

# Sedentarism and chronic disease risk in COVID 19 lockdown – a scoping review

Baskaran Chandrasekaran<sup>1</sup>  and Thiru Balaji Ganesan<sup>2</sup>

## Abstract

**Background & Aims:** Though viewed as a critical measure to prevent the spread of the virus, a prolonged homestay may result in unfavourable sedentary behaviour and chronic disease risk. This systematic review focuses on sedentary behaviour resulting from this quarantine period which may elevate the cardiovascular disease risk, obesity, hypertension, cancer and mental health illness.

**Methods:** Evidence of breaking sedentary behaviour and global recommendations were investigated. Potential unanswered questions regarding sedentary behaviour and physical activity during lockdown were explored.

**Results:** Five systematic reviews and six prospective trials explored the effect of sedentarism affecting chronic disease through potential pathophysiological mechanisms. Sedentary behaviour especially prolonged sitting is found to be a pleiotropic risk factor with altered energy expenditure, adipogenic signalling, immunomodulation, autonomic stability and hormonal dysregulation perpetuating underlying chronic diseases such as obesity, cardiovascular disease, cancer and mental health disorders.

**Conclusion:** Breaking sitting and physical activity are found to reverse the adverse effects associated with excessive sitting during the lockdown.

## Keywords

Sitting, physical activity, exercise, chronic disease, obesity, cardiovascular disease

## Introduction

Though Chinese origin, Coronavirus disease (COVID-19) has become the global concern and public health emergency as declared by the World Health Organization (WHO). With 1st case reported on 4 March, cases are increasing at an alarming rate. As of 22 May 2020, WHO situation report-123 reveals 4993470 confirmed cases and 327738 deaths globally.<sup>1</sup> The extent, prognosis of the COVID-19 and lockdown remains mostly unknown.

### *National lockdown and sedentary behaviour*

The public has been advised by various health authorities to reduce travelling and stay at home as an essential means of limiting people's exposure to the virus as the virus transmission is continued to outgrow.<sup>2</sup> Our government has implemented several mitigating measures such as travel bans, shutting more significant industries and institutions, essential commodities at the doorsteps and work from home for employees. Further implementing restrictions on necessary

commodities such as groceries, medical shops, etc. has reduced the commute in the community. Shutting down schools and colleges, playgrounds, ban on outdoor games have reduced the quality of activity from toddlers till young adults substantially. Though unarguably a safety measure against the virus, lockdown or quarantine may have negative consequences, especially on increasing sedentary behaviour and may pave the way for chronic diseases. Prolonged stay at home was found to be substantially spent on lying and sitting in front of electronic gadgets (television, social network

<sup>1</sup>Assistant Professor, Department of Exercise & Sports Sciences, Manipal College of Health Professions, Manipal Academy of Higher Education, India

<sup>2</sup>Programmer Analyst Trainee, Cognizant KNC, India

### **Corresponding author:**

Baskaran Chandrasekaran, Department of Exercise & Sports Sciences, Manipal College of Health Professions, Manipal Academy of Higher Education, Manipal, Karnataka 576104, India.  
Email: baskaran.c@manipal.edu

through smartphones, laptops for educational and work). This prolonged sedentary behaviour may increase cardiometabolic risks such as hyperglycemia, hyperinsulinemia, autonomic instability, altered immune markers expression, especially interleukins (IL 6), cytokines and tumor necrosis factor (TNF). Further hormonal dysfunction, including leptin, thyroxine which may potentially worsen underlying chronic diseases.<sup>3</sup> This systematic review would demonstrate the possible molecular mechanisms of sedentary behaviour, especially uninterrupted sitting and chronic diseases, its evidence and physical measures administered to curb sedentary behaviour during the quarantine. This review may potentially improve the reader's awareness of sedentary behaviour during the self-quarantine period and how to maintain fitness to overcome the negative consequences.

### *Sedentary behaviour and chronic diseases*

Sedentary behaviour (defined as any awakened activity such as lying or sitting characterized by the energy expenditure of fewer than 1.5 METS) is found to be one of the prime risk factors for onset and worsening of chronic diseases such as obesity, hypertension, coronary artery diseases and cancer.<sup>4</sup> Further early cognitive decline, including worsening of memory, reaction times and implicit association is strongly associated with inactivity.<sup>5</sup> Human evolution survived through ages because of our "hunter-gatherer" genes which are now being adapted for sedentary lifestyle due to technology spur and in turn leading to chronic disease.<sup>6</sup> In a recent cross-sectional survey from a National Family Health survey, the prevalence of overweight and obesity was found to be doubled between 1998 and 2016. Total disability-adjusted life years have increased by 170% from 1990 to 2016 due to diabetes,<sup>7</sup> but survey considered only socioeconomic status not considered the physical activity as a contributing risk to chronic diseases. Bountiful western literature is available that identified sedentary behaviour especially excessive sitting as the independent risk factor for the incidence or worsening of cardiometabolic and other chronic diseases.<sup>8</sup> The following search and subsequent literature summary may reinforce the importance of curbing sedentary behaviour and its adverse effects during the lockdown period

## **Methods**

### *Literature search*

Scopus, Web of Science, PubMed and Ovid Medline databases were searched until 23 April 2020, with the following MeSH term "Sedentary behavio?r",

"Sitting", "Physical inactivity", "chronic diseases", "Non communicable diseases", "obesity", cardiovascular diseases", "cardiometabolic", "cancer", "diabetes", "hypertension". Boolean operators such as AND, OR and wild cards \*,? were used as necessary. We limited our search to full text and English only. Observational studies, randomized trials, systematic reviews, narrative reviews that have identified sedentary behaviour as the independent risk factor for chronic diseases. We synthesized the retrieved results to data extraction table that included author, year, country, objective, study design, participants, method, sedentary behaviour measurement, key findings, possible physiology mechanisms (Table 1).

## **Results**

Five systematic reviews and six prospective trials explored the effect of sedentarism affecting chronic disease through potential pathophysiological mechanisms (Table 1). The research articles included in both systematic reviews and included trials were heterogeneous in intervention, participants and outcome measure assessments. Hence qualitative synthesis of the researches was established.

Myriad of cardiometabolic risks, alterations in physiological systems determining future chronic diseases were found.<sup>9-14</sup> Four reviews<sup>9,10,12,13</sup> and two randomized controlled trials<sup>11,15</sup> have established cardiometabolic risks such as hyperglycemia, hypertension, altered triglycerides and body mass index due to sedentary behaviour.

Further elevated cancer risk is identified from three articles (one prospective,<sup>15</sup> one systematic review<sup>16</sup> and one cross-sectional trial<sup>17</sup>) with altered immune functions, especially on proinflammatory cytokines such as interleukin and tumor necrosis factors. Most of the studies administered the physical activity interventions in the sedentary participants (self reported or accelerometer based activity of >6 h/day).<sup>16,18,20</sup>

Most of the studies, including systematic reviews, are found to originate from the United States of America, Australia and the United Kingdom. It's not surprising fact that there is a lack of evidence linking sedentary behaviour and chronic diseases in low and middle-income countries. Observed low physical activity in lower middle-income countries (16.6%) compared to Western countries (25.4%) probably speculated to be the reason for the poor evidence for the less research and lack of evidence in low-middle income countries.<sup>21</sup> We found a significant difference in measurement techniques of sedentary behaviour ranging from questionnaires to accelerometers which might have facilitated a significant measurement bias in the studies. Further chronic disease risks, gender,

Table 1. Table showing the studies included in the systematic review and the key findings.

References	Country	Objective	Design	Participants	Method	Sedentary behaviour measurement	Key findings	Physiology
Obesity Megan Crowe et al. <sup>9</sup>	Canada	To find out the risk associated with combined MPA and screen time on overweight or obesity	Cross-sectional study	9913 students of 7–12 grades	MVPA (active >60 min/day; inactive <60 min/day) and sedentary (>2 h of screen time; not sedentary (<2 h of screen time) were related with overweight and obesity	Sedentary > 2 h screen time/day; not sedentary < 2 h/day (questionnaire)	The inactive and sedentary group was likely to have overweight or obesity than the active and not sedentary group (OR = 1.71; 95% CI, 1.26–2.32)	The body composition and energy expenditure were the possible reasons
Saeidifard et al. <sup>10</sup>	USA	To find out the differences in EE between sitting and standing	Systematic review and meta-analysis	46 studies (1184 participants)	The literature was searched until June 2017 for studies involving EE between sitting and standing in non-pregnant adults	EE was measured using accelerometers and indirect calorimeters	The mean difference in EE between standing and sitting was 0.15 kcal/min (95% confidence interval (CI) 0.12–0.17)	Sitting reduces muscle recruitment and reduces the EE. Postures other than sitting improves NEAT and reduces obesity
Henson et al. <sup>11</sup>	United Kingdom	To examine associations between sedentary time and adiposity	A nested study from a large RCT	124 participants at the risk of diabetes	Accelerometers objectively measured sedentary time and MRI measured adiposity	Accelerometer (Actigraph)	Sixty minutes of sedentary time was adversely associated with 1.74 L higher total abdominal fat, 0.62 L higher visceral fat, 1.14 L higher subcutaneous fat, and 1.86% higher liver fat.	Partially explained by excess esterified fatty acids (NEFA), glycerol, and hormones released from adipose tissue
Cardiovascular diseases Lawie et al. <sup>12</sup>	USA	To establish the relationship between cardiovascular outcomes and physical inactivity	Scoping review	Heterogenous population. 15 studies (4,58,879 men & 4,66,106 women)	The study reviewed several studies and elaborated the physiological mechanisms relating to chronic diseases and physical inactivity	Heterogenous measurement: subjective and objective measures	<ul style="list-style-type: none"> <li>Fit men were found to have reduced mortality by 52% than unfit men</li> <li>everyone estimated MET increase in CRF was associated with 13% and 15% reductions in all-cause and CVD</li> </ul>	Reduced mitochondrial content and respiration, increased inflammation in skeletal muscles, $\beta$ adrenergic receptor desensitization
Carter et al. <sup>13</sup>	Netherlands	To review the studies establishing the relation between cardiovascular metabolic risk and prolonged sitting	Scoping review	Eight studies (198 participants)	Several studies were reviewed. The cardiovascular outcomes were associated with the physical inactivity or prolonged sitting bouts	Not mentioned	Sitting reduces flow-mediated dilatation by 2.2%; inflammatory cytokines increased, endothelial shear $2.2\% \pm 2.15\%$	Endothelial stress, cardiac remodelling and endurance, inflammatory markers (IL-6, IL-12), adiposity and atherogenesis
Cancer Rangul et al. <sup>15</sup>	Norway	To examine the association between physical activity and sitting time with cancer incidence	Prospective study	8,154 healthy participants from the Norwegian community	adults in the Nord-Trøndelag Health Study (HUNT) followed up for 17–19 years for cancer incidence	Sitting time was measured subjectively through the questionnaire	<ul style="list-style-type: none"> <li>sitting <math>\geq</math> eight hr/day was associated with 22% (95% CI, 1.05–1.42) higher risk of prostate cancer compared to sitting &lt; 8 h/day.</li> <li>low physical activity (<math>\leq 8.3</math> MET-h/week) had 31% (95% CI, 1.00–1.70) increased risk of colorectal cancer (CRC) and 45% (95% CI, 1.01–2.09) increased risk of lung cancer</li> </ul>	Possibly attributed to insulin resistance, adiponectin levels, insulin-like growth factors testosterone, muscle- and fat-related proteins as follistatin, myostatin, activin and inhibin.

(continued)

Table 1. Continued

References	Country	Objective	Design	Participants	Method	Sedentary behaviour measurement	Key findings	Physiology
Nguyen et al. <sup>17</sup>	USA	To see whether sedentary behaviour related to colorectal cancer incidence	Cross-sectional study	89,278 women in the Nurses' Health Study II ages 25–42 years	The participants from Nurses' Health Study II ages 25–42 years (1991–2011) were assessed for sedentary behaviour and colorectal cancer	TV viewing time through the questionnaire	If TV viewing hours is more than 7 hours increased the risk of colorectal cancer (RR: 1.25). If more than 14 hours of RR increased by 1.69. In spite of cumulative exercise, prolonged sitting time increases the risk of colorectal cancer	unbroken sitting results in extended exposure to faecal carcinogens, such as secondary bile acids, impair glucose homeostasis and decrease vitamin D levels
Lynch et al. <sup>16</sup>	Canada	To systematically review studies examining associations of sedentary behaviour with cancer risk	Systematic review and meta-analysis	176 studies were retrieved investigating the effect on adiposity, sex hormones, inflammation and metabolic function	Literature search on peer-reviewed databases with SB and cancer risk. Also, the study investigated other health risks in cancer survivors.	95% of the studies measured SB through subjective measures	A significant association between SB time and cancer risk factors (OR 1.02 – 1.17). TV times were found significantly related to cancer risk and early mortality	SB increases adiposity, sex hormones, inflammation and metabolic dysfunction predisposing to cancer
Diabetes Asvold et al. <sup>14</sup>	Norway	To find whether prolonged sitting is a risk for diabetes	Prospective trial	28,051 adult participants of the Nord-Trøndelag Health Study (the HUNT Study) were followed for diabetes incidence from 1995–1997 to 2006–2008 (11 years)	The trial used the HUNT2 Survey as the baseline risk factor examination. Diabetes risk was assessed at 11 years follow-up Self-reported sitting time	Sitting time was estimated from the questionnaires	<ul style="list-style-type: none"> <li>Sitting <math>\geq</math> eight hr/day was associated with a 17% higher risk of developing diabetes compared with sitting <math>\leq</math> four hr/day.</li> <li>Without leisure-time physical activity, this risk becomes 30% in participants sitting <math>&lt;</math>8 h/day</li> </ul>	Hyperinsulinemia, postprandial hyperglycaemia, impaired glucose tolerance was observed.
Yates et al. <sup>18</sup>	United Kingdom	To investigate whether prolonged sitting or any interruption alter the postprandial glycaemia	Cross over randomized trial	60 participants (30 south Asians and 30 Europeans)	Sitting, sitting with interruptions was administered and postprandial blood glucose was measured	Objective measure through accelerometer (ActivPAL)	insulin response was reduced by 22.4 (12.4, 32.4) mU/L (27%) during walking breaks compared to prolonged sitting	Possible mechanisms were insulin sensitivity and GLUT4 transporters sensitivity
Anxiety and depression Dale et al. <sup>19</sup>	Canada	To examine the relationship between physical activity and mental health outcomes	Systematic review	32 studies were included	Studies were searched until 2017 relating physical activity and self-esteem, anxiety and depression	Included both subjective and objective measures of physical activity included	Studies showed physical activity is inversely related to depression, anxiety and directly related to self-esteem	Self-esteem has found to reduce anxiety and depression. Possibly by endorphins and autonomic stability

Supplementary file: Table 2. Breaking Sitting Behavior through Exercises during COVID-19 lockdown.

nationality posed a significant heterogeneity in the studies. However, the possible associations between sedentary behaviour and possible pathophysiological mechanisms behind cardiometabolic risk were illustrated and discussed later.

## Discussion

### *Sedentary behaviour and physiological mechanisms behind chronic diseases*

**Obesity.** Sedentary behaviour is found to elevate the positive energy balance through reduced energy expenditure. Non-exercise activity thermogenesis plays a crucial role in elevating daily energy metabolism and found to be lowered with uninterrupted prolonged sitting bouts.<sup>22</sup> Further sitting time is found to be adversely related to increased body mass index and waist circumference.<sup>23</sup> The possible physiological mechanisms by which sitting causes overweight and obesity are leptin and ghrelin dysregulation, increased IL-6, thyroid dysregulation, adiponectin signalling, adipose tissue morphology, adipogenic signalling and poor gastrointestinal metabolism.<sup>24</sup>

**Cardiovascular diseases.** Sedentary behaviour is found to adversely associated with increased cardiometabolic risk. Atherogenesis through inadequate endothelial response to stress, inflammatory markers such as IL-6, reactive oxygen species (ROS), adiponectin and leptin dysregulation, reduced nitric oxide production and cascading atherosclerosis is postulated to enhance underlying coronary artery diseases.<sup>12</sup> Prolonged sitting bouts increase postprandial hyperglycemia, triglyceridemia, hyperlipidemia and hypertension, which may further increase the risk of fat deposition and thrombotic nature of the blood vessels and increasing the risk of coronary artery diseases.<sup>25</sup>

**Diabetes.** Sedentary behaviour, especially uninterrupted sitting, is associated with reduced insulin sensitivity and GLUT 4 transporters, which in turn results in diabetes risk. Further increased inflammatory markers expression such as IL-6, cytokines, ROS causes damage to  $\beta$  cell damage further compounding the problem. Increased insulin resistance is found significantly associated with uninterrupted sitting.<sup>25</sup>

**Cancer.** Prolonged sitting is associated with increased inflammatory markers (C-reactive protein, leptin and adiponectin), increased adiposity, sex hormones such as poor androgen status and Vitamin C which are presumed to be the risk factors for cancer.<sup>16</sup>

**Mental health.** Sedentary behaviour is found to be adversely affecting mental health, especially anxiety and depression. Dale et al. recently established excessive sitting increase the risk of depression and anxiety from the 32 studies and physical activity reverses the effect on depression and anxiety.<sup>19</sup> The pooled risk ratios of depression for sedentary behaviour were 1.31 (95% CI = 1.16–1.48) in 13 cross-sectional studies and 1.14 (95% CI = 1.06–1.21) in 11 longitudinal studies.<sup>26</sup> Sedentary behaviour especially prolonged interrupted sitting causes depression and anxiety through potential physiological mechanisms: altered 5HT synthesis, lower serotonin, BDNF and depletion of tryptophan.<sup>27</sup> Even lower self-esteem is found to be associated with increased sedentary behaviour leading isolation and depression.

The overall physiological mechanisms of chronic disease and sedentary behaviour impact are depicted in the infographic (Figure 1).

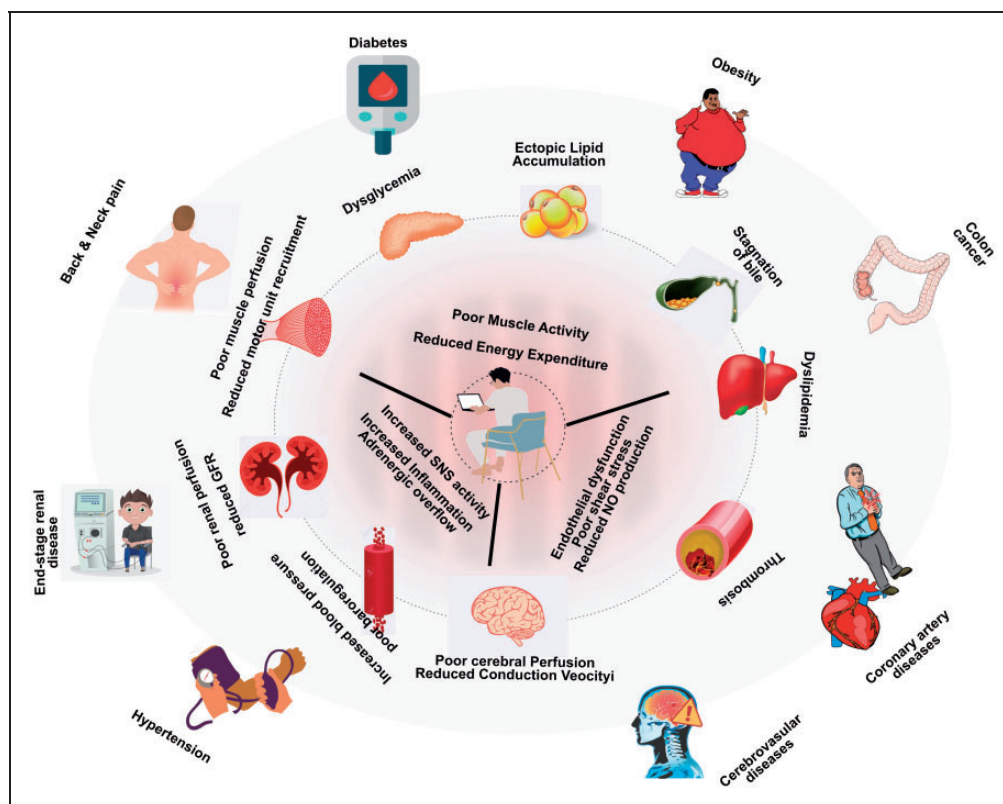
With all the above plausible biological mechanisms with the sedentary behaviour as elucidated above, it is speculated that breaking sitting with exercises or scheduled exercises may reverse the biological mechanisms and thus may improve or halt the progression of chronic diseases.

### *Breaking sedentary behaviour while staying at homes*

Critical restriction measures for societal mobility as proclaimed by the government doesn't mean that exercises should also be ceased. Exercise at home with safe, simple, and easily implementable exercises is well suited to maintain fitness levels during the lockdown period. These exercises may include but are not limited to, aerobic exercises, strengthening exercises, activities for balance and control and stretching exercises. Examples of home exercises may include walking in the house, alternating leg lunges, stair climbing, stand-to-sit and sit-to-stand using a chair and from the floor, chair squats, and sit-ups and push-ups.<sup>28</sup> Table 2 demonstrates sample exercises that are found to be safe and straightforward and can be done in-home without expensive equipment (*supplementary file*). The use of eHealth and mHealth videos, which focuses on encouraging and delivering physical activity through the smartphone applications and television should be done with precautions (based on underlying fitness & chronic diseases), and dosage should be considered after appropriate advice from exercise professional during this critical period.

### *Recommendation for breaks and exercises*

Global guidance for preventing chronic diseases and maintain general fitness is to exercise for at least



**Figure 1.** An infographic showing the relation between excessive sitting and possible biological mechanisms of chronic diseases. The inner dotted circle shows the potential physiology behind sitting leads to chronic diseases. The outer coloured circle shows the possible chronic diseases associated with excessive sitting.<sup>29</sup>

30 minutes every day at least five days a week.<sup>30</sup> In this central lockdown period, it is recommended to do exercise for 30 minutes all days of a week. Further, the prolonged sitting bouts (sitting >30 minutes) should be limited to a maximum of 2 per day and a mandatory break for 2 minutes every 30 minutes of sitting.<sup>31</sup> Sleep is not added to the sedentary behaviour.

### Staying active throughout the day

Apart from exercises mentioned above, it is recommended that every citizen should be active throughout the day by lifting and carrying groceries from neighbourhood groceries with necessary protective equipment, stair climbing even though not mandatory, using smartphone applications for a scheduled walk and step count, playing with children, gardening and standing while watching television. These simple measures, when cumulated over a while, may serve as potential measures for preventing and managing chronic disease risks.

### Questions remaining unanswered?

The following questions remain unanswered: (1) whether sedentary behaviour during quarantine or homestay

alters the Coronavirus disease risk and prognosis? (2) Whether patients with underlying coronavirus and known cardiovascular diseases suffer more significant coronary events than patients without coronavirus? (3) Whether immune responses boost up with the moderate or high intensity of exercise during the quarantine to prevent coronavirus? (4) Whether hospital stay, the cost differs among patients who exercised regularly or sedentary.

### Conclusion

Though a fundamental safety step to limit infections from spreading widely in the Indian community, prolonged home stays can increase sedentary behaviours and may increase chronic disease risks. During the Coronavirus crisis, maintaining a regular physical activity and routinely exercising in homes is an essential strategy for happy and healthy lives. Future trials should focus on the questions remaining unanswered to emphasize physical activity and reducing sedentary behaviour as an essential measure to combat cardiometabolic disease risk during such future pandemics.

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## Authors' contribution

BC conceived and designed the literature review, TBG carried out data analysis. BC interpreted the findings and drafted the article.

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## ORCID iD

Baskaran Chandrasekaran  <https://orcid.org/0000-0003-1439-9158>

## Supplemental Material

Supplemental material for this article is available online.

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