

# Changes in physical activity and sedentary behaviours from before to during the COVID-19 pandemic lockdown: a systematic review

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## ABSTRACT

**Objective** In March 2020, several countries banned unnecessary outdoor activities during COVID-19, commonly called 'lockdowns'. These lockdowns have the potential to impact associated levels of physical activity and sedentary behaviour. Given the numerous health outcomes associated with physical activity and sedentary behaviour, the aim of this review was to summarise literature that investigated differences in physical activity and sedentary behaviour before vs during the COVID-19 lockdown.

### Design, data sources and eligibility criteria

Electronic databases were searched from November 2019 to October 2020 using terms and synonyms relating to physical activity, sedentary behaviour and COVID-19. The coprimaries outcomes were changes in physical activity and/or sedentary behaviour captured via device-based measures or self-report tools. Risk of bias was measured using the Newcastle-Ottawa Scale.

**Results** Sixty six articles met the inclusion criteria and were included in the review (total n=86 981). Changes in physical activity were reported in 64 studies, with the majority of studies reporting decreases in physical activity and increases in sedentary behaviours during their respective lockdowns across several populations, including children and patients with a variety of medical conditions.

**Conclusion** Given the numerous physical and mental benefits of increased physical activity and decreased sedentary behaviour, public health strategies should include the creation and implementation of interventions that promote safe physical activity and reduce sedentary behaviour should other lockdowns occur.

## INTRODUCTION

In March 2020, WHO declared the COVID-19 outbreak a global pandemic, and as of 26 October 2020, over 42 000 000 confirmed cases have been diagnosed in more than 130 countries and territories, resulting in approximately 1 150 000 deaths.<sup>1</sup> COVID-19 has led to over 100 countries enforcing social distancing to reduce the rate of COVID-19 transmission, commonly called 'lockdown'.<sup>2</sup> The severity of lockdown has varied from country to country,

## Summary box

### What is already known?

► COVID-19-related lockdowns have affected people's physical activity (PA) and sedentary behaviour (SB).

### What are the new findings?

- The majority of studies show that PA levels decreased during the COVID-19 lockdown across all reviewed populations, except for eating disorder patients.
- The majority of studies show that SB levels increased.
- Public health strategies should include the promotion of PA and effective guidance on how to decrease SB during a lockdown, especially in populations with medical conditions that are improved by PA, such as type 1 and type 2 diabetes.

even region to region, with some countries limiting the distance people could travel from their homes, and some banning any unnecessary outdoor activity.<sup>2</sup> These lockdowns have impacted people's work, education, travel and recreation, and subsequent levels of physical activity (PA) and sedentary behaviours (SB).<sup>3</sup>

PA can be defined as any bodily movement produced by skeletal muscle that results in energy expenditure,<sup>4</sup> and can include exercising, walking, gardening and doing household chores. Research shows that PA is positively associated with several desirable outcomes, including social contentedness,<sup>5</sup> physical health<sup>6</sup> and mental health.<sup>7,8</sup> Specific to COVID-19, PA has been shown to improve physical and mental health and has been suggested to provide protective elements against COVID-19.<sup>9-11</sup> Furthermore, it has been reported that the COVID-19 lockdown yielded decreases in PA,<sup>12</sup> however, the literature has not been systematically reviewed to date.

SB can be defined as any waking behaviour with an energy expenditure of  $\leq 1.5$  Metabolic

Equivalent (METs) while in a sitting or reclining posture,<sup>13</sup> including watching TV, video gaming and computer use. The literature has shown SB to be negatively associated with physical, mental health and social outcomes.<sup>14–15</sup> Specific to COVID-19, it has been reported that periods of enforced quarantine can yield increases in SB,<sup>9–13 16</sup> however, this has not been systematically assessed to date in the context of the COVID-19 lockdown.

Understanding the changes in PA and SB behaviours during lockdown is important not only for health outcomes associated with these behaviours, but also for aiding development of public health interventions in specific populations (such as PA promotion and interventions to decrease SB) should another lockdown be enforced, a similar pandemic scenario and/or during the return to ‘normal life’.<sup>17</sup> The aim of this study, therefore, was to conduct a comprehensive systematic review on changes in all reported PA and SB behaviours during versus before the COVID-19 pandemic lockdown, stratifying between adults and children, and special populations.

## METHODS

The current systematic review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.<sup>18</sup> Details of the full protocol for this systematic review were registered on PROSPERO (protocol number: CRD42020193065).

### Search strategy

Electronic databases were searched from November 2019 to June 2020 including PubMed, EMBASE, PsycINFO, CINAHL, Social Science Citation Index, Cochrane Central Register of Controlled Trials, SPORTDiscus and Scopus. Grey literature was searched by entering terms into OpenGrey. Search terms were as follows:

COVID-19 OR “Novel Coronavirus” OR “2019 novel coronavirus” OR 2019-nCoV OR SARS-CoV-2

AND isolation OR lock\* OR self-isolation

AND

“Physical activity” OR exercise OR walking OR running OR cycling OR swimming OR sports OR sedentary OR “sedentary behaviour” OR activity OR “screen time” OR sitting.

Full information on database-specific search strategies can be found in online supplemental table 1.

Results of the searches were included in a bibliographic database and duplicates removed. Titles and abstracts of the retrieved studies were screened for inclusion by two reviewers independently (SS and MT), and then the full text of all potentially eligible papers was reviewed independently by the same reviewers before making a final decision on eligibility. Any discrepancies were discussed until a decision was achieved. A third senior reviewer acted as an adjudicator if a decision was not reached (LS).

## Study inclusion and exclusion

Studies were included if they met the following criteria: (1) observational cross-sectional, prospective or retrospective cohort studies (2) that investigate any form of PA and/or SB (as defined by the authors) (3) in any population (healthy or with a specific disease condition) (4) before and during the COVID-19 Lockdown (5) in any setting. Published articles that had received ethical approval from an ethics committee and were written in English were included. Studies were excluded if they were not observational in design (eg, qualitative, primary randomised controlled trials, primary case series, editorials or commentaries or study protocols). Furthermore, the rapid publication of studies related to COVID-19 meant many bypassed the typical institutional ethical approval process; therefore, studies were excluded if they failed to explicitly include an explicit statement stating that institutional ethical approval was received. If no ethical approval was in the manuscript, corresponding authors were contacted to establish if institutional approval had been granted. If no reply was received, or institutional ethics was confirmed as being not obtained, these studies were excluded (see online supplemental table 2).

### Primary outcomes

The coprimary outcomes were changes in PA and/or SB captured via device-based measures or self-report tools.

### Data extraction

Data were extracted by two reviewers (SS and MT) independently including: first author, year, country, aims of the study, type of the study (pretest and post-test, cross-sectional, cohort), descriptions of the lockdown by the authors for the respective location of data collection, number of participants, participant characteristics (eg, age, sex), inclusion criteria, type of recruitment, type and definition of PA and SB investigated, type of measurement of PA and SB, confounding variables, acknowledged limitations by authors and authors conclusions, other/notes. A third reviewer (LS) was available to resolve any discrepancies. The data was synthesised in a narrative approach.

### Quality assessment

Risk of bias was assessed by two independent reviewers (SS and MT) using the Newcastle-Ottawa Scale (NOS),<sup>19</sup> later adapted for cross-sectional studies.<sup>20</sup> A third reviewer (LS) was available to resolve any inconsistencies. There are three parts in which studies are assessed and stars awarded: (1) selection (max. 5 stars)—representativeness of the sample, sample size, non-respondents and ascertainment of the exposure (risk factor); (2) comparability (max. 2 stars)—participants in different outcome groups are comparable; (3) outcome (max. 3 stars)—assessment of outcome, and statistical test. Scores can range from 0 to 10 stars, with higher scores indicating better quality research.

## RESULTS

After initial screening, 187 studies were eligible for full-text review. From these, 66 studies<sup>12 21–84</sup> were eligible for inclusion. The PRISMA flow chart is shown in online supplemental figure 1. Full study characteristics can be found in online supplemental table 3. The 66 included studies yielded a total of 86981 participants and the age ranged from 13 to 86 years old. Regarding specific populations, forty-five studies were conducted on healthy adults (four in specifically elite athletes and five in university students), and six studies in healthy children. Regarding populations with medical conditions, two studies were conducted on adult women with eating disorders, two respective studies with adult participants with type 1 and types 2 diabetes, one respective study with adult participants with ‘chronic medical conditions’, one study on heart failure patients, one study on neuromuscular disease, one study on obesity clinic patients, one study on participants with a ‘perceived risk’ of severe COVID-19 symptoms, one study on pregnant women and one study reported on children with obesity. The mean NOS score of the included studies was 4.8 (SD=1.0; range 3–7;). For detailed NOS scoring, see online supplemental table 4.

### PA in healthy adults

Forty-five studies examined PA changes in healthy adults, with only four studies<sup>31 75 80 85</sup> using device-based measures of PA. The remaining 41 studies used subjective questionnaires, and in 30 studies these questionnaires were not previously validated. The majority of studies (26/45) reported PA changes in the form of time (eg, METS/min/week, mins/day or steps/day), with the remaining studies reporting PA changes as a percentage of the respective population (see online supplemental table 5).

Of the studies that measured PA change in the form of time spent on PA, all but one study<sup>70</sup> reported overall decreases in the amount of PA pre-COVID-19 versus post-COVID-19 lockdown. When stratifying across different forms of PA, two studies<sup>27 28</sup> reported increases in time spent in ‘leisure-time PA’ and one study<sup>85</sup> reported increases in time spent in ‘endurance training’ in elite cyclists, although total PA still decreased in all three studies. All other studies reported time spent in all subtypes of PA—for example, light, moderate, vigorous and walking—if specified) decreased. Of the studies that measured PA changes as a percentage of the respective populations, eight studies<sup>29 33 38 53 55 59 67 81</sup> reported that >50% of the examined population decreased PA during lockdown, with all other studies reporting >50% of the examined population’s PA either stayed the same or decreased. For further information, see online supplemental table 5.

### PA in healthy children and adolescents

Of the six studies that examined PA changes in healthy children and adolescents, all were measured using subjective questionnaires, with half using validated questionnaires. Two studies<sup>48 84</sup> used total scores from

validated questionnaires and two studies<sup>65 82</sup> reported PA changes in the form of a time measurement, all reporting decreases in PA. Two studies<sup>62 71</sup> reported PA changes as a percentage of the respective population and reported >50% of the population decreased their PA during lockdown.

### PA in adults and children with medical conditions

Thirteen studies examined populations with medical conditions for which all but one study,<sup>80</sup> used subjective measurements of PA change, and in only 6/12 were these previously validated measurement tools. Regarding the types of changes reported, nine studies<sup>23 26 36 40 43 44 72 80 86</sup> reported changes in time spent in PA, all reporting decreases in PA time. The remaining four studies<sup>34 66 69 74</sup> reported PA changes as a percentage of respective populations, with all reporting >50% of the population decreasing their PA during lockdown.

### SB in healthy adults

Of the 26 studies examined changes in SBs, 18 were conducted in healthy adults. All studies used subjective questionnaires and validated questionnaires were used in six. Studies reported changes in SB as either time spent on SB or as a percentage of the sample. The majority of studies (13/18) reported SB changes in the form of time spent, with the remaining studies reporting SB changes as a percentage of the respective population. Increased SB was reported in all 26 studies. For further information, see online supplemental table 6.

### SB in healthy children and adolescents

Of the five studies that measured changes in SB in children and adolescents, three studies<sup>42 62 65</sup> used non-validated questionnaires and the remaining two studies<sup>71 82</sup> used validated questionnaires. Time spent in SB was reported in 3/5 studies, with the remaining two studies reporting changes in SB as a percentage of their respective populations. All five studies reported increases in SB.

### SB in adults and children with medical conditions

All of the three<sup>26 43 86</sup> studies that measured changes in SB in special populations used non-validated questionnaires, and reported that time spent in SB increased during the lockdown.

## DISCUSSION

The current systematic review of 66 studies demonstrated that the majority of studies found that PA declined and SB increased during the COVID-19 pandemic lockdown, regardless of the subpopulation or the methodology used. In healthy adults and children, PA during lockdown decreased compared with prelockdown, despite various government organisations and health or exercise practitioners providing guidance on how to stay active during the pandemic and in self-quarantine.<sup>87–89</sup> When stratifying between prelockdown PA levels, three studies found that people who were more active prelockdown were more likely to show larger decreases in PA.<sup>37 49 67</sup>



PA has also been consistently linked with several mental health conditions, suggesting that decreases in PA may lead to increases in undesirable mental health outcomes. Indeed, studies have shown significant increases in anxiety and depression levels during the lockdown.<sup>10</sup> Given that decreases in PA have been shown to yield negative affect, increases in anxiety and lower energy levels,<sup>39</sup> PA promotion during lockdowns should be aimed not just at people who are currently sedentary, but also for those with high PA levels outside of lockdown. Due to the likelihood of further COVID-19-related restrictions (or another similar pandemic), the promotion of digital based PA (such as PA apps, online video fitness classes or physical training) is recommended. Digital based PA yielded favourable results during the first COVID-19 lockdown, with studies showing positive associations with such digital based initiatives and overall PA during a lockdown.<sup>83</sup>

Another finding of this review was that participants who had medical conditions also yielded decreases in PA levels, except for patients with an eating disorder. The decreases in PA is particularly concerning as in several of the medical conditions studied because PA can be a form of treatment or symptom alleviation. For example, levels of PA have been shown to be positively associated with quality of life outcomes in both type 1 and type 2 diabetes.<sup>90-91</sup> Concurrently, increases in SB have been shown to yield detrimental outcomes in patients with these conditions, except for patients with eating disorder.<sup>92-93</sup> Given these added risks of decreasing PA and increasing SB in these special populations, PA promotion and strategies to reduce SB should be implemented should further lockdowns occur. Moreover, practitioners working with these groups should be especially mindful of the detriment that decreasing PA and increasing SB could yield during lockdowns and make the monitoring of PA levels a priority. Patients with eating disorders were found to increase their PA, specifically exercise, during lockdowns. This is equally concerning as there is often pathological relationship between eating disorders and exercise and can lead to increased risks of physical complications such as stress fractures.<sup>94</sup> Therefore, practitioners working with patients with eating disorders are advised to keep closely monitoring patients as much as possible during future lockdowns.

There were also large decreases in both the training volume and training intensity of elite athletes while in lockdown, which has led to relative decreases in sport-specific physical performance tests post-lockdown.<sup>85</sup> This decrease in athletic readiness for competition should be noted and considered by practitioners who are working with elite athletes, especially regarding training loads and competition scheduling postlockdown.

According to the behavioural change wheel, for a behaviour—for example, PA or SB—to occur, there are three components that are required: capability (psychological and physical), opportunity (physical and social) and motivation (reflective and automatic).<sup>95</sup> Despite information on safe exercise during lockdown being

available from exercise professionals and some governments (psychological capability), it is not clear from the included studies the reasons why people did or did not engage in PA; however, we can speculate potential reasons for these findings. A reduction in PA is expected as lockdowns required that governments closed sport and leisure facilities, group activities were suspended, and in many countries limits were in place for time spent outdoors.<sup>96</sup> This potentially meant people's regular PA routines were difficult to continue with during lockdown, as indicated by the evidence stating that people considerably changed their modes of PA during lockdown.<sup>97</sup> For example, one study found that all types of PA decreased except for 'moderate intensity leisure-time PA' (such as housework and gardening) increased,<sup>26</sup> another found that 'yard work' increased,<sup>77</sup> and another found that 'housework' increased during lockdown.<sup>82</sup> However, despite these mode-specific increases, total PA levels in these respective populations still decreased. This suggests that promoting increases in house-related PA may not be sufficient to increase total PA during lockdowns.

There was also an increase in the number of people working from home during lockdown,<sup>98</sup> consequently, PA ordinarily accumulated during commuting will have substantially decreased. A previous study found that adults in the UK (mean age 50.5 years) accumulated 195 min/week ( $\pm 188.6$ ) of active travel.<sup>99</sup> Those who actively commute report significantly greater total PA than those who do not, despite no significant differences in recreational PA shown.<sup>99-100</sup> In addition, with schools closed, many parents were balancing home schooling, while working from home themselves; in the UK, this was the case for 85% of employees with school-aged children.<sup>101</sup> A decrease in opportunities to be active and additional responsibilities may have led to a decrease in PA.

The majority of the studies in this review showed increases in SB during lockdown. This is unsurprising as many people worked from home, leading to extended sedentary periods and increased screen time.<sup>102-103</sup> For instance, de Haas *et al*<sup>104</sup> reported that 44% of Dutch workers had either started to work from home or increased their home working hours, with 30% reporting increases in remote meetings (eg, via videoconferencing). In addition, with most gyms, leisure and sporting facilities closed, time allowed outdoors limited or not allowed, some people may have found it difficult to be active during the lockdown.<sup>3-105</sup> With increased 'free' time, many may resort to engaging in pastimes such as reading, playing video games and watching television (TV), many of which are sedentary.<sup>67</sup>

Given that the majority of studies reported a decrease in PA with a concurrent increase in SB during the lockdown, and the impact of these on physical and mental health, it is recommended that interventions or policies are implemented to increase PA (eg, body weight home-workouts, using online exercise classes, walking, running and cycling outdoors) and decrease SB (eg, by using a standing desk and taking regular breaks from sitting)

should further lockdowns be enforced in the future. In addition, interventions for PA and/or SB postlockdown should consider that individuals may suffer deconditioning as a result of the lockdowns.

Many of the included studies used surveys to gather information about ‘exercise’, ‘PA’, ‘sport’ and ‘training’ but failed to report on how these terms were defined to participants. Future studies should report these definitions for clarity and comparison to be made more easily between studies. This lack of definition may mean that despite ‘exercise’ and ‘training’ decreasing, changes in daily PA may be different in these studies. Monbiot<sup>106</sup> reports volunteers providing food packages, collecting medical supplies for the elderly, providing childcare for those in need, meaning they potentially accumulate similar or more ‘activity’ than they realise as it is not prescribed ‘exercise’ or ‘training’.

It is important to note different degrees of lockdown in different countries, even regions within a country, across different dates occurred, making it difficult to quantify the severity of a lockdown and therefore challenging to objectively assess how this impacted behaviours. For instance, those in countries that were able to exercise outdoors following social distancing guidelines may have engaged differently in PA/SB behaviours to those who were not able to leave home, despite both countries being in ‘lockdown’. Although the authors have presented the lockdown descriptions for each included study as reported by the authors, these descriptions vary greatly in detail, making it challenging to categorise them into ‘levels’ of lockdown. The creation of a scale to indicate lockdown severity would be highly beneficial for comparisons to be made between countries when investigating different behaviours, or at the very least it is recommended that this type of information is reported in all future studies. Moreover, within countries some people are given specific guidance (eg, shielding) which requires more intensive lockdown than the general population—none of the included studies recorded this information. It may be beneficial to know participants adherence to lockdown guidelines to provide an indication of potential opportunity to engage in PA. Most studies also report PA without investigating in detail the types, intensities and durations of PA engaged in before and during lockdown, thus, it would be beneficial to investigate these as the magnitude of changes will impact the effects on health.

### Limitations

While this systematic review is the first to our knowledge to assess changes in the frequency and modes of PA and SB prelockdown versus during the COVID-19 lockdown, the findings should be considered within the limitations of the study. First, the tools used to measure PA and SB were highly heterogeneous, making direct comparison of respective results difficult. Second, demographic information was largely limited, meaning that we were unable to assess any further changes according to demographics further than the discussed topics, which would

have given more insight into the review. In addition, the vast majority of studies were based on subjective questionnaires, which carry with them inherent limitations.<sup>107</sup> Moreover, many studies asked participants retrospectively about their prelockdown behaviours and their current behaviours during lockdown, thus, the accuracy of participants abilities to accurately recall their behaviours may be questionable. Lastly, most of the studies included were not designed to be nationally representative, making the generalisation of these results difficult.

Future research in this area should focus on yielding directly comparable data using validated PA and SB questionnaires or using objective accelerometer data where possible. In addition, it would be beneficial to have more detailed demographic information, information on the severity of lockdown and participant adherence to lockdown guidelines, and more detailed information on PA behaviours, for instance, the types, intensities and duration of PA before and during lockdown. Future research should also consider investigating the magnitude of the decrease in PA and increases in SB across different populations during the lockdown to aid the identification of populations most in need of targeted interventions. Lastly, future research should consider investigating the reasons why people are showing changes in PA and/or SB. Using behavioural change theory to assess barriers and facilitators to PA/SB during lockdowns would be highly beneficial in the creation of future interventions and policies should lockdowns occur in the future.

### CONCLUSION

During the COVID-19 lockdown, PA levels have significantly reduced with concurrent increases in SB. Considering the evidence of favourable outcomes of higher levels of PA and lower levels of SB in both physical and mental health outcomes, and the emerging evidence that exercise can yield favourable COVID-19 outcomes, it is recommended that public health officials promote ways of increasing PA and reducing SB should further lockdowns occur, especially in populations with medical conditions that are improved by PA, such as type 1 and type 2 diabetes. Interventions designed for postlockdown should also consider that individuals may suffer from deconditioning during the lockdown period, especially in athletic populations and people with medical conditions.

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