


Management of long-COVID-19 patients with sleep disorders: practical advice to general practitioners

Fatma Guezguez^{a,b,c}, Mohamed Romdhan^{d,e}, Amine Boutaleb-Jouteif, Karim Chamari^{f,g}
and Helmi Ben Saad ^{a,b,c}

^aFarhat HACHED Hospital, Heart Failure (LR12SP09) Research Laboratory, University of Sousse, Sousse, Tunisia; ^bFaculty of Medicine of Sousse, Laboratory of Physiology, University of Sousse, Sousse, Tunisia; ^cFarhat HACHED Hospital, Laboratory of Physiology and functional explorations, Sousse, Tunisia; ^dMotricité-Interactions-Performance, MIP, UR4334, Le Mans Université, Le Mans, France; ^ePhysical activity, Sport and health, UR18JS01, National Observatory of Sports, Tunis, Tunisia; ^fAspetar, Orthopaedic and Sports Medicine Hospital, FIFA Medical Centre of Excellence, Doha, Qatar; ^gISSEP Ksar-SaidSaid, La Manouba University, Tunis, Tunisia

ABSTRACT

Given the high prevalence of sleep disorders (e.g. insomnia) among long-COVID-19 patients (LC19Ps), approaches to tackle these disorders should not only depend on sleep specialists, but they should also involve general practitioners (GPs). Indeed, according to the World Health Organization, GPs should be on the front line in the management of LC19Ps. However, in real practice, little data with regard to the management of LC19Ps are available for GPs, which represents an embarrassing situation. Thus, the main aim of this correspondence was to provide GPs with some advice related to the management of sleep disorders in LC19Ps. The pieces advice presented in this correspondence are related to: *i*) Early and accurate recognition of sleep disorders, *ii*) General recommendations to manage sleep disorders in LC19Ps (e.g. encouraging vaccination against the virus); and *iii*) Specific recommendations, such as improving sleep hygiene (patients' behavior and diet), psychological or behavioral therapies (stimulus control therapy, relaxation, sleep restriction), promising tools (heart coherence, neurofeedback), and pharmacological treatment. The authors of this correspondence deeply believe that given the undesirable side effects associated with the use of hypnotics, the pharmacological approach must only be a "last resort". The authors believe that an important percentage of pharmacological prescriptions could be avoided if more focus is put on educating GPs to provide LC19Ps with more tools to deal with sleep disorders. The pieces advice presented in this correspondence are indispensable to resume the normal life of LC19Ps and to promote their mental health recovery.

ARTICLE HISTORY

Received 3 November 2022
Accepted 16 February 2023



KEYWORDS

Behavioral therapy; cognitive therapy; insomnia; SARS-Cov-2; sleep quality

1. Background

Coronavirus disease 2019 (COVID-19) is a systemic disease that emerged in late 2019. By 11 February 2023, a total of 677 378 151 COVID-19 infections and 6 781 126 Covid-19-related deaths (1.00%) have been reported worldwide (<https://www.worldometers.info/coronavirus/>). Despite the actions taken by health establishments and governing bodies (lockdown, confinement, isolation, social distancing, and vaccination), aiming at avoiding the deterioration of people's immunocompetence and limiting the occurrence of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) [1], the inevitable acute repercussions of the COVID-19 pandemic may result in multiple health issues. Not only do the COVID-19 infection induce psychological problems, decrease physical activity behaviour, increase sedentary time, and alter the nutritional status [1,2], but it can also alter the sleep schedule and induce some sleep disorders, and potentially

result in sleep-related diseases [3,4]. Even after being cured, 40–90% of patients with COVID-19 still experience several signs/symptoms for weeks or months. The disease is consequently termed 'long-COVID-19, LC19' [5,6]. LC19 is defined by the perseverance of signs/symptoms beyond three months after getting the infection with no alternative diagnosis, regardless of the viral status [5,6]. More than 50 signs/symptoms have been recognized in LC19 [5]. The latter has numerous clinical manifestations, such as the alterations in the cardiorespiratory and neuromuscular chain, the alteration in the nutritional status, and the disturbance of sleep [5]. In addition to some common manifestations [e.g. fatigue (58%), headache (44%), attention disorder (27%), hair loss (25%), dyspnea (24%)], some sleep-related signs/symptoms are also reported [e.g. sleep disorders, including insomnia (26%), poor sleep quality (11%), and sleep apnea (8%)] [5,7]. A systematic review conducted in 2022

CONTACT Helmi Ben Saad  helmi.bensaad@rns.tn  Laboratory of Physiology, Faculty of Medicine of Sousse, Street Mohamed KAROUI, Sousse 4000, Tunisia

© 2023 The Author(s). Published by Informa UK Limited, trading as Taylor & Francis Group.
This is an Open Access article distributed under the terms of the Creative Commons Attribution-NonCommercial License (<http://creativecommons.org/licenses/by-nc/4.0/>), which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

reported that sleep-related signs/symptoms are highly prevalent, affecting approximately 52% (95% confidence interval: 42–63%) of LC19 patients (LC19Ps) [8]. In LC19Ps, persistent signs/symptoms of sleep disturbance and fatigue are reported to have an impact on health-related quality of life, productivity, physical activity, and mental ill-health. They are also reported to be associated with high frequencies of positive screening tests for anxiety, depression, and post-traumatic stress disorder [9]. Special attention should be paid to insomnia as a formal sleep disorder accounting for 80% of sleep disturbance in LC19Ps [8]. Insomnia may contribute to adverse health outcomes, including metabolic and cardiovascular diseases, impaired psychological function and concentration, decreased immune responses, increase in accidents, and presentation of psychiatric disorders, such as depression and anxiety [10,11]. Therefore, an effective management of these disorders is crucial, and it should be performed according to specific guidelines [12–17]. Yet, given the high prevalence of sleep disorders among LC19Ps, approaches to deal with them cannot only involve sleep specialists. Indeed, general practitioners (GPs) should also be involved. GPs should be aware of the management of sleep disorders based on their evidence-proven effectiveness [3,4,12–17]. Therefore, management of sleep disorders following the discharge of COVID-19 patients requires attention and such management is necessary to overcome the pandemic situation as well as its consequences [7,18–24]. Our team previously reported the cardiorespiratory and nutritional rehabilitation ‘minimal advice’ that should be provided by GPs managing LC19Ps [25,26]. Cardiorespiratory and nutritional rehabilitation helps in relieving the symptoms of dyspnea, anxiety and depression, and it eventually improves patients’ physical functions and quality of life [24].

Several procedures related to the management of LC19Ps are available [3,4,17–30]. However, these procedures target specialists, mainly cardiologists, pulmonologists, physical medicine and rehabilitation specialists, psychiatrists, or a combination of these different specialties [3,4,19,20,27–29]. According to the clinical guideline established by the World Health Organization [30], management of LC19Ps should be mainly performed at primary-care with a real and direct involvement of GPs. Indeed, GPs should be on the front line in the management of LC19Ps [31]. Therefore, GPs need to be prepared to manage patients with chronic manifestations of this complex disease [31]. However, in real life, little data related to the management of LC19Ps are available for GPs [18,25,26,31], which represents a conflicting and embarrassing situation. Consequently, the aim of this paper was to provide GPs with some advices related

to the management of sleep disorders in LC19Ps. Indeed, combining nutritional and physical exercise rehabilitation [25,26], and management of sleep disorders is indispensable for patients to resume a normal life and to promote their physical and mental health recovery [3,4,17–30].

2. Early and accurate recognition of sleep problems related to LC19

First, GPs should be able to make an early and accurate recognition of sleep disorders in LC19Ps after recovering from the infection [32]. Insomnia represents the main sleep complaint in LC19Ps [32]. Insomnia is the difficulty or inability to fall and/or stay asleep, generally accompanied by a low sleep quantity and quality despite the adequate sleep circumstances, resulting in different kinds of daytime dysfunction [16]. The use of standardized questionnaires, such as the Pittsburgh sleep quality index for overall sleep quality or the insomnia severity index, could be useful for identifying patients with sleep disturbances [16]. Patients with sleep complaints should also complete a two-week sleep log to identify the general patterns of sleep-wake times and day-to-day variability [16]. Sleep log is useful for evaluating several aspects of sleep, such as bed and wake-up times, sleep latency (i.e. the time that separates bedtime from the actual sleep onset), awakenings after sleep onset (i.e. number and duration of awakenings), total sleep time (TST: the duration between sleep onset and wake-up time), time in bed (TIB: the duration between bed and wake-up times), sleep efficiency (i.e. (TST/TIB) ×100), and napping [16]. Sleep log helps to determine the type of insomnia (i.e. sleep onset insomnia and/or sleep maintenance insomnia) and its severity, to guide treatment, and to evaluate its effectiveness [16]. In addition, a general medical questionnaire should be performed to assess the potential comorbidities that may interfere with sleep [16]. Particular attention should be paid to anxiety, depression, and chronic pain, which are highly prevalent in LC19Ps [5], and which are also major contributors to insomnia.

3. General recommendations

In the document published by the World Health Organization entitled ‘support for rehabilitation self-management after COVID-19-related illness’ [30], the following vague and general statement is reported ‘..... get enough quality sleep. Your sleep was likely disrupted during hospital. Feeling stressed can also affect your sleep. Try to return to a regular sleeping and waking time, using alarms to remind you. You or your family/careers can ensure that your environment

is free from things that might disturb you, such as too much light or noise. Minimizing nicotine (such as from smoking), caffeine, and alcohol and adding relaxation strategies will help you with falling and staying asleep'.

Following two doses of SARS-CoV-2 vaccinations, sleep disorders are significantly reduced in patients with chronic conditions [33]. Therefore, GPs should promote vaccination against SARS-CoV-2 for patients with chronic conditions as a solution that would also help them to cope with sleep disorders.

4. Specific recommendations

Treatment of insomnia includes educational, cognitive, behavioral, and pharmacological approaches [16]. To improve sleep quality and quantity in bed sleepers, the European academy for cognitive-behavioral treatment of insomnia has developed practical recommendations dealing with sleep problems during the pandemic that could be extended to LC19Ps [13]. In addition, since no specific recommendations have been developed for the management of sleep disorders in LC19Ps, the following recommendations were inspired from the American association of sleep medicine guidelines for the management of chronic insomnia in adults [14–16].

4.1. Improving sleep hygiene (quality and quantity)

Sleep hygiene is a set of instructions designed to help patients maintain good sleep habits. The recommendations involve patients' education with regard to healthy lifestyle practices that could improve sleep [13,14,16,17,34]. They include some advice related to LC19Ps' behavior ($n = 13$) and diet ($n = 5$).

4.1.1. Some advice related to LC19Ps' behavior

LC19Ps with insomnia should (Figure 1):

- (i) create and follow a routine for regular night-time and wake-up schedule [13];
- (ii) have a quiet sleeping environment without noise and light;
- (iii) go to bed only when sleepy;
- (iv) maximize exposure to natural daylight, especially in the morning;
- (v) reduce exposure to artificial light at night (light-emitting diode devices; television, phones and/or computers) [35];
- (vi) maintain a regular exercise routine (preferably outdoors, early during the day) as well as a healthy diet [25,26,36];
- (vii) have a relaxing activity, such as reading a book, meditation, and/or practicing Yoga before bedtime [13];
- (viii) wear comfortable clothes [37];
- (ix) choose a comfortable bed and mattress [38]; and
- (x) keep the bedroom at a moderate temperature (preferably 22–26°C) [39].

LC19Ps with insomnia should avoid:

- (i) clock watching in bed;
- (ii) stimulating activities (e.g. exercise, video games) before bedtime [13]; and
- (iii) eating, or watching videos, or playing games in bed.

4.1.2. Some advice related to LC19Ps' diet

LC19Ps with insomnia should:

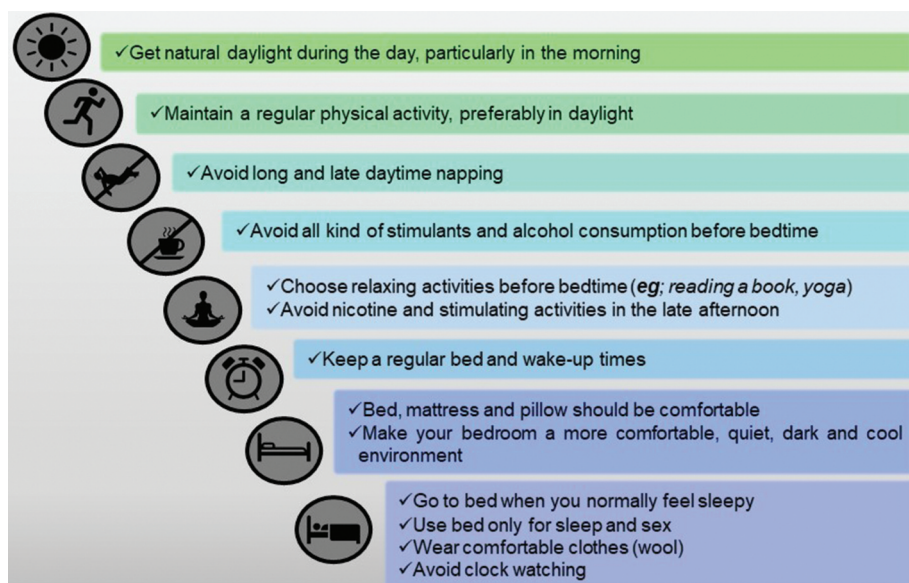


Figure 1. Behavioral recommendations to improve sleep of patients with long-Coronavirus disease 2019.

- (i) have a light dinner composed of carbohydrates and food rich in melatonin and/or tryptophan [36,40,41];
- (ii) drink some infusions before sleep (e.g. chamomile, basswood, orange blossom) [42], and
- (iii) use essential oil to perfume the bedroom (e.g. citrus reticulata to reduce sleep onset latency) [43].

LC19Ps with insomnia should avoid:

- (i) all types of stimulants (e.g. caffeine, nicotine) at least 8.8 hours before bedtime [36], and
- (ii) alcohol consumption before bedtime [13].

Yet, if chronic insomnia has a negative impact on patients' sleep quality, health, or daytime function, sleep hygiene alone is ineffective [14,15]. In this case, sleep hygiene should not be used as a standalone therapy. It should be associated with psychological and/or behavioral therapies (preferably face-to-face) [44], or squarely pharmacological treatment [13–16]. However, the latter should be prescribed by GPs only in extreme cases.

4.2. Psychological or behavioral therapies

Psychological and behavioral therapies have proven their effectiveness as a first line treatment for chronic insomnia [13,14,16,45]. These therapies include behavioral intervention (e.g. stimulus control therapy, relaxation therapy, restriction) alone or in combination with cognitive therapy [14,16,45].

4.2.1. Behavioral intervention: stimulus control therapy

For patients suffering from insomnia, bed is associated with wakefulness and frustration rather than sleep [14,46]. This negative association occurs insidiously as patients make undue efforts to sleep and spend prolonged periods in bed while being awake [14,46]. The stimulus control therapy aims at establishing a positive and clear association between the bed and sleep and to set a stable sleep-wake schedule [14,46]. It is for those reasons that LC19Ps presenting with insomnia should:

- (i) maintain a regular waking schedule regardless of the amount of sleep completed the night before, and avoid daytime napping;
- (ii) set aside at least one hour to relax before bedtime;
- (iii) go to bed only when feeling sleepy;
- (iv) use bed only for sleep and sex, and not for any other activity (e.g. working, reading, watching television); and

- (v) if unable to sleep within approximately 30 minutes, leave bed and engage in a relaxing activity (preferably in low luminosity and quiet environment) until feeling drowsy.

4.2.2. Behavioral intervention: relaxation

Relaxation aims at reducing somatic and cognitive hyperarousal states, which interfere with sleep [14,16,46]. The relaxation techniques include abdominal breathing, guided imagery, meditation, and progressive muscle relaxation [16]. The latter has proven its effectiveness in patients with acute COVID-19 [47]. Yet, the optimal relaxation method for insomnia remains the one that is the easiest to learn and the most acceptable for patients [46]. Progressive muscle relaxation involves methodological tensing and relaxing different muscle groups to learn how to distinguish between the sensation of muscle tension and relaxation [14,16]. Specific techniques can be delivered via live instruction, audio form, video, or immersive video forms [48]. Thus, the instructions include *i*) forcing tension with a group of muscles and concentrating on the feeling of tension; and *ii*) trying to hold the feeling of tension for seconds, and then relax. LC19Ps should experience the sensation of muscle relaxation resulting from the very recent relaxation exercise. They are recommended to move to another muscle group, once the previous group is relaxed.

4.2.3. Behavioral intervention: sleep restriction

Patients with insomnia tend to go to bed earlier and/or to get out of bed later than their pre-insomnia sleep schedules [14,46]. The patient's strategy aiming at increasing the possibility of sleep is counterproductive and may exacerbate sleep problems [14,46]. Indeed, when sleep opportunity exceeds sleep ability, the consequence is a more prolonged time in bed and more frequent awakenings. Sleep restriction consists in limiting the TIB to the TST (therefore increasing sleep efficiency), as estimated from baseline sleep logs [14,46]. Sleep restriction is intended to improve sleep continuity [14,46]. As sleep pressure increases and the window of opportunity to sleep remains restricted with prohibited daytime napping, sleep becomes more consolidated [14,46]. When sleep continuity substantially improves, TIB gradually increases [14,46]. This provides sufficient sleep time for the patient to feel rested during the day while preserving the acquired sleep consolidation [14,46]. This procedure should be carefully provided by trained GPs with caution about possible daytime sleepiness [14]. The following six steps should be followed:

- (i) determine the average time slept per night on the basis of a two-week sleep log;

- (ii) establish a fixed wake-time according to the patient's preferences;
- (iii) determine a sleep window (**ie**; TST plus 30 min of sleep onset latency) within which the patient is allowed to sleep (the sleep window should not be shorter than five hours);
- (iv) prescribe bedtime by working backwards from the wake time in accordance with the determined sleep window;
- (v) keep weekly sleep logs and adjust the sleep window weekly according to the sleep efficiency of the previous week; increase the sleep window by 15 minutes if the sleep efficiency is higher than 85%, and decrease the sleep window by 15 minutes if it is lower than 80%; and
- (vi) continue to do so until an optimal TST is reached.

If the three aforementioned behavioral intervention techniques fail, GPs should refer LC19Ps with insomnia to specialists for a multicomponent cognitive-behavioral therapy [45]. The latter is a combination of cognitive therapy and behavioral treatments with or without relaxation therapy [14]. Indeed, the patient's attitude towards his/her sleep disorders is an important sustaining factor [14]. Disastrous interpretations and excessive concerns about the consequences of sleep deprivation produce negative

emotions that interfere with sleep [14]. The cognitive therapy aims at identifying the cognitive distortions, to change the unrealistic expectations about sleep, and to reconstruct cognitive pathways with positive concepts about sleep and its effects [14].

4.3. Promising tools

4.3.1. Heart coherence

This tool is very easy to implement. It consists in breathing in (i.e. inspiration) for five seconds, breathing out (i.e. expiration) for five seconds (6 cycles/min) during five minutes, three times per day. The positive outcome is based on a single clinical case [49], but it opens the way for future studies involving larger samples.

4.3.2. Neurofeedback

This technique could reduce cortical hyperarousal associated with chronic insomnia; however, it might take months to reach the desired improvement [50].

4.4. Pharmacological treatment

Although pharmacological treatment should be the last resort, it is the preferred approach by GPs [45]. Indeed, about 60% of patients diagnosed with a sleep disorder by their GPs receive a benzodiazepine prescription [45]. Three reasons could be advanced to explain why GPs are

Box 1. Hypnotics recommended for the treatment of chronic insomnia in adults^x.

Hypnotic	Family	Dose (mg)	Indication	Side effects
Benzodiazepines	.Triazolam	.0.25	.Sleep onset insomnia	.Speech disorder
	.Temazepam	.15 ^Ψ	.Sleep onset insomnia .Sleep maintenance insomnia	.Headache .Blurred vision .Depression .Confusion
Benzodiazepine receptor agonists	.Eszopiclone	.2–3 [#]	.Sleep onset insomnia .Sleep maintenance insomnia	.Dizziness .Dry mouth .Headache .Somnolence .Unpleasant taste
	.Zaleplon	.10 [#]	.Sleep onset insomnia	.Headache .Asthenia .Neurasthenia .Pain .Fatigue .Somnolence
	.Zolpidem	10 [#]	.Sleep onset insomnia .Sleep maintenance insomnia	.Amnesia .Dizziness .Daytime somnolence
Orexin receptor antagonist Heterocyclics	.Suvorexant	10–20	.Sleep maintenance insomnia	.Daytime somnolence
	.Doxepin	3–6	.Sleep maintenance insomnia	.Daytime somnolence .Dizziness .Dry mouth .Constipation
Melatonin agonists	.Ramelteon	8	.Sleep onset insomnia	.Daytime somnolence .Dizziness .Fatigue .Nausea

***Box 1** is inspired from the American academy of sleep medicine clinical practice guideline for the pharmacologic treatment of chronic insomnia in adults [15].

^ΨWith the dose of 30 mg: daytime impairment, drowsiness, lethargy and vertigo.

[#]Reduce to half in the elderly.

Note: duration of treatment as brief as possible (<4 weeks).

more likely to treat insomnia using medications. First, management of insomnia in primary care may be challenging due to insufficient time available during consultations. Secondly, GPs are usually not trained to provide cognitive behavioral therapy. Thirdly, it is easy for them to prescribe medicine, thus avoiding time-consuming approaches (i.e. influencing the consultation time).

It is well-known that benzodiazepines are as effective as the cognitive and behavioral approaches for sleep optimization [51]. Yet, these hypnotics do not restore 'physiological sleep' [51]. Indeed, they increase the amount of light sleep and decrease the slow-wave sleep [51]. The main disadvantage is related to the residual pharmacological effects (e.g. daytime sleepiness, impaired alertness and performance), rebound insomnia after discontinuation, and/or withdrawal symptoms [51]. The residual effects depend on the doses used, the pharmacokinetics, and the chemical structure properties that differ between the molecules of benzodiazepines [51]. Furthermore, GPs should be aware that LC19Ps may present with sleep apnea [5,7], for which benzodiazepines are contraindicated unless the problem is effectively managed [15]. **Box 1** (inspired from the American academy of sleep medicine clinical practice guideline for the pharmacologic treatment of chronic insomnia in adults [15]) lists the hypnotics recommended for the treatment of chronic insomnia, with no major safety issues. The authors of this paper deeply believe that the pharmacological approach must be a 'last resort', given the undesirable side effects associated with the use of hypnotics. An important percentage of the pharmacological treatments could be avoided if more focus is put on educating GPs by providing them with more tools to deal with insomnia and sleep disturbances in general.

To conclude, since GPs are on the front line in the management of LC19Ps, they should consider the advice related to sleep disorders, and how they can potentially relieve mental problems and accelerate the recovery process in LC19Ps. This correspondence, which is the third one advanced to GPs managing LC19Ps [25,26], aims at supporting GPs in improving their knowledge and management skills with regard to insomnia in the context of LC19. However, multi-center studies incorporating sleep and insomnia in a multidisciplinary intervention in LC19Ps and including cardiorespiratory and diet intervention factors should be conducted.

Acknowledgments

The authors thank Professor **Samir BOUKATTAYA** for his invaluable contribution in the improvement of the quality of the writing in the present correspondence.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

The author(s) reported there is no funding associated with the work featured in this article.

ORCID

Helmi Ben Saad  <http://orcid.org/0000-0002-7477-2965>

References

- [1] Ghram A, Briki W, Mansoor H, et al. Home-based exercise can be beneficial for counteracting sedentary behavior and physical inactivity during the COVID-19 pandemic in older adults. *Postgrad Med*. 2021 Jun;133(5):469–480.
- [2] Fiorindi C, Campani F, Rasero L, et al. Prevalence of nutritional risk and malnutrition during and after hospitalization for COVID-19 infection: preliminary results of a single-centre experience. *Clin Nutr ESPEN*. 2021 Oct;45:351–355.
- [3] Papagiouvanni I, Kotoulas SC, Vettas C, et al. Sleep during the COVID-19 pandemic. *Curr Psychiatry Rep*. 2022 Oct 4;24:635–643. DOI:10.1007/s11920-022-01371-y.
- [4] Pataka A, Kotoulas S, Sakka E, et al. Sleep dysfunction in COVID-19 patients: prevalence, risk factors, mechanisms, and management. *J Pers Med*. 2021 Nov 14;11(11):1203. DOI:10.3390/jpm11111203
- [5] Lopez-Leon S, Wegman-Ostrosky T, Perelman C, et al. More than 50 long-term effects of COVID-19: a systematic review and meta-analysis. *Sci Rep*. 2021 Aug 9;11(1):16144. DOI:10.1038/s41598-021-95565-8
- [6] Raveendran AV, Jayadevan R, Sashidharan S. Long COVID: an overview. *Diabetes Metab Syndr*. 2021 May-Jun;15(3):869–875.
- [7] Almas T, Malik J, Alsubai AK, et al. Post-acute COVID-19 syndrome and its prolonged effects: an updated systematic review. *Ann Med Surg (Lond)*. 2022 Aug;80:103995.
- [8] Jahrami HA, Alhaj OA, Humood AM, et al. Sleep disturbances during the COVID-19 pandemic: a systematic review, meta-analysis, and meta-regression. *Sleep Med Rev*. 2022 Apr;62:101591.
- [9] Matalon N, Dorman-Ilan S, Hasson-Ohayon I, et al. Trajectories of post-traumatic stress symptoms, anxiety, and depression in hospitalized COVID-19 patients: a one-month follow-up. *J Psychosom Res*. 2021 Apr;143:110399.
- [10] Bacaro V, Chiabudini M, Buonanno C, et al. Insomnia in the Italian population during COVID-19 outbreak: a snapshot on one major risk factor for depression and anxiety. *Front Psychiatry*. 2020;11:579107.
- [11] Watson NF, Badr MS, Belenky G, et al. Recommended amount of sleep for a healthy adult: a joint consensus statement of the American academy of sleep medicine and sleep research society. *Sleep*. 2015 Jun 1;38(6):843–844. DOI:10.5665/sleep.4716

- [12] Staffolani S, Iencinella V, Cimatti M, et al. Long COVID-19 syndrome as a fourth phase of SARS-CoV-2 infection. *Infez Med.* 2022;30(1):22–29.
- [13] Altena E, Baglioni C, Espie CA, et al. Dealing with sleep problems during home confinement due to the COVID-19 outbreak: practical recommendations from a task force of the European CBT-I Academy. *J Sleep Res.* 2020 Aug;29(4):e13052.
- [14] Edinger JD, Arnedt JT, Bertisch SM, et al. Behavioral and psychological treatments for chronic insomnia disorder in adults: an American academy of sleep medicine clinical practice guideline. *J Clin Sleep Med.* 2021 Feb 1;17(2):255–262. DOI:10.5664/jcsm.8986
- [15] Sateia MJ, Buysse DJ, Krystal AD, et al. Clinical practice guideline for the pharmacologic treatment of chronic insomnia in adults: an American academy of sleep medicine clinical practice guideline. *J Clin Sleep Med.* 2017 Feb 15;13(2):307–349. DOI:10.5664/jcsm.6470
- [16] Schutte-Rodin S, Broch L, Buysse D, et al. Clinical guideline for the evaluation and management of chronic insomnia in adults. *J Clin Sleep Med.* 2008 Oct 15;4(5):487–504. DOI:10.5664/jcsm.27286
- [17] Romdhani M, Rae DE, Nedelec M, et al. COVID-19 lockdowns: a worldwide survey of circadian rhythms and sleep quality in 3911 athletes from 49 countries, with data-driven recommendations. *Sports Med.* 2022 Jun;52(6):1433–1448.
- [18] Greenhalgh T, Knight M, A'court C, et al. Management of post-acute COVID-19 in primary care. *BMJ*;370:m3026. 2020 Aug 11. DOI:10.1136/bmj.m3026.
- [19] Andrejak C, Blanc FX, Costes F, et al. Guide for follow-up of patients with SARS-CoV-2 pneumonia. Management proposals developed by the French-language Respiratory Medicine Society. *Rev Mal Respir.* 2020 Jun;37(6):505–510.
- [20] Stein J, Visco CJ, Barbuto S. Rehabilitation medicine response to the COVID-19 pandemic. *Am J Phys Med Rehabil.* 2020 Jul;99(7):573–579.
- [21] Agostini F, Mangone M, Ruiu P, et al. Rehabilitation setting during and after Covid-19: an overview on recommendations. *J Rehabil Med.* 2021 Jan 5;53(1):jrm00141. DOI:10.2340/16501977-2776
- [22] Bessis S. The COVID-19 pandemic. *Med Mal Infect.* 2020;50(8):8520.
- [23] World health organization. Support for rehabilitation self-management after COVID-19-related illness [cited 2023 Feb 11]. Available from: https://cdn.who.int/media/docs/default-source/ageing/support-for-rehabilitation-self-management-after-covid-19-related-illness-engf5cec00b-350b-4eb0-bc24-0704df509ae1.pdf?sfvrsn=203566f0_1&download=true.
- [24] Toulgui E, Benzarti W, Rahmani C, et al. Impact of cardiorespiratory rehabilitation program on submaximal exercise capacity of Tunisian male patients with post-COVID19: a pilot study. *Front Physiol.* 2022;13:1029766.
- [25] Ghram A, Ayadi H, Knechtel B, et al. What should a family physician know about nutrition and physical exercise rehabilitation' advices to communicate to 'long-term COVID-19' patients? *Postgrad Med.* 2022 Mar;134(2):143–147.
- [26] Benzarti W, Toulgui E, Prefaut C, et al. General practitioners should provide the cardiorespiratory rehabilitation' 'minimum advice' for long COVID-19 patients. *Libyan J Med.* 2022 Dec;17(1):2009101.
- [27] Antoniou KM, Vasarmidi E, Russell AM, et al. European respiratory society statement on long COVID follow-up. *Eur Respir J.* 2022 Aug;60(2):2102174.
- [28] European society of cardiology. Guidance for the diagnosis and management of CV disease during the COVID-19 pandemic [cited 2023 Feb 11]. Available from: <https://www.escardio.org/Education/COVID-19-and-Cardiology/ESC-COVID-19-Guidance>.
- [29] Barker-Davies RM, O'sullivan O, Senaratne KPP, et al. The Stanford Hall consensus statement for post-COVID-19 rehabilitation. *Br J Sports Med.* 2020 Aug;54(16):949–959.
- [30] Negrini S, Mills JA, Arienti C, et al. "Rehabilitation research framework for patients with COVID-19" defined by Cochrane rehabilitation and the world health organization rehabilitation programme. *Arch Phys Med Rehabil.* 2021 Jul;102(7):1424–1430.
- [31] Greenhalgh T, Knight M. Long COVID: a primer for family physicians. *Am Fam Physician.* 2020 Dec 15;102(12):716–717.
- [32] National Institute for health and care excellence: COVID-19 rapid guideline: managing the long-term effects of COVID-19. London: National Institute for Health and Care Excellence (NICE); 2020 Dec 18; [cited 2023 Feb 11]. Available from: https://www.ncbi.nlm.nih.gov/books/NBK567261/pdf/Bookshelf_NBK567261.pdf
- [33] Pawar N, Taylor KE, Yang M, et al. Sleep disturbance improves with SARS-COV2 vaccinations in patients with chronic inflammatory disease. *Arthritis Care Res (Hoboken).* 2022 Dec 7. DOI:10.1002/acr.25065
- [34] Stepanski EJ, Wyatt JK. Use of sleep hygiene in the treatment of insomnia. *Sleep Med Rev.* 2003 Jun;7(3):215–225.
- [35] Burns AC, Saxena R, Vetter C, et al. Time spent in outdoor light is associated with mood, sleep, and circadian rhythm-related outcomes: a cross-sectional and longitudinal study in over 400,000 UK Biobank participants. *J Affect Disord.* 2021 Dec 1;295:347–352. DOI:10.1016/j.jad.2021.08.056.
- [36] National institute of sleep and vigilance. Sleep is on the plate; [cited 2023 Feb 11]. Available from: https://institut-sommeil-vigilance.org/wp-content/uploads/2019/07/INSV_D%C3%A9pliant_-Sommeil-et-Nutrition.pdf.
- [37] Chow CM, Shin M, Mahar TJ, et al. The impact of sleep-wear fiber type on sleep quality under warm ambient conditions. *Nat Sci Sleep.* 2019;11:167–178.
- [38] Chen Y-X, Guo Y, Shen L-M, et al. The quantitative effects of mattress and sleep postures on sleep quality. In: Qi, E, Shen, J, Dou, R. (eds) International Asia conference on industrial engineering and management innovation (IEMI2012) Proceedings; 2013. Berlin, Heidelberg: Springer. p. 107–115. https://doi.org/10.1007/978-3-642-38445-5_11.
- [39] Troynikov O, Watson CG, Nawaz N. Sleep environments and sleep physiology: a review. *J Therm Biol.* 2018 Dec;78:192–203.
- [40] Sutanto CN, Loh WW, Kim JE. The impact of tryptophan supplementation on sleep quality: a systematic review, meta-analysis, and meta-regression. *Nutr Rev.* 2022 Jan 10;80(2):306–316.
- [41] Souissi A, Dergaa I, Romdhani M, et al. Can melatonin reduce the severity of post-COVID-19 syndrome? *Excli J.* 2023;22:173–187.
- [42] Adib-Hajbaghery M, Mousavi SN. The effects of chamomile extract on sleep quality among elderly people: a clinical trial. *Complement Ther Med.* 2017 Dec;35:109–114.

- [43] Kwangjai J, Cheaha D, Manor R, et al. Modification of brain waves and sleep parameters by Citrus reticulata Blanco. cv. Sai-Nam-Phueng essential oil. *Biomed J*. 2021 Dec;44(6):727–738.
- [44] Xu D, Cardell E, Broadley SA, et al. Efficacy of face-to-face delivered cognitive behavioral therapy in improving health status of patients with insomnia: a meta-analysis. *Front Psychiatry*. 2021;12:798453.
- [45] Baglioni C, Altena E, Bjorvatn B, et al. The European academy for cognitive behavioural therapy for insomnia: an initiative of the European insomnia network to promote implementation and dissemination of treatment. *J Sleep Res*. 2020 Apr;29(2):e12967.
- [46] Pigeon WR. Treatment of adult insomnia with cognitive-behavioral therapy. *J Clin Psychol*. 2010 Nov;66(11):1148–1160.
- [47] Ozlu I, Ozturk Z, Karaman Ozlu Z, et al. The effects of progressive muscle relaxation exercises on the anxiety and sleep quality of patients with COVID-19: a randomized controlled study. *Perspect Psychiatr Care*. 2021 Oct;57(4):1791–1797.
- [48] Mezo PG, Hall J, Duggan CM, et al. An initial comparison of live instruction and immersive video modes of progressive muscle relaxation. *J Technol Hum Serv*. 2011;29(3):212–223. DOI:10.1080/15228835.2011.616470
- [49] Pallanca O, Brion A. Cardiac coherence in chronic insomnia. *Med Sommeil*. 2016;13(4):157–165.
- [50] Marzbani H, Marateb HR, Mansourian M. Neurofeedback: a comprehensive review on system design, methodology and clinical applications. *Basic Clin Neurosci*. 2016 Apr;7(2):143–158.
- [51] Jausse I, Ancelin ML, Berr C, et al. Hypnotics and mortality in an elderly general population: a 12-year prospective study. *BMC Med*. 2013 Sep 26;11:212. DOI:10.1186/1741-7015-11-212.