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Physical exercise as a potential strategy to mitigate the effects of Covid-19 in sleep quality: A systematic review

Ferreira-Souza LF[1,2,*], Coelho-Oliveira AC[1,3], Julianelli-Peçanha M[7], Melo-Oliveira MES[1,2], Moura-Fernandes MC[1,3], Paineiras-Domingos LL[1,4,5], da Cunha de Sá-Caputo D[1,3,4,6] and Bernardo-Filho M[1]

[1]Laboratório de Vibrações Mecânicas e Práticas Integrativas - LAVIMPI, Departamento de Biofísica e Biometria, Instituto de Biologia Roberto Alcântara Gomes and Policlínica Piquet Carneiro, Universidade do Estado do Rio de Janeiro, Rio de Janeiro, RJ. 20950-003, Brazil

[2]Programa de Pós-graduação em Saúde, Medicina Laboratorial e Tecnologia Forense, Universidade do Estado do Rio de Janeiro, Rio de Janeiro, RJ. 20950-003, Brazil

[3]Programa de Pós-Graduação em Fisiopatologia Clínica e Experimental, Faculdade de Ciências Médicas, Universidade do Estado do Rio de Janeiro, Rio de Janeiro, RJ. 20550-900, Brazil

[4]Programa de Pós-Graduação em Ciências Médicas, Faculdade de Ciências Médicas, Universidade do Estado do Rio de Janeiro, Rio de Janeiro, RJ. 20551-030, Brazil

[5]Departamento de Fisioterapia, Instituto de Ciências da Saúde, Universidade Federal da Bahia, Salvador, Bahia, 40110-902, Brazil

[6]Faculdade Bezerra de Araújo, Rio de Janeiro, RJ, 23052-180, Brazil.

[7]Coordenação Médica do Hospital Estadual da Mulher Heloneida Studart, São João de Meriti, RJ, 25565-171, Brazil

Introduction

The rapid spread of the new coronavirus 2019 (Covid-19) led many governments and public health agencies to take drastic mitigation measures, including community-wide lockdowns, home quarantines, working-from-home, social distancing, and the prohibition of social gatherings, to stop the spread of Covid-19 and reduce the risk of human-to-human transmission [1]. These changes have affected the normal routines of health behaviors and lifestyles for people of all ages, such as restriction of free-living physical activity (PA) and increasing sedentary time, interrupting sleep and consequently, negatively affecting the quality of life [2]. These attitudes led to a significant increase in psychological distress and symptoms of mental illness, worsening sleep quality in the general population [3], and can last much longer than the physical symptoms of the disease [4].

Despite public awareness, there are levels of anxiety and stress that affect sleep quality during epidemics including periods of population home quarantine [2,5,6] mainly in the medical team and hospitalized patients [7,8]. Furthermore, the imposed restrictions led to a decrease in sunlight exposure and PA, which are important factors for circadian rhythm maintenance and that could influence the quality of sleep [9].

The functions of the brain, the cardiovascular system, the immune system, and the metabolic system are strongly associated with sleep. As a prevalent sleep disorder, insomnia has been closely concerned, and it is necessary to find effective therapies [10-12].

For poor sleep quality and insomnia complaints, prescription hypnotic medications offer short-term efficacy but are plagued by concerns about dependency, hazardous side effects, and long-term health risk [13,14]. In contrast, cognitive-behavioral therapy for insomnia provides greater long-term efficacy and fewer side effects than hypnotics; however, availability remains restricted [15].

The available evidence suggests that physical exercise holds promise as a nonpharmacologic therapy for adults with poor or disordered sleep [12], as it is associated with an improvement in sleep [13] and that confers health benefits for individuals living with the following chronic conditions [16,17]. Prevalence of sedentary behavior and low physical exercise levels have been reported in those comorbidities and have been linked with increased susceptibility to contracting viral infections, including pandemic influenzas such as Influenza A (H1N1) and Covid-19 [18].

The effect of physical exercise on mental health (MH) has been proven in depression, anxiety, stress, sleep, dementia, and psychological well-being. Improvement in sleep quality after physical exercise can be attributed to reduced length of time it takes to go to sleep, reduced awakening, increased deep sleep, and reduced daytime sleepiness [19-22]. Some non-pharmacological interventions during the hospitalization [23], confinement [24], and post Covid-19 infection have been suggested [25]. This demonstrates the need to prevent and reduce these complications through psychological support and physical exercise regularly while staying home quarantine or working-from-home during the self-isolation [5], as it is also suited for the avoidance of the airborne coronavirus, especially during quarantine, and may include strengthening, balance, and control, stretching, or a combination of them [17,26].

This systematic review aims to assess the effects of the Covid-19 pandemic on sleep quality in sedentary individuals using the Pittsburgh Sleep Quality Index (PSQI).

Methodology

Research question, search, and registration

This systematic review aimed to answer the following question. Can physical exercise during the Covid-19 pandemic influence sleep

Correspondence to: Luiz Felipe Ferreira-Souza, Laboratório de Vibrações Mecânicas e Práticas Integrativas, Departamento de Biofísica e Biometria, Instituto de Biologia Roberto Alcântara Gomes and Policlínica Piquet Carneiro, Universidade do Estado do Rio de Janeiro (UERJ), Avenida Marechal Rondon, 381, São Francisco Xavier, Rio de Janeiro, RJ. 20950-003, Brazil, E-mail: lumadaragu@gmail.com

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quality? The PECO (P: Population, E: Exposition, C: Comparison, O: Outcomes) method was used to define the four major components of the research question [27]: P: general population; E: Quarantine; C: people not practicing physical exercise; O: Negative impacts on sleep quality by PSQI. The search performed using the electronic databanks PubMed, Embase, and Scopus; held on Apr 14th, 2021. The keywords "Covid-19 and sleep and Physical exercise ", "randomized controlled trial or clinical trial" were used in the search to find publications related. Therefore, there are situations where it is not possible to conduct randomized clinical trials (for ethical, operational, or financial issues), observational studies are presented as a suitable alternative. Research at the International Prospective Registry of Systematic Reviews (PROSPERO) was conducted before the development of this systematic review to exclude the existence of reviews or protocols for the same purpose as the present. Since no similar study was found, the systematic review protocol was registered with PROSPERO (www.crd.york.ac.UK/Prospero/) under the number CRD42020209378 [28].

Study selection and data extraction

Independently of the year, all publications found on the three databases were exported to a file, and the duplicates were manually removed (LFFS, DCSC). Afterward, four steps were considered in the review. Records were identified in the searched databases (Identification) and two reviewers (MJP, ACCO) individually evaluated the titles and abstracts, and exclusion of irrelevant studies was made considering in eligibility criteria (Screening). Appropriated full texts were analyzed for eligibility (Eligibility criteria), and all relevant studies were taking into consideration to be selected for the current systematic review. The no agreements were solved by a third reviewer (MCMF). Gray literature was not considered in the current systematic review. The same researchers made the data extraction (author and year), sleep quality, physical exercise, subjects (sample size), demographics (country, age, gender), study design were extracted.

Eligibility criteria

The studies included in this review should (i) investigate effects of the Covid-19 in the sleep quality of practicing or not practicing physical exercise individuals through of the PSQI; (ii) be written in English; (iii) to be cross-sectional design, control case, a cohort study. Articles were excluded if they were duplicates, comments, letters, conference abstracts, books, book chapters, incomplete, systematic reviews, and meta-analysis or narrative reviews. Besides, articles that did not address physical exercise, sleep quality, or did not specifically report the findings of Covid-19 were also rejected. The publications involving other diseases and comorbidities in the quality of sleep were also withdrawn.

PSQI and outcomes

The PSQI allows evaluating the quality and disturbances of sleep over one month. The questionnaire consists of 19 self-assessed questions that are categorized into 7 components: 1) sleep quality, 2) sleep latency, 3) sleep duration, 4) sleep efficiency, 5) sleep disorders, 6) medication use to sleep, and 7) daytime sleepiness. Each component is classified in a score ranging from 0 to 3. The sum of the scores for these 7 components produces a score ranging from 0 to 21. It presents a cutoff point where good sleep quality is PSQI < 5 and poor sleep quality is PSQI ≥ 5 [29].

Level of evidence (LE)

The LE of each work was classified according to the National Health and Medical Research Council (NHMRC) [30] 2003-2009 and the hierarchy of evidence was used to classify the included studies in this systematic review, which consists of six levels: I) LE I - Systematic review; II) LE II - Randomized controlled trial; III) LE III-1 – Pseudo-randomized controlled trial; IV) LE III-2 - Comparative study with concurrent controls: non-randomized experimental trial, cohort study, case-control study, interrupted time series without a parallel control group; V) LE III-3 - Comparative study without concurrent controls: historical control, two or more single-arm study, interrupted time series without a parallel control group; VI) LE IV – Cases series with either post-test or pre-test/post-test outcomes.

Risk of bias of selected studies

The evaluation of the risk of bias of the included studies was using the "A Cochrane Risk of Bias Assessment Tool for Non-randomized, Studies instrument" (ACROBAT-NRSI) [31], which compares the health effects of interventions. ACROBAT- NRSI covers seven domains divided into pre-intervention and post-intervention, at intervention, and post-intervention. Each item was classified as a low, moderate, serious, or critical risk of bias and is needed to inform when no information is presented.

Data analysis

Considering the different study designs with several populations and the number of individuals that were in other specific conditions due to the Covid-19 pandemic, and six publications were "poor", a metanalysis was not performed. Moreover, the study summarized the findings as a systematic review.

Results

Figure 1 shows a PRISMA flowchart [27] with the different steps of the current systematic review, showing the number of articles selected, as well as the entire search process. Fifty-two papers were found from the databases and twenty-nine were deleted because they were reviews (narrative or systematic or metanalysis) and duplicates. Of twenty-three papers, seventeen were excluded because they do not address sleep quality, physical exercise and do not specifically report findings of coronavirus 2019, as well as incomplete articles, with other comorbidities, conference summary, or in a language different from the English, remaining six papers reached all the criteria to be included in this qualitative study. In the end, a total of six articles resulted in meeting all criteria to be included in this qualitative study.

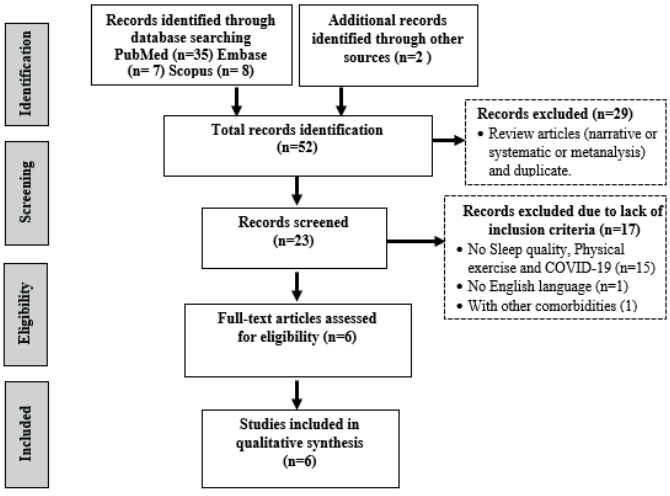

Figure 1. PRISMA flowchart of bibliographic research and the different stages of the selection.

Table 1. ACROBAT-NRSI risk of bias and level of evidence of the selected publications.

Author/Year	Items*								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	LE†
1. Zhang et al.(2020).[32]	low	moderate	low	moderate	low	low	low	low	IV
2. Barrea et al.(2020).[33]	low	low	low	moderate	low	low	low	low	IV
3. Wu et al.(2020).[12]	moderate	low	low	moderate	low	low	low	low	III-2
4. Wang et al.(2020).[2]	low	moderate	low	moderate	low	moderate	low	low	IV
5. Kilani et al.(2020).[34]	low	moderate	low	moderate	low	low	low	low	IV
6. Trabelsi et al.(2020).[35]	low	low	low	moderate	low	moderate	low	low	IV

*Items: (1) Bias Due to Confounding; (2) Bias in Selection of Participants; (3) Bias in Measurement of Interventions; (4) Bias Due to Departures from Intended Interventions; (5) Bias Due to Missing Data; (6) Bias in Measurement of Outcomes; (7) Bias in Selection of Reported Results; (8) Overall RoB Judgment; †LE- the level of evidence according to the National Health and Medical Research Council (NHMRC).

Table 2. Individuals' characteristics of the selected studies about the author, year, population, size, country, age, gender, and study design.

Author/ Year	Target population size/ Country or continents	Age (M_{age} ± SD* or year)	Gender (Male/Female)	Study Design
Zhang et al.(2020)[32]	66 college students from China	from 15 to 69 years	25/41	Longitudinal surveys
Barrea et al.(2020)[33]	121 adults from Italy	44.9 ± 13.3	43/78	Retrospective study
Wu et al.(2020)[12]	120 front-line medical staff from China	from 25 to 59 years	31/89	Observational study
Wang et al.(2020)[2]	2.289 participants from 34 provinces from China	27.8± 12.0	1176/1113	Cross-sectional design
Kilani et al.(2020)[34]	1723 participants to universities in the Middle Eastern and North Africa	34.9 ± 12.8	917/806	Cross-sectional design
Trabelsi et al.(2020)[35]	5056 participants from Europe, Western-Asia, America, North-Africa.	> 18 years	2052/3004	Observational study

*M_{age}: Average age; SD: Standard deviation.

Considering the LE, Table 1 shows one study classified as Level III-2 [12] and five classifieds as a Lever IV (NHMRC) [2,32-35], without interventions in the investigations.

Regarding the risk of bias according to the ACROBAT-NRSI instrument A Cochrane Risk of Bias Assessment Tool for Non-randomized Studies, all selected publications have a "low risk" of bias [2,12,32-35].

Table 2 indicates the characteristics of the populations of the selected publications. The population participant was from China [2,12,32], from Italy [33] and many continents (Middle Eastern, Europe, America, Asia, and North Africa) [34,35]. A total of 9,375 individuals participated in the studies and were 5,131females, 4,244 males. The ages ranged from 15 to 69 years old. Considering the specifications of the studied populations, one publication was about individuals at front-line medical staff [12], two publications were about individuals in quarantine during coronavirus outbreak [2,33], two publications were about students and faculty members [32,34] and all the people worldwide [35].

Table 3 shows the results in PSQI according to the population involved and presented the sleep disturbance score. The questionnaire PSQI was used in all the publications to evaluate sleep quality. The short form of the International Physical Activity Questionnaire (IPAQ) consists of seven items that provide information about walking, moderate PA, and vigorous PA categorized as per metabolic equivalents minutes per week (MET). The results of the selected studies were demonstrated given their aims, programs, and conclusions.

Discussion

The objective of this systematic review was to study the role of physical exercise as a potential preventive intervention in the decline in sleep quality during the pandemic. It also aimed to investigate what type of physical exercise, how much, and how intense this physical exercise has a differential effect on sleep performance in individuals.

The Covid-19 has already been recognized as a cause of direct and indirect psychological and social consequences that might impact MH not only during the pandemic per se but also in the future [36].

Since the impact on MH is expected to persist beyond this critical situation, it is crucial to study the most effective interventions to reduce the burden of psychological and social consequences [37]. Indeed, individuals in quarantine reported a higher prevalence of psychological symptoms such as emotional disturbance, depression, stress, low mood, irritability, insomnia, and post-traumatic stress symptoms than those who had not been in quarantine [38].

The selected studies (Table 3) were conducted using an anonymous self-reported PSQI questionnaire, asking respondents, through the online system (digital media), for information on sleep quality during the endemic period. For this, several digital media activities were accessed for data collection, using internet browsing by computer [2,12,32], mobile phone [33], or Google forms link via email, WhatsApp, Facebook, Twitter, and LinkedIn [34,35]. As it was shown in the same Table, it demonstrated that the sleep quality of the various populations assessed concerning the Covid-19 pandemic was poor. Good sleep scores were associated with better mental health and a lack of mobility and the shutdown has affected physical exercise and the mental wellbeing of the subjects [34]. To conduct the assessment of PA levels were adopted the IPAQ [2,32,34,35], the rehabilitation physical exercise prescription performing [12], and 30 min/day of aerobic physical exercise(yes/no) [33].

People who stay at home during confinement spent much more time involved in low-intensity activities, such as housework (for

Table 3. Characteristics of the description about studies and the sleep evaluation by PSQI.

Authors/ year	Measurement tools	Evaluation PSQI[§] N(%)[†] or Mean (SD)[*]	Aim	Description of Programs	Conclusion
Zhang et al.(2020)[32]	Used online system questionnaire IPAQ-S[‡] and PSQI.	28 (42.42) poor	To assess the adverse impact of the COVID-19 outbreak on MH[¶], understand the underlying mechanisms, and explore feasible mitigation strategies.	PA to maintain psychological health of 108 min of light, 80 min of moderate, or 45 min of vigorous PA[**] daily.	The outbreak has an indirect effect on negative emotions by affecting sleep quality. A strategy for improving MH includes taking suitable amounts of daily PA and sleeping well.
Barrea et al.(2020)[33]	Telephone interview about performing at 30 min/day of aerobic exercise and PSQI	8.64 ± 3.73 poor	Assess the effects of quarantine on sleep quality and body mass index and the related do working modalities.	Neutralize sleep disorders with healthy eating and increased PA (at least 30 min/day of aerobic exercise).	worsening of sleep quality in individuals doing smart work and an increase in body mass indices.
Wu et al.(2020)[12]	Used online system questionnaires PSQI and exercise prescription.	16.07 ± 3.76 poor	The changes in psychological factors and sleep status and provide evidence of exercise interventions.	Psychological counseling and strengthening exercise intervention.	Aerobic physical exercise with suitable intensity and quantity can relieve psychological pressure and protection for good sleep.
Wang et al.(2020)[2]	Assessed online system questionnaire using IPAQ-SF[‡] and PSQI	3.8 ± 2.4 poor	Information to develop new action plans for physical education and public health services if another outbreak occurs.	Aerobic PA with a moderate-to-vigorous intensity for a minimum of 30min/5days/week or vigorous-intensity aerobic PA for a minimum of 20min/3days/week.	Recommend practical guidance for adults to participate in PA with a moderate-to-vigorous intensity that can be easily adopted at home.
Kilani et al.(2020)[34]	online multicategory questionnaire IPAQ and PSQI	383 (68.1) poor	Determine the extent to which lifestyle behaviors such as PA, sleep, and diet contributed to MH.	Moderate PA, and vigorous PA categorized as MET[††] minutes per week.	Adopted a healthy lifestyle in terms of PA, dietary, and sleep behaviors.
Trabelsi et al.(2020)[35]	Assessed online system questionnaire using IPAQ-SF and PSQI	5.32 ± 3.23 poor	Assess the effects of COVID-19 home confinement on sleep patterns and PA levels.	three different groups based on the MET–min/wk. walking: moderate-intensity, vigorous-intensity, lowly active	Home confinement deleteriously altered sleep quality and PA levels in a large global sample of people.

[*] M_{age}: Average age; SD: Standard deviation; [†] n (%): Number and percentage; [‡] IPAQ-S or IPAQ-SF: short version of the international physical activity questionnaire; [§]PSQI: Pittsburgh Sleep Quality Index; [¶] MH: Mental health; [**]PA: Physical activity; [††] MET: metabolic equivalent of task.

example, washing dishes, cooking, gardening when applicable [35]. The high screen-time also demonstrated the greatest negative impact on life quality when individuals increased hours sitting and lying down to play with mobile phones, checking the news on the phone, joining online studies or meetings and computers, and watch live stream movies on TV, presenting a sedentary lifestyle [34]. Physical exercise significantly predicted sleep quality and indirectly affected life quality [2]. In the study by Brito-Marques, et al. [39], more than 70% of the evaluated physicians had impaired sleep quality, characterizing insomnia symptoms during the Covid-19 outbreak, and among the related factors included an isolation environment, concerns about the Covid-19 outbreak, and symptoms of anxiety and depression. It is also worth mentioning that during the initial phase of the Covid-19 outbreak in China, the assessed population reported that the psychological impact and anxiety were classified as moderate-to-severe [40].

Recently, in the face of a study by Bennie and Tittlbach [41], with a representative sample of 23,635 German adults, it was suggested that successful public health campaigns that promote and support muscle-strengthening physical exercises may improve sleep quality at the population level. There is evidence that in acute bouts, regular physical exercise improves sleep and health-related quality of life outcomes in adults [18]. Maintaining a regular exercise program is difficult at the best of times, and the conditions surrounding the Covid-19 pandemic may be making it even more difficult.

Progressive resistance exercise (RE) is an alternative modality that has also been shown to improve sleep quality [42,43], being one of the most effective approaches to counteract the physical and functional changes associated with aging [41]. A previous preliminary study on a sample of 1,047 respondents in an international electronic survey, "before even during the confinement", demonstrated a decrease in physical exercise was associated with a worse quality of sleep [44]. Consequently, many individuals during Covid-19 home confinement increased their medication intake to help them fall asleep [45].

Ferris et al. [46], concluded that one-circuit RE performed three times per week in the morning leads to an improvement in strength and sleep-in older participants whose average age is about 80 years. According to the American College of Sports Medicine (ACSM), American Heart Association (AHA), American Physical Therapy Association (APTA), International Association of Physiotherapists Working with Elderly People (IPTOP), World Health Organization (WHO), Confederation Physiotherapy World Championship (WCPT) and the International Physiotherapy Regulatory Authorities Network (INPTRA), recommend 150-300 minutes per week of moderate/ intensity aerobic PA and two sessions per week of muscle strength training [20,47].

There is no doubt that physical exercise is one of the most effective ways for individuals to maintain functional independence, maintain physical skills, and reduce the risk of various diseases and injuries [48]. The need for physical exercise expresses the question of how individuals can be physically active in the current quarantine period. It is necessary to integrate simple and safe ways to remain a physical exercise in a limited space [49]. A national policy to support physical exercise at home seems essential in this context, especially for older adults [50]. Policies that address the improvement of unhealthy behaviors, as well as sleep quality and MH, are important during quarantine, with physical exercise as an effective and affordable non-pharmacological therapy option, of low cost and without side effects, to achieve this objective in an economical and sustainable way [51,52].

With unsatisfactory sleep and physical inactivity, each one recognized as key public health priorities, additional research into the bidirectional relationship between exercise and sleep has significant implications for facilitating greater exercise adherence and improving sleep [13]. Sleep quality and total physical activity energy expenditure were significant predictors of the decrease in mental wellbeing from pre- to during lockdown [53]. The results showed that those who remained physically active during the pandemic with the adoption of aerobic physical exercise alone or combined with resistance training had a positive impact on sleep quality.

Based on these results, suggestions to preserve physical health and MH in future situations of the blockade should be applied, how: to maintain healthy eating habits, motivate people to practice their physical exercises, be active and expose themselves to natural daylight [54]. Therefore, physical exercise intervention programs should be prescribed based on the individual's physical functioning [55,56], as well as on the assessment of psychological interventions to mitigate the significant immediate and long-term effects on sleep quality due to the undesirable consequences of Covid-19 [57].

However, according to a study by Szwarcwald et al. [58], there is a relationship between social, biological, and psychological factors, mediated by lifestyles and variables belonging to the confinement and isolation of the immediate social circle, such as family, neighbours, and community. Taken together, these factors negatively affected the self-rated health of Brazilians during the Covid-19 pandemic.

Finally, I highlight the quote from gerontologist Dr. Robert N. Butler [53], "If exercise could be packed into a pill, it would be the single most widely prescribed and beneficial medicine in the nation".

Limitations

This investigation has some limitations, and the findings of this systematic review must be interpreted with caution. Although three well-known databases were used, including more sources of data could have improved the amount of literature included in the review. Due to the several limitations of this review, we urge the readers to view the results with caution. (i) the self-selection bias is possible because of the imposed social distance since online surveys on social networks are subjective and can inhibit the results of the study; (ii) the cross-sectional design does not establish a causal relationship between the variables and this needs to be better investigated in randomized clinical trials; (iii) self-reported bias can also affect the results; (iv) exclusion of non-English language studies can have excluded some relevant information; (v) more representative need for research in other affected countries; (vi) there was a lack of follow-up studies to show changes in sleep disorders; (vii) few studies have been used on the subject in question; (viii) we didn't include in this study the diet analysis.

The main strength of this study was to describe the association between trends in the use of progressive resistance physical exercise and its importance in periods of confinement, given the bibliometric analysis and visualized in the studies, as an effective intervention to improve sleep quality.

Conclusion

Despite these issues, this study provides evidence for the potential impacts of physical exercise on the sleep quality in individuals during periods of lockdown. Physical exercise activities enhance the immune system and reduce susceptibility to infections, especially respiratory infections including Covid-19.

Therefore, new strategies to increase and maintain exercise levels should be widely encouraged, spreading messages of getting physically active through alternative programs at home, suggesting that the population avoids a sedentary lifestyle, improves the level of independence, the state of mental health, and emotional balance during the quarantine. Most observational studies are needed to further examine the implications of physical exercises as an important behavioral treatment during the lockdown in the Covid-19 pandemic to improve poor sleep and/or disorder.

Ongoing evaluation of the impact of lifestyle changes associated with the pandemic is needed and future studies should examine a variety of clinical cohorts using both objective and subjective measures to confirm the efficacy of Resistance Exercise on sleep and enhance the currently limited understanding of the physiological and psychological underpinnings of this relationship.

References

1. World Health Organization (2020) Overview of public health and social measures in the context of COVID-19.
2. Wang X, Lei SM, Le S, Yang Y, Zhang B et al. (2020) Bidirectional Influence of the COVID-19 Pandemic Lockdowns on Health Behaviors and Quality of Life among Chinese Adults. *Int J Environ Res Public Health* 17: 5575. [Crossref]
3. Marelli S, Castelnuovo A, Somma A, Castronovo V, Mombelli S, et al. (2021) Impact of COVID-19 lockdown on sleep quality in university students and administration staff. *J Neurol* 268: 8-15. [Crossref]
4. Liu D, Baumeister RF, Zhou Y (2021) Mental health outcomes of coronavirus infection survivors: A rapid meta-analysis. *J Psychiatr Res* 137: 542-553. [Crossref]
5. Yuan S, Liao Z, Huang H, Jiang B, Zhang X, et al. (2020) Comparison of the Indicators of Psychological Stress in the Population of Hubei Province and Non-Endemic Provinces in China During Two Weeks During the Coronavirus Disease 2019 (COVID-19) Outbreak in February 2020. *Med Sci Monit* 26: e923767. [Crossref]
6. Fu W, Wang C, Zou L, Guo Y, Lu Z, et al. (2020) Psychological health, sleep quality, and coping styles to stress facing the COVID-19 in Wuhan, China. *Transl Psychiatry* 10: 225.
7. Xiao H, Zhang Y, Kong D, Li S, Yang N (2020) The Effects of Social Support on Sleep Quality of Medical Staff Treating Patients with Coronavirus Disease 2019 (COVID-19) in January and February 2020 in China. *Med Sci Monit* 26: e923549. [Crossref]
8. Liu K, Chen Y, Wu D, Lin R, Wang Z, et al. (2020) Effects of progressive muscle relaxation on anxiety and sleep quality in patients with COVID-19. *Complement Ther Clin Pract* 39: 101132. [Crossref]
9. LeGates TA, Fernandez DC, Hattar S (2014) Light as a central modulator of circadian rhythms, sleep and affect. *Nat Rev Neurosci* 15 :443-454. DOI: 10.1038/nrn3743. [Crossref]
10. Wang X, Li P, Pan C, Dai L, Wu Y, et al. (2019) The Effect of Mind-Body Therapies on Insomnia: A Systematic Review and Meta-Analysis. *Evid Based Complement Alternat Med.* 2019: 9359807. [Crossref]
11. Doherty R, Madigan S, Warrington G, Ellis J (2019) Sleep and Nutrition Interactions: Implications for Athletes. *Nutrients* 11: 822. [Crossref]
12. Wu K, Wei X (2020) Analysis of Psychological and Sleep Status and Exercise Rehabilitation of Front-Line Clinical Staff in the Fight Against COVID-19 in China. *Med Sci Monit Basic Res* 26: e924085. [Crossref]
13. Kline CE (2014) The bidirectional relationship between exercise and sleep: Implications for exercise adherence and sleep improvement. *Am J Lifestyle Med* 8: 375-379. [Crossref]
14. Glass J, Lanctôt KL, Herrmann N, Sproule BA, Busto UE (2005) Sedative hypnotics in older people with insomnia: meta-analysis of risks and benefits. *BMJ* 331: 1169. [Crossref]
15. Espie CA (2009) "Stepped care": a health technology solution for delivering cognitive behavioral therapy as a first line insomnia treatment. *Sleep* 32: 1549-1558. [Crossref]
16. Rabold E, Virani A, Arshad H, Cheema T (2021) Nonpharmacological Therapies in COPD. *Crit Care Nurs Q* 44:26-32. [Crossref]
17. Bull FC, Al-Ansari SS, Biddle S, Borodulin K, Buman MP, et al. (2020) World Health Organization 2020 guidelines on physical activity and sedentary behaviour. *Br J Sports Med* 54: 1451-1462. [Crossref]

18. Alkhatib A (2020) Antiviral Functional Foods and Exercise Lifestyle Prevention of Coronavirus. *Nutrients* 12: 2633. [Crossref]

19. DHHS. Physical Activity Guidelines Advisory Committee. Physical Activity Guidelines Advisory Committee Report, (2008).Washington, DC: U.S.

20. Dasso NA (2019) How is exercise different from physical activity? A concept analysis. *Nurs Forum* 54: 45-52. [Crossref]

21. Yang YJ (2019) An Overview of Current Physical Activity Recommendations in Primary Care. *Korean J Fam Med* 40: 135-142. [Crossref]

22. Youngstedt SD (2005) Effects of exercise on sleep. *Clin Sports Med* 24: 355-365. [Crossref]

23. Sañudo B, Seixas A, Gloeckl R, Rittweger J, Rawer R, et al. (2020) Potential Application of Whole Body Vibration Exercise For Improving The Clinical Conditions of COVID-19 Infected Individuals: A Narrative Review From the World Association of Vibration Exercise Experts. *Int J Environ Res Public Health* 17: 3650. [Crossref]

24. Da Cunha de Sá-Caputo D, Taiar R, Seixas A, Sanudo B, Bernardo-Filho M, et al. (2020) A Proposal of Physical Performance Tests Adapted as Home Workout Options during the COVID-19 Pandemic. *Appl Sci* 10: 4755.

25. Li Z, Zheng C, Duan C, Zhang Y, Li Q, et al. (2020) Rehabilitation needs of the first cohort of post-acute COVID-19 patients in Hubei, China. *Eur J Phys Rehabil Med* 56: 339-344. [Crossref]

26. Stanton R, To QG, Khalesi S, Williams SL, Alley SJ, et al. (2020) Depression, Anxiety and Stress during COVID-19: Associations with Changes in Physical Activity, Sleep, Tobacco and Alcohol Use in Australian Adults. *Int J Environ Res Public Health* 17: 4065. [Crossref]

27. Liberati A, Altman DG, Tetzlaff J, Mulrow C, Gøtzsche PC, et al. (2009) The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. *J Clin Epidemiol* 62: 1–34. [Crossref]

28. PROSPERO 2020 -International prospective register of systematic reviews..

29. Buysse DJ, Reynolds CF, Monk TH, Berman SR, Kupfer DJ (1089) The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. *Psychiatry Res* 28: 193-213. [Crossref]

30. Merlin T, Weston A, Tooher R (2009) Extending an evidence hierarchy to include topics other than treatment: revising the Australian 'levels of evidence. *BMC Med Res Methodol* 9: 34. [Crossref]

31. Thomson H, Sterne J, Higgins J (2015) ACROBAT-NRSi (A Cochrane Risk Of Bias Assessment Tool: for Non-Randomized Studies of Interventions) for non-clinical community based studies: a participatory workshop using a worked example from public health. In: Filtering the information overload for better decisions. Abstracts of the 23rd Cochrane Colloquium; Vienna, Austria.

32. Zhang Y, Zhang H, Ma X, Di Q (2020) Mental Health Problems during the COVID-19 Pandemics and the Mitigation Effects of Exercise: A Longitudinal Study of College Students in China. *Int J Environ Res Public Health* 17: 3722. [Crossref]

33. Barrea L, Pugliese G, Framondi L, Di Matteo R, Laudisio D, et al. (2020) Does Sars-Cov-2 threaten our dreams? Effect of quarantine on sleep quality and body mass index. *J Transl Med* 18: 318. [Crossref]

34. Kilani HA, Bataineh MF, Al-Nawayseh A, Atiyat K, Obeid O, et al. (2020) Healthy lifestyle behaviors are major predictors of mental wellbeing during COVID-19 pandemic confinement: A study on adult Arabs in higher educational institutions. *PLoS One* 15: e0243524 [Crossref]

35. Trabelsi K, Ammar A, Masmoudi L, Boukhris O, Chtourou H, et al. (2020) Globally altered sleep patterns and physical activity levels by confinement in 5056 individuals: ECLB COVID-19 international online survey. *Biol Sport* 38: 495-506.

36. Holmes EA, O'Connor RC, Perry VH, Tracey I, Wessely S, et al. (2020) Multidisciplinary research priorities for the COVID-19 pandemic: a call for action for mental health science. *Lancet Psychiatry* 7:547-560. [Crossref]

37. Gualano MR, Lo Moro G, Voglino G, Bert F, Siliquini R (2020) Effects of Covid-19 Lockdown on Mental Health and Sleep Disturbances in Italy. *Int J Environ Res Public Health* 17:4779. [Crossref]

38. Goularte JF, Serafim SD, Colombo R, Hogg B, Caldieraro MA, et al. (2021) COVID-19 and mental health in Brazil: Psychiatric symptoms in the general population. *J Psychiatr Res* 132: 32-37. [Crossref]

39. Brito-Marques JMAM, Franco CMR, Brito-Marques PR, Martinez SCG, Prado GF (2021) Impact of COVID-19 pandemic on the sleep quality of medical professionals in Brazil. *Arq Neuropsiquiatr* 79: 149-155. [Crossref]

40. Wang C, Pan R, Wan X, Tan Y, Xu L, et al. (2020) Immediate Psychological Responses and Associated Factors during the Initial Stage of the 2019 Coronavirus Disease (COVID-19) Epidemic among the General Population in China. *Int J Environ Res Public Health* 17: 1729. [Crossref]

41. Bennie JA, Tittlbach S (2020) Muscle-strengthening exercise and sleep quality among a nationally representative sample of 23,635 German adults. *Prev Med Reports* 20: 101250.

42. Buman MP, King AC (2010) Exercise as a Treatment to Enhance Sleep. *Am J Lifestyle Med* 4: 500-514.

43. Kovacevic A, Mavros Y, Heisz JJ, Fiatarone Singh MA (2018) The effect of resistance exercise on sleep: A systematic review of randomized controlled trials. *Sleep Med Rev* 39: 52-68. [Crossref]

44. Ammar A, Trabelsi K, Brach M, Chtourou H, Boukhris O, et al. (2021) Effects of home confinement on mental health and lifestyle behaviours during the COVID-19 outbreak: Insight from the ECLB-COVID19 multicenter study. *Biol Sport* 38: 9–21. [Crossref]

45. Alnofaiey YH, Alshehri HA, Alosaimi MM, Alswat SH, Alswat RH, et al. (2020) Sleep disturbances among physicians during COVID-19 pandemic. *BMC Res Notes* 13: 493.

46. Ferris LT, Williams JS, Shen CL, O'Keefe KA, Hale KB (2005) Resistance training improves sleep quality in older adults a pilot study. *J Sports Sci Med* 4: 354-360. [Crossref]

47. Šarabon N, Kozinc Ž, Löfler S, Hofer C (2020) Resistance Exercise, Electrical Muscle Stimulation, and Whole-Body Vibration in Older Adults: Systematic Review and Meta-Analysis of Randomized Controlled Trials. *J Clin Med* 9: 2902. [Crossref]

48. Goethals L, Barth N, Guyot J, Hupin D, Celarier T, et al. (2020) Impact of Home Quarantine on Physical Activity Among Older Adults Living at Home During the COVID-19 Pandemic: Qualitative Interview Study. *JMIR Aging* 3:e19007. [Crossref]

49. Lee SY, Kua HA, Qiu W, Lai KY, Jumala J, et al. (2020) Exercise as Medicine in Frailty Prevention and Management: Why Now, Why Here, and Making it Happen. *Ann Acad Med Singap* 49: 810-813. [Crossref]

50. Werneck AO, Silva DR, Carvalho Malta D, Lima MG, Souza-Júnior PR, et al. (2020) The mediation role of sleep quality in the association between the incidence of unhealthy movement behaviors during the COVID-19 quarantine and mental health. *Sleep Med* 76: 15. [Crossref]

51. López-Moreno M, López MTI, Miguel M, Garcés-Rimón M (2020) Physical and Psychological Effects Related to Food Habits and Lifestyle Changes Derived from Covid-19 Home Confinement in the Spanish Population. *Nutrients* 12: 3445. [Crossref]

52. Cancela-Carral JM, López-Rodríguez A, Mollinedo-Cardalda I (2021) Effect of physical exercise on cognitive function in older adults' carriers versus noncarriers of apolipoprotein E4: systematic review and meta-analysis. *J Exerc Rehabil* 17: 69-80. [Crossref]

53. Trabelsi K, Ammar A, Masmoudi L, Boukhris O, Chtourou H, et al. (2021) Sleep Quality and Physical Activity as Predictors of Mental Wellbeing Variance in Older Adults during COVID-19 Lockdown: ECLB COVID-19 International Online Survey. *Int J Environ Res Public Health* 18: 4329. [Crossref]

54. Butler RN (1978) Public interest report no. 23: exercise, the neglected therapy. *Int J Aging Hum Dev* 8: 193-195. [Crossref]

55. Angulo J, El Assar M, Álvarez-Bustos A, Rodríguez-Mañas L (2020) Physical activity and exercise: Strategies to manage frailty. *Redox Biol* 35:101513. [Crossref]

56. Marashi MY, Nicholson E, Ogrodnik M, Fenesi B, Heisz JJ (2021) A mental health paradox: Mental health was both a motivator and barrier to physical activity during the COVID-19 pandemic. *PLoS One* 16: e0239244. [Crossref]

57. Souza LFF, Domingos LLP, Oliveira MESM, Freitas JP, Marconi EM, et al. (2021) The impact of COVID-19 pandemic in the quality of sleep by Pittsburgh Sleep Quality Index: A systematic review. *Cien Saude Colet* 26: 1457-1464. [Crossref]

58. Szwarcwald CL, Damacena GN, Barros MBA, Malta DC, Júnior PRBS, et al. (2021) Fatores que afetam a autopercepção de saúde dos brasileiros durante a pandemia da COVID-19. *Cad Saúde Pública* 37: e00182720.