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“Exercise with facemask; Are we handling a devil's sword?” – A physiological hypothesis

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ABSTRACT

Straying away from a sedentary lifestyle is essential, especially in these troubled times of a global pandemic to reverse the ill effects associated with the health risks as mentioned earlier. In the view of anticipated effects on immune system and prevention against influenza and Covid-19, globally moderate to vigorous exercises are advocated wearing protective equipment such as facemasks. Though WHO supports facemasks only for Covid-19 patients, healthy “social exercisers” too exercise strenuously with customized facemasks or N95 which hypothesized to pose more significant health risks and tax various physiological systems especially pulmonary, circulatory and immune systems. Exercising with facemasks may reduce available Oxygen and increase air trapping preventing substantial carbon dioxide exchange. The hypercapnic hypoxia may potentially increase acidic environment, cardiac overload, anaerobic metabolism and renal overload, which may substantially aggravate the underlying pathology of established chronic diseases. Further contrary to the earlier thought, no evidence exists to claim the facemasks during exercise offer additional protection from the droplet transfer of the virus. Hence, we recommend social distancing is better than facemasks during exercise and optimal utilization rather than exploitation of facemasks during exercise.

Introduction

The year 2020, is definitely one to go down in the history books. As new Covid-19 cases continue to emerge with a global count of 6,535,354 cases and 387,155 deaths as of 6th June 2020 [1], healthy individuals have been advised to stay at home and follow self-quarantine regulations declared by local governance and World Health Organization (WHO) [2]. Access to outdoor tracks has been denied, and fitness centres have been closed for the prevention of community spread of the deadly virus. Prolonged stay at home, could result in physical inactivity, which could further lead to ill health. Sedentary behaviour (any waking behaviour characterized by the energy expenditure of fewer than 1.5 METS in reclining or sitting postures) is identified as a pleiotropic risk factor for cardiometabolic disease risks such as obesity, coronary artery diseases, hypertension and cancer disease [3].

Straying away from a sedentary lifestyle is essential, especially in these troubled times of a global pandemic to reverse the ill effects associated with the health risks mentioned earlier. Exercising even at a low intensity is found to maintain the muscle mass, cardiovascular fitness and prevent the bone loss that is imposed by the sedentary behaviour during this lockdown period [4]. Owing to the current world scenario, specific exercise guidelines have been proposed during the Covid-19 lockdown period, specifically for at-risk or chronically ill individuals [5]. Exercise training is anticipated to stave off or lessen the chances of acute respiratory distress syndrome (ARDS) associated with Covid-19 [6]. In his systematic review, Zhan Yan 2020 found that antioxidant extracellular superoxide dismutase (EcSOD) associated with exercise training might be protective against Covid-19 ARDS [7]. Though moderate to vigorous exercise training is proposed to improve immune system [8], few studies refute this proposition suggesting a window period for immunosuppression, primarily reduction in CD4 cells after vigorous exercise or unaccustomed exercise performed for a longer duration (> 2 h/day). Dramatic reduction in cytotoxic T cells should be anticipated in sedentary individuals participating in the accustomed strenuous exercise [9].

Despite the conflicting evidence, low-intensity exercise for sedentary individuals and moderate exercise for active individuals are recommended by Center for Disease Control (CDC) and American College of Sports Medicine (ACSM) to maintain cardiovascular and musculoskeletal fitness in global population [10].

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Hypothesis

Worldwide, governments are slowly relaxing their national lockdowns even though the number of cases continues to rise. Although concerning, it has still brought a sigh of relief to athletes as well as social exercisers, who can resume their training/fitness sessions, and they can now be seen everywhere with facemasks. However, the wearing of facemasks to prevent the community spread of the novel Covid-19 is itself debatable, considering the limited evidence on the subject matter [11]. WHO recommends masks only for Covid-19 patients but the usage of masks is morally "exploited" among community individuals [12]. The present physiological hypothesis paper is an attempt to explore the unanswered questions: 1) Does the use of facemasks offer any benefit for 'social exercisers' during this pandemic; 2) Does exercising with facemasks alter normal physiological responses to exercise; 3) Does exercising with facemasks increase the risk of falling prey to Coronavirus; 4) How could "social exercisers" combat the physiological alteration?

Evolution of hypothesis

Do facemasks offer benefit during exercise?

Coronavirus is known to spread via droplets and causes upper respiratory tract infections with ARDS. Respirator facemasks (N95) serve as personal protective equipment that could filter fine airborne particles and prevent them from reaching the respiratory system as well as prevent inter-individual infections, especially influenza and coronaviruses [13]. The current trend indicates the proclivity of Coronavirus towards the nasal or oral cavity, due to its lower temperature as compared to the core. Gupta et al. 2020 proposed that facemasks may provide a "therapeutic" environment (95 F hot and 80 humid), and act as a barrier against these viral impactions in the naso-oropharynx region [14].

Facemask and physiology alteration during exercise

Exercising with customized tight facemasks induces a hypercapnic hypoxia environment [inadequate Oxygen (O_2) and Carbon dioxide (CO_2) exchange] [15]. This acidic environment both at the alveolar and blood vessels level induces numerous physiological alterations when exercising with facemasks: 1) Metabolic shift; 2) cardiorespiratory stress; 3) excretory system altercations; 4) Immune mechanism; 5) Brain and nervous system. Fig. 1 illustrates the possible physiological alterations while exercising with facemasks.

Metabolism altercation

Muscle metabolism highly depends on the uninterrupted O_2 supply and CO_2 exchange with the atmosphere. The efficiency of muscle metabolism depends on patency of oropharynx, autonomic stability, cardiac fitness and muscle blood supply [16]. Fat metabolism occurs at rest and low to moderate-intensity exercise, sparing glucose. But during moderate to vigorous intensity exercise, anaerobic metabolism predominates and requires substantial O_2 supply after cessation of the activity for the conversion of lactic acid. The face mask forms a closed circuit for the inspired and expired air, though not completely airtight. Rebreathing of the expired air increases arterial CO_2 concentrations and increases the intensity of acidity in the acidic environment [17]. Thus individuals exercising with a mask would have physiological effects similar to a Chronic Obstructive Pulmonary Disease (COPD) person exercising such as discomfort, fatigue, dizziness, headache, shortness of breath, muscular weakness and drowsiness [18]. Besides, light activity, like walking with a MET value of 2, could increase the amount of inhaled CO2 and decrease the amount of O2 via an N95 mask, increasing the work of breathing. Therefore, we could assume this effect to magnify when performing any aerobic or resistance exercise at a higher workload. The resistance offered to the inspiratory and expiratory flow, for prolonged periods (about 10 mins), could result in respiratory alkalosis, increased lactate levels and early fatigue [9]. The aforementioned symptoms affect the exercising individuals psychologically as well as bring about physiological alterations such as muscle damage, muscle fibre switch and fast-twitch fibres size.

Further, poor saturation of haemoglobin would be anticipated due to increased partial pressure of CO_2 at higher exercise intensity [19]. Fig. 2 demonstrates the extreme right shift of the oxyhemoglobin dissociation curve, which would be higher than that expected during exercise. This acidic environment would unload O_2 faster at the muscle level, but due to higher heart rate and reduced affinity at the alveolar junction, the partial pressure of O_2 would substantially fall, creating a hypoxic environment for all vital organs.

Poor immune responses

Substantial evidence exists concerning the long term effects of exercise and the improvement in adaptive immunity [20]. Though, moderate exercise, in the long run, is found to increase natural killer cell count and downregulate inflammatory factors such as tumour necrosis factors, acute bouts of vigorous exercise over a while may influence these changes negatively. Exercising with facemasks induces an acidic environment, and thus mobility of hypoxic natural killer cells to the target cells would be affected, aggravating the chances of infection during the pandemic. A further change in humidity and temperature in the upper airway causes immotile cilia syndrome predisposing individuals to lower respiratory tract infections by deep seeding of oropharyngeal flora [21].

Increased cardiorespiratory stress

The reduced availability of O_2 and CO_2 would increase the heart rate and blood pressure exponentially even at low workloads. This physiological alteration may increase aortic pressure and left ventricular pressures, leading to an upsurge of cardiac overload and coronary demand [22]. Further increased respiratory load against the "valve breathing", leads to increased respiratory muscle load and pulmonary artery pressure, in turn, adding to the cardiac overload. These changes may be subtle in healthy individuals during exercise. Still, in persons with established chronic illness, these changes may aggravate the underlying pathophysiology, leading to hospitalization or increased use of medication.

Altered renal function

Hypercapnic hypoxia reduces renal blood flow and glomerular filtration rate posing a risk of reduced renal functions. Thus, aciduria and resulting tubular damage may potentially aggravate the compromised renal functions in individuals with established chronic diseases [23]. Further, the autonomic dysfunction and reduced immune responses, increase the inflammatory substances such as C reactive protein, interleukins (IL-6, IL-12) resulting in generalized nephritis in chronic kidney failure patients [24]. Additionally, poor renal artery flow causes hypoxemia in nephrons perpetuating the pathophysiology of poor renal functions.

Brain metabolism and mental health

Acute hypercapnia, a double-edged sword, on the one hand, elevates intracranial pressure, lowers cerebral perfusion, and triggers cerebral ischemia and, on the other hand, it is found to be neuroprotective decreasing the excitatory amino acids and minimizing the cerebral metabolism [25]. Studies from obstructive sleep apnea [26] provide irrefutable evidence of hypercapnic hypoxemia affecting the postural stability, proprioception, altered gait velocities and falls. The above findings can be extrapolated to elderly persons as well as individuals with established respiratory diseases exercising with N95 respirator masks.

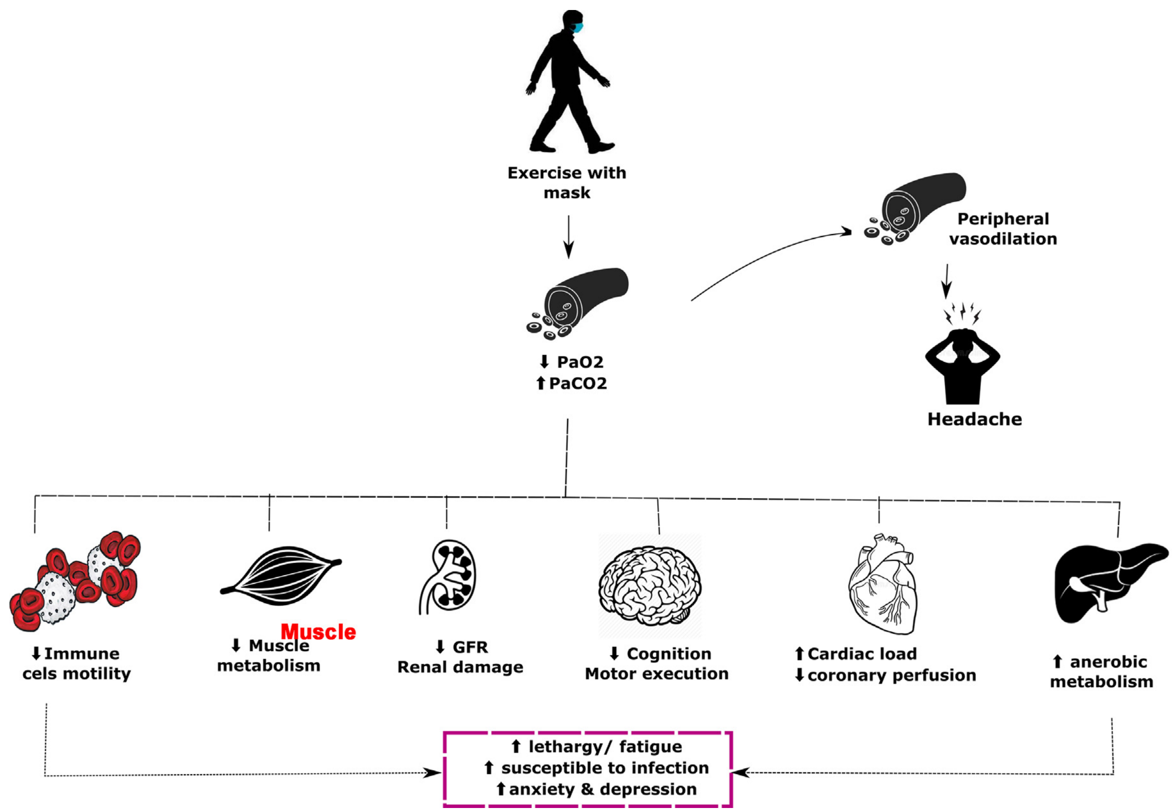

Fig.1. Pathophysiological changes associated during exercise with facemasks. Potential changes that occur in the immune, muscular, renal, brain, cardiovascular and metabolic systems contributing to anxiety and depression. GFR – Glomerular Filtration Rate; PaCO2 – Partial pressure of Carbondixide; PaO2 – Partial pressure of Oxygen; ↓- decreased; ↑- increased.

Can facemasks increase the risks of Coronavirus?

Though the respirator masks are perceived to be the barriers for preventing aerosol depositions to the respiratory tract, the bitter reality is that masks increase the risk of more in-depth respiratory tract infections. As quoted by Perencevich et al. 2020, “The average healthy person shouldn't be wearing masks as it creates a false sense of security and people tend to touch their face more often when compared to not wearing masks” [27]. The surgical masks are debated to trap the droplets containing the virus inside, increasing rather than reducing the risk of infection.

Possible mitigatory measures

Even with the usage of a protective face mask, social distancing while exercising outdoors is essential. To avoid the adverse effects of exercising with a face mask, the individual should first be aware of their exercise limit. Low to moderate-intensity exercise would be beneficial and would help reduce the ill effects of mask breathing. When experiencing symptoms of dizziness, imbalance, excessive fatigue [13], and shortness of breath, it would be advisable to stop and take a break, until symptoms subside. Intermittent atmospheric breathing without the mask would be beneficial to restore the normalcy of breathing and reducing the stress on the cardiopulmonary system, in an area which is not densely occupied by people. Individuals with chronic diseases should avoid venturing outdoors to exercise. Home-based exercises, performed under the supervision of a health professional, would be preferred to avoid any adverse outcomes.

Conclusion

Exercising with facemasks might increase pathophysiological risks of underlying chronic disease, especially cardiovascular and metabolic risks. Social exercisers are recommended to do low to moderate-intensity exercise, rather than vigorous exercise when they are wearing facemasks. We also recommend people with chronic diseases to exercise alone at home, under supervision when required, without the use of facemasks. Given the identified and hypothesized risks, social distancing and self-isolation appear to be better than wearing facemasks while exercising during this global crisis.

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Conflicts of interest

None.

CRediT authorship contribution statement

Baskaran Chandrasekaran: Conceptualization, Data curation, Methodology, Supervision, Validation. **Shifra Fernandes:** Visualization, Writing - original draft, Writing - review & editing.

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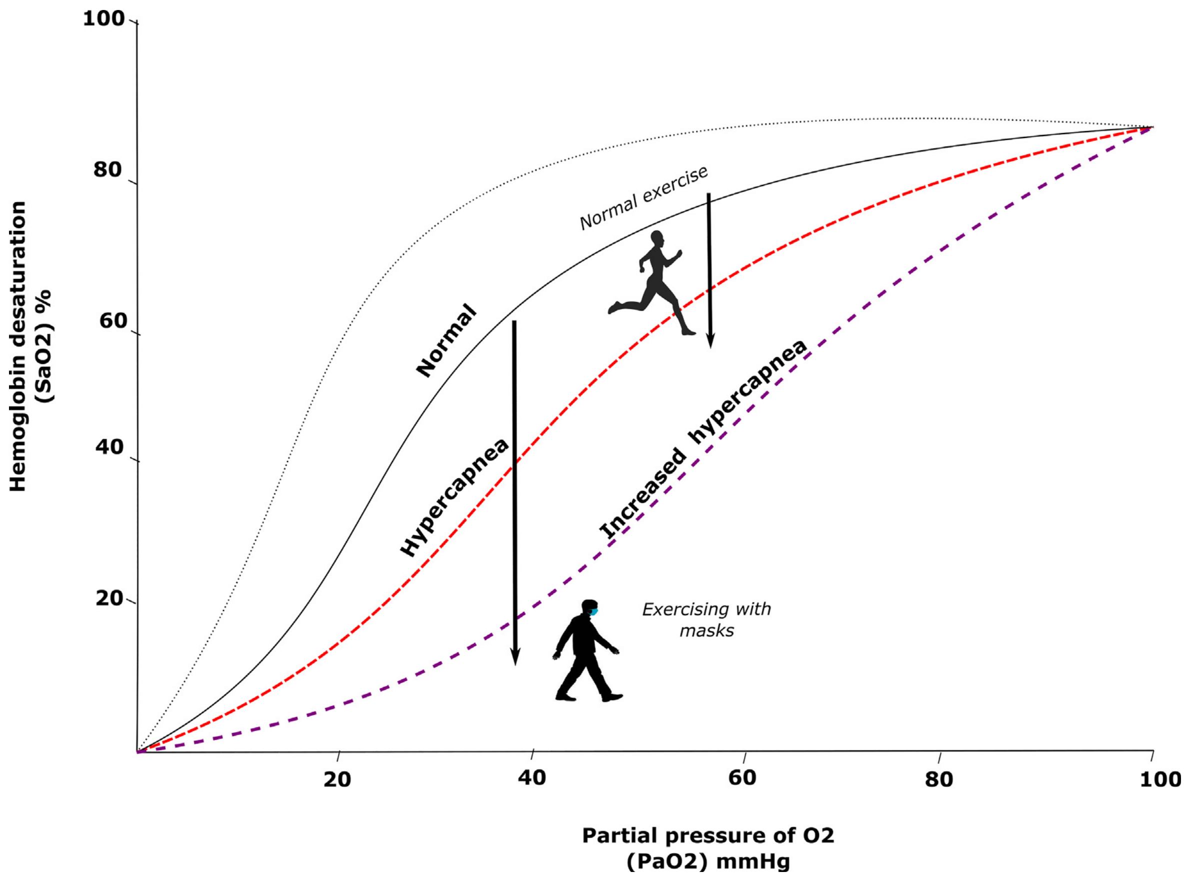

Fig.2. Bohr's oxyhemoglobin dissociation curve is showing the extreme right side shift with the carbon dioxide rebreathing (PaCO2) and inadequate available Oxygen (P_AO_2). Red dotted lines shows the right shift of the curve due to exercise without masks (↑PaCO2, PH and temperature). Violet dotted lines shows the extreme curve shift during exercise with masks (↑↑↑↑PaCO2, PH and temperature). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.mehy.2020.110002.

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