

MSA was assessed by a single question: 'Before/since COVID-19, on average, how many days per week did you do strength training? Examples: pilates, push-ups, squats, yoga and exercises involving free weights, weight machines or elastic band'. The answers were capped at 4+ (days per week), given that the recommendations are for 2 days of MSA per week.

Data on MVPA and MSA were used to categorise participants, separately for before/since COVID-19, into four groups based on whether they met the WHO recommendations for MSA (at least 2 days/week) and MVPA (≥150 min/week)[8]: meeting neither, meeting MSA only, meeting MVPA only or meeting recommendations for both MSA and MVPA.

Change in MVPA and MSA

Changes in MVPA (RQ3) and MSA (RQ4) were calculated by subtracting the before COVID-19 levels of MSA or MVPA from the since COVID-19 levels. Participants were categorised into: maintenance (change in MVPA <20 min; change in MSA=0), decrease or increase in activity (MVPA by ±≥20 min; MSA by ±≥1 day). Dichotomous variables were then created: decreased (vs maintained/increased) and increased (vs maintained/decreased) MVPA and MSA levels.

To minimise the bias due to ceiling and floor effects when assessing changes to MVPA and MSA, the analyses for RQ3 and RQ4 were conducted after stratifying for before COVID-19 MVPA and MSA. Separately for MVPA and MSA, participants were categorised into: inactive (ie <30 min of MVPA/week[4 5]; 0 days of MSA/week) and active (≥30 min/week of MVPA; ≥1 day/week of MSA) before COVID-19.

Participants who were active since COVID-19 were also asked, 'Do you do the same form of exercise as you did before the COVID-19 (even if it is in a different location)?'. The answer options were: none of the same/some of the same/about half the same/mostly the same/exactly the same.

Explanatory factors and correlates

Socio-demographic characteristics and living conditions assessed were: gender (participants were asked to select which answer they identify with most, and the answers were dichotomised into: female/all other), ethnicity (white/non-white); education (post-16-years of age/other); employed (yes/no); furloughed/laid off (yes/no); income (low-middle <50 000 GBP/high ≥50 000 GBP/prefer not to say) and age (in decades was entered as a continuous variable where it met assumptions, or as a 3-level categorical variable: ≤34 years, 35–64 years and 65+ years).

We assessed health behaviours, health and living conditions that could impact on MVPA or MSA levels: self-reports of any condition that limited physical activity (yes/no); body mass index (BMI[34]: normal and underweight ≤24.99 kg/m^2/overweight=25–29.99 kg/m^2/obese ≥30 kg/m^2); smoking status (current smoker vs not)[36]; weekly frequency of alcohol drinking[37]; deterioration in psychological well-being from before to since COVID-19 (yes/no); participants' perceived risk of COVID-19 to their health ('no or minor risk'/other); access to a garden or balcony big enough to exercise in comfortably (yes/no); access to a public park/green space that is within a walking distance and open during COVID-19 (yes/no); living with children aged ≤15 years (yes/no); living with vulnerable persons (persons over the age of 70 years, in poor health or who may be vulnerable to COVID-19 (yes/no)). Participants were asked about the status of their isolation at the time of completing the survey: 'Which

type of COVID-19 induced isolation are you experiencing?': (1) total isolation/quarantine (not leaving the house for any reasons, not even to buy groceries or medications or to exercise); (2) some isolation (not leaving the house except to buy essential items, such as groceries or medication or to exercise); (3) general isolation but still go out to work (still go out to work and to buy essential items, such as groceries or medications or to exercise); (4) no isolation (I am free to leave the house whenever I like, including participating in social gatherings or group sports, going to a bar or restaurant and travelling for leisure). The answers were dichotomised into: (1) total isolation/(2)–(4) all other.

The regression models described below included two time covariates to account for weather changes: enrolment time (up until 15 May, the second half of May and the first half June) and time when COVID-19 started to affect individuals (before mid-March/later) as these could affect exercise levels.

Analysis

Analyses were conducted in SPSS V.26 with the data weighted using the 2018 Census and APS mid-year estimates for age, gender, ethnicity, country of living and household income. The analysis used weights trimmed to top 98th percentile to minimise the impact of extremely high weights.[38] Differences between the included and excluded participants were assessed with χ^2 test for categorical and t-test for continuous data.

For RQ1, descriptive statistics were computed to characterise the levels of MVPA, MSA, inactivity before/since the pandemic and changes in exercise form. For RQ2, univariate and fully adjusted multinomial regression models were computed. For RQ3 and RQ4, the sample was stratified using before pandemic MVPA or MSA levels to assess outcomes of interest using univariate and adjusted logistic regression models. All independent variables were entered into the models together as they were selected due to their previously established or theoretical importance. Sensitivity analyses involved replicating the analyses using unweighted data to check for the robustness of the results, and for RQ3 using different cut-off values of 15 mins and 30 mins. Familywise error was corrected for by using the Benjamini-Hochberg procedure separately for each RQ.[39]

RESULTS

Out of 2992 participants who were included in the HEBECO baseline sample, 2657 adults (weighted N=2442) had complete data for this study and were included in the analytical sample. Table 1 presents comparisons of the excluded and included sample. The included weighted sample comprised 52% females, 90.5% of white ethnicity and 67.0% with high school education or higher.

The sections below summarise the significant results for the weighted fully adjusted analyses. Results from univariable analyses are reported in online supplemental materials 3, and from sensitivity analyses in online supplemental materials 4 and 5. The results of the sensitivity analyses did not change the direction or magnitude of the results.

RQ1: changes in MVPA and MSA from before to since COVID-19

Table 2 presents data on physical activity levels before and since COVID-19. Before COVID-19, 17.6% of adults engaged in no MVPA and MSA, 55.3% engaged in no MSA and 19.4% engaged in no MVPA. Just under 15% of adults met the recommended levels of both MVPA and MSA before and since COVID-19. The proportion of those who had no MVPA or MSA activity increased minimally (17.6%–22.1%), which was primarily driven by declines in MVPA. Among those who were active since COVID-19, 41.5% continued with mostly or exactly the same form of activity as before COVID-19.

From before to since COVID-19, similar proportions of adults maintained (30.4%), decreased (36.2%) or increased (33.5%) their weekly MVPA. Among those who were active before COVID-19, 46.7% decreased MVPA. The decrease was of on average 219 min/week. Among those who were inactive before COVID-19, 29.7% increased MVPA, with an average increase of 144 min/week.

Maintenance of MSA was relatively more common (61.6%), with 18.2% decreasing and 20.2% increasing the number of days they engaged in MSA. Among those who were active before COVID-19 (40.2%), 45.1% decreased MSA, with an average decrease of 1.9 days/week. Among those who engaged in no MSA before COVID-19 (59.8%), 16.4% increased MSA, with an average increase of 2.5 days/week.

RQ2: predictors of meeting WHO recommendations

Table 3 presents results from fully adjusted models. Being aged 65+ years (adjusted OR (aOR)=0.53, 95% CI 0.32 to 0.87), having a lower pre-COVID-19 household income (aOR=0.65, 95% CI 0.46 to 0.91), having a condition limiting physical activity (aOR=0.44, 95% CI 0.28 to 0.71), having obesity (aOR=0.49, 95% CI 0.33 to 0.73), living in total isolation (aOR=0.44, 95% CI 0.23 to 0.83) and deterioration in psychological well-being (aOR=0.56, 95% CI 0.43 to 0.73) were significantly associated with lower odds, while having at least high school education (aOR=1.57, 95% CI 1.14 to 2.17) or meeting the WHO recommended levels of MVPA (aOR=3.88, 95% CI 2.64 to 5.70), MSA (aOR=6.38, 95% CI 4.26 to 9.54) or both before COVID-19 (aOR=16.11, 95% CI 11.24 to 23.07), were significantly associated with greater odds of meeting both MVPA and MSA WHO guidelines since COVID-19, as compared with not meeting either.

Having a condition that limited physical activity (aOR=0.43, 95% CI 0.29 to 0.63), being in total isolation (aOR=0.26, 95% CI 0.14 to 0.50) and deterioration in psychological well-being (aOR=0.71, 95% CI 0.56 to 0.89) was significantly associated with lower odds,

Table 1 Sample characteristics (weighted) and comparison of participants who were included and excluded from the study (due to incomplete data)

	Included sample N=2442	Excluded sample N=350	P value
Female	52.6%	48.7%	0.179
Age (years): mean (SD)	50.0 (16.0)	42.7 (18.9)	<0.001
White ethnicity	90.5%	82.4%	<0.001
Household income ≥50 000 GBP	18.1%	15.5%	0.095
Income: <50 000 GBP	73.5%	73.1%	
Income: prefer not to say	8.3%	11.5%	
Education: high school or higher	67.0%	69.1%	0.432
Employed	48.3%	40.7%	0.008
Laid-off/furloughed	12.7%	15.2%	0.197
Condition limiting physical activity	16.3%	21.2%	0.035
BMI ≤24 kg/m^2	43.2%	27.3%	<0.001
BMI: 25–29.99 kg/m^2	35.1%	16.8%	
BMI: obese: 30+ kg/m^2	21.7%	8.4%	
BMI: do not know/prefer not to say*	0%	47.6%	
Total isolation	7.8%	8.8%	0.541
Minor/no COVID-19 risk percept	33.3%	38.6%	0.069
Living with children	17.0%	15.7%	0.549
Living with vulnerable	15.1%	21.8%	0.001
Access garden/balcony	72.2%	62.6%	<0.001
Access green space	59.5%	52.4%	0.012
Time life affected by COVID-19 mid-March or sooner†	44.8%	53.3%	0.003
Enrolled from 1 June (reference)	4.4%	5.4%	0.404
Enrolled up until 15 May	50.1%	46.7%	
Enrolled second half of May	45.4%	47.9%	
Smoker	24.1%	38.9%	<0.001
Weekly alcohol drinking, none (reference)	21.8%	21.8%	0.920
Weekly or less	27.9%	26.9%	
More than weekly	50.3%	51.3%	
Deteriorated psychological well-being	54.1%	52.8%	0.708
Meeting WHO MVPA and MSA levels before COVID	15.6%	17.3%	0.218
Meeting only MVPA before	23.0%	22.0%	
Meeting only MSA before	13.0%	7.7%	
Meeting neither before	48.4%	53.0%	

*As per protocol, the participants who did not provide BMI data (eg, they selected 'prefer not to say' or 'do not know' on the question on height or weight) but who provided other study data were to be included in the analyses but were ultimately excluded due to having missing data on other variables.
†Time that participant's life started to be affected by COVID-19 in any way.
BMI, body mass index; MSA, muscle-strengthening activity; MVPA, moderate-to-vigorous aerobic physical activity.

and meeting the WHO recommended levels of MVPA (aOR=7.57, 95% CI 5.82 to 3.39) or both MVPA and MSA (aOR=2.31, 95% CI 1.59 to 3.39) was significantly associated with greater odds of meeting MVPA only since COVID-19. Being aged 35–64 years (aOR=0.56, 95% CI 0.38 to 0.82), and having obesity (BMI ≥30 kg/m^2; aOR=0.37, 95% CI 0.24 to 0.56), were associated with lower odds, while higher education, and meeting both MVPA and MSA or only MSA recommendations before COVID-19, were associated with greater odds of meeting the recommendations for MSA only since COVID-19.

RQ3: associations with changes in MVPA

Older age (aOR=0.91, 95% CI 0.85 to 0.98), white ethnicity (aOR=0.62, 95% CI 0.44 to 0.86), education:

Table 2 MVPA and MSA before and since COVID-19

	Before COVID-19*	Since COVID-19*
No activity (0 sessions MVPA and 0 days MSA): % (n)	17.6 (430)	22.1 (540)
MVPA		
MVPA 0 sessions: % (n)	19.4 (473)	24.8 (604)
MVPA min/week among active: median (IQR)	125 (210.0)	150 (220.0)
Mean (SD)	238.1 (424.0)	230.9 (398.8)
MVPA min/week among entire sample: median (IQR)	90 (180.0)	90 (224.5)
Mean (SD)	196.2 (395.4)	179.8 (364.7)
MSA		
MSA: % (n)		
0 days/week	55.3 (1557)	56.2 (1584)
1 day/week	11.1 (314)	9.6 (271)
2 days/week	10.4 (293)	7.9 (223)
3 days/week	9.0 (253)	7.6 (213
4+ days/week	7.0 (197)	11.3 (320)
MSA: median (IQR)	0 (2)	0 (2)
Meet guidelines: % (n)		
Neither MVPA nor MSA	45.1 (1271)	44.6 (1256)
Meet MVPA (≥150 min/week) only	21.3 (599)	21.2 (598)
Meet MSA (≥2 days/week) only	11.7 (330)	11.9 (336)
Meets both MVPA and MSA	14.5 (410)	14.8 (416)
Change in form of exercise among those who exercise: % (n)		
None of the same	–	17.1 (331)
Some of the same	–	32.7 (632)
About half the same	–	8.7 (168)
Mostly the same	–	26.0 (503)
Exactly the same	–	15.5 (299)

*As part of the HEBECO baseline survey, participants were asked about their physical activity levels Before/Since the COVID-19 pandemic has started to affect their livese in any way.
MSA, muscle-strengthening activity; MVPA, moderate-to-vigorous aerobic physical activity.

post-16 years of age (aOR=0.73, 95% CI 0.58 to 0.91) and access to a garden/balcony to exercise comfortably in (aOR=0.75, 95% CI 0.60 to 0.94) were significantly less likely to decrease MVPA activity (table 4). Those with conditions limiting PA (aOR=1.74, 95% CI 1.27 to 2.39), living in total isolation (aOR=3.81, 95% CI 2.33 to 6.23) and experiencing a deterioration in psychological well-being during lockdown (aOR=1.40, 95% CI 1.15 to 1.71) were significantly more likely to decrease MVPA from before COVID-19 levels.

White ethnicity, being employed during COVID-19 and living in total isolation were significantly associated with lower odds of increasing MVPA among this group. At least high school education and living with children were significantly associated with higher odds of increasing MVPA activity.

RQ4: associations with changes in MSA

Being employed during lockdown (aOR=1.81, 95% CI 1.34 to 2.46) and having overweight (BMI=25–29.99 kg/m^2; aOR=1.88, 95% CI 1.39 to 2.55) or obesity (BMI ≥30 kg/m^2; aOR=23.38, 95% CI 2.23 to 5.14) were significantly associated with higher odds of decreasing MSA activity. Older age (35–64 years, aOR=0.22, 95% CI 0.15 to 0.33; and 65+ years, aOR=0.34, 95% CI 0.20 to 0.58) and deterioration in psychological well-being (aOR=0.62, 95% CI 0.46 to 0.83) were significantly associated with lower odds of increasing MSA. See table 5 for details.

DISCUSSION

This study shows that the first COVID-19 lockdown in the UK affected the levels of MVPA and MSA differently, with several unique factors associated with engagement in and changes in these two activity types. Furthermore, although MVPA and MSA declined among a substantial proportion of UK adults during the first lockdown, which is in line with a majority of studies reporting declines across different measures of physical activity,[17 20] the

Table 3 Predictors of meeting both, MVPA only and MSA only WHO guidelines since COVID-19 in comparison to not meeting WHO guidelines for MVPA and MSA (reference, n=1178)

	Both MVPA and MSA (n=388)			MVPA only (n=570)			MSA only (n=306)		
	aOR	95% CI	P value	aOR	95% CI	P value	aOR	95% CI	P value
Female	1.08	0.82 to 1.41	0.588	0.79	0.62 to 1	0.049	1.02	0.77 to 1.35	0.906
Age ≤34 years									
Age: 35–64 years	0.7	0.49 to 0.99	0.047	1.11	0.78 to 1.56	0.566	**0.56**	**0.38 to 0.82**	**0.003**
Age: 65+ years	**0.53**	**0.32 to 0.87**	**0.012**	1.1	0.71 to 1.7	0.676	0.99	0.6 to 1.61	0.961
White ethnicity	1.61	1.03 to 2.52	0.036	1.57	0.99 to 2.49	0.054	0.72	0.47 to 1.1	0.13
Household income ≥50 000 GBP									
Income: <50 000 GBP	**0.65**	**0.46 to 0.91**	**0.011**	0.71	0.52 to 0.96	0.028	1.13	0.76 to 1.67	0.556
Income: prefer not to say	**0.44**	**0.25 to 0.77**	**0.004**	0.63	0.38 to 1.03	0.065	0.88	0.49 to 1.59	0.666
Education: post-16 years of age or higher	**1.57**	**1.14 to 2.17**	**0.006**	1.04	0.81 to 1.35	0.745	**1.74**	**1.24 to 2.45**	**0.002**
Employed	0.76	0.55 to 1.05	0.094	1.09	0.82 to 1.43	0.562	1.06	0.75 to 1.49	0.734
Laid-off/furloughed	0.79	0.51 to 1.23	0.295	1.05	0.71 to 1.54	0.813	1.14	0.71 to 1.83	0.584
Condition limiting physical activity	**0.44**	**0.28 to 0.71**	**0.001**	**0.43**	**0.29 to 0.63**	**<0.001**	0.97	0.65 to 1.45	0.881
BMI ≤24 kg/m^2									
BMI: 25–29.99 kg/m^2	0.81	0.6 to 1.1	0.176	1.01	0.78 to 1.32	0.926	0.72	0.53 to 0.99	0.043
BMI: obese: 30+ kg/m^2	**0.49**	**0.33 to 0.73**	**<0.001**	0.87	0.64 to 1.19	0.394	**0.37**	**0.24 to 0.56**	**<0.001**
Total isolation	**0.44**	**0.23 to 0.83**	**0.011**	**0.26**	**0.14 to 0.5**	**<0.001**	0.83	0.49 to 1.4	0.478
Minor/no COVID-19 risk percept	1	0.74 to 1.34	0.977	1.2	0.93 to 1.55	0.167	0.94	0.68 to 1.3	0.718
Living with children	0.81	0.57 to 1.16	0.254	0.75	0.55 to 1.03	0.079	0.66	0.44 to 0.99	0.045
Living with vulnerable	1.17	0.82 to 1.68	0.395	0.86	0.61 to 1.2	0.366	0.87	0.58 to 1.3	0.499
Access garden/balcony to exercise comfortably in	1.1	0.81 to 1.51	0.533	1.02	0.79 to 1.33	0.861	0.8	0.58 to 1.09	0.159
Access green space within walking distance	1.27	0.96 to 1.69	0.096	1.31	1.03 to 1.66	0.028	0.91	0.68 to 1.23	0.548
Smoker	0.72	0.51 to 1.02	0.062	0.93	0.7 to 1.22	0.593	0.8	0.57 to 1.14	0.218
Weekly alcohol drinking, none (reference)									
Weekly or less	1	0.68 to 1.49	0.988	1.43	1.02 to 2	0.038	1.06	0.71 to 1.59	0.782
More than weekly	1.04	0.73 to 1.5	0.811	1.28	0.94 to 1.74	0.121	0.89	0.61 to 1.29	0.528
Deteriorated psychological well-being	**0.56**	**0.43 to 0.73**	**<0.001**	**0.71**	**0.56 to 0.89**	**0.003**	0.72	0.55 to 0.96	0.025
Meeting WHO PA* recommendations before COVID-19 (meeting neither=reference)									
Meeting both before	**16.11**	**11.24 to 23.07**	**<0.001**	**2.31**	**1.58 to 3.39**	**<0.001**	**3.72**	**2.45 to 5.62**	**<0.001**
Meeting only MVPA before	**3.88**	**2.64 to 5.7**	**<0.001**	**7.57**	**5.82 to 9.84**	**<0.001**	1.47	0.94 to 2.3	0.092
Meeting only MSA before	**6.38**	**4.26 to 9.54**	**<0.001**	0.74	0.44 to 1.25	0.264	**9.61**	**6.7 to 13.77**	**<0.001**

Results from fully adjusted models using all variables listed on weighted data with Benjamini-Hochberg false discovery rate (BH FDR) correction of p values (significant in bold).
All models were also adjusted for the time of enrolment and time when COVID-19 started to affect individuals in any way. Following the BH FDR correction, the highest p value that met the threshold for significance was p=0.019.
*Meeting WHO's physical activity recommendations before the first COVID-19 lockdown in the UK.
aOR, adjusted OR; BMI, body mass index; MSA, muscle-strengthening activity; MVPA, moderate-to-vigorous aerobic physical activity.

Table 4 Independent associations of change in MVPA (models fully adjusted using all the variables listed)

	Sample active (≥30 min/week)			Sample inactive (<30 min/week)		
	Before COVID-19 (weighted n=1857)			Before COVID-19 (weighted n=585)		
	Decrease (n=868) versus not			Increase (n=174) versus not		
	aOR	95% CI	P value	aOR	95% CI	P value
Female	1.22	1 to 1.49	0.047	1.56	1.02 to 2.38	0.04
Age (in decades)	**0.91**	**0.85 to 0.98**	**0.015**	**0.72**	**0.61 to 0.84**	**<0.001**
White ethnicity	**0.62**	**0.44 to 0.86**	**0.005**	1.01	0.44 to 2.33	0.982
Household income ≥50 000 GBP						
Income:<50 000 GBP	1.3	1 to 1.67	0.048	0.49	0.26 to 0.93	0.03
Income: prefer not to say	1.22	0.81 to 1.85	0.335	0.36	0.14 to 0.93	0.034
Education: post-16 years of age or higher	**0.73**	**0.58 to 0.91**	**0.006**	**2.26**	**1.4 to 3.63**	**0.001**
Employed	0.86	0.69 to 1.07	0.18	**0.51**	**0.31 to 0.85**	**0.009**
Laid-off/furloughed	1.05	0.76 to 1.47	0.75	1.3	0.72 to 2.37	0.385
Condition limiting PA	**1.74**	**1.27 to 2.39**	**0.001**	0.49	0.27 to 0.89	0.019
BMI ≤24 kg/m^2						
BMI: 25–29.99 kg/m^2	1.03	0.82 to 1.28	0.816	1.54	0.94 to 2.53	0.088
BMI: obese: 30+ kg/m^2	0.87	0.66 to 1.14	0.317	0.74	0.42 to 1.31	0.307
Total isolation	**3.81**	**2.33 to 6.23**	**<0.001**	**0.29**	**0.12 to 0.73**	**0.008**
Minor/no COVID-19 risk percept	0.99	0.8 to 1.23	0.926	1.2	0.76 to 1.92	0.436
Living with children	0.84	0.65 to 1.09	0.187	**2.32**	**1.27 to 4.24**	**0.006**
Living with vulnerable	0.78	0.59 to 1.02	0.074	0.9	0.51 to 1.59	0.716
Access garden/balcony to exercise comfortably in	**0.75**	**0.6 to 0.94**	**0.011**	0.72	0.46 to 1.13	0.157
Access green space within walking distance	0.82	0.67 to 1.01	0.059	1.1	0.72 to 1.67	0.665
Smoker	1.09	0.85 to 1.4	0.504	1.15	0.73 to 1.8	0.551
Weekly alcohol drinking, none (reference)						
Weekly or less	0.78	0.59 to 1.04	0.087	0.77	0.43 to 1.38	0.378
More than weekly	0.78	0.6 to 1.02	0.068	0.88	0.52 to 1.5	0.644
Deteriorated psychological well-being	**1.4**	**1.15 to 1.71**	**0.001**	1.09	0.72 to 1.66	0.682

All models were also adjusted for the time of enrolment and time when COVID-19 started to affect individuals in any way. Following the Benjamini-Hochberg false discovery rate (BH FDR) correction, the highest p value that met the threshold for significance was p=0.019 (the significant results are presented in bold).
Segmented analyses of active sample (before COVID-19; MVPA activity ≥30 min; predicting decrease by ≥20 min) and inactive sample (before COVID-19 MVPA; activity <30 min; predicting increase by ≥20 min).
aOR, adjusted OR; BMI, body mass index; MVPA, moderate-to-vigorous aerobic physical activity.

present findings show that a substantial minority of UK adults maintained or increased MVPA or MSA levels. These findings underline the importance of measuring MVPA and MSA, and their correlates, separately.

Meeting WHO recommendations for MVPA and MSA before and since COVID-19

Adherence to WHO recommendations for both MVPA and MSA before and since COVID-19 was low—at about 15%, which is lower than 26% reported in the Health Survey for England (HSE) for 2012–2016.[40] Also, in comparison to the findings from HSE (36%), fewer of the adults in this study (21%) met MVPA only recommendations, but more met MSA only recommendations (12% in this study vs 1% in HSE). The current MSA levels are reflecting other epidemiological data.[9 41] The differences between the HEBECO and HSE findings could be due to the differences in the measures of MSA and MVPA used, participant characteristics (eg, in comparison to the HSE study,[40] the HEBECO sample included more educated adults who may be more aware of the benefits of MSA), or reflect genuine changes to the patterns of physical activity in the UK across time. In line with other studies,[40 42] older adults (aged 65+ years), adults who were obese, those with before COVID-19 household income below 50 000 GBP and those who had conditions limiting physical activity were at greater risk of not meeting the WHO recommendations for both MVPA and MSA. These groups should be targeted by future interventions aimed at increasing

Table 5 Independent associations of change in MSA (models fully adjusted using all the variables listed)

	Sample active (≥1 day/week)			Sample inactive (0 days/week)		
	Before COVID-19 (weighted n=985)			Before COVID-19 (weighted n=1456)		
	Decrease (n=444) versus not			Increase (n=239) versus not		
	aOR	95% CI	P value	aOR	95% CI	P value
Female	0.94	0.71 to 1.23	0.634	0.96	0.7 to 1.31	0.792
Age (in decades)	1.03	0.94 to 1.14	0.516	–		–
Age ≤34 years						
Age: 35–64 years	–		–	**0.22**	**0.15 to 0.33**	**<0.001**
Age: 65+ years	–		–	**0.34**	**0.2 to 0.58**	**<0.001**
White ethnicity	0.75	0.51 to 1.11	0.154	0.71	0.41 to 1.23	0.216
Household income ≥50 000 GBP						
Income:<50 000 GBP	1.11	0.8 to 1.55	0.535	0.67	0.45 to 0.99	0.047
Income: prefer not to say	0.94	0.54 to 1.62	0.818	0.56	0.29 to 1.08	0.084
Education: post-16 years of age or higher	0.82	0.59 to 1.15	0.26	1.2	0.85 to 1.7	0.31
Employed	**1.81**	**1.34 to 2.46**	**<0.001**	1.08	0.75 to 1.55	0.671
Laid-off/f	1.34	0.85 to 2.12	0.205	1.3	0.8 to 2.1	0.289
Condition limiting physical activity	1.11	0.72 to 1.72	0.632	0.64	0.38 to 1.05	0.078
BMI ≤24.99 kg/m^2						
BMI: 25–29.99 kg/m^2	**1.88**	**1.39 to 2.55**	**<0.001**	0.89	0.63 to 1.26	0.512
BMI: obese: 30+ kg/m^2	**3.38**	**2.23 to 5.14**	**<0.001**	0.64	0.42 to 0.97	0.037
Total isolation	1.87	1.02 to 3.42	0.042	0.8	0.42 to 1.52	0.499
Minor/no COVID-19 risk percept	**1.43**	**1.06 to 1.92**	**0.019**	0.93	0.65 to 1.31	0.669
Living with children	1.01	0.71 to 1.44	0.964	1.48	0.94 to 2.31	0.088
Living with vulnerable	1.17	0.79 to 1.74	0.437	0.95	0.63 to 1.44	0.809
Access garden/balcony to exercise comfortably in	1.02	0.74 to 1.41	0.891	0.84	0.6 to 1.17	0.301
Access green space within walking distance	1.07	0.79 to 1.43	0.667	0.87	0.64 to 1.18	0.37
Smoker	**0.63**	**0.43 to 0.91**	**0.013**	1.04	0.74 to 1.46	0.828
Weekly alcohol drinking, none (reference)						
Weekly or less	1.11	0.74 to 1.65	0.62	1.13	0.73 to 1.76	0.58
More than weekly	1.26	0.86 to 1.85	0.237	1.06	0.71 to 1.59	0.786
Deteriorated psychological well-being	1.27	0.97 to 1.66	0.082	**0.62**	**0.46 to 0.83**	**0.002**

All models were also adjusted for the time of enrolment and time when COVID-19 started to affect individuals in any way. Following the Benjamini-Hochberg false discovery rate (BH FDR) correction, the highest p value that met the threshold for significance for was p=0.019. Segmented analyses of active sample (before COVID-19; MSA activity ≥1 day/week; predicting decrease by ≥1 day/week) and less inactive sample (before COVID-19; MSA activity 0 days/week; predicting increase by ≥1 day/week). Findings from fully adjusted logistic regression models on weighted data and using BH FDR adjustment (significant in bold).
aOR, adjusted OR; BMI, body mass index; MSA, muscle-strengthening activity.

physical activity. Such targeting could include dedicated reach out campaigns of more generic interventions among these groups, as well as developing interventions that address the unique circumstances in which these populations can engage in physical activity.

Meeting the recommendations for MVPA and MSA before COVID-19 was strongly predictive of meeting them since COVID-19. Additionally, adults who remained active tended to maintain at least similar levels and forms of the exercises as in the pre-pandemic period. Thus, as UK adults remain relatively consistent in their behaviour, even during the lockdown, this study highlights the need to especially support those with low activity levels to develop healthy exercising routines.

Changes to MVPA and MSA levels from before to since the COVID-19 pandemic start

Although group level data suggest little change in physical activity from before to since COVID-19, especially in MSA, about a third of adults decreased and another third increased their MVPA from before to since COVID-19. Those who changed MVPA decreased or increased their

MVPA levels by over 3 hours/week and 2 hours/week, respectively. Those who changed MSA either gained or lost 2 days of MSA per week. These changes are substantial and likely to affect health outcomes.

Decreases in MVPA were found among other adults samples in the UK,[19] Italy[26] and Spain.[27] However, the finding that over 70% of UK adults maintained or increased their MVPA could be at least partially attributed to the UK government's consistent lockdown policies that allowed leaving the house for exercising, which is in contrast to other countries with more restrictive policies.[27 43]

The maintenance of MSA levels could be at least partially explained by the low before COVID-19 MSA levels. Additionally, many MSA exercises can be performed with no equipment and at one's home (eg, pilates and push-ups) and thus may be less affected by social distancing measures. This is further supported by the finding that total isolation (ie, not leaving the house for any reason) was associated with MVPA but not MSA levels.

Factors associated with changes and maintenance of MVPA and MSA since COVID-19

Older adults were more likely to maintain their before COVID-19 MVPA and MSA levels, including inactivity. Due to more established routines and lower baseline physical activity, this group might have been less affected by the lockdown restrictions, such as gym closures or team sports bans.[44]

MVPA inactivity was more commonly maintained by those who were employed or living in total isolation. Such adults likely had fewer opportunities or flexibility to exercise. Additionally, those who had a health condition limiting physical activity and those living in total isolation tended to decrease MVPA. Factors that were associated with maintaining MVPA activity since COVID-19 were white ethnicity, higher education and having a garden or balcony large enough to exercise.

Increasing MVPA levels among those who were previously inactive was most common among those with higher education, which is in line with prior studies,[45] and those who lived with children. Caring for children might have promoted some forms of MVPA, including outdoors, particularly as parents became responsible for children's physical education during school lockdown closures.

In terms of changes in MSA levels, older adults were at a higher risk of maintaining MSA inactivity, while adults with higher BMI levels were at a greater risk of decreasing MSA from before to since COVID-19. Adults with higher BMI reported lower levels of physical activity during lockdowns in other studies as well.[28] Therefore, both older adults and those with higher BMI should be among priority groups targeted with MSA interventions, particularly as MSA can bring important clinical benefits to these two groups.[46–49] Other priority groups for MSA training are those with lower household income and lower educational attainment.

Finally, as found previously,[24] psychological well-being was associated with physical activity levels. In the present study, deterioration in psychological well-being was associated with not meeting guidelines for MVPA or decreasing MVPA levels, but not with MSA. Due to the cross-sectional design, causality cannot be assumed as poorer psychological well-being (eg, lower mood, anxiety and stress) can be both a predictor and a consequence of low exercise levels.[50 51] However, interventions aimed at improving physical activity are likely to improve mental health as well.[50–52]

Strengths and limitations

The study is one of a few that assessed the levels of, and changes in, both MVPA and MSA during the first UK lockdown. The study drew on previously used measures of MVPA and MSA,[53] which were supplemented by images to clarify exercise types. This study also benefits from measuring and including in the models a large number of correlates and covariates that could act as potential confounding variables. Several sensitivity analyses were conducted to test the robustness of findings. The key limitations are that this was a cross-sectional study among a self-selected sample that relied on self-report and recall that are prone to bias. This could lead to over-reporting of physical activity and the possibility that the wider population had an even poorer physical activity profile during the pandemic. A small sample (11%) of all HEBECO baseline participants were excluded from the present analyses due to incomplete data (eg, attrition before reporting physical activity). However, while some of the characteristics of the excluded participants could be associated with greater physical activity (ie, younger age, non-female gender and lower BMI), others may be associated with lower physical activity levels (ie, not being in employment, not having access to garden or balcony, being a smoker or being of non-white ethnicity). On balance, the present findings, therefore, may be reflective of the changes in physical activity at the population level in the UK. Finally, the unfolding of the COVID-19 pandemic has coincided with the seasonal change from winter to spring. Without a true baseline from the same period in 2019, it is not possible to tease apart the effect of weather change from that of the pandemic.

Implications

This study adds to the growing body of literature that emphasises the importance of researching MSA in addition to the more commonly assessed MVPA.[9] It also shows that although the first UK lockdown adversely affected many individuals, a considerable proportion of the adults managed to maintain or even improve MVPA and MSA. These findings suggest that future interventions and policies should not only aim to prevent deterioration in physical activity but also try to capitalise on the opportunities brought by lifestyle disruption to support increases in activity levels. We have at our disposal many interventions and tools, including those that are digital based or

technology based, which could be offered at relatively low cost to large target populations while adhering to even the strictest lockdown measures. Efforts should focus now on identifying acceptable and effective ways of delivering such interventions for both MVPA and MSA, especially among the groups in the population that are at risk of poorer PA outcomes and given the ongoing challenges brought by the COVID-19 pandemic.

CONCLUSIONS

The findings highlight social inequalities in how the first lockdown in the UK has affected physical activity levels, with differential impact on aerobic and strength training. Dedicated interventions are needed to support MVPA and MSA, especially among those who are older, have lower income and have higher BMI with general low activity levels.

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Supplementary Materials 1-5

Manuscript Title: Correlates of and changes in aerobic physical activity and strength training before and after the onset of COVID-19 pandemic in the UK – findings from the HEBECO study.

Article pre-registration: https://osf.io/spdtb

Contents

Supplementary Materials 1: Changes to the pre-registered protocol

The analysis protocol pre-registered on OSF prior to data inspection outlined analyses for research questions 3 and 4 involving unstratified multinomial analyses with change in MVPA and MSA as dependent variables. Specifically, the pre-registered protocol specified that we will use multinomial regression models to assess the correlates of a three-level dependent variables on change in (i) MVPA (increase by at least 20min/week, maintenance with change between 0 to 19min, and a decrease in MVPA by at least 20min/week) and in (ii) MSA (increase by at least 1 day/week, maintenance with change=0 days/week, and a decrease with change by at least 1 day/week). All the analyses were performed as per the original plan and can be accessed here: https://osf.io/2ujxq/.

Upon inspecting the data and the results a decision was made that this approach is not satisfactory as the group of maintainers of MVPA and MSA category included both inactive and active participants. This has motivated us to conduct and report the present analyses that stratified the sample based on pre-Covid-19 activity levels to identify meaningful changes.

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Supplementary Materials 2: detailed description of study measures

Below are the details of the all the explanatory measures assessed at baseline that are relevant for the study. For the full wording of the baseline survey see: https://osf.io/bja7g/

Socio-demographic, health and wellbeing characteristics

Gender (female gender/other; prefer not to say (PNS) were treated as missing) was assessed by asking participants: "Which of the following best describes how you think of yourself?".

Ethnicity (white/non-white; PNS treated as missing) was assessed by asking participants: "What is your ethnic group?".

Education (high school education or higher; yes/no) was assessed by asking participants: "What is the highest level of education that you have completed?"

Employment (employed or self-employed; yes/no) and **furloughed/laid off** (yes/no) were assessed by asking participants: "What is your current MAIN occupation (during COVID-19)?".

Income (low-middle <50 000 GBP vs high ≥50 000 GBP vs PNS) was assessed by asking participants: "What was your household annual income BEFORE COVID-19? (do not include income of friends)".

Age was assessed as a continuous variable. For the analyses we used age in decades and entered it as a continuous variable. Where the continuous variable violated the linearity assumptions of the logistic regression models (as did its logarithmic and square root transformation), a 3-level categorical variable was created (≤34, 35-64, 65+).

Health behaviours and conditions

- **Body mass index, BMI** (normal and underweight ≤24.99/overweight 25-29.99/ obese ≥30/ unknown (included answers 'don't know' and PNS to height or weight variables)). BMI was calculated by dividing participants weight in kilogram by their squared height in meters and categorised into: normal weight and underweight. BMI is associated with both MVPA and MSA levels (Churilla et al., 2018).

- **Self-reports of any condition that limited their ability to engage in physical activity** (yes/no; PNS treated as missing). Participants were asked: "Do you now suffer from any condition that limits you from engaging in physical activity, including walking or doing housework?"

- **Self-perceived risk of Covid-19 to one's health** (minor or no risk/major, significant, moderate risk or 'don't know') was assessed with the question: "What risk does COVID-19 pose to your health?"

- **Smoking status** (current smokers vs not) was assessed using a single item: "Which statement about tobacco use and cigarette smoking best describes you?". Those responding 1 ("I smoke cigarettes (including hand-rolled) every day") and 2 ("I smoke cigarettes (including hand-rolled), but not every day") were classified as current smokers. Smoking is associated with physical activity levels (Kaczynski, Manske, Mannell, & Grewal, 2008).

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- **Weekly alcohol consumption** since the Covid-19 pandemic has started was assessed by asking participants how many times they had a drink containing alcohol, with the categorical answers converted to weekly frequencies from 0 to 6.5 times per week (0=I have not had any alcohol after COVID-19 started, 0.25=monthly or less, 0.75=2 to 4 times a month, 2.5=2 to 3 times a week, 4.5=4 to 5 times a week, 6.5=6 or more times a week). In models where the continuous alcohol frequency variable violated the linearity assumptions of the logistic regression models (as did its logarithmic and square root transformation), weekly alcohol frequency was categorised into three levels (none/weekly or less often/more frequently than weekly). Alcohol drinking is associated with physical activity levels (Leasure, Neighbors, Henderson, & Young, 2015).

- **Deterioration in psychological wellbeing** (yes/no). Deterioration in psychological wellbeing was assessed on a five-point Likert scale (1=poor, 3=average, 5=excellent) by asking participants: "How would you rate the below aspects of your life? – Psychological wellbeing". The question was asked about the period before Covid-19 and since Covid-19. A change score was calculated by deducting the score before from since score. As the continuous variable violated the linearity assumptions of the logistic regression models (as did its logarithmic and square root transformation), participants were categorised into either deteriorated psychological wellbeing (change score < 0) versus maintained or improved psychological wellbeing (change score ≥ 0).

- **Isolation status** (total isolation/other) was assessed by asking which type of Covid-19 induced isolation participants were experiencing. Answers were dichotomised into indications of total isolation/quarantine ("not leaving the house for any reasons, not even to buy groceries or medications or to exercise") versus any other (some, general, or no isolation). Participants' perceived risk of Covid-19 to their health was dichotomised into 'no or minor risk perception' versus any other indication (moderate risk, significant, major or not known). It was hypothesised that perceived risk could affect physical activity, especially MVPA that may happen outdoors.

- **Access to space to exercise** was assessed using a single question on participants' access to spaces that allowed multiple answers, including for: „a garden or balcony big enough to exercise comfortably" and to "a public park/green space that is within a walking distance and open during Covid-19". The answers were dummy coded into separate binary variables (yes/no).

- **Living with children age 15 and younger** (yes/no) and **living with vulnerable persons** (any of: persons over the age of 70, persons in poor health versus, or persons who they believed may be vulnerable to Covid-19 for any reason) was assessed by asking participants: "Do you live with any of these persons below? (select all that apply)." It was hypothesised that living with these groups could limit some of the opportunities to exercise.

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Supplementary materials 3: Univariable analyses.

Supplementary Table S3.1. (univariable) Research question 2 -Predictors of meeting both, MVPA only and MSA only in comparison to meeting WHO guidelines for neither MVPA nor MSA (reference, n=1178). Results from unadjusted models on weighted data with BH FDR correction of p-values (significant in bold).

	Both (n=388)				MVPA only (n=570)				MSA only (n=306)			
	OR	95% CI		*p*	OR	95% CI		*p*	OR	95% CI		*p*
Female	1.01	0.80	1.27	0.928	**0.62**	**0.51**	**0.76**	**<0.001**	0.93	0.72	1.19	0.546
Age ≤34[a]												
Age: 35-64	**0.57**	**0.43**	**0.75**	**<0.001**	1.08	0.82	1.42	0.604	**0.41**	**0.30**	**0.56**	**<0.001**
Age: 65+	**0.41**	**0.28**	**0.60**	**<0.001**	1.02	0.73	1.43	0.893	**0.58**	**0.40**	**0.84**	**0.004**
White ethnicity	0.77	0.52	1.12	0.166	1.53	1.02	2.30	0.040	**0.43**	**0.30**	**0.62**	**<0.001**
Household income ≥50.000												
Income: <50 000 GBP	**0.44**	**0.33**	**0.59**	**<0.001**	**0.66**	**0.50**	**0.85**	**0.002**	0.80	0.57	1.12	0.194
Income: Prefer not to say	**0.41**	**0.25**	**0.66**	**<0.001**	**0.50**	**0.32**	**0.77**	**0.002**	0.79	0.47	1.34	0.385
Education: Highschool or higher	**2.57**	**1.96**	**3.38**	**<0.001**	**1.34**	**1.09**	**1.65**	**0.006**	**2.41**	**1.79**	**3.24**	**<0.001**
Employed	1.14	0.90	1.43	0.272	1.20	0.98	1.46	0.077	1.05	0.81	1.35	0.714
Laid-off/Furloughed	0.95	0.67	1.35	0.784	1.01	0.75	1.36	0.972	1.04	0.72	1.51	0.839
Condition limiting PA	**0.24**	**0.16**	**0.37**	**<0.001**	**0.27**	**0.19**	**0.37**	**<0.001**	**0.64**	**0.46**	**0.89**	**0.009**
BMI ≤24												
BMI: 25-29.99	**0.62**	**0.48**	**0.81**	**<0.001**	0.86	0.68	1.08	0.191	**0.60**	**0.45**	**0.79**	**<0.001**
BMI: Obese: 30+	**0.31**	**0.22**	**0.43**	**<0.001**	**0.62**	**0.48**	**0.81**	**<0.001**	**0.27**	**0.19**	**0.40**	**<0.001**
Total isolation	**0.30**	**0.17**	**0.52**	**<0.001**	**0.17**	**0.10**	**0.31**	**<0.001**	0.67	0.43	1.05	0.079
Minor/no Covid-19 risk percept	**1.70**	**1.34**	**2.16**	**<0.001**	**1.39**	**1.12**	**1.72**	**0.002**	**1.37**	**1.05**	**1.79**	**0.019**
Living with children	0.99	0.73	1.33	0.925	0.81	0.61	1.06	0.121	0.70	0.49	1.01	0.056
Living with vulnerable	1.09	0.80	1.48	0.583	0.80	0.59	1.06	0.122	0.87	0.61	1.25	0.450
Access garden/balcony to exercise comfortably in	1.18	0.91	1.54	0.212	1.01	0.81	1.27	0.918	0.82	0.63	1.08	0.157
Access green space within walking distance	**1.70**	**1.33**	**2.16**	**<0.001**	**1.59**	**1.29**	**1.95**	**<0.001**	1.29	1.00	1.67	0.049
Smoker	**0.48**	**0.35**	**0.64**	**<0.001**	**0.72**	**0.57**	**0.91**	**0.006**	**0.64**	**0.47**	**0.87**	**0.004**
Alcohol drinking frequency, never (ref)												
Weekly or less	1.32	0.94	1.85	0.106	**1.50**	**1.12**	**2.02**	**0.006**	1.48	1.04	2.11	0.032
More than weekly	**1.47**	**1.09**	**1.98**	**0.012**	**1.50**	**1.15**	**1.95**	**0.003**	1.21	0.87	1.68	0.249
Deteriorated psychological wellbeing	**0.62**	**0.50**	**0.79**	**<0.001**	**0.71**	**0.58**	**0.87**	**0.001**	0.74	0.58	0.95	0.019
Meeting WHO PA rec (meeting neither=ref)												
Meeting both before	**17.58**	**12.53**	**24.65**	**<0.001**	**2.30**	**1.60**	**3.31**	**<0.001**	**4.03**	**2.72**	**5.99**	**<0.001**
Meeting only MVPA before	**4.53**	**3.13**	**6.55**	**<0.001**	**8.30**	**6.47**	**10.65**	**<0.001**	1.67	1.08	2.58	0.021
Meeting only MSA before	**7.72**	**5.27**	**11.32**	**<0.001**	0.86	0.52	1.42	0.549	**10.31**	**7.37**	**14.43**	**<0.001**

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Supplementary Table S3.2. (univariable) Research question 3: Independent associations of change in MVPA. Segmented analyses of active sample (pre-Covid-19 MVPA activity ≥30min; predicting decrease by ≥20min) and less active/inactive sample (pre-Covid-19 MVPA activity <30min; predicting increase by ≥20min). Findings from unadjusted logistic regression models on weighted data and using BH FDR adjustment (significant in bold).

	Sample active (≥30min/week) pre-Covid-19 (weighted n=1857)				Sample inactive (<30min/week) pre-Covid-19 (weighted n=585)			
	Decrease (n=868) vs not				Increase (n=174) vs not			
	OR	95% CI		*p*	OR	95% CI		*p*
Female	**1.38**	**1.15**	**1.65**	**0.001**	1.13	0.79	1.62	0.496
Age (in decades)	0.94	0.88	0.99	0.024	**0.67**	**0.59**	**0.75**	**<0.001**
White ethnicity	**0.57**	**0.42**	**0.77**	**<0.001**	0.46	0.24	0.88	0.019
Household income ≥50.000								
Income: <50 000 GBP	**1.36**	**1.08**	**1.71**	**0.010**	**0.45**	**0.27**	**0.77**	**0.003**
Income: Prefer not to say	**1.59**	**1.09**	**2.33**	**0.017**	0.53	0.25	1.14	0.103
Education: Highschool or higher	**0.72**	**0.59**	**0.88**	**0.001**	**2.67**	**1.81**	**3.93**	**<0.001**
Employed	0.82	0.69	0.99	0.036	0.80	0.55	1.16	0.235
Laid-off/Furloughed	1.22	0.92	1.62	0.165	**2.16**	**1.36**	**3.43**	**0.001**
Condition limiting PA	**2.28**	**1.71**	**3.04**	**<0.001**	**0.27**	**0.16**	**0.43**	**<0.001**
BMI ≤24								
BMI: 25-29.99	1.01	0.82	1.23	0.961	1.04	0.69	1.55	0.863
BMI: Obese: 30+	0.99	0.78	1.27	0.945	0.56	0.34	0.90	0.016
Total isolation	**4.95**	**3.11**	**7.88**	**<0.001**	**0.22**	**0.10**	**0.49**	**<0.001**
Minor/no Covid-19 risk percept	0.94	0.77	1.14	0.503	**2.17**	**1.50**	**3.14**	**<0.001**
Living with children	0.89	0.70	1.13	0.319	1.37	0.82	2.30	0.225
Living with vulnerable	**0.72**	**0.56**	**0.93**	**0.012**	1.14	0.70	1.85	0.599
Access garden/balcony to exercise comfortably in	0.82	0.67	1.00	0.053	**0.61**	**0.42**	**0.89**	**0.011**
Access green space within walking distance	0.81	0.67	0.98	0.026	**1.66**	**1.16**	**2.37**	**0.006**
Smoker	0.94	0.75	1.17	0.576	1.15	0.79	1.68	0.454
Alcohol drinking frequency, never (ref)								
Weekly or less	**0.68**	**0.52**	**0.89**	**0.005**	1.19	0.73	1.96	0.483
More than weekly	**0.60**	**0.47**	**0.76**	**<0.001**	1.22	0.78	1.90	0.387
Deteriorated psychological wellbeing	**1.42**	**1.18**	**1.71**	**<0.001**	1.03	0.73	1.47	0.854

Adjusted for the time of enrolment and time when Covid-19 started to affect individuals in any way.

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Supplementary Table S3.3 Research question 4: Independent associations of change in MSA. Segmented analyses of active sample (pre-Covid-19 MSA activity ≥1 day/week; predicting decrease by ≥1 day/week) and less inactive sample (pre-Covid-19 MSA activity 0 days/week; predicting increase by ≥1 day/week). Findings from unadjusted logistic regression models on weighted data and using BH FDR adjustment (significant in bold).

	Sample active (≥1 day/week) pre-Covid-19 (weighted n=985)				Sample inactive (0 days/week) pre-Covid-19 (weighted n=1456)			
	Decrease (n=444) vs not				Increase (n=239) vs not			
	OR	95% CI		*p*	OR	95% CI		*p*
Female	0.87	0.67	1.12	0.274	0.85	0.64	1.12	0.249
Age (in decades)	1.02	0.94	1.10	0.625	-	-	-	-
Age ≤34[a]								
Age: 35-64	-	-	-	-	**0.20**	**0.14**	**0.28**	**<0.001**
Age: 65+	-	-	-	-	**0.27**	**0.18**	**0.40**	**<0.001**
White ethnicity	0.80	0.57	1.13	0.210	**0.36**	**0.22**	**0.58**	**<0.001**
Household income ≥50.000								
Income: <50 000 GBP	1.01	0.75	1.36	0.953	**0.61**	**0.42**	**0.87**	**0.007**
Income: Prefer not to say	0.80	0.48	1.31	0.368	0.64	0.36	1.17	0.147
Education: Highschool or higher	0.74	0.55	1.00	0.051	**1.86**	**1.37**	**2.52**	**<0.001**
Employed	**1.60**	**1.24**	**2.06**	**<0.001**	1.01	0.76	1.33	0.951
Laid-off/Furloughed	0.99	0.67	1.45	0.954	1.33	0.91	1.96	0.141
Condition limiting PA	1.35	0.92	1.97	0.120	**0.43**	**0.27**	**0.67**	**<0.001**
BMI ≤24								
BMI: 25-29.99	**1.88**	**1.42**	**2.50**	**<0.001**	0.68	0.50	0.93	0.016
BMI: Obese: 30+	**3.20**	**2.18**	**4.72**	**<0.001**	**0.43**	**0.29**	**0.63**	**<0.001**
Total isolation	**2.05**	**1.22**	**3.45**	**0.007**	0.62	0.35	1.10	0.102
Minor/no Covid-19 risk percept	1.07	0.83	1.38	0.596	**1.61**	**1.20**	**2.15**	**0.001**
Living with children	0.83	0.60	1.15	0.266	1.44	0.95	2.18	0.086
Living with vulnerable	1.13	0.79	1.63	0.498	1.01	0.69	1.47	0.971
Access garden/balcony to exercise comfortably in	0.90	0.67	1.19	0.453	0.74	0.55	0.99	0.043
Access green space within walking distance	0.94	0.72	1.22	0.621	1.12	0.85	1.49	0.420
Smoker	0.65	0.46	0.90	0.010	1.00	0.74	1.36	0.995
Alcohol drinking frequency, never (ref)								
Weekly or less	0.88	0.61	1.27	0.508	1.50	1.00	2.27	0.051
More than weekly	0.93	0.67	1.30	0.677	1.40	0.97	2.03	0.072
Deteriorated psychological wellbeing	1.37	1.06	1.77	0.014	0.72	0.55	0.95	0.021

Adjusted for the time of enrolment and time when Covid-19 started to affect individuals in any way.

[a]Age was categorised in models where the continuous predictor violated the linearity assumption.

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Supplementary Materials 4: Unweighted analyses

Supplementary Table S4.1. (unweighted data) Sample characteristics % (N).

	Included sample (2657)	Excluded sample (336)	*p*
Female	68.9 (1831)	68.1 (224)	0.760
Age; M (SD)	48.4 (15.2)	43.7 (16.7)	<0.001
White ethnicity	94.4 (2507)	91.1 (297)	0.020
Household income ≥50.000	90.9 (993)	9.1 (100)	<0.001
Income: <50 000 GBP	54.5 (1447)	55.5 (186)	
Income: Prefer not to say	8.2 (217)	14.6 (49)	
Education: Highschool or higher	86.8 (2307)	85.7 (288)	0.571
Employed	56.1 (1490)	49.1 (164)	0.016
Laid-off/Furloughed	9.8 (261)	12.3 (41)	0.161
Condition limiting PA	13.2 (351)	19.6 (54)	0.003
BMI ≤24	49.1 (1305)	23.8 (62)	<0.001
BMI: 25-29.99	31.3 (832)	15.8 (41)	
BMI: Obese: 30+	19.6 (520)	9.2 (24)	
Total isolation	7.2 (190)	7.2 (21)	0.955
Minor/no Covid-19 risk percept	37.5 (996)	42.4 (123)	0.101
Living with children	19.6 (520)	19.0 (64)	0.820
Living with vulnerable	14.8 (394)	16.1 (54)	0.547
Access garden/balcony	71.9 (1911)	63.1 (212)	0.001
Access green space	63.5 (1687)	57.1 (192)	0.023
Time affected up till mid March	49.5 (1316)	55.1 (185)	0.056
Enrolled from 1st June (ref)	5.2 (139)	4.8 (16)	0.479
Enrolled up until 15th May	48.9 (1298)	45.8 (154)	
Enrolled second half of May	45.9 (1220)	49.4 (166)	
Smoker	17.7 (470)	25.6 (86)	<0.001
Alcohol drinking frequency, never (ref)	17.0 (453)	19.6 (66)	0.092
Weekly or less	27.5 (732)	31.3 (105)	
More than weekly	55.4 (1472)	49.1 (165)	
Deteriorated psychological wellbeing	55.1 (1465)	50.2 (117)	0.148
Meeting WHO PA rec (meeting both=ref)	17.9 (475)	14.9 (26)	0.332
Meeting only MVPA before	22.8 (605)	23.0 (40)	
Meeting only MSA before	14.9 (395)	11.5 (20)	
Meeting neither before	44.5 (1182)	50.6 (88)	

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Supplementary Table S4.2. (unweighted data) Aerobic physical activity (MVPA) and strength training (MSA) before to after the Covid-19 pandemic has started to affect individuals in the UK (up until 14th June 2020).

	Before Covid-19[1]	Since Covid-19[1]
Inactive (0 sessions MVPA and 0 days MSA) % (N)	14.1 (375)	16.0 (425)
MVPA 0 sessions % (N)	15.9 (422)	18.5 (491)
MVPA		
MVPA min/week among active; Median (IQR)	135.0 (180.0)	150.0 (240.0)
Mean (SD)	215.3 (363.4)	227.0 (341.7)
Mean (SD) replacing extremes with 840 min/week	191.8 (186.9)	206.9 (193.7)
MVPA min/week among entire sample; Median (IQR)	120.0 (185.0)	120.0 (215.0)
Mean (SD)	184.9 (345.0)	190.7 (324.1)
Mean (SD) replacing extremes with 840 min/week	164.7 (185.6)	173.8 (193.1)
MSA Median (IQR)	0 (2)	0 (2)
MSA % (N)		
0 das/week	53.0 (1408)	54.0 (1435)
1 day/week	14.3 (379)	11.7 (311)
2 days/week	14.6 (387)	10.5 (280)
3 days/week	10.4 (277)	9.6 (254)
4+ days/week	7.8 (206)	14.2 (377)
Meet guidelines % (N)		
Neither MVPA nor MSA	44.5 (1182)	42.0 (1117)
Meet MVPA (≥150min/week) only	22.8 (605)	23.7 (629)
Meet MSA (≥2 days/week) only	14.9 (395)	14.7 (390)
Meets both MVPA and MSA	17.9 (475)	19.6 (521)
Change in form of exercise % (N)		
None of the same		13.2 (350)
Some of the same		29.1 (774)
About half the same		8.8 (233)
Mostly the same		23.4 (622)
Exactly the same		10.0 (267)

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Supplementary Table S4.3. (unweighted data) Research question 2 – Factors associated with meeting both, MVPA only and MSA only in comparison to meeting WHO guidelines for neither MVPA nor MSA (reference, n=1117) after the Covid-19 pandemic has started to affect individuals in the UK (up until June 2020[1]). Results from fully adjusted models on unweighted data with BH FDR correction of p-values (significant in bold).

	Both (n=521)				MVPA only (n=629)				MSA only (n=390)			
Characteristics and associations	aOR	95% CI		*p*	aOR	95% CI		*p*	aOR	95% CI		*p*
Female	1.17	0.89	1.52	0.256	0.93	0.73	1.18	0.546	1.16	0.87	1.53	0.308
Age ≤34[a]												
Age: 35-64	0.92	0.67	1.25	0.589	**1.49**	**1.09**	**2.05**	**0.013**	**0.59**	**0.43**	**0.82**	**0.001**
Age: 65+	0.64	0.40	1.03	0.067	**1.80**	**1.17**	**2.75**	**0.007**	0.90	0.57	1.44	0.664
White ethnicity	1.36	0.81	2.27	0.245	1.79	1.01	3.15	0.044	0.67	0.42	1.08	0.099
Household income ≥50.000												
Income: <50 000 GBP	**0.58**	**0.44**	**0.76**	**<0.001**	**0.70**	**0.55**	**0.90**	**0.006**	1.00	0.75	1.33	0.976
Income: Prefer not to say	**0.55**	**0.34**	**0.89**	**0.014**	0.76	0.49	1.17	0.214	0.90	0.54	1.48	0.667
Education: Highschool or higher	1.38	0.92	2.09	0.121	1.20	0.86	1.67	0.293	**1.86**	**1.19**	**2.90**	**0.007**
Employed	0.78	0.58	1.05	0.102	1.11	0.85	1.47	0.442	1.22	0.89	1.68	0.212
Laid-off/Furloughed	1.00	0.64	1.55	0.997	1.07	0.70	1.62	0.759	1.33	0.84	2.13	0.227
Condition limiting PA	**0.42**	**0.27**	**0.65**	**<0.001**	**0.36**	**0.24**	**0.54**	**<0.001**	0.78	0.53	1.16	0.219
BMI ≤24												
BMI: 25-29.99	**0.61**	**0.46**	**0.80**	**<0.001**	0.80	0.62	1.02	0.076	**0.66**	**0.49**	**0.88**	**0.005**
BMI: Obese: 30+	**0.35**	**0.24**	**0.51**	**<0.001**	**0.69**	**0.51**	**0.93**	**0.014**	**0.43**	**0.30**	**0.62**	**<0.001**
Total isolation	**0.39**	**0.22**	**0.69**	**0.001**	**0.22**	**0.12**	**0.41**	**<0.001**	0.84	0.52	1.38	0.498
Minor/no Covid-19 risk percept	0.82	0.64	1.07	0.147	0.92	0.72	1.17	0.476	0.90	0.68	1.20	0.477
Living with children	0.79	0.58	1.07	0.130	**0.56**	**0.42**	**0.76**	**<0.001**	0.89	0.64	1.24	0.497
Living with vulnerable	1.14	0.81	1.60	0.457	1.07	0.79	1.46	0.662	0.94	0.65	1.35	0.721
Access garden/balcony to exercise comfortably in	1.09	0.82	1.44	0.562	1.00	0.78	1.29	0.994	0.98	0.74	1.31	0.901
Access green space within walking distance	1.17	0.90	1.51	0.243	1.23	0.97	1.56	0.081	1.16	0.89	1.53	0.278
Smoker	**0.56**	**0.40**	**0.79**	**0.001**	**0.69**	**0.52**	**0.93**	**0.016**	**0.65**	**0.46**	**0.92**	**0.016**
Alcohol drinking frequency, never (ref)												
Weekly or less	1.24	0.84	1.82	0.279	1.16	0.82	1.63	0.405	1.07	0.72	1.58	0.745
More than weekly	1.25	0.88	1.78	0.221	1.14	0.83	1.56	0.412	1.02	0.71	1.47	0.923
Deteriorated psychological wellbeing	**0.61**	**0.48**	**0.78**	**<0.001**	0.78	0.63	0.98	0.029	**0.65**	**0.51**	**0.84**	**0.001**
Meeting WHO PA rec (meeting neither=ref)												
Meeting both before	**14.58**	**10.48**	**20.30**	**<0.001**	**2.47**	**1.74**	**3.52**	**<0.001**	**3.53**	**2.44**	**5.10**	**<0.001**
Meeting only MVPA before	**3.31**	**2.35**	**4.66**	**<0.001**	**5.86**	**4.54**	**7.55**	**<0.001**	0.84	0.54	1.31	0.445
Meeting only MSA before	**4.98**	**3.49**	**7.11**	**<0.001**	0.79	0.51	1.24	0.303	**6.59**	**4.80**	**9.06**	**<0.001**

Models adjusted for the time of enrolment and time when Covid-19 started to affect individuals in any way.

[1] Covering the period of the strictest first lockdown in the UK

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Supplementary Table S4.4. Research question 3: Independent associations of change in MVPA from before to after the Covid-19 pandemic has started to affect individuals in the UK (up until 14th June 2020[2]). Segmented analyses of active sample (pre-Covid-19 MVPA activity ≥30min; predicting decrease by ≥20min) and less active/inactive sample (pre-Covid-19 MVPA activity <30min; predicting increase by ≥20min). Findings from fully adjusted logistic regression models on unweighted data and using BH FDR adjustment (significant in bold).

Characteristics and associations	Sample active (≥30min/week) pre-Covid-19 (unweighted n=2132)				Sample inactive (<30min/week) pre-Covid-19 (unweighted n=525)			
	Decrease (n=905) vs not				Increase (n=195) vs not			
	aOR	95% CI		*p*	aOR	95% CI		*p*
Female	1.05	0.86	1.27	0.660	1.12	0.73	1.74	0.605
Age (in decades)	**0.91**	**0.85**	**0.98**	**0.011**	**0.80**	**0.68**	**0.94**	**0.007**
White ethnicity	**0.52**	**0.35**	**0.76**	**0.001**	0.80	0.30	2.15	0.656
Household income ≥50.000								
Income: <50 000 GBP	**1.41**	**1.15**	**1.73**	**0.001**	0.95	0.59	1.53	0.829
Income: Prefer not to say	1.31	0.92	1.87	0.130	0.72	0.32	1.65	0.441
Education: Highschool or higher	0.73	0.54	0.98	0.036	1.87	1.07	3.26	0.028
Employed	0.96	0.77	1.18	0.682	0.70	0.43	1.13	0.140
Laid-off/Furloughed	0.95	0.68	1.34	0.782	1.51	0.77	2.93	0.227
Condition limiting PA	**1.87**	**1.37**	**2.55**	**<0.001**	**0.47**	**0.27**	**0.83**	**0.010**
BMI ≤24								
BMI: 25-29.99	1.08	0.88	1.33	0.456	1.11	0.69	1.79	0.665
BMI: Obese: 30+	0.97	0.75	1.26	0.833	0.71	0.42	1.19	0.195
Total isolation	**2.91**	**1.89**	**4.46**	**<0.001**	**0.22**	**0.09**	**0.54**	**0.001**
Minor/no Covid-19 risk percept	1.21	0.99	1.47	0.067	1.19	0.76	1.87	0.441
Living with children	0.80	0.64	1.01	0.061	0.86	0.52	1.44	0.570
Living with vulnerable	0.92	0.71	1.20	0.551	0.83	0.49	1.43	0.511
Access garden/balcony to exercise comfortably in	**0.74**	**0.60**	**0.91**	**0.005**	0.96	0.61	1.49	0.847
Access green space within walking distance	0.95	0.78	1.15	0.589	1.45	0.96	2.19	0.077
Smoker	0.88	0.68	1.13	0.311	1.70	1.05	2.74	0.030
Alcohol drinking frequency, never (ref)								
Weekly or less	1.08	0.81	1.44	0.605	0.96	0.54	1.71	0.890
More than weekly	0.89	0.68	1.16	0.378	1.24	0.75	2.06	0.399
Deteriorated psychological wellbeing	**1.40**	**1.16**	**1.68**	**<0.001**	1.12	0.74	1.67	0.597

Models adjusted for the time of enrolment and time when Covid-19 started to affect individuals in any way.

[2] Covering the period of the strictest first lockdown in the UK

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Supplementary Table S4.5. (unweighted data). Research question 4: Independent associations of change in MSA from before to after the Covid-19 pandemic has started to affect individuals in the UK (up until 14th June 2020[3]). Segmented analyses of active sample (pre-Covid-19 MSA activity ≥1 day/week; predicting decrease by ≥1 day/week) and less inactive sample (pre-Covid-19 MSA activity 0 days/week; predicting increase by ≥1 day/week). Findings from fully adjusted logistic regression models on unweighted data and using BH FDR adjustment (significant in bold).

	Sample active (≥1 day/week) pre-Covid-19 (unweighted n=1249)				Sample inactive (0 days/week) pre-Covid-19 (unweighted n=1408)			
	Decrease (n=534) vs not				Increase (n=284) vs not			
Characteristics and associations	aOR	95% CI		*p*	aOR	95% CI		*p*
Female	0.83	0.64	1.08	0.160	1.216	0.899	1.647	0.205
Age (in decades)	1.03	0.94	1.12	0.579	-	-	-	-
Age ≤34[a]								
Age: 35-64	-	-	-	-	**0.353**	**0.248**	**0.502**	**<0.001**
Age: 65+	-	-	-	-	**0.305**	**0.178**	**0.524**	**<0.001**
White ethnicity	0.89	0.57	1.39	0.611	0.553	0.298	1.024	0.060
Household income ≥50.000								
Income: <50 000 GBP	1.25	0.96	1.64	0.096	**0.678**	**0.496**	**0.928**	**0.015**
Income: Prefer not to say	1.39	0.88	2.18	0.155	0.480	0.258	0.893	0.020
Education: Highschool or higher	0.96	0.62	1.49	0.863	1.310	0.837	2.051	0.237
Employed	**1.49**	**1.12**	**1.97**	**0.005**	0.900	0.634	1.278	0.557
Laid-off/Furloughed	1.18	0.75	1.85	0.467	1.104	0.676	1.803	0.694
Condition limiting PA	1.08	0.72	1.62	0.708	0.664	0.409	1.078	0.097
BMI ≤24								
BMI: 25-29.99	**1.63**	**1.24**	**2.13**	**<0.001**	0.846	0.613	1.168	0.310
BMI: Obese: 30+	**2.50**	**1.73**	**3.60**	**<0.001**	0.707	0.484	1.031	0.072
Total isolation	**2.03**	**1.18**	**3.50**	**0.011**	0.861	0.481	1.543	0.615
Minor/no Covid-19 risk percept	1.18	0.91	1.52	0.216	1.045	0.769	1.421	0.777
Living with children	1.04	0.77	1.41	0.784	0.708	0.503	0.997	0.048
Living with vulnerable	1.11	0.78	1.59	0.553	0.990	0.677	1.446	0.957
Access garden/balcony to exercise comfortably in	0.86	0.65	1.13	0.275	0.765	0.562	1.040	0.088
Access green space within walking distance	0.95	0.74	1.23	0.713	1.102	0.816	1.489	0.527
Smoker	**0.61**	**0.43**	**0.87**	**0.007**	1.096	0.772	1.557	0.608
Alcohol drinking frequency, never (ref)								
Weekly or less	1.01	0.69	1.49	0.943	1.192	0.776	1.833	0.422
More than weekly	0.99	0.69	1.42	0.951	1.124	0.755	1.672	0.565
Deteriorated psychological wellbeing	**1.38**	**1.09**	**1.76**	**0.008**	**0.643**	**0.488**	**0.848**	**0.002**

Models adjusted for the time of enrolment and time when Covid-19 started to affect individuals in any way.

[a]Age was categorised in models where the continuous predictor violated the linearity assumption.

[3] Covering the period of the strictest first lockdown in the UK

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Supplementary Materials 5: Sensitivity Analyses for RQ3 (different cut-off values for MVPA change).

Supplementary Table S5.1. Predicting MVPA decrease of at least 15 min in the active sample from before to after the Covid-19 pandemic has started to affect individuals in the UK (up until 14th June 2020). (fully adjusted model, weighted data).

Characteristics and associations	**aOR**	**95% CI**		***p***
Female	1.232	1.010	1.503	.039
Age (in decades)	**.914**	**.849**	**.983**	**.015**
White ethnicity	**.649**	**.464**	**.909**	**.012**
Household income ≥50.000	1.0			
Income: <50 000 GBP	1.272	.986	1.641	.064
Income: Prefer not to say	1.182	.783	1.783	.427
Education: Highschool or higher	**.754**	**.602**	**.944**	**.014**
Employed	.841	.677	1.045	.118
Laid-off/Furloughed	1.025	.738	1.423	.884
Condition limiting PA	**1.732**	**1.260**	**2.381**	**.001**
BMI ≤24	1.0			
BMI: 25-29.99	1.025	.822	1.280	.824
BMI: Obese: 30+	.875	.667	1.147	.334
Total isolation	**3.682**	**2.252**	**6.020**	**.000**
Minor/no Covid-19 risk percept	.984	.791	1.224	.882
Living with children	.858	.661	1.114	.251
Living with vulnerable	.801	.607	1.058	.118
Access garden/balcony to exercise comfortably in	.773	.618	.968	.025
Access green space within walking distance	.813	.662	.998	.048
Smoker	1.106	.861	1.420	.432
Alcohol drinking frequency, never (ref)	1.0			
Weekly or less	.790	.596	1.049	.103
More than weekly	.772	.594	1.003	.053
Deteriorated psychological wellbeing	**1.422**	**1.170**	**1.728**	**.000**

Model was adjusted for all the variable sin the table as well as the time of enrolment and time when Covid-19 started to affect individuals in any way. Significant results are in bold.

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Supplementary Table S5.2. Predicting MVPA increase of at least 15 min in the active sample from before to after the Covid-19 pandemic has started to affect individuals in the UK (up until 14th June 2020; fully adjusted model, weighted data).

Characteristics and associations	aOR	95% CI		p
Female	1.513	1.003	2.282	.048
Age (in decades)	**.750**	**.642**	**.876**	**.000**
White ethnicity	.564	.249	1.276	.169
Household income ≥50.000	1.0			
Income: <50 000 GBP	.633	.339	1.182	.152
Income: Prefer not to say	.663	.271	1.620	.367
Education: Highschool or higher	1.700	1.078	2.683	.023
Employed	.846	.526	1.362	.492
Laid-off/Furloughed	1.380	.762	2.498	.288
Condition limiting PA	**.445**	**.249**	**.795**	**.006**
BMI ≤24	1.0			
BMI: 25-29.99	1.640	1.014	2.652	.044
BMI: Obese: 30+	.778	.451	1.343	.368
Total isolation	.395	.172	.907	.029
Minor/no Covid-19 risk percept	1.349	.857	2.122	.196
Living with children	1.600	.917	2.793	.098
Living with vulnerable	.872	.505	1.508	.624
Access garden/balcony to exercise comfortably in	.730	.469	1.136	.163
Access green space within walking distance	.986	.656	1.481	.944
Smoker	1.491	.963	2.309	.073
Alcohol drinking frequency, never (ref)	1.0			
Weekly or less	.719	.407	1.272	.257
More than weekly	.941	.567	1.563	.814
Deteriorated psychological wellbeing	1.275	.850	1.913	.241

Model was adjusted for all the variable sin the table as well as the time of enrolment and time when Covid-19 started to affect individuals in any way. Significant results are in bold.

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Supplementary Table S5.3. Predicting MVPA decrease of at least 30 min in the active sample (fully adjusted model, weighted data).

Characteristics and associations	aOR	95% CI		p
Female	1.207	.989	1.474	.064
Age (in decades)	**.904**	**.841**	**.973**	**.007**
White ethnicity	**.618**	**.441**	**.865**	**.005**
Household income ≥50.000	1.0			
Income: <50 000 GBP	1.356	1.049	1.753	.020
Income: Prefer not to say	1.276	.845	1.927	.246
Education: Highschool or higher	**.741**	**.592**	**.928**	**.009**
Employed	.853	.686	1.061	.153
Laid-off/Furloughed	1.037	.747	1.441	.827
Condition limiting PA	**1.672**	**1.219**	**2.293**	**.001**
BMI ≤24	1.0			
BMI: 25-29.99	1.047	.838	1.308	.684
BMI: Obese: 30+	.880	.671	1.155	.357
Total isolation	**3.426**	**2.130**	**5.511**	**.000**
Minor/no Covid-19 risk percept	.978	.785	1.218	.842
Living with children	.837	.644	1.087	.182
Living with vulnerable	.756	.572	.998	.048
Access garden/balcony to exercise comfortably in	**.744**	**.594**	**.932**	**.010**
Access green space within walking distance	.820	.667	1.008	.059
Smoker	1.097	.854	1.410	.468
Alcohol drinking frequency, never (ref)	1.0			
Weekly or less	.753	.567	.999	.049
More than weekly	.752	.578	.977	.033
Deteriorated psychological wellbeing	**1.403**	**1.154**	**1.706**	**.001**

Model was adjusted for all the variable sin the table as well as the time of enrolment and time when Covid-19 started to affect individuals in any way. Significant results are in bold.

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Supplementary Table S5.4. Predicting MVPA increase of at least 30 min in the inactive sample (fully adjusted model, weighted data).

Characteristics and associations	aOR	95% CI		p
Female	**1.877**	**1.213**	**2.902**	**.005**
Age (in decades)	**.707**	**.599**	**.836**	**.000**
White ethnicity	1.391	.575	3.363	.464
Household income ≥50.000	1.0			
Income: <50 000 GBP	**.394**	**.205**	**.757**	**.005**
Income: Prefer not to say	**.208**	**.077**	**.560**	**.002**
Education: Highschool or higher	**2.116**	**1.296**	**3.456**	**.003**
Employed	**.516**	**.309**	**.861**	**.011**
Laid-off/Furloughed	1.380	.757	2.517	.293
Condition limiting PA	.478	.257	.887	.019
BMI ≤24	1.0			
BMI: 25-29.99	1.511	.917	2.490	.105
BMI: Obese: 30+	.616	.341	1.113	.108
Total isolation	.332	.133	.827	.018
Minor/no Covid-19 risk percept	1.001	.620	1.616	.997
Living with children	**2.290**	**1.225**	**4.283**	**.009**
Living with vulnerable	.936	.519	1.687	.825
Access garden/balcony to exercise comfortably in	.764	.482	1.209	.250
Access green space within walking distance	.960	.622	1.481	.853
Smoker	.979	.622	1.542	.926
Alcohol drinking frequency, never (ref)	1.0			
Weekly or less	1.028	.555	1.904	.931
More than weekly	1.234	.708	2.152	.459
Deteriorated psychological wellbeing	.888	.579	1.362	.585

Model was adjusted for all the variable sin the table as well as the time of enrolment and time when Covid-19 started to affect individuals in any way. Significant results are in bold.

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Reporting checklist for cross sectional study.

Based on the STROBE cross sectional guidelines.

Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

Your article may not currently address all the items on the checklist. Please modify your text to include the missing information. If you are certain that an item does not apply, please write "n/a" and provide a short explanation.

Upload your completed checklist as an extra file when you submit to a journal.

In your methods section, say that you used the STROBE cross sectionalreporting guidelines, and cite them as:

von Elm E, Altman DG, Egger M, Pocock SJ, Gotzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies.

		Reporting Item	Page Number
Title and abstract			
Title	#1a	Indicate the study's design with a commonly used term in the title or the abstract	2
Abstract	#1b	Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background / rationale	#2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	#3	State specific objectives, including any prespecified hypotheses	4
Methods			

Study design	#4	Present key elements of study design early in the paper	5-6
Setting	#5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Eligibility criteria	#6a	Give the eligibility criteria, and the sources and methods of selection of participants.	5
	#7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5-6, Supplement 2
Data sources / measurement	#8	For each variable of interest give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group. Give information separately for for exposed and unexposed groups if applicable.	5-6
Bias	#9	Describe any efforts to address potential sources of bias	7
Study size	#10	Explain how the study size was arrived at	5, 7
Quantitative variables	#11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	5-7
Statistical methods	#12a	Describe all statistical methods, including those used to control for confounding	7
Statistical methods	#12b	Describe any methods used to examine subgroups and interactions	7
Statistical methods	#12c	Explain how missing data were addressed	5-7, Supplement 2
Statistical methods	#12d	If applicable, describe analytical methods taking account of sampling strategy	7
Statistical methods	#12e	Describe any sensitivity analyses	7

Results

Participants	#13a	Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed. Give information separately for for exposed and unexposed groups if applicable.	7
Participants	#13b	Give reasons for non-participation at each stage	7
Participants	#13c	Consider use of a flow diagram	N/A
Descriptive data	#14a	Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. Give information separately for exposed and unexposed groups if applicable.	7, Table 1
Descriptive data	#14b	Indicate number of participants with missing data for each variable of interest	Table 1
Outcome data	#15	Report numbers of outcome events or summary measures. Give information separately for exposed and unexposed groups if applicable.	7-8 Tables
Main results	#16a	Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	7-8 Tables
Main results	#16b	Report category boundaries when continuous variables were categorized	5-8
Main results	#16c	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	#17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	7, Suplements
Discussion			
Key results	#18	Summarise key results with reference to study objectives	8-10
Limitations	#19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias.	10
Interpretation	#20	Give a cautious overall interpretation considering	10

		objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	
Generalisability	#21	Discuss the generalisability (external validity) of the study results	10
Other Information			
Funding	#22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	11