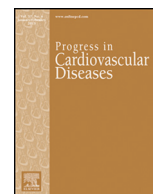




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## A tale of two pandemics revisited: Physical inactivity, sedentary behavior and poor COVID-19 outcomes reside in the same Syndemic City



In *A Tale of Two Cities*, Charles Dickens highlights the duality of London and Paris, the former being safe and peaceful while that latter in the throes of revolution and chaos - “*It was the best of times, it was the worst of times*”.<sup>1</sup> Despite the duality, this classic novel suggests London also suffered from underlying inequities and struggles that are present in Paris, serving a warning for the future. During the early stages of the coronavirus disease (COVID-19) pandemic, we wrote a commentary entitled “A tale of two pandemics: How will COVID-19 and global trends in physical inactivity and sedentary behavior affect one another?”.<sup>2</sup> In this commentary, we proposed the COVID-19 and physical inactivity (PI)/sedentary behavior (SB) pandemics could have deleterious and lasting effects on one another. At the time of our first commentary, objective data was limited and therefore our concerns, while scientifically sound, were theoretical. Following the publication of our first commentary, there initially appeared to be hope that at least some of our concerns may prove to be unfounded, as Ding et al.<sup>3</sup> reported a surge in internet search queries related to *exercise*, indicating individuals may have an interest in becoming more physically active during the COVID-19 pandemic. Unfortunately, intent to *become* physically active and *becoming* physically active are very different, and, over the preceding months since publication of the initial commentary, data has emerged that strongly supports our main concerns. The current commentary provides an update with a review of what has quickly become a robust body of literature on PI/SB patterns and outcomes during the COVID-19 pandemic.

Numerous studies assessing the impact of the COVID-19 pandemic and associated infection mitigation strategies (e.g., social distancing, closures, stay at home orders, etc.) on physical activity (PA) patterns are now available. Collectively, these studies capture a large sample of males and females across the lifespan (i.e., children, youth, and adults) from around the world. The following synopsis of findings provide an example of global trends: 1) Using worldwide data from the Argus smartphone app in over 450,000 individuals from 187 countries around the world, Tison et al.<sup>4</sup> demonstrated daily step count decreased 5.5% and 27.3% within 10 and 30 days of the COVID-19 pandemic declaration, respectively; 2) In 3052 adults in the United States (US), Meyer et al.<sup>5</sup> found self-reported PA decreased 32.3% during the COVID-19 pandemic in those reporting being physically active prior to the pandemic. Conversely, self-reported PA was relatively unchanged (i.e., 2.3%) during the COVID-19 pandemic in those who reported being physically inactive prior to the pandemic. Moreover, not meeting PA guidelines and increased SB during the pandemic was significantly associated with worsening “depression, loneliness, stress, and positive mental health”; 3) Surveying parents of US children, aged 5–13 years, representing 35 states and the District of Columbia, Dunton et al.<sup>6</sup> found perceived PA declined and SB increased in children from the pre-COVID-19 period

(February 2020) to the early-COVID-19 period (April – May 2020). Approximately 36% of surveyed parents reported their children performed significantly less PA during early-COVID-19 compared to pre-COVID-19. Moreover, 41% of the parents reported their children were participating in significantly more SB during early-COVID-19 compared to pre-COVID-19; 4) Moore et al.<sup>7</sup> reported similar findings in a survey of parents of Canadian children (5–11 years old) and youth (12–17 years old). Except for household chores, a significant decline in PA was reported in conjunction with a significant increase in screen time during COVID-19 compared to pre-COVID-19. Respondents also reported a greater amount of family time comprised of sedentary activities during COVID-19 compared to pre-COVID-19; 5) Ammar et al.<sup>8</sup> collected pre-COVID-19 to during COVID-19 PA data in adults (i.e., 18 years or older) from countries around the world [Western Asia (36%), North Africa (40%), Europe (21%), other continents (3%)] using an online survey. The percentage of individuals reporting 0–1 days per week of PA significantly increased from 14.7% pre-COVID-19 to 29.9% during COVID-19; 6) In a sample of more than 40,000 Brazilian adults (i.e., 18 years or older), Werneck et al.<sup>9</sup> reported 21.3% of the respondents reported becoming more inactive and 28% reported more screen time during COVID-19 compared to pre-COVID-19. Conversely, only 3.3% reported becoming more active and 0.8% reported less screen time during COVID-19 compared to pre-COVID-19. Numerous other studies from around the world have reported similar findings, convincingly indicating a significant global decline in PA coupled with a significant increase in SB during the COVID-19 pandemic.<sup>10–20</sup>

Previous research has found PI during adolescence increases the risk for obesity at age 25 by approximately 4-fold.<sup>21</sup> With declines in PA and increases in SB during COVID-19 appearing to be a certainty on a global population level, the recent findings by Lange et al.<sup>22</sup> may come as no surprise. Between pre-COVID-19 and COVID-19 pandemic periods, in a cohort of over 400,000 individuals aged 2–19 years in the US, the rate of body mass index (BMI) increased by approximately two-fold (0.052 vs. 0.100 kg/m<sup>2</sup>/month). Moreover, individuals who were classified as either overweight or obese by BMI prior to COVID-19 demonstrated a significantly higher rate of BMI increase compared to individuals classified as having a healthy body weight. Other analyses have found similar results, indicating a significant increase in pediatric obesity in the US during the COVID-19 pandemic,<sup>23</sup> particularly when comparing underrepresented minority and White children, indicating the disparities in obesity according to race may be widening further.<sup>24</sup> Accelerated weight gain during the COVID-19 pandemic has also been reported in adults.<sup>25</sup> The progression from PI/SB to obesity to chronic disease is an all-too-common occurrence. Increased PI/SB behavior contributing to an increased prevalence of overweight and obesity during the COVID-19 pandemic will, if not reversed, have catastrophic health

consequences in the future, particularly related to chronic disease incidence and prevalence.<sup>26</sup>

A link between COVID-19 severity and outcomes and PI has now been reported in several independent studies, two in extremely large cohorts lending to the validity of findings to this point. Sallis et al.<sup>27</sup> examined severity of outcomes in approximately 48,000 individuals with a confirmed COVID-19 diagnosis who had at least three previous assessments of self-reported PA (i.e., “consistently inactive=0–10 min/week, some activity=11–149 min/week, consistently meeting guidelines=150+ min/week”). Those who reported consistently being inactive had the highest risk for hospitalization, intensive care unit (ICU) admission and death due to COVID-19 compared to those who reported consistently performing  $\geq 150$  min/week of PA. Moreover, those reported being consistently PI remained at significantly higher risk for untoward events compared to individuals reporting *some* PA. In a United Kingdom (UK) Biobank study including 387,109 adults, PI, assessed by the International Physical Activity Questionnaire (IPAQ) short form,<sup>28</sup> was linked to a significantly higher risk for hospital admission due to COVID-19.<sup>29</sup> Other smaller scale investigations have reported similar findings – linking PI to greater COVID-19 severity and poorer outcomes (e.g., hospital/ICU admission and death).<sup>30,31</sup> Moreover, research has convincingly demonstrated higher cardiorespiratory fitness (i.e., aerobic capacity), heavily influenced by higher levels of habitual PA, is linked to a significantly lower risk of poor COVID-19 outcomes.<sup>32,33</sup> These findings are not surprising given the importance being physically active has on immune health and the ability to combat infection.<sup>34–37</sup> In fact, initial evidence demonstrates a single bout of exercise may be able to boost immune health in individuals previously infected with COVID-19.<sup>38</sup>

In addition to the convincing evidence indicating a direct link between PI and COVID-19 outcomes, PI/SB, a primary marker of an unhealthy lifestyle, plays a central role in elevating the risk for developing obesity as well as one or more chronic diseases (e.g., cardiovascular disease, diabetes, etc.), a link that was mentioned previously.<sup>39–41</sup> We have clearly and quickly learned, the presence of both obesity and/or one or more chronic disease diagnoses are linked to poorer outcomes with COVID-19 infection in both younger and older adults.<sup>42–48</sup> Initial evidence also indicates COVID-19 severity and the need for mechanical ventilation is higher in children infected with COVID-19.<sup>49</sup> In this context, the long-standing PI/SB pandemic has certainly helped to *prime the pump* for the onslaught of poor outcomes we are all-to-often observing in patients with obesity and/or one or more chronic disease diagnosis who are infected with COVID-19.

As mentioned previously, our initial commentary posed the question of how the PI/SB and COVID-19 pandemics would impact one another?<sup>2</sup> A main initial concern was centered on how social distancing, school/business closures, stay at home orders, etc., would lead to even lower levels of PA and higher levels of SB on a population level. The currently available data supports these initial posited concerns – the COVID-19 pandemic has caused the PI/SB pandemic to worsen. It also appears we are already starting to feel the effects of the pandemic-induced increases in PI/SB through increased weight gain in both children and adults. If this trend is not reversed once we recover from the COVID-19 pandemic, the long-term consequences of a worsening PI/SB pandemic will be even higher levels of obesity and chronic disease in the years to come, which will have a devastating impact on population health. Another concern raised in our initial commentary was that the PI/SB pandemic may significantly contribute to COVID-19 severity and poorer outcomes in individuals who become infected (i.e., hospital admissions and mortality). This has in fact proven to be the case – individuals who are physically inactive, obese, and/or have one or more chronic disease diagnosis have a significantly higher risk of poor outcomes if infected with COVID-19. Physical inactivity is not only an independent predictor of poorer outcomes with COVID-19 infection, but also a primary contributor to both the development of obesity and chronic disease and, as such, is having a particularly detrimental impact during

the pandemic. As such, our worst fears posed in our initial commentary have unfortunately come true.

In the context of the classic novel by Charles Dickens,<sup>1</sup> parallels to our current situation can be drawn. Dicken's depiction of Paris represents a present-day city with a COVID-19 pandemic and a high prevalence of PI/SB, obesity, and chronic disease – a healthcare crisis in this city is fully realized and chaos ensues – the *worst of times*. London has not yet experienced COVID-19 infections and therefore life is continuing as normal, the *best of times* so to speak. However, the PI/SB pandemic has been and continues to rage under the surface as well as the high prevalence of obesity and chronic disease. In this latter theoretical parallel city, London has grown to accept the PI/SB pandemic as well as the incidence and prevalence of obesity and chronic disease as *business as usual* rather than serve as warning signs for troubling times ahead. The world continues to express concern over the global declines in PA and the unacceptably high prevalence of SB. Unfortunately, this concern has not led to meaningful change. The warning signs were clearly present and now, Dicken's modern-day Paris, one with coexisting COVID-19 and PI/SB pandemics and a high prevalence of both obesity and chronic disease has gripped most of the world. We have created a new PI/SB-Obesity-Chronic Disease-COVID-19 syndemic (i.e., “two or more health conditions or diseases that cluster by person, place or time which adversely interact with and negatively affect the outcomes of one another”), a syndemic that was within our control to prevent through broad adoption of a healthy lifestyle.<sup>50</sup> Imagine if, decades ago, the world embraced healthy living medicine and PA counseling and promotion were commonplace in healthcare. Moreover, the society where people lived, worked, and went to school created and promoted a healthy, physically active lifestyle. What would the outcomes of the COVID-19 pandemic look like in that utopian world? We suspect the health outcomes would be much better with a much higher resiliency in the face of a viral pandemic. The question now is, have we finally learned our lesson? Will we finally recognize how important PA and leading a healthy lifestyle is to prevent premature morbidity and mortality from numerous conditions, including those arising from chronic disease and viral infection? The authors of this commentary certainly hope that is the case. If so, the time for a radically new direction is certainly relevant now more than ever.

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