Research Article

Open Access

CrossMark

During COVID: Who slept better? Who slept worse? Recommendations for sleep frailty and sleep robustness

Abstract

COVID 19 pandemic had worldwide negative repercussions. The overall prevalence of sleep disorders during Covid 19 was around 40%, with differences according to specific populations, more vulnerable or with greater exposure. Since sleep is a fundamental pillar of health and essential for survival and for physical and mental health it is essential to know what preserves and what deteriorates sleep in adverse situations.

Objectives: Comparison of those who slept better, equal or worse, using a multimodal ecologic model.

Methods: Sleep Quality and Awakening quality before and during the pandemic were used as referential measures. Analysis of variance of quantitative variables in COVID and pre-COVID stress was performed, and a linear discriminant analysis (LDA) was applied to classify the 3 sleep groups: Worse, Equal and Better.

Results: Despite many statistical differences between groups, the LDA discrimination of subgroups ranged globally from 70 to 86%. Using LDA the Worse group was correctly classified with high correctness, from 74.3 to 97.3%; Equal group classification ranged from 67.1 to 97.7%; Better group however was correctly classified with low values (25.7 to 27.9%). LDA discrimination achieved higher values with Sleep Quality.

Conclusion: The results are discussed and the recommendations focused on what you should or should not do, to avoid poor sleep in adverse conditions.

Keywords: sleep, sleep quality, stress, mental health, attitudes, habits, morbidities, covid 19

Teresa Paiva,[1,2,3] Margarida Gaspar Matos[1,2,4,5]
[1]CENC – Centro de Medicina do Sono, Portugal
[2]ISAMB – Instituto de Saúde Ambiental – FMUL, Portugal
[3]CHRC - Comprehensive Health Research Center, Nova Medical School, Portugal
[4]APPSYci, ISPA – Instituto Universitário, Portugal
[5]Faculty of Human Sciences, Portuguese Catholic University, 1649-023 Lisbon, Portugal

Correspondence: Teresa Paiva, CENC- Sleep Medicine Center, Rua Conde das Antas 5, Lisboa, Portugal, Tel +351968011648, Email teresapaiva0@gmail.com

Abbreviations: AIS, athens insomnia scale; ANOVA, analysis of variance; AQ, awakening quality; BMI, body mass index; CECL, calamity experience check list; CPAP, continuous positive airway pressure; ISI, insomnia severity index; JSS, Jenkins sleep scale; LSEQ, leeds sleep evaluation questionnaire; LDA, linear discriminant analysis; MSP, mid sleep point; MSQ, mini-sleep questionnaire; PA, physical activity; PhD, doctor of philosophy; Pre-Dur, prior during covid comparison; PSQI, Pittsburgh sleep quality scales; SQ, sleep quality; TV, television

Introduction

The overall prevalence of sleep disorders during COVID 19 was 40.49% with a confidence interval (CI) between 37.56 and 43.48%. Differences related to specific populations, more vulnerable or more exposed, namely patients infected with COVID: 52.39% [CI 41.69; 62.88%], children and adolescents 45.96% [CI 36.90; 55.30%], health workers: 42.47% [CI 37.95; 47.12%], populations with specific health care needs: 41.50% [CI 32.98; 50.56%], university students: 41.16% [CI 28.76; 54.79%] a8nd, in the general population, 36.73% [CI 32.32; 41.38%].[1]

The deterioration of the mean values of sleep parameters during COVID was also observed by our group,[2,3] but it was possible to identify subgroups for which sleep did not worsen or even got better.

Currently research is focused on what goes "wrong" forgetting what goes "well". Depression/sadness is talked about and studied much more than joy. A search in Pubmed for "poor sleep" in the title or abstract gives 15,647 results, while for "good sleep" 7,186 results were obtained, many of which are about strategies on how to go from bad to good sleep or have good sleep hygiene rules. This is the result of a centuries-old medical strategy: "treating disease," which has, only recently, turned to the "preservation of health".

Sleep quality (SQ) is considered a basic sleep variable impacting the individual's daily wellbeing. It may be considered a subjective evaluation item of sleep satisfaction or may be objectively quantified by polysomnography and actigraphy. Poor sleep quality is negatively impacted by multiple factors, namely anxiety, stress and worries, depression medical, psychiatric and sleep disorders, poor habits and sleep hygiene, social and work environment.[2]

Awakening quality (AQ) is essential to subjectively determine the restorative function of sleep; the final morning awakening is indeed a critical functional period due to its association with sleep inertia, sleep restoration, increased blood pressure and cortisol circadian rhythms.[2]

Considering the essential functions of sleep for physical, psychological, mental and cognitive health, for behavior and decision-making, and consequently for survival and adaptation to the environment,[4-6] it was decided to evaluate not only those who were bad, but also those who were the same or even better, since, knowledge of sleep success can be beneficial to those who do not.

Objectives

The objectives are as follows: 1) Compare those who slept better, the same, or worse using the differences in Sleep Quality (SQ) and Awakening Quality (AQ) before and during the pandemic as measures; 2) Use linear discriminant analysis to classify the 3 subgroups; 3) To compare the capacity of subjective SQ and AQ in sleep evaluation; 4) Use the relevant differences for public recommendations.

During COVID: Who slept better? Who slept worse? Recommendations for sleep frailty and sleep robustness

Copyright:
©2025 Paiva et al.

15

Methods

Procedures and participants: This work is part of the study "Covid, Sleep, Health, Habits and Behaviors", collected through a questionnaire created on the Survey Legend platform during the first wave of the COVID-19 pandemic (between April and August 2020). The total sample consists of 5746 participants. The full description of the design, participants and instruments was previously detailed.[2]

Variables: Socio-demographic characterization variables (gender, age, marital status, and level of education) were used, as well as differences in sleep quality, body mass index (BMI), pre-covid work stress variables, number lockdown days, "experience of confinement", irritability, concerns, CECL,[7] sleep characteristics duration during the week and weekends, TV and mobile phone and social networks per day, diet not recommended.

Statistical analysis: The difference in Sleep and Awakening Quality before and during the pandemic was calculated: pre-dur QS. The 3 subgroups Worse, Equal, Better were calculated as follows: Better from -9 to -1, Equal = 0, Worse = > 1. The comparison of the 3 groups was made by unidimensional comparison of means (ANOVA) with Bonferroni correction, and the differences were discussed.

Linear Discriminant Analysis (LDA) was applied to the subsets of groups without missing values in any continuous variable, having as dependents (predictors): age, body mass index (BMI), pre-covid work stress variables, lockdown days, number of morbidities", "How are you living confinement", "How is your irritability", Worries, CECL, sleep duration during the week, TV and cell phones per day, food not recommended. Adherence to the predicted group was calculated for the total sample with no missing cases (n=1814). SPSS® v25 was used and a significance level of 0.05.

Results

For the pre-dur SQ, the number of valid cases was 4233, Mean=0.92, SD=1.832, Min -9, Max 9, asymmetry 0.542+-0.38, kurtosis 2.575+- 0.75. Its distribution is represented in Figure 1, together with the differences pre-dur of the Awakening Quality (AQ).
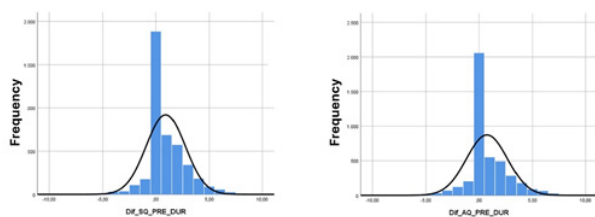

Figure 1 Left graph: Histogram of the differences in Sleep Quality (SQ) Pre-Dur COVID; Right graph: Histogram of the differences in Awakening Quality (AQ) Pre-Dur COVID. Note in both the marked deviation to the Worse QS/AQ (differences with positive values).

The Better Sleep group includes 377 individuals and corresponds to 8.9% of the cases; the Equal group includes 1883 (44.6%) individuals and the Worse group 1963 (46.5%) cases.

Differences in Gender, Marital status, BMI scores, Education, and Harassment for both SQ and AQ are shown in Table 1

Women predominate in the Worse group for both variables, while men remain mostly in Equal. For marital status married, divorced and widowed predominate in the Equal group and Bachelor and Union in the Worse group for both variables.

WHO BMI classification subgroups showed that underweight and Normal weight groups predominate in the Worse group, while pre-obesity and all obesity subgroups stayed Equal, for AQ the only difference refers to the normal weight groups with similar percentages in Worse and Equal. The results were significant for SQ and AQ.

For Education, primary, secondary, professional education, bachelors and PhD predominate in the Equal group, Graduate has identical percentages in the Worse and Equal and Master´s predominate in the Worse (Chi2= 191.623%; p<0.001).

People suffering from moral or sexual harassment before COVID have higher percentages in Worse and Better groups, with significant results in Chi 2.

In terms of age, in the Worse group they are younger and in the Equal group they are older, with the 3 groups being different from each other. As for BMI, age in the Worse group has the lowest average and in the Equal group the highest, the 3 groups being different from each other. In stress at work, interruptions, multitasking, conflicts, responsibility and intellectually heavy work, the Better group has the highest average and the Equal the lowest, with the Worse group having an intermediate value. The 3 groups are different from each other. For physically heavy work, the highest value is in the Worse group, which differs from the other two (Table 2).

The Better group has been in Lockdown for more days and feels better, with the Worse group being different from the other two; depression, anxiety, irritability, worries, and CECL (Calamity Experience Check List) are higher in the Worse group and different from the other two. Economic problems are greater, and the frequency of sexual activity is lower in the Worse group and different the Equal group. Positive attitudes and behaviors are less frequent, and negative attitudes and negative behaviors are more frequent in the Worse group, which is different from the other two; trauma is lower in the equal group. The better group has significantly more positive attitudes and positive behaviors and less negative behaviors than the other two (see Table 3).

In the sleep parameters, only the sleep duration is longer in the Better group and shorter in the Worse group, with the 3 groups being different from each other, and the MSP (mid sleep point) is later, close to 4am, in the Better group, being different from the other two. Concerning morbidities the Worse group has more worsening of morbidities and less improvements, while the Better group is exactly the opposite; the 3 groups differ from each other (see Table 4).

PA hours are lower in the Worse group, which is different from the other 2. The number of meals per day is lower in the Equal group, which is different from the other two. Alcohol consumption is higher in the equal group which is different from the Worse. The Worse group eats fewer recommended foods and more non-recommended ones, being different from the other two. The Better group always has better values and in the non-recommended ones it is different from the others. Time on social media is slightly different between groups; mobile phone use and dependencies on TV networks and social networks are lower in the Equal group, which is either different from the Worse or from both (see Table 5).

The discriminant analysis done for the global population and for each gender determined 2 canonical functions; in the 3 situations the Wilks Lambda values are significant, and the values of the variables are different for the two canonical functions (see Table 6). With LDA the ability to correctly classify each group and the ability to discriminate between two groups, two by two, was achieved. With the

During COVID: Who slept better? Who slept worse? Recommendations for sleep frailty and sleep robustness

Copyright:
©2025 Paiva et al.   **16**

variables used, only 58.5% of the classifications were correct, being slightly higher for the Worse group (63.4%) and lower for the Better group (52.7%), with no substantive differences with the classification for each sex, partly due to the overlap of the 3 groups of difference in terms of SQ and AQ (Figure 2).

The discrimination ability between groups was however much higher (see Table 7). The Worse group was correctly classified with high correctness, from 74.3 (Worse-Equal) to 97.3% (Worse-Better); Equal group classification ranged from 67.1 (Equal-Worse) to 97.7%

(Equal-Better); Better group however was correctly classified with very low values: 25.7 (Better-Equal) to 27.9% (Better-Worse).

The evaluation of the better measure to evaluate sleep, namely Sleep Quality or Awakening Quality provided the following results: In ANOVA comparisons SQ was different for the Worse group 57, for Equal 49, and for Better 38 cases, while AQ was different more often, respectively 59, 59 and 50 (see Table 8). However, using LDA the discriminant capacity of AQ was much lower when compared to SQ (see Table 7).

Table 8 Comparison of the performance of Sleep Quality (SQ) and Awakening Quality (AQ) in ANOVA intergroup comparisons as presented in Tables 2 to 5. The final values are quite similar with values a bit higher for AQ, with better performance in the Better group

Comparing SQ and AQ									
	SQ			AQ					
	Worse Equal	Worse Better	Equal Better	Worse Equal	Worse Better	Equal Better		SQ	AQ
Table 2	9	5	8	9	5	9	Worse	57	59
Table 3	14	11	0	14	11	10	Equal	49	59
Table 4	3	4	3	4	5	4	Better	38	50
Table 5	8	3	4	7	4	2			
Total	34	23	15	34	25	25			

Finally, it is important to identify each group considering the statistical results.

The Worse group, i.e., those that during the COVID pandemic slept worse are: Predominantly Women, Single and in Union, underweight, with a master's degree, prior victims of sexual or moral harassment, with higher work stress prior the pandemic with frequent Interruptions, Multitasking, Conflicts and Responsibility, and a work intellectually and/or physically heavy, didn't feel well during lockdown, with higher levels of Depression, Anxiety, Irritability, and Worries, and higher levels in the CECL scale, more economic problems, less frequent sexual activity, less positive attitudes and behaviors and negative attitudes and behaviors, increased worsening of morbidities and decreased improvement, and poorer habits in terms of lower physical activity, less meals, less recommended foods, and higher TV dependence.

The Equal group includes predominantly males, Married or Widowed, Overweight, with Lower and higher education (PhD), older age, low levels of depression and anxiety, and drink more alcohol.

The Better group includes people with high Obesity levels, prior victims of moral or sexual Harassment, with higher work stress prior the pandemic with frequent interruptions, Multitasking, Conflicts and Responsibility, and a work intellectually heavy, longer Lockdown, but feel high during lockdown with better sleep and later MSP (mid sleep point) in weekdays; they have a higher number of morbidities which improved, eat more meals per day, and eat less food not recommended, use the mobile for longer time, but are less dependent of social networks.

Discussion and conclusion

These results show that the Worse or Better groups differ from the others more frequently than the Equal group, and that the conclusions with this optimistic attempt to propose explanations for the improvement were not sufficient in terms of sleep quality and awakening quality.

The data from the Linear Discriminant Analysis Classification showed correct classification in only about 60% of cases, which is insufficient, but has a higher capacity to discriminate between groups, specially the Worse and Equal.

This result is partly explained by the extreme variability of the subjective classification of both sleep quality, awakening quality and duration; people with insomnia often rate both the duration and quality of sleep pessimistically, when there is an objective measure of it,[8,9] on the contrary, people with Apnea often make optimistic and pessimistic ratings with and without CPAP.[10,11]

To make the problem more complicated, the definition of a good sleeper is subjective or based on Pittsburgh Sleep Quality Scales (PSQI), Athens Insomnia Scale (AIS), Insomnia Severity Index (ISI), Mini-Sleep Questionnaire (MSQ), Jenkins Sleep Scale (JSS), Leeds Sleep Evaluation Questionnaire (LSEQ), SLEEP-50 Questionnaire, many of which are difficult to use in epidemiological studies, and those that are easier to use lack more detailed validation (JSS and MSQ).[12]

Another difficulty is the group proximity in our setting, since in group equal the difference in SQ and AQ pre-dur is zero and in the other groups is plus or minus 1, up to the respective maximum. Another difficult factor is the much lower number of subjects in the Better group.

The discrimination correctness results are quite understandable for the Worse group; with so many significant differences it is the easiest to classify. The Equal group discrimination is low when paired with the Worse group (67.1%) but is very high relatively to Better group, 97.7%; the first result is explained by the proximity of both groups, the second relates to the characteristics of the Better group itself.

It is apparent in Figure 2 that the small blue circles of Better sleepers surround the areas of Worse and Equal, and are located both at higher and at lower levels. This fact suggests that besides being less in number they include a marked diversity and a group with higher complexity.
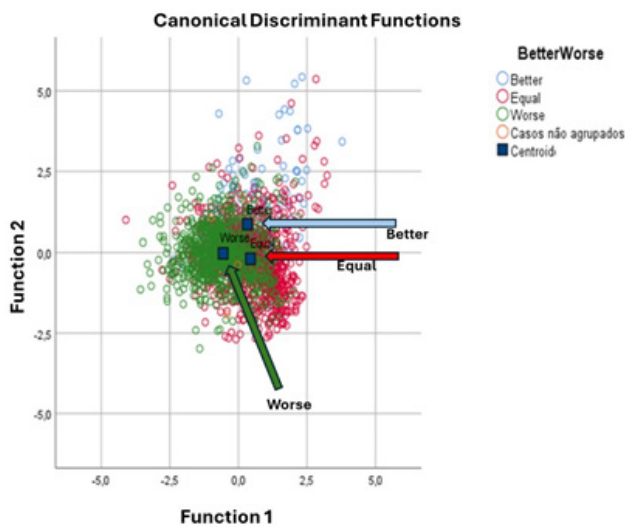
During COVID: Who slept better? Who slept worse? Recommendations for sleep frailty and sleep robustness

Copyright:
©2025 Paiva et al.   17

Figure 2 LDA Classification results and dispersion graphic of the canonical functions for the 3 groups: Better in Blue, Equal in Red, Worse in Green together with each group centroid.

"The term complexity is used informally both as a quality and as a quantity. As a quality, complexity has something to do with our ability to understand a system or object — we understand simple systems, but not complex ones. On another level, complexity is used as a quantity, when we talk about something being more complicated than another."[13]

Conventionally is its considered that, any disturbance, either medical or psychiatric is associated with increased complexity, however the opposite can be postulated: a healthy person or a good sleeper are systems with higher complexity, since they have a higher number of degrees of freedom. Making it simple a healthy person a much wider range of possible behaviors than a thick person, who is restricted by the illness limitations. In sleep this has been shown, some years ago, using stochastic grammars for hypnogram analysis: normal hypnograms were described by a much higher number of rules than disturbed hypnograms of several sleep and psychiatric disorders.[14]

In this study data from the Better group are in line with this complexity concept: 1)It include individuals with high Obesity levels suggesting the overrating of sleep quality in sleep apnea;[10] 2) prior victims of moral or sexual Harassment, suggesting that either they have overcome the problem or feel better because lockdown prevents direct contact with aggressors; 3) They had higher work stress prior the pandemic with frequent interruptions, Multitasking, Conflicts and Responsibility, and a work intellectually heavy, suggesting they are better because they can finally rest, and/or because they make decisions to prevent stress in the future; 4) Longer lockdown, but feel high during lockdown with better sleep and later MSP (middle sleep point) in weekdays; 5) they have a higher number of morbidities which improved; 6), eat more meals per day, and eat less food not recommended; 7) use the mobile for longer time, but are less dependent of social networks.

Recommendations

Along with this pandemic other types of natural disasters, attributable, to climate change and extreme weather episodes, together with armed conflicts, are leading to humanitarian and economic crises that unbalance the lives of the people involved and send them to unusual levels of need.[15]

Social cohesion, innovation and people-to-people collaboration at various levels was remarkable during the first phase of the COVID-19 pandemic, given the circumstances and the ignorance and "unpreparedness" of everyone on a global scale.

Now, with the acquired knowledge it is urgent to define contingency plans so that we can be forewarned and act even more timely, but above all leveraging the advantages of the development of science and technology and accumulated experience.

Scientifically validated contingency plans are urgently needed for immediate implementation.

In the COVID phase of global emergency, people and governments in general privilege physical "survival", which implied restrictive health measures to protect people: confinements; physical distancing, use of masks, ventilation of homes, hand hygiene, self-monitoring of symptoms and self-isolation, testing and vaccination.

These health measures most likely saved lives but left sequelae to be avoided in the next time, such as physical health, psychological health, relational health, lifestyles and health habits (sleep, diet, sedentary lifestyle) and economic health.

Curiously, in times where globally equity and equal opportunities between men and women and between younger and older people would seem to be a culturally acquired fact, several differences to be considered in the future, were accentuated, both in terms of enhancing the individual well-being of men and women at different ages, as well as in the definition of public policies in the various sectors.

The next challenge is to minimize data and promote this survival with the greatest well-being and the least damage to physical and psychological health and to social and economic health, minimizing damage in terms of learning and work. This and many other studies around the world showed that the factors associated with worse physical and psychological health were the following: being a woman, less educational, being a health professional, excessive and unhealthy diet, abusive use of screens, poor quality of sleep and awakening, overweight, consumption of psychoactive substances, being the target of relational abuse at work or in a family context and practicing less physical activity.

Recommendations that include an individual level, a professional level and a level of public policies, not only to minimize damage in a possible future crisis, but also to immediately activate contingency plans that allow to take care of the health and well-being of citizens in areas such as work, schooling, physical and psychological health, sleep, food, physical activity, use of screens, leisure.

A contingency plan for future crises is recommended in order to be immediately activated, without interruption of assistance responses to diseases, using several resources: agile, fast and competent hierarchy of emergencies; diversification of health responses, limiting emergencies to emergency situations, and reorganizing local primary health care services, by encouraging telecare, monitoring via telephone; the hierarchical use of other technicians in partnership. An increase in the population's health care literacy is recommended, particularly in terms of prevention, self-care and seeking assistance Psychological Health.

Diet and body mass index: A moderate diet, with low consumption of salt, sugar and fats and high consumption of vegetables and fibre (Mediterranean diet), is generally associated with great benefits for

During COVID: Who slept better? Who slept worse? Recommendations for sleep frailty and sleep robustness

Copyright:
©2025 Paiva et al.   18

physical and mental health, for sleep. There are co-influencing factors such as BMI, sleep, PA, use of screens. An increase in literacy about the impact of excess weight on people's physical and psychological health is recommended, with the development of preventive strategies in the family and at school and at the municipal level.

Screen time: "Moderate use of screen time" is associated with great benefits for physical and mental health, attitudes towards life and adaptation to circumstances. Excess is associated with harmful effects such as dependence, violence, sedentary lifestyle, narrowing of the field of interests, poor diet, concomitant consumption of alcohol and drugs.

Physical activity: "A little more PA" is associated with great benefits for physical and mental health, sleep, attitudes towards life and adaptation to circumstances, although some harmful effects such as violence, injuries, concomitant consumption of alcohol and drugs must be prevented. The recommendations for the possibility of access and encouragement to the practice of PA, outdoors and daytime practice. It is recommended to increase literacy about physical activity and sport in order to increase knowledge and practices about the characteristics of the various activities.

Work and leisure: A friendly work environment and a work-leisure balance are associated with great benefits for physical and mental health, sleep, attitudes towards life and adaptation to circumstances. The recommendations of friendly and healthy workplaces and promoters of personal and social development, work-leisure balance, active leisure, outdoor leisure, moderation of screens and consumption associated with leisure, are essential for health and well-being and adaptations to adverse situations. Recommendation of an increase in literacy on work/school health, work-leisure balance, and self-care, to increase knowledge and practices that can improve the quality and balance between these periods of citizens'.

Sleep: Good sleep and chronobiologic hygiene is associated with great benefits for physical and mental health, attitudes towards life and adaptation to circumstances. The recommendations have to do with what you should or should not do to sleep better: reduce stress, practice PA, moderate the use of screens, eat healthy, have positive attitudes and behaviors that is, emotionally rewarding, avoiding the negative ones.

Substance use: Many defend the effectiveness of a cigarette, an alcoholic beverage or a drug to induce sleep, to increase well-being and to enhance socialization. In fact, some of the effects of substances with psychotropic effects felt as positive disappear over time, but the problems remain and do not increase individual competence to deal with them.

Violence in interpersonal relationships: The COVID-19 pandemic, with confinements, physical distancing, health protection measures, associated social changes and associated fears, has resulted in a potential privileged stage for various relational disorders, abusive and unmonitored relational situations. People with more stress at work and victims of harassment had more negative consequences on physical and mental health, sleep and some behaviors associated with health risks in the pandemic. The existence of a common pattern to the traumatic situations analysed (Stress and Harassment at work, Conflicts, Loneliness and Trauma) refers to the existence of a common mechanism of response to aggression, with consequences on physical and mental health and behaviours associated with health risks. Prevention of these situations of interpersonal abuse refers to early action, in families, at school, in the community, and may include educational measures, promotion of personal and social skills and conflict management, but also legislative measures indicating that relational abuse is civilisational unacceptable and punishable by law.

Acknowledgments

Endorsements/Dissemination

CENC, Ordem dos Médicos, Ordem dos Enfermeiros, Ordem dos Psicólogos Portugueses, European Sleep Research Society (ESRS), Associação Portuguesa de Sono (APS), Sociedade Portuguesa de Neurologia e Ordem dos Farmacêuticos.

Conflicts of interest

The authors declare no conflict of interest.

Funding

References

1. 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;62:101591.

2. Paiva T, Reis C, Feliciano A, et al. Sleep and awakening quality during covid-19 confinement: complexity and relevance for health and behavior. Int J Environ Res Public Health. 2021;18(7):3506.

3. de Almondes KM, Castro EAS, Paiva T. Sleep habits, quality of life and psychosocial aspects in the older age: before and during covid-19. *Front Neurosci*. 2022;16:694894.

4. Weiss JT, Donlea JM. Roles for sleep in neural and behavioral plasticity: reviewing variation in the consequences of sleep loss. *Front Behav Neurosci*. 2022;15:777799.

5. Nollet M, Franks NP, Wisden W. Understanding sleep regulation in normal and pathological conditions, and why it matters. *J Huntingtons Dis*. 2023;12(2):105–119.

6. Fjell AM, Walhovd KB. Individual sleep need is flexible and dynamically related to cognitive function. *Nat Hum Behav*. 2024;8(3):422–430.

7. Tomé G, Paiva T, Ramiro L, et al. The new Calamity Experience Checklist (CECL): pandemic individual and group impact evaluation at a population level, and among patients suffering from sleep related disorders. In: Milcu M, Stevens M, Dahl I, eds. *The Psychology of Pandemics: New Trends and Prospects, XIII*. Editura Universitara; 2021:186–193.

8. Castelnovo A, Ferri R, Punjabi NM, et al. The paradox of paradoxical insomnia: A theoretical review towards a unifying evidence-based definition. *Sleep Med Rev*. 2019;44:70–82.

9. Stephan AM, Siclari F. Reconsidering sleep perception in insomnia: frommisperception to mismeasurement. *J Sleep Res*. 2023;32(6):e14028.

10. Wei H, Zhu J, Lei F, et al. Clinical phenotypes of obstructive sleep apnea: a cluster analysis based on sleep perception and sleep quality. *Sleep Breath*. 2023;27(5):1829–1837.

11. Lee SA, Im K, Yang HR. Effects of continuous positive airway pressure on sleep state misperception in patients with obstructive sleep Apnea. *J Korean Med Sci*. 2023;38(8):e54.

19

12. Fabbri M, Beracci A, Martoni M, et al. Measuring subjective sleep quality: a review. *Int J Environ Res Public Health*. 2021;18(3):1082.

13. Standish R. *Concept and definition of complexity*. 2008.

14. Fred A, Paiva T. Sleep dynamics and sleep disorders: a syntactic approach to hypnogram classification. *Medical & Biological Engineering & Computing*. 1996;34(Suppl 1, part 1):395–396.

15. Matos MG, Paiva T, Canhão H. *Recomendações aos cidadãos, aos doentes, aos profissionais e para as políticas públicas*. In: Paiva T, Gaspar de Matos MG, Canhão H, eds. Saúde, Sono e Estilos de Vida em Era COVID. My Sleep & I; 2023:321–329.