Impact of Insolation on Melatonin, Sleep Disorders, Cerebral Ischemia, and Cognitive Functions

Zufar Adambaev*, *Markhamat* Yakubova, and *Ravshan* Olmosov

Tashkent Medical Academy, Tashkent, Uzbekistan

Abstract. The article explores the effect of insolation on the level of serum melatonin, sleep disorders, chronic cerebral ischemia and cognitive functions. Eighty patients with chronic cerebral ischemia (CCI) were examined. The average age of the patients was 58.5±1.4 years. The patients were divided into 6 groups depending on the presence of sleep disorders and the stage of CCI. The concentration of melatonin in the blood was studied depending on the season. Sleep disorders and cognitive impairment were assessed using special questionnaires, and cognitive evoked potentials P300 were studied. To correct sleep disorders, patients took melatonin. The concentration of melatonin in the blood is subject to seasonal changes in the duration of daylight, with maximum values in winter and minimum in summer. With increasing age and severity of cerebral ischemia, a decrease in the concentration of melatonin in the blood is observed. As the severity of CCI increases, cognitive indices deteriorate, as indicated by questionnaires and cognitive evoked potentials, which show an increase in P300 latency. Additionally, daytime sleepiness, as measured by the Epworth scale, also tends to worsen. Sleep disturbance in patients with CCI leads to a decrease in cognitive functions.

Keywords: insolation, seasonality, sleep disorders, cognitive impairment, cognitive evoked potentials, chronic cerebral ischemia, melatonin

1 Introduction

With a global life expectancy exceeding 60 years and projected to reach 2 billion people of this age by 2050 [1], cerebrovascular diseases, particularly chronic cerebral ischemia (CCI), are becoming increasingly common, currently accounting for almost two-thirds of all cerebrovascular diseases [2]. CCI often leads to cognitive impairment (CI), with mild to moderate symptoms often serving as early indicators of the disease [4]. Studies have shown that methods such as the P300 cognitive evoked potential (CEP) are effective in detecting CI as they reveal changes in impulse propagation and latency, particularly due to age-related neuronal changes [7].Melatonin, a hormone with antioxidant properties, plays a key role in regulating sleep and cognitive functions. Its production declines with age, leading to potential sleep disturbances and contributing to the progression of cerebrovascular diseases [3,6].

* Corresponding author: zufargms@mail.ru

© The Authors, published by EDP Sciences. This is an open access article distributed under the terms of the Creative Commons Attribution License 4.0 (https://creativecommons.org/licenses/by/4.0/).

Seasonal variations, such as insolation changes, significantly affect melatonin synthesis, further complicating CCI symptoms and sleep disturbances [5]. This study aims to explore how seasonality influences serum melatonin levels and CCI severity, offering a potentially beneficial approach to understanding and managing CCI and related cognitive impairments in the elderly. These findings may provide crucial insights for enhancing treatments in medical sciences.

2 Materials and methodology

The study involved 80 patients with chronic cerebral ischemia (CCI), with an average age of 57.8±11.4 years, divided equally between men and women. The diagnosis of CCI was confirmed using clinical data and neuroimaging methods. To assess melatonin levels and their seasonal variations, blood samples were collected from all patients at 22:00 and analyzed using enzyme-linked immunosorbent assay (ELISA) on the Mindray MR 96 A system. Melatonin levels were compared against the reference value of 180 pg/ml. Of these 80 patients, 63 were further examined for sleep disorders and cognitive impairment, split into two groups based on the presence of sleep disturbances and further divided into three subgroups according to the stage of CCI. Cognitive function was assessed using the Mini-Mental State Examination (MMSE) and Montreal Cognitive Assessment (MOCA), while daytime sleepiness was evaluated using the Epworth Sleepiness Scale (ESS). Additionally, the P300 method was employed to measure cognitive evoked potentials using auditory stimuli.

Inclusions for the study included patients with confirmed CCI, while exclusions likely involved those with other comorbid conditions affecting cognition or sleep. The study likely spanned several months to account for seasonal variations, and statistical significance was assessed using Student's t-test, with a p-value of less than 0.05 considered significant.

3 Results

The results of the study indicate that melatonin levels in patients with chronic cerebral ischemia (CCI) were significantly lower compared to healthy individuals, demonstrating a 2-2.5 times reduction. As observed in Table 1, melatonin levels decreased progressively with the severity of CCI. Patients in the CCI stage 1 group had an average melatonin level of 143.82 pg/ml, while those in CCI stage 3 had a significantly lower level of 54.57 pg/ml, illustrating a clear correlation between CCI severity and melatonin reduction.

Table 1. Melatonin Levels in CCI Patients.

Group	n	Melatonin, pg/ml
CCI 1	32	143.82
CCI 2	17	76.81
CCI 3	31	54.57
All patients	80	94.99

Additionally, seasonal fluctuations in melatonin were analysed. As shown in Figure 1 (not displayed here), the highest concentrations of melatonin were found in winter when daylight hours were shortest, while the lowest concentrations occurred during the summer months, supporting the hypothesis that melatonin levels are inversely related to daylight duration.

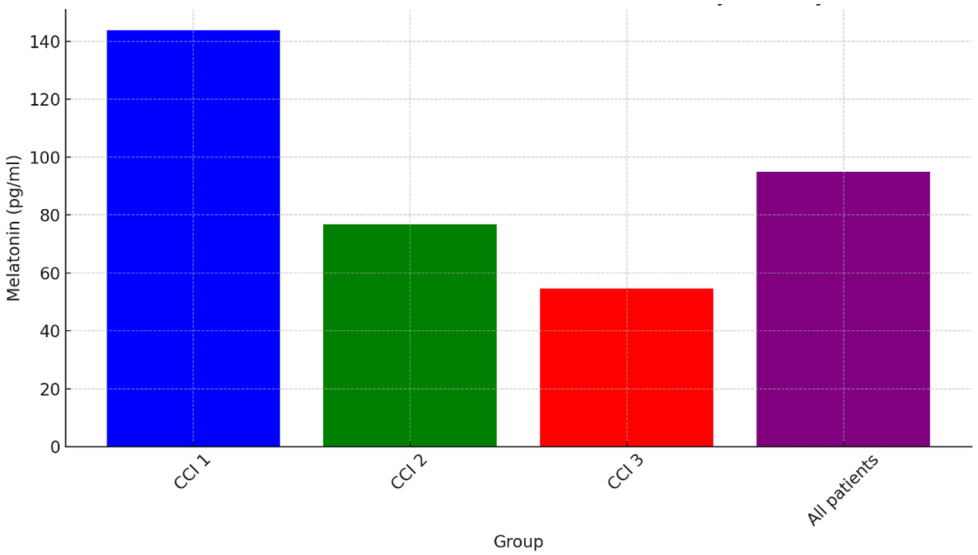

Fig. 1. Serum Melatonin Levels in Patients with CCI by Severity.

In terms of sleep disorders, patients were assessed for daytime sleepiness using the Epworth Sleepiness Scale (ESS), and cognitive impairment was measured through the MMSE and MOCA scales. Patients with higher stages of CCI and sleep disturbances showed significant cognitive impairment, with increased latency in P300 evoked potentials, further reflecting the decline in cognitive function as CCI worsened.
Melatonin therapy led to significant improvements, particularly in patients with sleep disorders, as indicated by reduced daytime sleepiness scores and shortened P300 latencies (see Table 2).

Table 2. Epworth, MMSE, And MOCA Scores in CCI Patients.

Stage	**Epworth Scale Before Treatment**	**Epworth Scale After Treatment**	**MMSE Before Treatment**
CCI 1st stage	7.1	6.8	25.2
CCI 2nd stage	14.2	12.1	25
CCI 3rd stage	17.7	13.4	21.9
Stage	**MMSE After Treatment**	**MOCA Before Treatment**	**MOCA After Treatment**
CCI 1st stage	27.1	28	28.2
CCI 2nd stage	26.2	26.3	26.8
CCI 3rd stage	24.1	20.8	22.9

Figure 2 above illustrate the results of the study, focusing on the Epworth Sleepiness Scale (ESS) and cognitive function assessments (MMSE and MOCA) for patients with chronic cerebral ischemia (CCI) across different stages. In the first chart, the Epworth scale scores show a significant decrease after melatonin therapy, particularly in patients at the second and third stages of CCI, indicating improved daytime alertness. The second chart highlights improvements in cognitive function, as both MMSE and MOCA scores increased after treatment, particularly in more advanced stages of CCI.

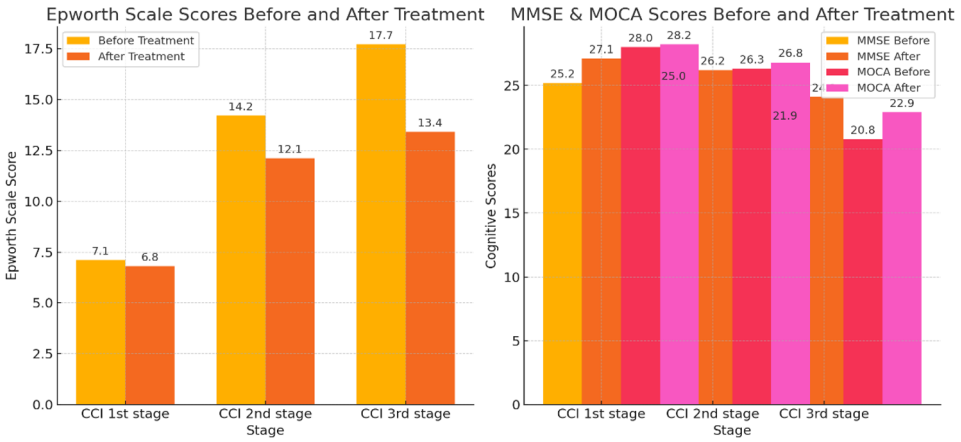

Fig. 2. MMSE & MOCA Scores Before and After Treatment.

The data clearly show that melatonin treatment had a positive effect on both sleep quality and cognitive performance, as demonstrated by the improved ESS, MMSE, and MOCA scores.

4 Discussion

The study reveals several critical insights into the relationship between melatonin levels, chronic cerebral ischemia (CCI), cognitive function, and sleep disturbances. The average melatonin levels in CCI patients were found to be 2-2.5 times lower than the reference values, affirming the well-documented age-related decline in melatonin production. Moreover, melatonin levels were further reduced in patients with more severe stages of CCI, with those in CCI stage 1 having an average level of 143.82 pg/ml, which dropped significantly to 54.57 pg/ml in stage 3 patients.

Seasonal variations also impacted melatonin concentrations, with the highest levels recorded in winter and the lowest in summer. This finding supports the hypothesis that melatonin secretion is inversely proportional to daylight exposure, which may exacerbate symptoms of CCI and sleep disorders during longer daylight periods.

In terms of cognitive impairment, patients with more advanced stages of CCI exhibited worse cognitive function, as reflected in their MMSE and MOCA scores. For example, stage 3 CCI patients had an average MMSE score of 21.9 before treatment, significantly lower than stage 1 patients. After one month of melatonin therapy, notable improvements were observed, especially in stages 2 and 3, where MMSE scores improved by 1.2 to 2.2 points.

Similarly, daytime sleepiness, measured by the Epworth Sleepiness Scale (ESS), worsened with the severity of CCI, but melatonin therapy led to marked improvements, especially in stage 3 patients, where scores reduced from 17.7 to 13.4. These findings suggest that melatonin supplementation positively influences sleep and cognitive functions, particularly in more advanced CCI cases.

5 Conclusion

In conclusion, this study highlights a significant decrease in melatonin levels in patients with chronic cerebral ischemia (CCI), especially in the late stages of the disease. Results showed that melatonin levels were 2-2.5 times lower in patients with CCI compared to

healthy controls, with a further decrease observed as the severity of CCI increased. Seasonal variations also affected melatonin levels, with the lowest levels observed in summer. Cognitive impairment and sleep disturbances, which worsened with the severity of CCI, were significantly improved after one month of melatonin therapy. Patients showed an improvement in cognitive function, as reflected by increased MMSE and MOCA scores, as well as a decrease in daytime sleepiness based on the Epworth Sleepiness Scale. These results suggest that melatonin supplementation may be a useful treatment for improving sleep quality and cognitive function in patients with CCI. Future research should focus on investigating the long-term effects of melatonin therapy, as well as its potential role in the treatment of other neurodegenerative and age-related conditions, offering broader clinical application.

References

1. United Nations Department of Economic and Social Affairs/Population Division. (2015). *World population prospects: The 2015 revision, key findings and advance tables* (p. 59).
2. Zakharov, V. V., Sleptsova, K. B., & Martynova, O. O. (2021). Chronic cerebral ischemia: A view from the 21st century. *RMJ*, *5*, 45–49.
3. Fedin, A. I. (2016). Diagnosis and treatment of chronic cerebral ischemia. *Consilium Medicum*, *18*(2), 8–12.
4. Ekusheva, E. V. (2018). Cognitive impairment is a pressing interdisciplinary problem. *RMJ*, *12*(I), 32–37.
5. Starchina, Y. A., & Zakharov, V. V. (2021). Severity and treatment of cognitive impairment. *Neurology, Neuropsychiatry, Psychosomatics*, *13*(3), 119–124. https://doi.org/10.14412/2074-2711-2021-3-119-124
6. Jos, Y. S., & Kalinina, L. P. (2018). Cognitive evoked potentials in neurophysiological studies (review). *Journal of Medical-Biological Research*, *6*(3), 223–235. https://doi.org/10.17238/issn2542-1298.2018.6.3.223
7. Ignatova, Y. P., Makarova, I. I., & Strakhov, K. A. (2022). Cognitive evoked potentials: P300 in neurophysiology and clinical practice. *Crimean Journal of Experimental and Clinical Medicine*, *12*(4), 80–91.