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Influence of lifestyle factors on susceptibility, disease course and recovery from post COVID-19 syndrome: a scoping review

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ABSTRACT

Background A healthy lifestyle is crucial for preventing illnesses and aiding recovery. Many individuals suffer long-term effects from SARS-CoV-2 infection, known as post COVID-19 syndrome (PCS). However, there is a lack of comprehensive understanding of how lifestyle factors influence development and recovery of PCS.

Methods A scoping review was conducted to explore the impact of various lifestyle factors—exercise, smoking, alcohol, diet, mental health, sleep and overall lifestyle—on PCS susceptibility, progression and recovery. Systematic reviews, clinical studies and additional literature from PubMed (MEDLINE), Scopus and the Cochrane Library (January 2022 to December 2024) were included.

Findings Out of 4665 unique articles, 82 met the inclusion criteria. The evidence indicates that smoking and poor mental health increase the risk of developing PCS, while adequate sleep and maintaining multiple healthy lifestyle factors reduce susceptibility to PCS. Dosed exercise-based rehabilitation and cognitive behavioural therapy are effective in relieving PCS symptoms. Specific food-derived components, mind-body therapies and combined healthy lifestyle factors may be beneficial in PCS course/recovery. However, the evidence remains insufficient or inconsistent regarding the effects of exercise, alcohol consumption and habitual diets on PCS susceptibility. Likewise, evidence is lacking on the effectiveness of smoking or alcohol cessation, sleep or combined lifestyle interventions in aiding PCS recovery. Most studies focus on hospitalised adults, leaving gaps for paediatric and outpatient populations.

Conclusions The evidence shows that certain lifestyle factors can reduce PCS susceptibility and improve symptom relief and quality of life in PCS. However, substantial knowledge gaps remain. Further research is needed to understand how lifestyle factors interact with PCS, so that new knowledge can contribute to the development of treatment strategies.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Currently, there is an extensive body of scientific literature about the impact of various lifestyle risk factors for susceptibility and recovery from post-COVID-19 syndrome (PCS). Despite the abundance of research, there is no comprehensive global overview that synthesises all existing evidence. This review aims to fill that gap by summarising the current knowledge and providing insights into the studies conducted to date.

WHAT THIS STUDY ADDS

⇒ Our review illustrates that certain lifestyle factors, such as insufficient sleep, poor mental health and smoking, increase susceptibility to PCS. Conversely, dosed exercise, mind-body therapies, cognitive–behavioural therapy and supplementation with biotics show promise for recovery from PCS. Current knowledge gaps include research for specific lifestyle factors, studies with outpatients and paediatric patients, as well as the need for uniformity in study design.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Our study shows that there is promising evidence that certain (combined) lifestyle interventions can reduce the susceptibility to PCS and support recovery from PCS, which highlights the importance of incorporating lifestyle in treatment strategies for PCS. This scoping review summarised existing evidence in a systematic manner which supports development of guidelines. Additionally, it identifies current knowledge gaps, which can help shape a future research agenda.

INTRODUCTION

Post COVID-19 syndrome (PCS), also known as long-term (long) covid, is a complex, multifactorial condition that occurs in persons with a history of a SARS-CoV-2 infection in which symptoms persist for at least 2 months and are unexplained due to another diagnosis after the acute phase of COVID-19.[1] Regardless of the severity of symptoms during the acute phase of the infection, both children and adults can develop PCS. Globally, approximately 10–20% of infected individuals develop PCS, but higher percentages have been reported.[2 3] In the USA,

prevalence is estimated at 7.2% of the total population, compared with 2.9% in the UK.[4] Similarly, in the Netherlands, 3% of adults (aged 26+) reported persistent long-term symptoms after SARS-CoV-2 infection, while about 5% of the younger population (aged 12–25).[5]

A wide spectrum of persistent symptoms has been described for PCS that vary in prevalence.[1 6] Common symptoms include fatigue, respiratory issues, pain, cognitive impairment, loss of taste/smell, sleep and gastrointestinal problems, anxiety and depression. These symptoms can severely impact the daily functioning of patients with PCS for a considerable time. However, at this stage, the disease course in terms of (duration of) symptoms and factors affecting symptom resolution is still unclear. Most studies cover 4–6 months, with few investigating beyond 1 or 2 years.[6]

The wide range of clinically presented PCS symptoms points to the involvement of multiple organ systems, but the precise pathophysiological mechanisms underlying PCS remain unclear. Possible mechanisms include hidden viral persistence, immune dysregulation (including reactivation of other pathogens and autoimmunity), endothelial infection leading to disruption of vascular homeostasis and formation of possible microclots, microbiome disruption and mitochondrial dysfunction.[7 8] Overall dysfunction of the immune response, including the innate immune system and its inflammatory cascade, seems to play a central role.[8]

A rising number of studies identified risk factors such as genetics, vaccination status, previous hospitalisation due to COVID-19, female sex, comorbidities, high body mass index (BMI>30), smoking and low socioeconomic position.[8 9] These are also well known for other chronic and infectious diseases.[10 11]

Lifestyle factors like physical activity, diet, stress and sleep modulate the development and course of many diseases, including autoimmune diseases (eg, multiple sclerosis, systemic lupus erythematosus, alopecia areata),[12] metabolic (eg, obesity, cardiovascular diseases, diabetes)[13] and infectious diseases such as acute COVID-19.[14 15] Lifestyle interventions have demonstrated beneficial effects in the prevention and treatment of chronic lifestyle-related diseases, also known as non-communicable diseases, which include cardiovascular diseases, diabetes, obesity, cancers, autoimmune diseases and neurological conditions.[16] The expanding body of evidence regarding the impact of lifestyle factors on disease susceptibility and remission, along with their beneficial effects on overall health, suggests that such interventions may also benefit patients suffering from PCS. The WHO and other bodies (eg, governments, health organisations) offer lifestyle advice to support patients with PCS (table 1 and online supplemental table S1). However, because PCS is a relatively new disease, the evidence on the influence of lifestyle factors in development, ameliorating clinical symptoms or supporting recovery remains limited.

The current scoping review therefore investigated what is known about the impact and effect of lifestyle on the susceptibility, course and recovery of PCS and identified possible knowledge gaps.

METHODOLOGY

Search strategy

The review explored the literature in PubMed (MEDLINE), Scopus and Cochrane library as of 14 January 2025, focusing on publications from 01 January 2022 to 31 December 2024. This timeframe was considered adequate, as a prior review covering 2020–2021 found no relevant clinical studies—only editorials suggesting exercise might benefit or potentially worsen PCS symptoms.[17] The present review prioritised systematic review and/or meta-analyses (SR(MA)) as they likely cover studies from 2020 to 2021 that may have been missed previously.

The search strategy used the PubMed 'Long Covid' syntax (November 2023)[18] and adapted it for Scopus and the Cochrane library. This syntax covers all terminologies used over the years to describe long-term clinical effects following acute COVID-19. The 'Long Covid' syntax was combined with terms for exercise, smoking, alcohol, diet, mental health, sleep and healthy lifestyle factors in separate searches due to the large number of retrieved records (online supplemental table S2).

Our aim was a scoping review to assess the current state of knowledge regarding each lifestyle factor and identify knowledge gaps, rather than conducting a full SR(MA) for each factor. Therefore, a comprehensive list of all clinical studies was not compiled; publications described in SR(MA) and found through the search were removed as duplicates, with SR(MA) serving as the primary guide. The study adhered to PRISMA-ScR (Preferred Reporting Items for Systematic Review and Meta-Analysis extension for Scoping Reviews) guidelines[19] (online supplemental table S3). The inclusion strategy prioritised SR(MA) for their higher evidence ranking. When fewer than three SR(MA) were identified, further investigation targeted human clinical studies, including observational studies (cross-sectional, case–control, cohort studies) and experimental studies (randomised controlled trials, quasi-experimental studies). Case reports were excluded. Snowballing was applied to identify additional studies. Accordingly, strategies varied by lifestyle factor based on the number and type of available articles.

Study selection criteria

Publications were eligible for inclusion if: (1) written in English; (2) peer-reviewed literature; (3) full text articles; (4) any age group; and (5) investigating the long-term clinical and persistent clinical symptoms in patients after an infection with SARS-CoV-2; (6) for each lifestyle factor a broad interpretation was applied to capture the full spectrum of how these concepts

Table 1 Lifestyle recommendations provided by WHO and/or national health organisations to maintain a healthy condition

Lifestyle factor	General health advice	PCS-specific recommendations
Exercise	Sufficient exercise in adults is defined as 150 min per week of moderately intensive activities, such as walking and cycling, spread over several days, or 75 min of intensive activity per week. In addition, it is recommended to perform muscle and bone strengthening activities at least two times a week and to avoid prolonged sitting (>8 hours/day). For additional health benefits, adults should increase their moderate-intensity physical activity to 300 min per week, or equivalent.	Regular light exercise helps, but avoid strenuous exercise, including heavy homework. The amount of exercise you can do will depend on how you are feeling. People with PEM should be careful and should consult experts' advice on physical exercise.
	Updated advice for chronic conditions (2023/2024): Individuals living with chronic conditions, such as hypertension, type 2 diabetes, HIV, cancer survivorship or physical disabilities, are advised to engage in at least 150–300 min of moderate-intensity aerobic physical activity per week; or at least 75–150 min of vigorous-intensity aerobic physical activity; or an equivalent combination of both throughout the week. In addition, they should also perform muscle-strengthening activities involving all major muscle groups at moderate or greater intensity on two or more days a week, as these provide additional health benefits.	
Smoking	Smoking cessation is generally seen as healthy, and people should be supported in smoking cessation as well as public health programmes likely exist for preventing taking up smoking.	Occasionally, smoking is mentioned as a risk factor. Specific advice to quit smoking is not often provided but can be mentioned in case you had a pneumonia.
Alcohol	Alcohol consumption has several negative effects on health (toxic, psychoactive, addictive and carcinogenic) and there is no safe level for alcohol consumption (WHO).	No specific advice is provided on alcohol consumption in PCS.
Diet	The WHO recommends a healthy diet that includes fruits, vegetables, legumes, nuts and whole grains. It is recommended to consume at least 400 g of fruits and vegetables per day (excluding potatoes, sweet potatoes, cassava and other starchy roots). To maintain a healthy diet, it is recommended to balance energy intake (calories) with energy expenditure. They also give specific advice on total fat intake, the intake of saturated fats and trans fats and free sugars. For additional health benefits, a further reduction to less than 5% of total energy intake is suggested. The exact composition of a diet depends on individual characteristics (age, gender, lifestyle), locally available food and dietary habits. The basic principles of what a healthy diet remains the same and broadly speaking guidelines are similar in their advice. Many countries have drawn up a national guideline for a healthy diet; these are summarised in the FAO Food-based dietary guidelines.	Advice is to adhere to general guides for healthy food and eat a balanced diet to eat nutritious food, and in some countries, there is specific advice to increase protein intake to support recovery. Additionally, it is important to monitor the intake of vitamins (D, B_{12} and C) in case you are eating less food during PCS.
Mental health	According to the WHO, 'Mental health is a state of mental well-being that enables people to cope with the stresses of life, realize their abilities, learn and work well, and contribute to their community. Mental health exists on a complex continuum, which is experienced differently from one person to the next. At any one time, a diverse set of individual, family, community and structural factors may combine to protect or undermine mental health. Although most people are resilient, people who are exposed to adverse circumstances are at higher risk of developing a mental health condition. Mental health conditions include mental disorders and psychosocial disabilities as well as other mental states associated with significant distress, impairment in functioning, or risk of self-harm'. General advice for mental well-being is provided. These include, for instance, connecting with people, being physically active, learning new skills and paying attention to the present moment (mindfulness). Usually, these also include recommendations related to sleep, eating habits and avoidance of alcohol.	Websites provide similar advice for people with PCS but besides practical tips for relaxation, including yoga, take time to walk, read and listen to music. Additionally, they often recommend considering cognitive–behavioural therapy as part of the recovery process.
Sleep	7–9 hours of sleep per night is recommended for adequate sleep. While the amount of sleep you get each day is important, other aspects of your sleep also contribute to your health and well-being, known as sleep quality. Poor sleep quality can result from waking up several times or not feeling rested because of sleep disorders such as snoring, sleep apnoea, insomnia, psychological or physical concerns or the use of specific medications.	Sleep hygiene advice is offered, with some websites specifically recommending daytime naps. However, a short power nap of max 20 min may help, though it is best to avoid napping after 14:00.

Websites consulted were from WHO, and national health organisations in UK (NHS, NICE) and NL (PostCovid NL, Thuisarts.nl) in 2023/2024 and the information is regularly updated when new scientific evidence emerges. The websites do not have one particular guidance but collect information from multiple websites. This table is for illustration purposes only and for the most updated information and advice one should consult the original websites of the WHO and local health organisations. The advice provided here is general and not clinical advice intended for individual patients with PCS (websites consulted see online supplemental table S1).
NHS, National Health Service; NICE, National Institute for Health and Care Excellence; NL, Netherlands; PCS, post COVID-19 syndrome; PEM, post-exertional malaise.

are currently present in studies. For example, exercise included all physical activity, from general exercise and sports to structured recovery programmes. Diet covered individual nutritional components, healthy diet or dietary patterns like Western or Palaeolithic diets. Similarly, for other lifestyle factors, all studies were considered. Mental health is a complex lifestyle concept (see WHO definition in table 1). Mental health includes both mental status (including mental disorders) as well as mind-body interventions. The latter aim to reduce stress and improve well-being through mind-body interaction techniques.[20] This inclusive approach ensured our review captured diverse research practices, essential for identifying trends and gaps. Studies were excluded if they examined biomarkers (eg, metabolites, cytokines) with unclear links to PCS or biomedical factors such as BMI, obesity or lifestyle-related comorbidities (eg, diabetes, cardiovascular disease, liver disease, cancer, sleep disorders), as these may result from unhealthy lifestyles.

In recent years, a variety of terms and definitions have been used to describe the clinical syndrome of persistent symptoms following SARS-CoV-2 infection. The WHO defines PCS as being present in individuals with a history of suspected or confirmed SARS-CoV-2 infection, usually 3 months after the onset of COVID-19, with symptoms lasting for at least 2 months and unexplained due to another diagnosis.[1] The UK NICE (National Institute for Health and Clinical Excellence) has adopted similar definitions, extending the duration of symptoms to at least 12 weeks. In addition, subjective concerns are also mentioned in addition to symptoms.[21] The US NIH (National Institutes of Health) describes PCS as an umbrella term that encompasses a variety of health conditions that occur after the first 28 days of acute illness, where symptoms must be present for at least 4 weeks.[22] Since there is no standard definition for defining PSC, the present review did not distinguish between studies about the duration of the symptoms.

Data extraction and study outcomes

Two independent researchers (WMB and MCD) screened titles and abstracts for selection. The full text of selected articles was evaluated for relevant information and inclusion in the review. Any discrepancies identified were resolved by discussion. For each publication, first author's surname, publication year and the type of study (SRMA; SR: systematic review, S: clinical study) were documented. Also, the number of included studies and search date in case of SR(MA), and the number of patients were extracted. The aim of the study and a short conclusion were noted, and it was indicated whether there was an association between the lifestyle factor and PCS, and whether the study investigated the effect for susceptibility or course/recovery from PCS.

Patient and public involvement

This study presents a scoping review of published peer-reviewed literature, patients and/or the public were not directly involved in this study.

RESULTS

The primary search of all investigated topics together resulted in the accumulation of 1559 records from PubMed, 2882 records from Scopus and 223 records from the Cochrane Library. After duplicate removal and screening, we included 82 unique publications, of which some were applicable in multiple subsets; therefore, in total, 28 publications were evaluated on exercise, 13 on smoking, 8 on alcohol, 17 on nutrition, 3 on mental status and 16 on mind-body interventions, 5 on sleep and 4 on healthy lifestyle (see figure 1 for the total overview and online supplemental figures S1A-G for each lifestyle factor). Details of each included study are provided in online supplemental tables S4 and S5. The following paragraphs discuss the findings for each lifestyle factor.

Effect of lifestyle factors in susceptibility, course and recovery from PCS

Exercise

A total of 28 publications (including 27 SR(MA), (online supplemental tables S4 and S5) were included.[23–50] None of the SR(MA) investigated the influence of exercise on susceptibility to PCS. In a longitudinal study in 2022, authors investigated whether specific lifestyle factors in the month prior to SARS-CoV-2 infection served as risk factors for long-term PCS, but did not find an association with susceptibility to PCS in people who exercise sufficiently compared with those who exercise less or not at all.[23] Sufficient exercise, reflecting current weekly physical activity recommendations of the WHO, in the month before the SARS-CoV-2 infection is associated with better self-care (washing, clothing) in patients with PCS.[23] These results indicate that sufficient exercise (or good fitness) before infection may be associated with a more favourable disease course during PCS.

Exercise in various forms plays an essential role in (pulmonary) rehabilitation programmes for PCS (online supplemental table S5). Rehabilitation programmes use a multidisciplinary strategy aimed at enhancing both the physical and psychological well-being of those with chronic respiratory diseases. The central part is the exercise training, but other aspects, such as psychosocial and nutritional support, could be incorporated to achieve improvement of patient well-being.[51] At this moment, 27 SR(MA) have been published and all but one[42] came to a similar conclusion: exercise through (online) rehabilitation programmes in patients with PCS led to improvements in lung function, functional and physical capacity, cardiorespiratory fitness or quality of life.

Smoking

The effect of smoking on PCS was described in 13 studies (including 2 SR(MA), (online supplemental tables S4 and

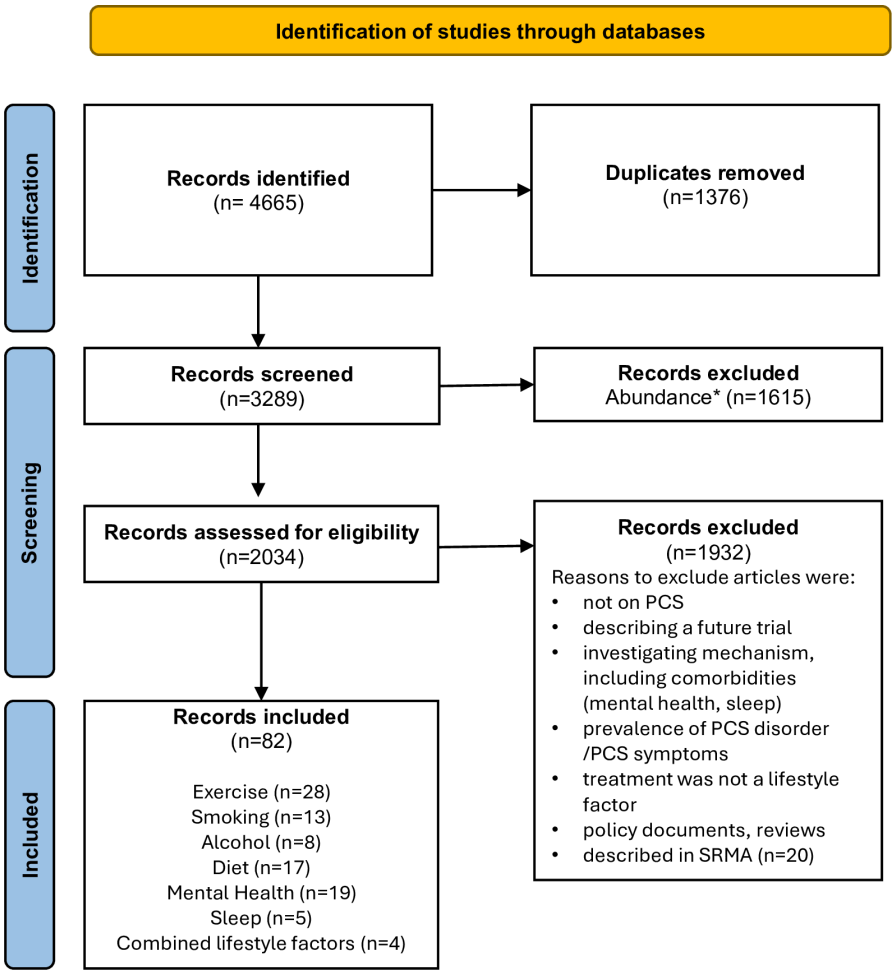

Figure 1 PRISMA flow diagram outlining the screening process.*Reports were excluded due to focus on SRMA. PCS, post COVID-19 syndrome; PRISMA, Preferred Reporting Items for Systematic Review and Meta-Analysis; SRMA, systematic review and/or meta-analyses.

S5).[9 23 52–62] Smoking was defined based on the categories person who smokes/person who does not smoke or person who has never smoked/person who smoked previously-/person who smokes currently, without further information on numbers or frequency and whether this concerns cigarette use or other tobacco products. A significant association between smoking status and the development of PCS was reported in a SRMA,[9] while the 20 studies included showed inconsistent results, and the final pooled OR was 1.10 (95% CI 1.07 to 1.13) indicating that the relative risk of smoking is small compared with other risk factors, such as female sex (OR 1.56; 95% CI 1.41 to 1.73), age (OR 1.21; 95% CI 1.11 to 1.33) and high BMI (OR 1.15; 95% CI 1.08 to 1.23). The clinical studies additionally retrieved also had conflicting conclusions as to whether smoking influences the susceptibility of PCS.[9 53–62] Further, one study reported that smoking prior to infection affected the course of PCS, by finding an association with difficulty in self-care (washing and clothing) in patients with PCS.[23]

Alcohol consumption

Eight studies about the impact of alcohol consumption on PCS were included (online supplemental tables S4 and S5).[23 53 58–61 63 64] In these studies, alcohol consumption was defined based on different categories, including more/less than 14 drinks per week, person who never drank alcohol/person who drinks alcohol frequently or ordinal variables with increasing doses of alcohol per day. Half of the studies, all recently published, found an association between alcohol use and the risk of developing PCS,[53 59 63 64] while the other half, mostly older studies, did not.[23 58 60 61] Alcohol consumption prior to infection was not associated with the disease course measured by mobility, cognition or self-care in patients with PCS (self-reported COVID).[23]

Diet

Assessment of possible modulating effects from diet is complex, since diets usually comprise multiple and variable foods and ingredients. Official recommendations and guidance for a healthy diet are provided by national health councils, FAO (Food and Agriculture Organization of the United Nations) and WHO.[65–67] Furthermore, nutritional recommendations exist for the intake of vitamins and minerals in maintaining good health.[68]

The current evaluation focused on the influence of diet, specific nutrients or ingredients and identified 17 relevant studies (including 1 SR), (online supplemental tables S4 and S5).[61 69–84] The impact of diet on susceptibility to PCS has been explored in two studies. Suganuma *et al*[69] investigated nutritional therapy during the acute phase of severe COVID-19 and found that higher energy and protein intakes were associated with a lower incidence of multiple PCS symptoms. Wang *et al*[61] reported that having a good quality diet alone was not sufficient to establish a correlation with PCS susceptibility. Of note, the two studies adopt different approaches: one examines the influence of diet before primary infection, while the other investigates the impact of nutritional interventions after infection. Five studies on various forms of biotics (prebiotic, probiotic, parabiotic and symbiotic) have recently been published, of which some showed promising results in aiding recovery from PCS including improvement in fatigue, depression, mood, quality of life, exercise tolerance and tissue metabolism.[70 72 76 84 85] High adherence to the Mediterranean diet and antioxidant-rich foods significantly improved inflammatory and oxidative stress markers and gut microbiota composition.[78] In addition, supplementation with L-arginine/vitamin C, or creatine-glucose mix reduced multiple symptoms related to PCS.[73 74 81 82] Fermented tropical fruit (*Carica papaya L.* and *Morinda citrifolia L.* (*noni fruit*)) improved heart and lung functionality.[80] The impact of coenzyme Q10 is inconclusive: Barletta *et al*[77] found positive influence on fatigue but no impact on quality of life in patients with PCS.[86] Beetroot juice supplementation for 2 weeks did not improve fatigue or physical function.[71]

Mental health and mind-body interventions

Mental health involves mental well-being, mental problems or psychological disorders.[87] Improving mental health by mind-body interventions such as relaxation refers to the act of reducing tension or stress, typically by engaging in activities that promote calmness and ease. In a clinical setting, mental health is approached with mind-body techniques that include therapeutic exercises indicated to assist patients in decreasing physical and psychological tension and anxiety. In a remote setting, it may involve activities that let one unwind both physically and mentally, such as resting, practicing mindfulness, enjoying hobbies or spending time in a peaceful environment. In addition, there is a personal element to what is most relaxing for each individual.[88] Studies that investigated whether a mental health condition influenced the susceptibility or recovery of PCS were also included.

A total of 19 different studies were included (including 6 SR(MA), (online supplemental tables S4 and S5).[50 89–106] Three SR(MA) looked at the effect of poor mental health (mental disorders) prior to infection with SARS-CoV-2 in an adult population,[89 91] and in children and adolescents.[90] All concluded that having poor mental health or having a psychological condition before and during the SARS-CoV-2 infection increases the risk of PCS development.

A wide range of different therapies was used in the treatment including cognitive behavioural therapy (CBT), acceptance and commitment therapy and mind-body therapies. Treatments like CBT, eye movement desensitisation and reprocessing and mindful exercises like qi gong, tai chi and yoga aimed at relieving symptoms like stress or anxiety, improved energy (mental or physical fatigue), resilience or quality of life in PCS with promising results.[50 92–94 97–102 104–106] Further, a randomised double-blind placebo-controlled trial with 40 women with PCS showed that aromatherapy improved energy levels (reduced fatigue).[103]

Sleep

A total of five studies (including 1 SRMA, (online supplemental tables S4 and S5) were included.[23 61 107–109] In a recent SRMA by Zhou *et al*,[107] authors found that abnormal sleep duration (as defined by less than 6 hours or more than 9 hours of sleep) was associated with an increased risk (OR 1.25) of developing PCS. Of note, the cross-sectional survey performed by Berezin *et al*[109] showed that, compared with average sleepers, there was no increased risk of developing PCS for either long or short sleepers without pre-existing medical conditions. However, for individuals with habitual short night-time sleep and pre-existing cardiac, chronic respiratory, neurological or autoimmune conditions, an increased risk for PCS was observed, indicating that the correlation with PCS might be due to these pre-existing conditions rather than the short night-time sleep. One study reported that poor sleep quality appears linked to specific post-COVID-related cognitive challenges, although this association weakened when covariates were included.[23]

Combined lifestyle factors

The above-mentioned studies examined the impact of individual lifestyle factors on PCS risk factors or PCS recovery. We conducted additional searches for studies examining these lifestyle factors collectively to determine whether an unhealthy lifestyle serves as a risk factor or influences recovery from PCS. Four studies were included (online supplemental table S4).[61 110–112]

Lifestyle scores in the following studies are typically determined by the number of healthy lifestyle factors a person adheres to. A longitudinal cohort study among women with a previous SARS-CoV-2 infection[61] evaluated six factors: healthy BMI, never smoking, high-quality diet, moderate alcohol intake, regular exercise and adequate sleep. Persons with five to six healthy lifestyle factors had about 50% lower risk of PCS development compared with participants without any healthy lifestyle factor. A healthy BMI and sufficient sleep were the most important contributors. The study describes that if these combined lifestyle factors were causal, 36% of PCS cases could have been prevented in this cohort if all participants would have had five to six healthy lifestyle factors.[61] Similar conclusions were drawn from large Chinese and UK cohorts where adherence to a healthy lifestyle reduced the risk of any post-COVID condition[111 112] and

Table 2 Concluding summary on the influence of lifestyle factors in PCS

Lifestyle factor	Susceptibility	Evidence*	Disease course/recovery	Evidence*
Exercise	One study suggests that sufficient exercise does not affect susceptibility.	**Insufficient** 1 S	One study suggests that good physical fitness prior to infection contributes to a more favourable course of PCS.	**Insufficient** 1 S
			Dosed exercise therapy (rehabilitation) has a positive influence on the course/recovery	**Sufficient** 27 SR(MA)
Smoking	Smoking increases susceptibility.	**Sufficient** 2 SR(MA), 10 S	One study suggests that smoking prior to infection contributes to a less favourable outcome of PCS.	**Insufficient** 1 S
Alcohol consumption	Contradictory results on whether alcohol affects susceptibility	**Inconsistent** 8 S	One study suggests that alcohol consumption prior to infection has no effect on the outcome of PCS.	**Insufficient** 1 S
Diet†	Studies suggest that a healthy diet alone does not affect susceptibility.	**Insufficient** 2 S	Studies suggest an improvement in various symptoms of PCS with a variety of dietary components	**Sufficient** 1 SR(MA), 14 S
			Mediterranean diet reduces inflammatory markers	**Insufficient** 1 S
Mental health and mind-body interventions†	Poor mental health (well-being, problems or a mental disorder) increases susceptibility.	**Sufficient** 3 SR(MA)	Various behavioural therapies, including CBT, improve various symptoms of PSC.	**Sufficient** 2 SR(MA), 10 S
	influence of relaxation/relaxed lifestyle	**No studies**	One study suggests that aromatherapy improves energy levels.	**Insufficient** 1 S
			Mind-body therapies such as yoga and mindfulness may reduce fatigue, depression and improve sleep quality.	**Sufficient** 1 SR(MA), 2 S
Sleep	Sufficient sleep (7–9 hours/day) reduces susceptibility.	**Sufficient** 1 SR(MA), 3 S	One study suggests that bad sleep quality prior to infection did not contribute to a less favourable outcome of PCS (one symptom).	**Insufficient** 1 S
Combined lifestyle factors	Combined healthy lifestyle factors reduce susceptibility.	**Sufficient** 4 S		**No studies**

Definition Insufficient: ≤3 clinical studies, Sufficient: >3 clinical studies and/or 1 or more SR(MA). Inconsistent: approximately equal numbers of studies showing significant associations and studies showing non-significant associations.
*When many publications were available for a lifestyle factor, the inventory was limited to systematic reviews (and/or) meta-analyses due to their highest rank in terms of evidence. When no/few systematic reviews and/or meta-analyses were available (<3), a further search was made for clinical studies (such as RCT, cohort studies and case–control studies).
†Research on diet focuses on dietary patterns or nutritional components, while research on mental health addresses poor mental status and various therapeutic approaches. For more details, see online supplemental tables S4 and S5).
PCS, post COVID-19 syndrome; RCT, randomised controlled trial; S, clinical study; SR(MA), systematic review and/or meta-analysis.

cardiopulmonary, neurological and fatigue sequelae.[111] Janko *et al* investigated COVID-19 prevalence and incidence among UK Seventh-day Adventists versus non-Adventists, focusing on the impact of lifestyle on health outcomes, including PCS.[110] Adventists, who follow a healthy lifestyle with a plant-based diet, fast and avoid alcohol and coffee, had a significantly lower COVID-19 incidence and were less likely to experience PCS despite being older on average than the non-Adventists in the study. Fewer Adventists with COVID-19 developed PCS compared with non-Adventists. However, the study did not provide percentages of individuals who experienced COVID-19 and subsequently developed PCS, and it was therefore impossible to accurately assess the influence of the Adventist lifestyle factors on PCS development.

Knowledge gaps

The current strength of evidence for the different lifestyle factors in relation to susceptibility, disease course and recovery from PCS is summarised in table 2. The number and type of publications varied considerably among lifestyle factors. For example, there were single papers per specific nutritional compound compared with 27 SR(MA) on exercise. Moreover, there were significant differences in the research regarding whether a lifestyle factor was investigated for its impact on susceptibility to PCS, or its potential effects on the course and/or recovery from PCS. Overall, significant knowledge gaps exist for the role of exercise (good physical fitness), mental status and diet or specific dietary components in the susceptibility for developing PCS. There are substantial gaps in research on the recovery from PCS, particularly on the influence of smoking, alcohol consumption, diet, sleep and the combination of lifestyle factors. Out of 82 selected publications, two papers performed research in children or adolescence.[58 90] Furthermore, most studies concern adults that have been hospitalised, highlighting a significant knowledge gap for the paediatric population and for patients developing PCS without hospitalisation during COVID-19.

DISCUSSION

This scoping review is the first to systematically summarise evidence on the influence of various lifestyle factors on susceptibility to PCS, as well as their role in disease progression and recovery. Present since 2020, PCS is a relatively young disease, which is reflected by limited evidence on potential beneficial or detrimental effects of several lifestyle factors, especially for diet types and certain forms of mind-body interventions improving mental health. Research most focused either on susceptibility (smoking, sleep, alcohol consumption, combined healthy lifestyle) or recovery from PCS (exercise, cognitive behaviour). In contrast, strong support exists for exercise, mind-body interventions and smoking cessation. In addition, the current broad overview shows that most studies focused on adult hospitalised patients highlighting a considerable gap for applicability of findings for paediatric, adolescent and outpatient populations.

Evidence supporting the role of exercise in recovery from PCS is robust, improving pulmonary function, cardiorespiratory fitness and quality of life. Exercise is included in rehabilitation programmes for chronic diseases such as cancer, cardiovascular disease and lower respiratory diseases for quite some time[113] and appears to offer similar benefits in PCS. While generally considered safe,[37] appropriate dosing of exercise is crucial, as physical activity can worsen PCS in some patients, particularly those with post-exertional malaise, and a personalised approach is therefore required.[37 114] A recent study showed that intensive physical activity increased muscle tissue damage and reduced mitochondrial functioning, providing a physiological basis for the potentially worsening of symptoms.[115] In contrast, the absence of evidence linking pre-infection exercise to reduced susceptibility to PCS highlights an area needing further exploration.

Given the overwhelming evidence linking smoking as a risk factor to various chronic diseases, including heart disease, diabetes and cancer,[16] it is not very surprising that smoking is identified as a risk factor for susceptibility to PCS in the present study. However, its role in recovery remains underexplored, despite smoking cessation has well-documented benefits for patients with respiratory diseases.[116]

Alcohol can impair immune function, including viral clearance, and dysregulate inflammatory response to viruses leading to poor health outcomes in lung viral infections like SARS, influenza and bacterial pneumonia, and also COVID-19.[117 118] However, its role in susceptibility to PCS remains unclear, because the present review showed contradictory outcomes. While earlier studies find no association, the newer studies reported alcohol as a potential risk factor for PCS. Moreover, a recent publication indicates patients with PCS may develop a new sensitivity to alcohol, which could lead to changes in symptoms and behaviours.[119] Evidence from other diseases shows light to moderate alcohol intake may lower cardiovascular diseases and type 2 diabetes risks. However, it can also have detrimental effects on several types of cancer, liver diseases, mental disorders and communicable disease.[120] Although alcohol has long been consumed and often considered part of the diet, there is no universally established safe amount of alcohol intake.

Health benefits have been attributed to both dietary patterns and individual food compounds, including enhanced resistance to respiratory infections[121] and improved recovery from diseases.[122] Diet or supplementation with vitamins and other nutritional components, sometimes combined with other therapies, is regularly mentioned in (systematic) reviews as supporting resistance to infectious diseases, including acute COVID-19 or PCS.[123 124] Current evidence focuses on single dietary interventions or different individual nutritional compounds/supplements and needs further exploration as there is insufficient evidence of a protective role in PCS development. Promising findings for certain synbiotics, probiotics and selected dietary supplements (eg, L-arginine+vitamin C; phytochemical preparations) are noted, but warrant further clinical trials. Further, a recent SR(MA) on vitamins confirmed the lack of studies on the possible influence of vitamins A, B, C and D in PCS.[125] Additionally, research shows nutritional intake or status (ie, presence or absence of nutritional deficiencies) is often not included in longitudinal studies on acute COVID-19 and PCS.[126]

Mental health appears a critical factor in both PCS susceptibility and recovery, with most evidence for CBT in reducing symptoms and improving quality of life. Other interventions, such as acceptance and commitment therapy and mind-body exercises (eg, yoga, tai chi), may reduce fatigue, depression and improve sleep quality. These findings highlight the need for integrated mental health support in PCS treatment strategies. Additionally, art forms[92] such as music or painting can improve mental health.[127] Exploring these areas could benefit patients with PCS, as relaxation techniques often depend on personal preference.[88]

There is consistent evidence that poor sleep quality and abnormal sleep duration (less than 6 or more than 9 hours per night) are associated with a higher PCS risk. However, no studies have evaluated sleep interventions for PCS recovery, representing a significant research gap. Existing interventions may improve sleep duration and quality and could support patients with PCS. For example, a mindfulness-based programme targeting cognitive issues in patients with PCS improved sleep quality.[100]

Combining multiple healthy lifestyle factors such as regular physical activity, balanced nutrition, adequate sleep, relaxation techniques for mental health and avoiding harmful habits like smoking is considered a synergistic approach to disease prevention and health improvement. Evidence suggests that combining two lifestyle factors, usually exercise and diet, is more effective than a single lifestyle in managing obesity,[128] diabetes risk[129] and cardiovascular risk.[130] In addition, high scores in various lifestyle factors seem to reduce the risk of developing disease.[131]

Additionally, also for PCS, there is evidence indicating that combining multiple healthy lifestyle practices may decrease susceptibility to PCS. However, this has not yet been studied specifically in patients.

A limitation of the present study is that it combined evidence for each lifestyle factor solely based on the number of studies, without considering their design, quality, investigated symptoms, PCS definitions or specific outcomes. However, this approach provided good insight into overall evidence and research gaps on the effect of lifestyles in PCS. We also did not explore whether the impact of lifestyle factors varied in their benefits for certain aspects or symptoms of PCS. The heterogeneity of current studies and the wide spectrum of symptoms associated with PCS makes such a study difficult, and further, it remains unclear which symptoms are most significant in disease progression. Most studies focus only on the first 3–6 months, even though the disease can persist for several years.[6] This variability among patients highlights the need for future research to identify which symptoms are most important, for which populations and at what stages of the disease. In addition, many studies concentrate on hospitalised adults, creating a gap in understanding PCS in non-hospitalised patients or among adolescents or children. Recent studies indicate that, similar to adults, dyspnoea, fatigue and headache are the most widely reported PCS symptoms in children and adolescents.[90] However, differences between adults and the younger population with PCS may exist, as some children develop multisystem inflammatory syndrome, a condition not reported for adults.[132]

There is a considerable pressure on capacity in hospital care settings and enormous costs of medicines worldwide. Chronic diseases account for a significant part of annual healthcare expenditures.[133] WHO and other advisory guidelines promote lifestyle-related strategies for managing and improving general health and, as shown in this review, there is accumulating evidence that certain lifestyle interventions can reduce the susceptibility to PCS and support recovery from PCS. This review also highlights that considerable knowledge gaps remain: most lifestyle interventions were studied in hospital settings and focused on hospitalised patients. Given that a substantial number of non-hospitalised individuals developed PCS after a relatively mild infection, the development of home-based programmes to help these patients seems crucial and cost-effective.[134]

CONCLUSIONS

This scoping review shows that lifestyle factors significantly influence susceptibility to and recovery from PCS (summarised in table 2). Smoking and poor mental health consistently increase susceptibility, whereas adequate sleep and adoption of multiple healthy lifestyle factors—including physical activity, balanced nutrition and avoidance of smoking—appear protective, substantially reducing the development of PCS. For recovery from PCS, dosed exercise-based rehabilitation and cognitive behavioural therapy effectively alleviate PCS symptoms and improve quality of life. Mind-body therapies, certain food-derived components and combined healthy lifestyle factors show promise but require validation.

Evidence regarding alcohol consumption, habitual diet, pre-infection exercise or relaxation remains insufficient for firm conclusions about their impact on PCS susceptibility or recovery. Research is lacking on interventions such as smoking cessation, alcohol cessation, sleep improvement and combined lifestyle programmes in supporting PCS recovery. Furthermore, most studies focus on hospitalised adults, leaving important research gaps for outpatient and paediatric populations.

These findings align with WHO guidance for PCS,[135 136] which emphasise smoking cessation, mental healthcare, sleep optimisation and structured rehabilitation to stop smoking, manage voice problems or support good sleep. WHO also advises rest, light exercise and nutritious food for recovery, based on general health guidance, rather than PCS-specific evidence. No combined lifestyle programmes specifically tailored for PCS are currently recommended.

In summary, major research gaps remain for diet, alcohol use, relaxation and integrated lifestyle strategies, and particularly for outpatient and paediatric populations. It underscores the need for rigorous investigation into the effectiveness of (home-based) lifestyle management to inform future guidelines and comprehensive care approaches.

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