DOI: https://doi.org/10.17921/2447-8938.2024v26n4p209-214

Physical Activity, Quality and Subjective Sleep Pattern in Adolescent Survivors of COVID-19 After Two Years of Hospital Discharge

Atividade Física, Qualidade e Padrão Subjetivo do Sono em Adolescentes Sobreviventes da COVID-19 Após Dois Anos da Alta Hospitalar

Gustavo Baroni Araujo[a]; Michelle Moreira Abujamra Fillis[b]; Helio Serassuelo Junior[a]

Universidade Estadual de Londrina, Programa de Pós-Graduação em Educação Física. PR, Brazil.
Universidade Estadual de Londrina. PR, Brazil.
E-mail: heliojr@uel.br.

Abstract

Investigating the long-term consequences of COVID-19 on sleep and physical activity in adolescence is essential to understanding the lasting impact of the infection on aspects of youth development. The aim of this study was to investigate the correlation between physical activity, quality, and subjective sleep patterns in adolescents after two years of hospitalization for COVID-19. This is a descriptive study composed of 34 adolescents between 11 and 17 years old (14.41 ± 1.52) who had a confirmed diagnosis of COVID-19 and required hospitalization (ward or intensive care unit) and were discharged from hospital between January and June 2021. The IPAQ short version was used to analyze the level of physical activity according to the weekly practice time. To investigate sleep time, we sought to verify sleep changes based on the last 30 days. Descriptive statistics elements were used through frequency analysis and Spearman's Rank Correlation Coefficient was applied to analyze the correlation between physical activity time and sleep. The significance adopted was <0.05. All analyses were performed using SPSS 27 software. Of the total, 25 (73.5%) were classified as insufficiently active and 26 (76.4%) reported feeling more sleepy after COVID-19. A strong negative correlation was observed between sleep time and physical activity level (ρ= -0.79; p<0.01). Physical activity level correlated with sleep time in adolescents two years after hospital discharge. Adolescents classified as insufficiently active had greater sleepiness and hours of sleep after COVID-19.

Keywords: Physical Activity. COVID-19. Sleep. Hospitalization.

Resumo

Investigar as consequências a longo prazo da COVID-19 sobre o sono e a atividade física na adolescência é fundamental para entender o impacto duradouro da infecção em aspectos do desenvolvimento dos jovens. O objetivo deste estudo foi investigar a correlação entre atividade física, qualidade e padrão subjetivo do sono em adolescentes após dois anos de hospitalização por COVID-19. Trata-se de um estudo descritivo composto por 34 adolescentes entre 11 e 17 anos (14.41±1.52) que tiveram diagnóstico confirmado da COVID-19 e necessitaram de hospitalização (Enfermaria ou Unidade de Terapia Intensiva) e tiveram alta hospitalar entre janeiro a junho de 2021. Utilizou-se o IPAQ versão curta para analisar o nível de atividade física de acordo com o tempo de prática semanalmente. Para investigar o tempo de sono, buscou-se verificar alterações de sono com base nos últimos 30 dias. Foram utilizados elementos da estatística descritiva através de análise de frequência e aplicou-se Coeficiente de Correlação por postos de *Spearman* para analisar a correlação entre tempo de atividade física e sono. A significância adotada foi <0,05. Todas as analises foram realizadas software SPSS 27. Do total, 25 (73,5%) foram classificados como insuficientemente ativos e 26 (76,4%) referiram sentir mais sono após a COVID-19. Observou-se correlação negativa forte entre tempo de sono e nível de atividade física (ρ= -0,79; p<0,01). O nível de atividade física apresentou correlação com o tempo de sono em adolescentes após dois anos da alta hospitalar. Os adolescentes classificados como insuficientemente ativos apresentaram maior sonolência e horas de sono após a COVID-19.

Palavras-chave: Atividade física. COVID-19. Sono. Hospitalização.

1 Introduction

The critical period of the SARS-CoV-2 pandemic between 2020 and 2021 was responsible for a major impact on the health system in Brazil and the world due to the rapid spread of the virus, causing health services to adapt in an emergent way in the face of high rates of hospitalization and deaths caused by the infection. It is known that certain social groups were more exposed to complications from COVID-19, including individuals with chronic non-communicable diseases (NCDs), autoimmune diseases and the elderly[1].

When dealing with younger populations, the clinical picture of the infection was less severe. Previous studies[2,3] showed less chances of clinical complications from the infection due to the functioning of the immune and physiological system during childhood and adolescence[4]. Despite the lower risks of hospitalization and hospitalization in this population, this

group was not exempt from these consequences. Therefore, it is worth highlighting that individual health conditions are extremely relevant in symptoms in the acute phase and after recovery.

Variability in the intensity and duration of symptoms varies from person to person and can last indefinitely. The long-term consequences of COVID-19 in children and adolescents are uncertain. Cohort studies[5-7] have sought to investigate the risk factors for the persistence of COVID-19 symptoms in different populations as a way of monitoring the losses long-term infection. In children and adolescents, the main symptoms prolonged after infection include changes in sleep patterns, irritability or mood changes, headache, excessive drowsiness, insomnia, among others.

The importance of healthy habits for improving sleep time and quality is already well established in the literature. From this perspective, the effects of regular physical activity are positive, contributing to an improvement in subjective and objective perception of sleep quality and quality of life. Furthermore, it is worth highlighting that considering the losses caused by the period of social isolation and COVID-19, physical activity is a habit that acts as a protective factor, especially in more severe cases of infection. Given the discussion, the objective of this study was to investigate possible correlations between physical activity, quality and subjective sleep pattern in adolescents after two years of hospitalization for COVID-19.

2 Material and Methods

2.1 Design and sample

This is a descriptive, cross-sectional, quantitative study, part of a research project entitled "Physical activity practice and life satisfaction of children and adolescents who were infected by SARS-CoV-2 during the pandemic period of COVID-19".

The sample consisted of 34 adolescents between 11 and 17 years old (14.41±1.52) who had a confirmed diagnosis of COVID-19 in the city of Londrina-PR, through the RT-PCR tests, Rapid Antigen Test (TR- Ag), KOVID Ab (COVID-19 IgG/IgM and rapid antigen test (Immunochromatography) who were hospitalized (ward or Intensive Care Unit) and discharged from hospital between January and June 2021. The established sample selection selections were the The length of stay was three days or more.

Participants were selected through access to the official platform of the Londrina Health Department "Notifica-Covid" with the city's COVID-19 cases. The platform allowed access to patients' personal information, such as name, telephone number, companion's name, among others. Even so, the platform enabled access to health conditions at the time of entry into the health service, such as symptoms, presence of comorbidities, diagnostic data, entry and exit data from hospitalization.

In this study, no laboratory materials or specific COVID-19 tests were collected, considering that the participants had previously tested positive in Primary Health Care (PHC) services in the city of Londrina-PR.

2.2 Instruments

The questionnaire used to investigate the time of physical activity was the International Physical Activity Questionnaire (IPAQ) – short version, which allows estimating the energy expenditure of physical activities seeking to investigate the practice of physical activity in different contexts, consisting of eight open questions where their information makes it possible to estimate the time spent, per week, in different areas of physical activity (walking and physical efforts of light, moderate and vigorous intensity). For better organization and management of the collected data, they were categorized into two groups: 1) "Physically active" (meet the recommendations or practice more physical activity than the recommendations proposed by the WHO); and 2) "Insufficiently active" (those who practice physical activity, but do not meet WHO recommendations).

To investigate subjective quality, sleep duration, sleep disorders and use of sleeping medication, we sought to verify sleep changes and time based on the last 30 days through a previously structured questionnaire, consisting of 5 sentences, namely:

1) Do you feel sleepier during the day after COVID? ( ) Yes ( ) No

2) During the last month, how would you rate the quality of your sleep in general? ( ) Very good; ( ) Good; ( ) Bad; ( ) Too bad.

3) During the last month, how many hours of sleep did you get per night on a weekday? ( ) >7 hours; ( ) 6 to 7 hours; ( ) 5 to 6 hours; ( ) < 5 hours.

4) During the last month, how many hours of sleep did you get per night during a weekend day? ( ) >7 hours; ( ) 6 to 7 hours; ( ) 5 to 6 hours; ( ) < 5 hours.

5) Do you use sleeping pills? ( ) Yes ( ) No.

Subsequently, total time was categorized into two groups based on group average time: ≤7 hours of sleep per day and ≥7 hours of sleep per day. It is worth noting that the sample in the present study had already reported changes related to sleep, considering that these adolescents were already being followed up previously to investigate possible persistent symptoms after the acute phase of COVID-19.

2.3 Data collection and ethical procedures

Data collection was carried out using an online digital form created using the Google platform (Google Forms) and sent via WhatsApp after the consent of the minor and guardian. Google Forms makes it possible to create multiple-

choice, discursive, and evaluative questions and answers on a numerical scale, among other options. The document contained all the information regarding the objectives and justification of the study, containing questions about the patient's demographic characteristics (name, sexand age) and the questionnaire to evaluate the practice of physical activity and aspects related to sleep. Data were collected between the months of July and August 2023. Before the application began, instructions regarding the questionnaire were provided to the respondent. The average time spent answering the proposed questionnaire is approximately ten minutes.

As this was a study with minors, initially contact was made with parents/guardians via telephone call, at which point the researcher informed the guardian of the objectives and justifications of the study. Upon acceptance of the guardian's authorization through agreement on the Free and Informed Consent Form, the Free and Informed Assent Form was provided to the adolescent. After acceptance, the adolescents were able to answer the questionnaires. The present study was accepted by the human research ethics committee of the State University of Londrina under opinion number 5.502.355 (CAAE:58074422.6.0000.5231).

2.4 Data analysis

Descriptive analyzes were carried out through frequency analysis to characterize the sample (gender, age, average number of days of hospitalization, type of hospitalization, symptoms during the infection phase, presence of comorbidities, and whether the adolescent was physically active or not).

The hypothesis of data normality was investigated using the Shapiro-Wilk test. The data presented a non-normal distribution, which presupposes the need to use non-parametric statistics. To investigate the correlation between physical activity level (physically active or insufficiently active) with sleep time, a Bivariate Correlation test was used. The data did not present normal distribution and homosticity, for this reason, it was decided to accept the Spearman rank correlation coefficient with two-tailed output significance test. The correlation coefficient value was presented by the ρ value and significance level (P). Correlational analysis indicates the relationship between the two variables, where the coefficient values are between +1 and -1. For the interpretation of reference values, ρ classifications were established: between +- 0.7 to +- 0.9 strong; +- 0.4 to +-0.6 moderate; and +-0.1 to +- 0.3 weak[8]. In all analyzes the significance adopted was <0.05. The data were organized and tabulated in the Excel program of the Office package and processed in the SPSS software version 27.0.

3 Results and Discussion

Of the 34 adolescents who participated in the study, 21 (61.7%) were male and 13 (38.3%) were female. The median number of symptoms at the time of hospitalization was 6 [3-11]. Regarding the duration of hospitalization, the median was 9 [3-26] days. Of the total, 61.7% were allocated to wards and 38.3% to the ICU. Table 1 presents the descriptive variables in the sample: Age, sample number by age, sex, type of hospitalization and presence of NCDs.

Table 1 - Absolute and relative values of the sample's descriptive variables: Age, sample number by age, sex, type of hospitalization and presence of NCDs.

Age	n= 34 (100%)	Sex		Type of Hospitalization		Presence of NCDs
		F (n=13)	M (n=21)	Nursery	UTI	-
11	2 (5,8%)	1 (50%)	1 (50%)	1 (50%)	1 (50%)	2 (100%)
12	5 (14,7%)	2 (40%)	3 (60%)	2 (40%)	3 (60%)	4 (80%)
13	3 (8,8%)	1 (33,3%)	2 (66,7%)	2 (66,7%)	1 (33,3%)	2 (66,7%)
14	8 (23,5%)	1 (12,5%)	7 (87,5%)	5 (62,5%)	3 (37,5%)	6 (75%)
15	4 (11,7%)	2 (50%)	2 (50%)	2 (50%)	2 (50%)	3 (75%)
16	5 (14,7%)	3 (60%)	2 (40%)	4 (80%)	1 (20%)	3 (60%)
17	7 (20,5%)	3 (42,8%)	4 (57,2%)	5 (71,4%)	2 (28,6%)	4 (57,1%)

Note: F: Female; M: Male; ICU: Intensive Care Unit; NCD: Chronic Noncommunicable Disease.
Source: research data.

It was also observed that the sample was enriched by insufficiently active adolescents. The group's overall average weekly physical activity time was 165 minutes. Furthermore, around 70.5% of the sample reported having at least one NCD. Table 2 presents the classification of physical activity and average sleep time.

Table 2 - Physical activity and average sleep time of adolescents after hospitalization for SARS-CoV-2 (n=34)

Physical Activity Classification		Sleep Time on a Weekday (Hour/ Minute)	Average Sleep Time on Weekends
Physically active	9 (26,4%)	7h15	7h40
Insufficiently active	25 (73,5%)	6h45	10h25

Source: research data.

It is worth noting that of the total, 26 (76.4%) reported feeling drowsy during the day after COVID-19. Regarding subjective sleep quality, 27 (79.4%) classified their sleep quality as "good". No significant association was observed between physical activity level and subjective sleep quality. However, both groups of adolescents had a shorter average sleep time on weekdays and longer sleep time on weekends. None of the adolescents reported

using sleeping medication. Table 3 presents the correlation between physical activity level and the variables sleep time, days of hospitalization and presence of comorbidities.

Table 3 – Correlation between physical activity time and the variables: average sleep time, days of hospitalization and presence of comorbidity

Physical activity classification		
Variable	**ρ**	**p-value**
Average sleep time	-,313	0,03*
Days of Hospitalization	-,117	0,18
Presence of comorbidity	-,121	0,12

Note: ρ: Correlation coefficient; *p<0.05.

Source: research data.

Regarding the variables analyzed, the Spearman correlation demonstrated that there is a strong negative correlation between sleep time and level of physical activity (ρ= -,313; p=0,03), however, no significant differences were observed in the correlation between days of hospitalization and level of physical activity (ρ= -,117; p=0.18) and presence of comorbidity and level of physical activity (ρ= -,121; p=0.12).

The objective of this study was to investigate the relationship between the level of physical activity and sleep time in adolescents who required hospitalization in the acute phase of COVID-19. During the initial waves of the pandemic in mid-2020 and 2021, this age group had a lower proportion of clinical worsening of the infection, therefore, children and adolescents with NCDs were the group with greater exposure to worsening of the disease[9].

It is also noteworthy that during the pandemic, infection in this age group was neglected and only understood as reservoirs for the transmission of the disease. However, future presentations demonstrated that this population could also develop serious and potentially fatal forms of the disease in the long term, including the so-called Pediatric Multisystem Inflammatory Syndrome[10].

In the city of Londrina-PR, the number of hospitalizations (ward or ICU) of children and adolescents were low throughout the critical period of the pandemic, possibly because they are an age group less susceptible to the clinical complications of the infection. It is believed that the few cases of hospitalization observed may be related to territorial aspects and local health conditions. In this case, it is noteworthy that hospital mortality due to COVID-19 in adolescents proved to be more intense among municipalities with lower Gross Domestic Product (GDP) per capita, evidenced by lower rates of biological sample collection for diagnosis, X-rays, CT scans, use of ventilatory support and ICU admission. The sample of the present study lives in the South region, which ranks fourth in terms of lethality and ICU admissions[11].

In the present study, the sample was enriched by male adolescents (61.7%). The findings of the present study corroborate a previous retrospective cohort[12] where the majority of children and adolescents hospitalized for COVID-19 were male. It is observed that in this age group, the gender variable is not related to a higher prevalence of hospitalizations, whether in the ward or ICU.

Regarding the symptoms of COVID-19, it was believed that the majority of children and adolescents had no symptoms or few symptoms. In this population, symptoms of the disease vary depending on age. As the sample profile of the present study involves hospitalized cases, it is believed that the median of 6 [3-11] symptoms may be related to the progression of the infection, added to the fact that 70.5% of the sample presented at least least one comorbidity, considered as risk factors for clinical complications in all age groups[13,14].

After the acute phase of SARS-CoV-2 infection, several studies have shown that COVID-19 symptoms can last for long periods, and can affect all age groups[15]. In adolescents, similar studies[16] showed that fatigue, headache, dizziness, dyspnea, chest pain, dysosmia, dysgeusia, reduced appetite, concentration difficulties, memory problems, mental exhaustion, physical exhaustion and sleep problems were more common in individuals with post-COVID syndrome in late adolescence compared to age-matched controls.

Studies with adolescents investigating timing and changes in post-COVID sleep patterns are still scarce, however, the results of the present study indicate that around 76.4% of the sample reported feeling daytime drowsy after infection. Similarly, after six months of being discharged from hospital after recovering from COVID-19, participants showed changes in their sleep. On the other hand, the prospective cohort study[17] carried out with adults showed that around 22.2% of post-COVID patients presented insomnia. Thus, it is possible to observe some variation in results in relation to changes and sleep time after infection[18].

It is also worth highlighting the negative and strong correlation between the level of physical activity and sleep time, which may indicate that the habit of practicing physical activity acts as a component in reducing the pattern of excessive sleep post-COVID, reducing it, as the time of physical activity increases. A study prior to the COVID-19[19] pandemic demonstrated the predominance of excessive sleepiness patterns among insufficiently active adolescents, when compared to physically active adolescents. Furthermore, it was observed that symptoms such as excessive drowsiness were among the most common in patients who were classified as serious/life-threatening cases due to COVID-19[20].

The data showed that around 73.5% of the sample did not meet the recommendations for 180 minutes of moderate physical activity per week proposed by the World Health Organization (WHO). Several studies[21,22] have demonstrated that physical activity acts as a beneficial factor in reducing prolonged symptoms after COVID-19, as well as in the prevention and treatment of infection, since regular physical

activity improves body composition, health cardiorespiratory, metabolic and mental health of patients and increases antibody responses during vaccination[23].

When analyzing the relationship between physical activity level and sleep time compared to pre-pandemic measures, the variables physical activity level, sleep time, screen time and eating pattern of children and adolescents significantly worsened during the COVID-19 pandemic[24]. The negative changes in patterns of healthy habits that remain after the pandemic seem alarming when we analyze the numbers of subjects who had COVID-19 and the long-term damage that the infection can cause, especially in patients who required hospitalization.

This study has limitations that must be considered, such as the cross-sectional design that did not make it possible to monitor the level of physical activity and sleep time since the subacute phase of the infection to investigate possible variations in sleep. Another possible limitation could be the quantitative design of the study, which does not allow for the establishment and understanding of qualitative issues related to the data obtained. Furthermore, the application of questionnaires using a digital form is subject to forgetfulness and information bias, in addition to excluding adolescents without access to technology and the internet.

However, this study contributes to the advancement of research on younger populations, across a wide age range, who were hospitalized due to COVID-19. The quantitative design provides valuable information about the specific group investigated, making it possible to establish relationships between activity and sleep after COVID. It is also expected that the findings of the present study will provide relevant information for professionals who work with post-COVID patients in children and adolescents, promoting possibilities for debates and new studies with interventions to promote healthy habits in populations that have developed an advanced clinical condition. of the infection. It is important that investigations with post-COVID patients continue to be carried out, as a way of observing long-term health outcomes after contamination by SARS-CoV-2.

4 Conclusion

The level of physical activity was correlated with sleep time in children and adolescents two years after hospital discharge. Children and adolescents classified as insufficiently active had more hours of sleep after COVID-19.

References

1. Silva EVS, Saraiva EV, Ferreira GJSN, Peixoto Junior, RM, Ferreira LF. Capacidade do sistema de saúde nos municípios do Rio de Janeiro: infraestrutura para enfrentar a COVID-19. Rev Adm Pública 2020;54(4):578-94. doi: 10.1590/0034-761220200128.
2. Helena M, Roncalli AG. Fatores associados a maior risco de ocorrência de óbito por COVID-19: análise de sobrevivência com base em casos confirmados. Rev Bras Epidemiol 2020;23. doi: 10.1590/1980-549720200106.
3. Leonor E, Gomes CC, Almada Junior LG, Cardoso OA, Jabor PM, et al. COVID-19 em crianças, adolescentes e jovens: estudo transversal no Espírito Santo, 2020. Epidemiol Serv Saúde 2021;30. doi: 10.1590/S1679-49742021000400001.
4. Bernardino FBS, Cristina, RS, Dinágila A, Roberto, MA. Perfil epidemiológico de crianças e adolescentes com COVID-19: uma revisão de escopo. Rev Bras Enferm 2021;74. doi: 10.1590/0034-7167-2020-0624.
5. Araujo, GB, Silva, MVB, Fillis, MMA, Serassuelo Junior, H. Main risk factors identified in hospitalized cases for Covid-19 in the state of Paraná – Brazil. IJDR 2022;12(8):58071-5. doi: 10.37118/ijdr.24937.08.2022.
6. Prado PR, Gimenes FRE, Lima MVM, Prado VB, Soares CP, Amaral TLM. Fatores de risco para óbito por COVID-19 no Acre, 2020: coorte retrospectiva. Epidemiol. Serv Saúde 2021;30(3). doi: 10.1590/S1679-49742021000300018.
7. Rosa RG, Robinson CC, Veiga VC, Cavalcanti AB, Azevedo LCP de, Machado FR, et al. Qualidade de vida e desfechos em longo prazo após hospitalização por COVID-19: Protocolo para um estudo de coorte prospectivo (Coalizão VII). Rev Bras Ter Intens 2021;33:31-7. doi: 10.5935/0103-507X.20210003.
8. Barioni M, Lameira T, Amaral M, Melquíades J, Neto R, Rezende do Prado P. Cawana da Silva do Nascimento Clinical indicators, nursing diagnoses, and mortality risk in critically ill patients with COVID-19: a retrospective cohort. Rev Esc Enferm. USP 2022:56. doi: 10.1590/1980-220X-REEUSP-2021-0568en.
9. Haldun Akoglu. User's guide to correlation coefficients. Turkish journal of emergency medicine [Internet]. Turk J Emerg Med 2018;18(3):91-3. doi: 10.1016/j.tjem.2018.08.001.
10. Feitoza, ALNG, Japhet L, Carla A, Ângela M, Maria D, et al. Comorbidades associadas em pacientes pediátricos positivos com COVID-19. Braz J Infect Dis 2021;25. doi: 10.1016/j.bjid.2020.101104
11. Toraih EA, Hussein MH, Elshazli RM, Kline A, Munshi R, Sultana N, et al. Multisystem inflammatory syndrome in pediatric COVID-19 patients: a meta-analysis. World J Pediatr 2021;17:141-51. doi: 10.1007/s12519-021-00419-y.
12. Fabrin C, Boing AC, Garcia LP, Boing AF. Socioeconomic inequality in hospital case fatality rate and care among children and adolescents hospitalized for COVID-19 in Brazil. Rev Bras Epidemiol 2023;26 doi: 10.1590/1980-549720230015.
13. Nulle T, Isabella M, Julia A, Percio J, Machado M, Maria J, et al. Coorte retrospectiva de crianças e adolescentes hospitalizados por COVID-19 no Brasil do início da pandemia a 1º de agosto de 2020. Rev Bras Epidemiol 2021;24:e210026. doi: 10.1590/1980-549720200026.
14. Feitosa, TMO, Chaves AM, Muniz, GTS. Comorbidades e COVID-19. Interfaces Saúde Hum Tecnol 2020;8(3):711-23. doi: 10.16891/800.
15. Mesenburg, MA, Hallal, PC, Menezes AMB, Barros AJD, Horta BL, Barros FC, et al. Doenças crônicas não

transmissíveis e covid-19: resultados do estudo Epicovid-19 Brasil. Rev Saúde Pública 2021;55(38). doi: 10.11606/s1518-8787.2021055003673.

16. Davis HE, McCorkell L, Julia Moore Vogel, Topol EJ. Author Correction: Long COVID: major findings, mechanisms and recommendations. Nat Rev Microbiol 2023;21(6):408. doi: 10.1038/s41579-022-00846-2.

17. Sorensen, AIV, Spiliopoullos, L, Bager P, Nielsen NM, Hansen JV, Koch A, et al. A nationwide questionnaire study of post-acute symptoms and health problems after SARS-CoV-2 infection in Denmark. Nat Comm 2022;13(1):4213. doi: 10.1038/s41467-022-31897-x.

18. Huang C, Huang L, Wang Y, Li X, Ren L, Gu X, et al. RETRACTED: 6-month consequences of COVID-19 in patients discharged from hospital: a cohort study. Lancet 2021;401)10393):e21-e33. 2021. doi: 10.1016/S0140-6736(23)00810-3.

19. Moura AEF, Oliveira DN, Torres DM, Tavares Junior JWL, Nobrega PR, Braga Neto P, et al. Central hypersomnia and chronic insomnia: expanding the spectrum of sleep disorders in long COVID syndrome - a prospective cohort study. BMC Neurol 2022;22(1):417. doi.10.1186/s12883-022-02940-7.

20. Rombaldi, AJ, Soares, DG. Indicadores da prática de atividade física e da qualidade do sono em escolares adolescentes. Rev Bras Ciên Esp 2016;38:290-6. doi: 10.1016/j.rbce.2015.10.010.

21. Merikanto I, Yves D, Chung F, Wing YK, Gennaro L, Holzinger B, et al. Sleep symptoms are essential features of long-COVID – Comparing healthy controls with COVID-19 cases of different severity in the international COVID sleep study (ICOSS-II). J Sleep Res 2023;32(1):e13754. doi: 10.1111/jsr.13754.

22. Jimeno-Almazán, A, Pallarés JG, Buendía-Romero A, Martinez-Cava A, Franco-Lopez F, Martinez BJS-A, et al. Post-COVID-19 Syndrome and the Potential Benefits of Exercise. Int J Env Res Public Health 2021;18(10):5329. doi: 10.3390/ijerph18105329.

23. Clemente-Suárez VJ, Beltrán-Velasco AI, Ramos-Campo DJ, Mielgo-Ayusoi J, Nikolaidis PA, Belando N, et al. Physical activity and COVID-19. The basis for an efficient intervention in times of COVID-19 pandemic. Physiol Behavior 2022;244. doi: 10.1016/j.physbeh.2021.113667.

24. Burkart S, Parker H, R Glenn Weaver, Beets MW, Jones A, Adams EL, et al. Impact of the COVID-19 pandemic on elementary schoolers' physical activity, sleep, screen time and diet: a quasi-experimental interrupted time series study. Pediatric Obesity 2021;17(1). doi: 10.1111/ijpo.12846.