The Role of Movement, Exercise, and Breathing in the Prevention and Treatment of COVID-19: An Umbrella Review

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ABSTRACT

Objective: To identify the published review literature regarding movement, exercise, and breathing in the prevention and/or treatment of the coronavirus 2019 disease (COVID-19) and long COVID, with the goal of describing the literature and identifying areas for further research and clinical application. Movement and exercise incorporate sedentary behaviours, various forms of exercise, breathing and respiratory therapies, and yoga-asanas (postures).

Methods: This paper progresses from a live review and incorporates systematic reviews and narrative reviews. A literature search occurred monthly using PubMed and Google Scholar from May 2022 to May 2023. A measurement tool to assess systematic reviews (AMSTAR) scoring assessed systematic review quality, while the scale for the assessment of narrative review articles (SANRA) guidelines were used to evaluate narrative reviews. Only information and data focused on movement and exercise relevant to COVID-19 prevention and/or treatment were extracted from each review.

Results: Three narrative reviews and five systematic reviews were included. Sedentary behaviours increased significantly during the pandemic. Decreased physical activity level was associated with risk of hospitalization from COVID-19. Physical activity and breathing exercises, whether conducted face-to-face (F-2-F) or via telerehabilitation were associated with improvement in dyspnea (shortness of breath), exercise capacity, lung function, fatigue, and quality of life (QoL). Extreme exercise is best avoided for at least 2 to 3 weeks after severe COVID-19 symptoms.

Conclusion: Sedentary behaviour and lack of regular physical activity is correlated with an increased risk of COVID-19. Various forms of movement, exercise, and breathing may be beneficial in the treatment of COVID-19 and in long COVID. Further research and understanding of the importance of movement, exercise, and breathing as it relates to immune health is warranted.

Key Words Physical activity, isometrics, calisthenics, inhalation, respiration, remedy

INTRODUCTION

The advent of the coronavirus disease 2019 (COVID-19; see Appendix 1 for a list of terms and acronyms used in this article) hampered the continuity of essential health services throughout the world during 2021–2022,[1] with the broader impacts of COVID-19 accounting for over 760 million confirmed cases worldwide since December 2019, affecting people of all ages.[2] Efforts during this tumultuous period were focused on identifying effective and efficient treatments for COVID-19,[4,5] improving rates of recovery,[6,7] and preventing transmission through public health initiatives.[8] Some of the prevention measures, such as the lockdowns and closures of many services, resulted in high levels of stress, and individuals across the globe not only delayed but entirely forwent health services when needed.[9] Individuals often changed their lifestyle behaviours and the frequency and type of interactions that they had with others.[10,11] COVID-19 strained the capacity for health systems worldwide to sustain the provision for essential health services. This pressure on health systems ultimately initiated the rapid roll-out and uptake of technology-assisted essential health services and lifestyle guidance via virtual telehealth appointments.[12,13]

Fatigue, shortness of breath, weakness, and other respiratory symptoms are common symptoms of COVID-19[14] and long

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COVID.[15] As sedentary lifestyles and lack of exercise are well known to be correlated with respiratory symptoms,[16] it stands to reason that the impact of movement and exercise should be explored as a preventive measure that may improve both immune health[17] and mental health[18] in the treatment of COVID-19 and long COVID.

The aim of this paper was to identify the published review literature regarding movement, exercise, and breathing in the prevention and/or treatment of COVID-19 and long COVID and the impact of the pandemic. The aspects of movement, exercise, and breathing that are included are sedentary lifestyles, various forms of aerobic and resistance exercises, various Western breathing exercises, yogic beathing (pranayama), and yoga asanas (postures). This review also analyzed the difference between face-to-face (F-2-F) and telerehabilitation interventions with the goal of describing the literature and identifying areas to consider for future research and clinical application.

METHODS

Design

This paper progresses from a live review of systematic reviews[40] which explored natural health products (NHPs) and natural therapies in the prevention and/or treatment of COVID-19. Along with five other papers, this is an umbrella review encompassing narrative reviews and systematic reviews that were collected as part of the live review completed in order to provide a comprehensive evaluation of various NHPs and natural therapies studied.

Search Strategy

A live literature search occurred monthly in PubMed and Google Scholar databases from May 2022 to May 2023, as guided by the Cochrane guidelines for a live systemic review.[41] A primary search strategy for the overarching live review was conducted utilizing some of the following search terms "natur*," "herb*," "nutraceuti," "botanical," "medicinal plant," "Ayurvedic," "herbal patent formula," "vitamin," "mineral," "exercise," "traditional medicine," "medicine, traditional Chinese," "lifestyle medicine," combined with "prevention," "prophylaxis," "deficiency," "treatment," "management," and "*COVID*," "Coronavirus," "SARS-CoV-2"; these search terms were filtered for meta-analysis, review, or systematic review (refer to Table S1 in the supplemental material). Individual therapies cited in the literature were searched and were subsequently added to the search criteria, for example "exercise," "meditation," and "breathing." This manuscript presents the results of a subset of studies identified through the live review focused on movement, exercise, and breathing.

Articles identified by the living review search strategy were then grouped based upon the type of review as stated in the abstract (1) systematic review/meta-analysis, (2) narrative, and (3) other.

Inclusion and Exclusion Criteria

This umbrella review includes systematic reviews and narrative reviews. Both review types were appraised by at least two reviewers for inclusion/exclusion and any discrepancies were assessed by an independent third reviewer. Systematic reviews were assessed according to A Measurement Tool to Assess Systematic Reviews (AMSTAR) guidelines[42] and narrative reviews according to the Scale for The Assessment of Narrative Review Articles (SANRA) guidelines.[43] Systematic reviews were included if the review authors, at least partially, accounted for risk of bias (RoB) in individual studies and used a satisfactory technique for assessing the RoB. Narrative reviews were included if the scientific reasoning score was 1 or 2 and the overall total sum >5.

Population, intervention, comparator, outcome (PICO) eligibility criteria requirements for study inclusion were as follows:

Population: Clinical/observational (humans of any age/gender, any setting), in vivo (including animals), in vitro, or in silico studies.

Intervention: Sedentary, movement, exercise, breathing

Comparison: No comparator limitation.

Outcome: Symptoms, biological markers, diagnostic criteria, or viral traits related to COVID-19.

Due to the potential for a bidirectional relationship between exercise and COVID-19, studies were also considered for inclusion when the outcome was the intervention.

Excluded were secondary analyses, literature reviews, editorial discussions, best practice guidelines, and book chapters. Only results that reported statistically significant outcomes relevant to COVID-19 prevention and/or treatment were extracted from each review. Any discrepancies for inclusion were verified by a separate reviewer.

Data Extraction

Narrative reviews were included to highlight the therapeutic considerations and known mechanisms of action of each criterion. The data extracted from the narrative reviews included study number, American Medical Association (AMA) style, author(s), date, journal, country/World Health Organization (WHO) region, review objective, details of any search conducted, area of focus (prevention, treatment, long COVID), and therapeutic considerations including properties (anti-inflammatory, antiviral, etc.) were extracted based on therapeutic properties outlined on https://www.ndhealthfacts.org/wiki/Action_of_Herbs .

The data extracted from the systematic reviews of this review includes study number, study identification, author(s), date, journal, area of focus (prevention, treatment, long COVID), WHO region, review objective, search date, search databases, study designs, included country, included studies, publication date range, tools for assessment of RoB, methods of synthesis/analysis. Data extracted for the systematic reviews for the study results includes relevant study interventions, relevant outcomes measured, number of studies, number of participants, age of included participants, sex of participants (percentage female), results/findings, heterogeneity (only if a meta-analysis).

RESULTS

The primary review identified 401 papers of which 155 (38.6%) were excluded as not meeting the primary review criteria, including critical appraisal thresholds. After additional deduplication and extraction, a further 40 additional studies were excluded, leaving 206 studies that were allocated amongst the various subsets that are reported as unique umbrella reviews. Specific to this subset, 50 studies were selected as potentially relevant for this subset analysis and further screened, through which 42 (84.0%) were removed as not meeting the criteria, resulting in 8 included for review in this manuscript: 5 systematic reviews and 3 narrative reviews.

Systematic Reviews

Of the 41 initially identified systematic reviews in this section, 5 papers were included in the final write-up[44-48] (Table 1). The included systematic reviews were conducted in the following WHO regions: the Western Pacific region (WPR) (n = 3), region of the Americas (AMR) (n = 1), and Eastern Mediterranean region (EMR) (n = 1). Movement and exercise were explored as they relate to being a comorbidity for COVID-19,[46] the impact of COVID-19 public health measures on movement and exercise,[47] physical activity (PA) as a prevention for COVID-19,[44] the impact of pulmonary respiratory muscle exercises (PRME) as an adjunct treatment for COVID-19,[45] and the value of respiratory muscle training (RMT) in long COVID.[48]

Narrative Reviews

Narrative reviews were included in this umbrella review to provide a broader perspective on the therapeutic considerations and to complement the details of the systematic reviews (Table 2). Of the nine narrative reviews initially included, eight remained for data extraction and three papers were included in the final write-up.[21,49,50] The three papers in the narrative reviews included the following WHO regions: European region (EUR) (n = 2) and South-East Asian region (SEAR) (n = 1). One of the narrative reviews focused on the impact of yoga asanas (postures) and yogic breathing (pranayama) on prevention and treatment of COVID-19. The other two narrative reviews discussed various forms of exercise for the treatment of long COVID.

Initially the systematic reviews and narrative reviews identified for this paper included all non-ingestible therapies that were not included in the other umbrella review papers. For example, systematic reviews on mind-body therapies, body-based therapies, Ayurveda, and acupuncture were included. The diminutive evidence base for some therapies in the prevention and treatment of COVID-19 is reflected in the high number of papers excluded from the final manuscript; papers that were not focused on COVID-19 were also excluded.

Symptom Severity and Hospitalization

Two systematic reviews discussed the correlation between activity level and the risk of COVID-19.[44,46] Luo et al. (2022)[46] concluded that the level of physical exercise correlated with an increased risk of COVID-19 and found that moderate-to-high PA may be associated with lower risk of COVID-19 severity, yet self-reported moderate-to-vigorous physical activity was not associated with lower risk. The meta-analysis by Li et al. (2023), involving 17 studies and over 1 million participants self-reporting on level of PA found a 40% reduction in the risk of COVID-19 hospitalization between those reporting a high dose of PA compared with those reporting a low level of PA. Although an increase in moderate-intensity PA was found to be beneficial in all groups, the benefit was greater in those that were initially doing less than 10 metabolic equivalents of task per-hour (Met-h)/week. Met-h is an objective measure of the energy cost for metabolic activity or the rate at which a person expands energy for PAs or exercise capacity.[52]

Impact of the Pandemic on Movement

The meta-analysis by Gigli et al. (2022)[47] involving 34 studies and 9,433 males and females looked at the self-reported impact of COVID-19 on various lifestyle behaviours and found that the lockdowns and school closures may have resulted in an increase in unhealthy lifestyle behaviours for most people. Between 36.5% and 43% respondents indicated that they did not engage in PA, or they experienced a significant reduction in PA during the lockdowns. The studies also indicated that adults over 40 with children, unemployed persons and those living in a macroeconomic region were more likely to engage in unhealthy behaviours. Children and adolescents were significantly affected, with one study indicating that PA in children and adolescents decreased from 540 min/week before the pandemic to 105 min/week during the pandemic and the other study indicating that the prevalence of physical inactivity in students increased from 21.3% to 65.6%. The studies also showed that screen time increased as PA decreased. There is also some indication that telemedicine may reduce the impact of unhealthy lifestyle behaviours.

Movement as an Adjunctive Treatment for COVID-19

One narrative review and one systematic review discussed movement as an adjunctive treatment for COVID-19. The narrative review by Umesh et al. (2022) discussed yoga asanas (postures), yogic breathing (pranayama), and meditation as a prophylaxis and an effective adjunctive therapy for COVID-19.[21] The paper outlined the anti-inflammatory and antioxidant impacts of yoga and presented the results from a range of studies, including a clinical trial to support their findings. When yogic meditation, moderate-intensity exercise, and a control group were compared, findings suggested that the yoga group had a lower mean severity score for respiratory symptoms compared with the exercise group, and both the yoga group and the exercise group fared better than the control group.

The systematic review by Ahmed et al. (2022) involved eight studies and 449 participants and assessed the impact of PRME conducted either F-2-F or via telerehabilitation on a number of COVID-19 rate-of-recovery (ROR) markers.[45] The study suggested that PRME produced significant improvements in exercise capacity. The results were better for those with acute symptoms

TABLE 1 (Part 1 of 2) Systematic Reviews: Movement, Exercise, and Breathing

First Author, Year of Publication	Area of Focus / WHO Region / Countries in Study	Number of Studies / Design Method / Search Date / Search Databases / Risk of Bias	Intervention/ Exposure	Participants: Number / Age / Sex	Outcomes Reported	Readings/Findings
Luo et al., 2022[46]	Prevention WPR / Europe, East Asia	50 / Meta-analysis NR / PubMed, EMBASE, MEDLINE No tools, relied on 3 main IV assumptions: relevance, independence, and exclusion.	Exercise along with a number of other characteristics and comorbidities were assessed.	NR / NR / NR	Risk of COVID-19.	The role of physical activity in the risk of COVID-19 was inconsistent. Moderate-to-high physical activity may be associated with lower risk of COVID-19 severity, yet self-reported MVPA was not.
Gigli et al., 2022[47]	Prevention AMR / China, Italy, UAE, Poland, Iraq	34 / meta-analysis / December 2021–April 2022 PubMed, Scopus, Science Direct, Scielo, Google Scholar Cochrane risk of bias tool	Impact of COVID-19 on lifestyle behaviours.	9,433 / males and females	Self-reported changes in lifestyle behaviours including exercise and screen time generally through online questionnaires. Note: the dietary behaviour changes are not included in this paper.	Observational studies reveal between 38.5% and 43% did not practice PA or reported sig decrease in PA and 36.2% to 49% significantly increased their screen time for entertainment during the pandemic. Most reported an increase in physical and emotional exhaustion, irritability and tension, as well as sleep disturbances. Children/adolescents showed sig altered lifestyle behaviour globally, including increased sedentary behaviour (median time spent in PA decreased from 540 min/wk before pandemic to 105 min/wk during the pandemic) and increased mental health outcomes. During the pandemic, the prevalence of physically inactive students increased from 21.3% to 65.6% and screen time averaged 30 hours per week during the pandemic. Several studies evidenced that for a small percentage of the participants, the pandemic resulted in improved lifestyle behaviours.
Li et al., 2023[44]	Prevention WPR / UAE, Canada, Slovenia, Sweden, UK, Iran, Palestine, Korea, Spain, Luxembourg, France, Brazil, USA, South Africa, China	17 / Meta-analysis / 1980–April 2022 PubMed, Web of Science	PA	1,038,768 / 18 to 69 / males and females	Self-reported PA level and its impact on hospitalization. Measurement based on MET-h MVPA, VPA	Those with the highest PA dose showed a 40% (RR 0.60, 95% CI [0.48, 0.71]) reduction in the risk of COVID-19 hospitalization compared with the lowest dose of PA. When PA<10 Met-h/week, an increase of 4 Met-h/week (1 hour of moderate-intensity or 1/2 hour of high-intensity) was associated with a 14% reduction in the risk of hospitalization for COVID-19 (157 $p<.01$, RR=0. 86, 95% CI [0.85, 0.87]). When PA>10 Met-h/week, the risk of hospitalization for COVID-19 decreased by 11% for each 158 additional 4 Met-h/week ($p<.01$, RR = 0.89, 95% CI [0.87, 0.90]). A 4 Met-h/week PA is equivalent to 1 hour MPA or 1/2 hour MVPA.

TABLE 1 (Part 2 of 2) Systematic Reviews: Movement, Exercise, and Breathing

First Author, Year of Publication	Area of Focus / WHO Region / Countries in Study	Number of Studies / Design Method / Search Date / Search Databases / Risk of Bias	Intervention/ Exposure	Participants: Number / Age / Sex	Outcomes Reported	Readings/Findings
Ahmed et al., 2022[45]	Treatment EMR / Spain, Saudi Arabia, Brazil, Turkey, China	8 / Meta-analysis / January 2020–April 2022 / PubMed, Web of Science, Cochrane Cochrane risk of bias tool	PR muscle exercise, device-based threshold positive expiratory pressure, airway cleaning exercises, Telerehabilitation or F-2-F	449 / NR / males and females	ROR exercise capacity (6-MWT), lung function FVC, dyspnea severity index, dyspnea 12, (mMRC), fatigue (Borg scale of perceived exertion) QoL (anxiety, depression based on SF-12, SF-36), squat test and grip strength Comparison of F-2-F telerehabilitation for all markers.	PR program was superior to no intervention in improving dyspnea, exercise capacity, lung function, and fatigue in patients with COVID-19. Exercise capacity: PR produced sig improvement in exercise capacity based on 6-MWT (8 studies, MD 65.85 M 95% CI [42.86, 88.83]; $p<.001$). PR effective in both acute (5 studies, MD 8269 95% CI [56.30, 109.07], $p<.001$) and chronic COVID-19 patients (3 studies, MD 44.16, 95% CI [20.30, 68.02], $p<.001$). Improvement in acute was better than chronic and PR was effective both with mild and moderate/severe COVID-19 patients. Telerehabilitation: Both F-2-F (2 studies, MD 41.46, 95% CI [24.28, 58.63], $p<.001$) and telerehabilitation (6 studies, MD 75.95, 95% CI [49.05, 102.84], $p<.001$) were effective in improving exercise capacity. Dyspnea: PR sig improvement dyspnea (5 studies, SMD –2.11, 95% CI [–2.96, –1.27], $p<.001$) and exercise capacity (MD 65.85 m, 95% CI [42.86, 88.83], $p<.001$) in patients with both acute and chronic COVID-19 with mild to severe symptoms. Benefits were identified with both F-2-F and telerehabilitation. Fatigue: improvement via telerehabilitation in acute patients having mild symptoms (4 studies, MD 2.42, 95% CI [–2.72, –2.11], $p<.05$) Lung function: only F-2-F improved FVC in acute patients with mild symptoms (MD 0.26 L, 95% CI [0.04, 0.48], $p<.05$) QoL: The effect of PR on QoL was inconsistent across studies, yet 1 study found that F-2-F PR for 2 weeks improved QoL in patients with COVID-19 (SMD 2.89, 95% CI [2.04, 3.75], $p<.05$) PR was found to be safe and feasible for patients with COVID-19.
Chen et al., 2022[48]	Post-COVID WPR / China, Saudi Arabia	3 / meta-analysis / NR PubMed, EMBASE, Chinese Science and Technology Journal full-text database (CNKI), Wan Fang Data, Chinese Biomedical Literature Database (VIP) Cochrane risk of bias tool	Three studies all employed RMT, with or without endurance training. Two studies adopted device-based threshold PEP, which can increase airway diameter and enhance mucus clearance by generating a force for flow obstruction that allows flow only when PEP reaches the requisite threshold level. One study also applied lower LMS exercises to improve muscle mass and strength, and one study integrated stretching exercise for body posture and flexibility. All three studies adopted the interval training approach.	233 / 48 to 69 / 58% male and 42% female with mild-to-moderate lung function impairments after COVID-19.	Exercise capacity: 6-MWT; PF: based on spirometry, lung volumes and diffusion capacity; QoL: SF Health Survey SF-12 and SF-36, ADL; Anxiety and depression: SDS and SAS	Exercise capacity: Sig improvement based on 6-MWT (50.41, 95% CI [34.34, 66.48], $p<.0001$) in treatment group. RMT sig improved exercise capacity, regardless of types of interventions (F-2-F or remote, with device-based or not, with endurance training or not). Dyspnea: improved in treatment group Pulmonary function: various parameters were used and interventions across the studies making improvements in PF difficult to assess. QoL: various inventories used. Sig improvement in all studies. One study used the SF-36 and indicated at 6 weeks sig improvement in all domains, yet no sig improvement in ADL. Another study using the SF-12 reported sig improvement on physical components at 6-weeks, but no sig improvement on the mental component. Anxiety and Depression: assessed in one study and indicated sign improvement in SAS, but not in SAD.

ADL=activities of daily living; AMR=region of the Americas; CI=confidence interval; EMR=European region; F-2-F=face to face; FVC=forced vital capacity; h=hour; IV=instrumental variable; LMS=limb muscle strength; MD=mean difference; MET-h=metabolic equivalents of task per hour; mMRC=modified Medical Research Council; MPA=moderate physical activity; MVPA=moderate to vigorous physical activity; MWT=minute walk test; NR=not reported; PA=physical activity; PEP=positive expiratory pressure; PF=pulmonary function; PR=pulmonary respiration; QoL=quality of life; RMT=respiratory muscle training; ROR=rate of recovery; RR=risk ratio; SAS=self-rating anxiety scale; SDS=self-rating depression scale; SF=short-form; sig=significant; SMD=standardized mean difference; UAE=United Arab Emirates; UK=United Kingdom; USA=United Sates of America; VPA=vigorous physical activity; WHO=World Health Organization; WPR=Western Pacific region.

TABLE 2 Narrative Reviews: Movement, Exercise, and Breathing

First Author, Year of Publication	Area of Focus	WHO Region	Search Details	SANRA Score	Therapies Investigated	Properties / Association	Therapeutic Considerations
Umesh et al., 2022[21]	Prevention, treatment	SEA	PubMed	8	Yoga	Physical inactivity and other lifestyle factors impact immune health.	Yoga: preventive strategy for COVID-19. Yoga asanas (postures) may increase anti-inflammatory neuro-hormonal substances and thereby reduce the severity of infection. A RCT of 8-week yoga program (postures, breathing – paranyama, and meditation) matched moderate intensity exercise to a control group and a yoga group and identified a lower mean severity of respiratory symptoms for the yoga group than the exercise group. Both the yoga group and exercise group reported lower mean severity of respiratory symptoms than the control group. Yoga was found to be effective in other conditions with a respiratory factor, e.g., HIV, anti-tuberculosis treatment, pulmonary tuberculosis and in increasing lung capacity. A number of RCT yoga studies have demonstrated improvement in inflammatory markers and antioxidant status. Studies suggest yoga may reduce the severity of infections by regulating the immune responses.
DeLuca et al., 2022[49]	Long COVID	EUR	Cochrane Library, PEDro, PubMed, and Google Scholar	9	Physical function: 2 sessions, 6 weeks, aerobic exercise (walking/ treadmill based), strength training of upper and lower limbs. Virtual reality exercises = 6 weeks, max 30 minutes/day. Brain stimulation: 9 over 3 weeks (20 mins/session)	Not specified / None	Cognitive imperative in long COVID requires a multifaceted treatment approach including addressing physical functions using various means. Physical function: Endurance and balance training had significant improvements in walking capacity, symptoms of fatigue, cognition, and respiratory symptoms. Virtual reality exercise at home was well tolerated resulting in positive health, and QoL improved in time, whereas cognitive function seemed unaltered.
Scurati et al., 2022[50]	Long COVID	EUR	Not specified	8.5	Exercise: various forms of exercise including, American College of Sports Medicine FITT-VP protocol Assessment of METs Aerobic, resistance training, exercises. Breathing exercises, stretching etc.	Anti-inflammatory, immune modulating, builds muscle mass, ameliorates cognitive function. Exercise mobilizes and activates innate immune cells, including neutrophils, inflammatory monocytes, dendritic, and NK cells Improved QoL	Consideration of exercise prescriptions as a concurrent treatment to modulate the molecular phenotype of long COVID. Exercise plays a preventive role and should be part of a long COVID treatment regimen. FITT-VP should start within 30 days after acute phase. Exercising over three METs should be avoided until 2/3 weeks after overcoming severe symptoms or 1 week after mild/moderate COVID-19. With mild COVID-19 symptoms only prolonged and exhaustive activity must be avoided. Avoid exercise in the acute phase of COVID-19. Once recovered, progressive increase in exercise recommended.

COVID-19=coronavirus disease 2019; EUR=European region; FITT-VP= frequency, intensity, time, type, volume and progression; MET-h=metabolic equivalents of task per hour; NK= natural killer; QoL=quality of life; RCT=randomized controlled trial; SEA=South East Asia region.

than for those with chronic symptoms and were more effective with mild versus moderate-to-severe patients. There were significant improvements in shortness of breath for both acute and chronic patients with mild-to-severe symptoms, though PA only improved fatigue in acute patients with mild symptoms. Physical activity only improved lung function in acute patients with mild symptoms when PA was in person F-2-F. Telerehabilitation may be effective in improving exercise capacity, shortness of breath, and fatigue.

Movement and Long-COVID

Two narrative reviews[49,50] and one systematic review[48] discussed exercise in the treatment of long COVID. DeLuca et al. (2022) discussed physical function exercises for the improvement of cognition and associated mental health symptoms.[49] These exercises were comprised within a rehabilitation program consisting of two supervised sessions over 6 weeks incorporating aerobic exercise (walking/treadmill-based), strength training of upper and lower limbs, or virtual reality exercises, at no more than 30 min/day. Significant changes in walking times ($p < .01$) were reported post-rehabilitation for both walking tests.

Scurati et al. (2022) discussed the use of various types of exercise to mobilize and activate innate immune cells, including neutrophils, inflammatory monocytes, dendritic, and natural killer cells in long COVID.[50] The exercise programs discussed included the American College of Sports Medicine FITT-VP (frequency, intensity, time, type, volume, and progression) exercise protocols, the assessment of metabolic equivalents of task (METs), and the use of aerobics, resistance training, breathing exercises, and stretching.

The paper recommended that FITT-VP should start within 30 days after an acute COVID-19 infection and that exercising over 3 METs should be avoided until 2 or 3 weeks after overcoming severe symptoms or 1 week after mild/moderate COVID-19.

Chen et al. (2022) explored pulmonary rehabilitation (PR) and impaired respiratory function associated with COVID-19 and provided evidence of improved exercise capacity when measuring a 6-minute walk test among 233 patients with long COVID.[48]

DISCUSSION

The results of this paper highlight the importance of movement and exercise in the prevention and/or treatment of COVID-19 and long COVID. Movement and exercise are also highlighted as important considerations for COVID-19 comorbidities, such as non-communicable diseases (NCDs).

Movement and Exercise as Part of Prevention Strategies

The WHO recommends that a combination of moderate and high-intensity activities equivalent to 10 MET hours/week is the most effective at reducing the risk of COVID-19 and/or risk of hospitalization from COVID-19.[54-56] Exercise serves several purposes and is a strong indicator for health. For example, exercise capacity is an important index for measuring overall health and the ability of the body to cope with external stressors.[57] Exercise and physical activity have beneficial effects on the immune system resulting in enhanced immunosurveillance, reduced systemic inflammation, improved regulation of the immune system, and delayed onset of immunosenescence.[55,56] Proper breathing is also a key consideration for optimizing immune health and respiratory health.[58,59]

Movement and Exercise as Part of a COVID-19 Treatment Regimen

Although research indicates that physical exercise is not advisable during the acute phase of COVID-19,[50] both physical exercise and PRME may improve the rate of recovery from COVID-19 and long COVID.[44,45,47] Shortness of breath, fatigue, and decreased exercise tolerance are commonly associated with symptoms of mild-to-severe COVID-19.[45] Research also indicates that physical exercise may have some preventive impact and may decrease the risk of hospitalization.[44]

Link Between Movement and Exercise and NCDs

Sedentary behaviour and lack of movement or exercise are strongly associated with increased risk of NCDs. Physical inactivity is often associated with other unhealthful lifestyle behaviours such as imbalanced diet, smoking, increased alcohol consumption, and the risk of a higher body mass index (BMI). Movement is an integral component of a healthful lifestyle and is a call to focus on salubrious lifestyles and diets[60] due to lifestyle factors being tied to chronic diseases and adverse health outcomes, for parents and children.[61,62] NCDs often manifest as chronic comorbidities or as a multimorbidity[63] and have been linked to worsening COVID-19 symptoms and prognosis.[64] Although many NCDs can be averted,[65] health states stemming from unbalanced lifestyle choices may well be attributing to instances of COVID-19 as evidence indicates that patients with chronic illness such as diabetes, hypertension, respiratory illness, or renal or hepatic illness are more likely to be affected by COVID-19.[66] Non-communicable diseases are a major threat to humankind and present a substantial global disease burden.[67] Even though initiating lifestyle changes takes time and may be challenging to evaluate in a short-term study, these studies highlight the importance of focusing on movement and exercise as part of a healthful lifestyle.

Mental health issues are considered an NCD[68] and have greatly increased during the pandemic due to the lockdowns,[69] the trend towards working from home,[70] the stress and fear associated with COVID-19 itself,[69,71] and as a long COVID symptom.[72] There is a significant body of research linking the risk of mental health and the lack of PA and an increase in sedentary behaviour.[73-75] Engaging in regular movement and exercise is an integral part of both preventing and treating mental health concerns.[76]

The breadth of this paper captures the role of movement in the prevention and treatment of COVID-19. Nevertheless, this paper has some limitations which should be considered when interpreting the findings. The search strategy for this study was based on a primary search strategy for a live review, reiterated monthly and using numerous search terms not relevant to this study. Also, literature may exist outside of the date ranges, databases, or search

language used to identify potential studies for inclusion. Movement as part of overall wellness requires longer-term studies to elucidate the true importance or impact.

CONCLUSION

This study synthesizes evidence related to the potential role of movement, exercise, and breathing in the prevention and treatment of COVID-19 and long COVID. During the pandemic, the level of PA decreased, especially in children and adolescents. Various types of movement and exercise including pulmonary respiratory exercises, aerobic and resistance exercises, yoga asanas (postures) and yogic breathing (pranayama) indicated benefit in the prevention of COVID-19 and in the treatment of long COVID resulting in an improvement in exercise capacity and lung function and a decrease in shortness of breath and fatigue. Physical activity is best avoided during acute COVID-19 but should be started within 2 to 3 weeks after the acute phase is resolved depending on a patient's symptoms and health status. Indeed, movement, exercise, and breathing are primary areas of interest for future research when exploring viral infections.

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CONFLICTS OF INTEREST DISCLOSURE

We have read and understood the *CAND Journal*'s policy on conflicts of interest and declare that we have none.

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SUPPLEMENTAL MATERIAL

Supplemental material linked to the online version of the paper at https://doi.org/10.54434/candj.163:

- Table S1 Live Review Search Strategy

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APPENDIX 1: GLOSSARY OF TERMS

AMA	American Medical Association
AMR	Americas WHO region
AMSTAR	a measurement tool to assess systematic reviews
BMI	body mass index
COVID-19	coronavirus disease 2019
EMR	eastern Mediterranean WHO region
F-2-F	face to face
FITT-VP	frequency, intensity, time, type, volume, and progression.
MET	metabolic equivalent of task
Met-h	metabolic equivalents of task per hour
NCD	non-communicable disease
NHP	natural health product
PA	physical activity
PICO	population, intervention, comparator, outcome
PRME	pulmonary respiration muscle exercise
RCT	randomized controlled trial
RMT	respiratory muscle training
RoB	risk of bias
ROR	rate of recovery
SANRA	scale for the assessment of narrative review articles
SEAR	South-East Asian WHO region
WHO	World Health Organization
WPR	Western Pacific WHO region