E.A. Abashidze[1], L.S. Namazova-Baranova[1,2,3], O.V. Kozhevnikova[1], V.V. Altunin[1], A.K. Gevorkyan[1,2]

[1]Scientific Center of Children's Health, Moscow, Russian Federation

[2]The First Sechenov Moscow State Medical University, Russian Federation

[3]Pirogov Russian State Medical Research University, Moscow, Russian Federation

Sleep quality and structure assessment in children with a pathology of ENT-organs, bronchial asthma and the most widespread nervous system diseases

Author affiliation:

Abashidze Eka Amiranovna, doctor at the instrumental and laboratory diagnostics of the consultative-diagnostic center of the research institute of preventive pediatrics and medical rehabilitation of the Scientific Center of Children's Health

Address: 2/1, Lomonosovskiy Av., Moscow, 119991, **tel.:** +7 (495) 967-14-20

Article received: 03.10.2012 accepted for publication: 24.03.2013

At present ca. 25% of children have sleep disorders. The main method of diagnosing sleep disorders is polysomnography. The article presents the analysis of night sleep study results in children with various pathologies. The study involved 103 children in total; 13 of them formed the control group. It is necessary to conduct a complex examination of sleep-wake cycle disorders involving a quantitative assessment of subjective complaints using a questionnaire and objective polysomnographic registration of night sleep parameters.

Key words: *sleep disorders, ENT pathology, bronchial asthma, neurological diseases, polysomnography, children.*

Sleep is a natural wonder and wonderful acquisition of the humankind. Sleep hosts human (especially children's) energy-saving activity. Sleep quality reflects life quality of a healthy or ill child. Sleep influences all aspects of children's physical, emotional, cognitive and social development. Sleep disorders are observed in 11% of small infants and in 25% of children of preschool and school age [1]. At present, ca. 25% of children have sleep disorders: from falling asleep difficulties and somnambulism to more serious problems, such as sleep apnea or narcolepsy [2]. Study conducted by P. Lam (2003) indicated the severity of this issue; they state that sleep disorders diagnosed in children under 1 year of age have a tendency to chronization in 32% of cases. Chronic sleep pathology consequences may be attention deficit hyperactivity disorder; aggressive, deviant behavior; learning capability impairment [3-5]. According to international studies, timely diagnostics of sleep disorders and sleep apnea syndrome in outpatient pediatric

practice reduces the number of children with severe disorders requiring hospitalization [6]. At the same time, it is especially important to timely detect and diagnose sleep disorders in children and adolescents with chronic pathology, as many of them are symptoms of the main disease and are effectively leveled by adequate therapy [7].

Sleep disorders in children may be connected with manifestations of nervous system diseases, such as attention deficit hyperactivity disorder, epilepsy and parasomnia. Studies show that attacks take place primarily or exclusively during sleep in 10-45% of children with epilepsy [8]. Sleep respiratory disorders are considered to be the most widespread cause of sleep disorders in children; they appear in 2-3% of children with ENT-pathology and can be detected at any age; however, they are most often found at the age of 2-7 years [9].

Night broncho-obstruction attacks are noted in more than 50% of cases in children with bronchial asthma [10]; this considerably impairs sleep quality and, thus, aggravates bronchial asthma course [11].

The sleep disorder diagnostics is based on polysomnography – simultaneous recording of multiple physiological parameters characterizing body state during sleep. Polysomnography is used to reveal cause and assess severity of sleep disorder. This method is the “gold standard” of obstructive sleep apnea syndrome.

There have been international studies of children’s sleep norms, however, their results vary dramatically due to cultural-ethnic peculiarities of the population under study [12]; this is the main problem when interpreting the obtained results.

Thus, one of the important tasks of pediatrics is to diagnose sleep disorders in children on the early development stages to conduct adequate correction and full-scale recovery. The developed techniques of early diagnostics should allow for peculiarities of sleep disorders in children with different pathologies [13, 14].

The aim of this research is to study sleep alterations in children with the most widespread nervous system diseases and somatic pathology by using special forms and night polysomnographic study.

Patients and methods

The study was conducted at the instrumental and laboratory diagnostics department of the Consultative-diagnostic center of the research institute of preventive pediatrics and medical rehabilitation “Scientific Center of Children’s Health”.

The study involved 103 children of 3-17 years of age: 90 patients with somatic pathology and nervous system diseases formed groups under study, while 13 apparently healthy children formed the control group.

The study was conducted in 2 stages:

1 – interviewing of patients and their parents, primarily to reveal complaints of sleep disorders and reveal their influence on the general condition in case they are present; form-filling;

2 – polysomnographic study throughout the nocturnal sleep.

The study involved patients with the most widespread nervous system diseases and somatic pathology divided into 4 groups.

Group I was comprised of 35 children (24 boys and 11 girls) with nervous system diseases: 15 children (43%) with parasomniae, 8 (22%) with epilepsy, 6 (18%) with cephalgia and 6 (18%) with attention deficit hyperactivity disorder.

Group II was comprised of 25 children (17 boys and 8 girls) with isolated ENT-pathology (II-III grade adenoids, II-III grade hypertrophy of palatine tonsils).

Group III was comprised of 30 children (20 boys and 10 girls) with diagnosis "Moderate and severe atopic bronchial asthma, remission" of median age of 13.5 years. Bronchial asthma in these children was fully controlled.

Control group was comprised of 13 conventionally healthy children of median age of 10 years.

On the 1st stage, all patient groups were polled. In order to diagnose sleep disorders in children we had developed a questionnaire for active finding of various complaints on the most frequent night sleep disorders in children. The form was filled during the interview with patients and parents. The interviewed were offered choice: "Present" or "Not present" ("Yes" or "No"). It is known that sleep quality depends on such parameters as duration of falling asleep, sleep duration and number of nocturnal awakenings, which is why we developed a questionnaire to reveal sleep disorders; it allowed for various complaints on the most frequent night sleep disorders in children. The form's general information included:

- child's passport details (surname, forename, date of birth), sex;
- sections on child's sleep schedule on weekdays, at the weekend, including holidays, day sleep schedule (if present), peculiarities of falling asleep;
- data on symptoms observed at night sleep and symptoms observed in the morning and in the afternoon.

On the 2nd stage, all patients underwent polysomnographic study for objective evaluation of sleep quality and structure; it included simultaneous registration of electroencephalogram, electro-oculogram, electromyogram of masseters, electrocardiogram, motion activity, respiratory motions of chest and abdominal wall, oronasal flow, hemoglobin oxygen saturation with synchronous video monitoring.

Hypnogram was graphed on the basis of the analysis of these parameters; it reflected dynamics of sleep stages and phases during registration.

Evaluating polysomnography, we analyzed duration of slow sleep and rapid eye-movement sleep in relation to the total sleep duration; total sleep duration; sleep effectiveness (total sleep duration in relation to total registration duration); latency to the stage I of slow sleep (amount of minutes from turning off light to the appearance of the first 3 EEG-observable consequent 30-

second-long epochs corresponding to stage I of sleep or the first 30-second-long epoch of any other stage); total wakefulness duration during sleep, apnea/hypopnea index (number of apnea/hypopnea episodes per 1 hour of sleep), average heart rate and the level of blood hemoglobin oxygen saturation (SpO_2). Polysomnographic recording continued throughout sleep.

Statistical processing of the obtained data was conducted using application packages "Statistica" (Statsoft Inc., USA; version 8.0).

As long as the level distribution of most studied parameters was not within norm and group dispersions were not equal, differences between groups were determined by a nonparametric Kruskall–Wallis test, and in case there were statistically significant differences, Mann-Whitney-test-assisted paired comparisons were conducted. We deemed differences with $p<0.05$ statistically significant. Link (correlation) analysis of 2 quantitative parameters was conducted using a Spearman nonparametric grade correlation method.

Study results and their discussion

The polling of apparently healthy children conducted on the 1st stage showed that only singular patients actively complained of sleep disorders (2 out of 13 children, 15%).

According to the forms, the overwhelming majority of patients with the most widespread children's diseases complained of sleep disorders – 85% (pic.). All main sleep characteristics were subjectively assessed rather low; the most significant were sleep breathing disorder (60%) and snore (55%). Respiration disorders, complaints of tumultuous sleep (56%) and night awakenings (44%) were frequent among complaints of sleep disorders. The widespread symptoms of sleep disorders also featured falling asleep difficulties; increase in time span needed for falling asleep; tumultuous sleep, somniloquence, gritting of teeth, diurnal drowsiness and morning restlessness. Further, we analyzed polling data of patients with various diseases.

Thus, a significantly bigger number of the group I children (76%) complained of night sleep disorders in comparison with the group of apparently healthy children.

Low subjective evaluation concerned most main sleep characteristics, the most frequent being night awakenings (32%) and tumultuous sleep (33%). The group I children mostly complained of night sleep disorders specifically (tumultuous sleep, night awakenings); at the same time, the main complaints of all patient groups were concerned with sleep respiratory disorders.

Appraisal of diurnal behavior of children revealed that diurnal drowsiness is observed in 26% of children; 39% of children complained of morning restlessness. All data are significantly different from the results obtained in the control group.

Analysis of subjective sleep appraisal in the group II children revealed that almost all children actively complained of night sleep disorders (95%), the most prevalent complaints being sleep respiratory disorders (88%), snore (80%), tumultuous sleep (79%), the less frequent being night awakenings and falling asleep difficulties; children complained of somniloquence and bruxism only in case of active purposeful questioning; snore was observed in 90% of children

complaining of sleep disorders. 60% of children complained of diurnal drowsiness; 40% of children complained of morning restlessness.

Thus, sleep respiratory disorders in the group II children were 4 times more frequent than in the group I children (88 and 20%, correspondingly). High representation of all main complaints among the group II children was caused by the influence of intense respiratory disorders on the sleep structure.

The group III children (with the most widespread allergic disease – bronchial asthma) complained of sleep disorders only in case of active purposeful questioning. This group's patients mostly complained of tumultuous sleep (36%) and respiratory disorders (30%), less – of falling asleep difficulties (25%) and snore (19%). According to the forms appraising diurnal behavior, 40% of children complained of diurnal drowsiness; 6% of children complained of morning restlessness.

Thus, the most frequent complaint in the group III children in comparison with groups I and II was diurnal drowsiness.

On the 2nd study stage we conducted polysomnography to apparently healthy children (control group) and revealed that the time percentage of superficial and deep slow sleep stages and of rapid eye-movement sleep were within children's norm. Apnea/hypopnea index, i.e. number of apnea/hypopnea per 1 hour of sleep and the average minimal blood hemoglobin oxygen saturation during night sleep in the control group was not significantly different from the recommended norm.

Objective polysomnographic sleep study in the group I children revealed that percentage of the superficial (I) slow sleep stage was statistically significantly higher in children with nervous system diseases than in the control group children (13.9 and 6.9%; $p<0.05$), which could have been caused by the restriction of sleep initiation and maintenance mechanisms. At the same time, the percentage of deep slow-wave sleep stages and of rapid eye-movement sleep was statistically significantly lower (22.9/36.5 and 14.8/24.0%, correspondingly; $p<0.05$); this may indicate the insufficiency of sleep recovery function (tb.). No significant alterations of sleep effectiveness, falling asleep duration and wakefulness duration during sleep were not found in the studied patients.

Thus, high spread of complaints of night sleep disorders associated with objective alterations of sleep structure parameters is noted in children with nervous system diseases. Moreover, deficit of the main sleep stages – delta sleep and rapid eye-movement sleep – is noted in all children with nervous system diseases. Disturbed sleep architecture in the group I children is most probably connected with the insufficiency of the basic somnogenic mechanisms.

Interdependence of severity of subjective complaints of sleep disorders and intensity of sleep architecture disorders was revealed in patients with ENT-pathology. Polysomnography of these children revealed a statistically significant shortening of slow sleep stage down to 23% and

rapid eye-movement down to 14.5% in comparison with the control group (36.5 and 24.0%, correspondingly; $p<0.005$); statistically significant alterations of respiratory parameters – increase in the apnea/hypopnea index to 6.8 per hour in comparison with the control group ($p<0.05$). Shorter rapid eye-movement sleep in children with ENT-pathology may have been caused by the fragmentation of rapid eye-movement sleep periods by apnea/hypopnea episodes. Thus, convincing link between subjective and objective parameters of sleep disorders was revealed in the group II children.

Sleep architecture analysis in children with bronchial asthma (group III) revealed that percentage of superficial slow sleep stages was significantly higher (more than 2.5 times) than in the group of apparently healthy children (18.7 and 6.9%, correspondingly; $p<0.05$). At the same time, percentage of deep slow-wave sleep (delta sleep) stages and rapid eye-movement sleep was statistically significantly lower (14.9 and 24.0%, correspondingly; $p<0.05$). We believe that these alterations may have been caused by insufficiency of primary sleep initiation and maintenance mechanisms.

Polysomnographic study of the group III also revealed increase in the wakefulness duration during sleep in patients with bronchial asthma in comparison with the group of apparently healthy children (5.4 and 1.5%, correspondingly; $p<0.05$); this correlate with subjective complaints of tumultuous sleep and diurnal drowsiness revealed by an active purposeful questioning of patients. Increase in the wakefulness duration during sleep in children with bronchial asthma manifested itself by an increase in the number of awakening episodes and, accordingly, negatively influenced sleep quality.

As tb. 1 shows, no clinically significant alterations of sleep duration and effectiveness, latency to the I slow sleep stage were revealed in the observed patients; apnea/hypopnea index, heart rate, average minimal blood hemoglobin oxygen saturation during night sleep in these children were not significantly different from the control group, too.

Thus, general polysomnographic sleep structure alterations in children with somatic pathology and the most widespread nervous system diseases in comparison with their healthy peers are the increase in superficial slow sleep stages in the setting of reduction of rapid eye-movement sleep and deep slow sleep stages. However, these alterations have different causes. These alterations in children with nervous system diseases may be caused by the insufficiency of the basic somnogenic mechanisms providing the recovery of mental and somatic spheres in children with chronic pathology. Sleep disorders in children with ENT-pathology are connected with sleep respiratory disorder (apnea/hypopnea episodes); this leads to secondary sleep structure alterations and indicates the reduction in the adaptive function of sleep.

Specific feature of sleep structure alteration in patients with bronchial asthma in comparison with the group of apparently healthy children is the increase in the wakefulness

duration (more than 3 times); this is most probably connected with the sleep disorder caused by work of the cerebral activating systems.

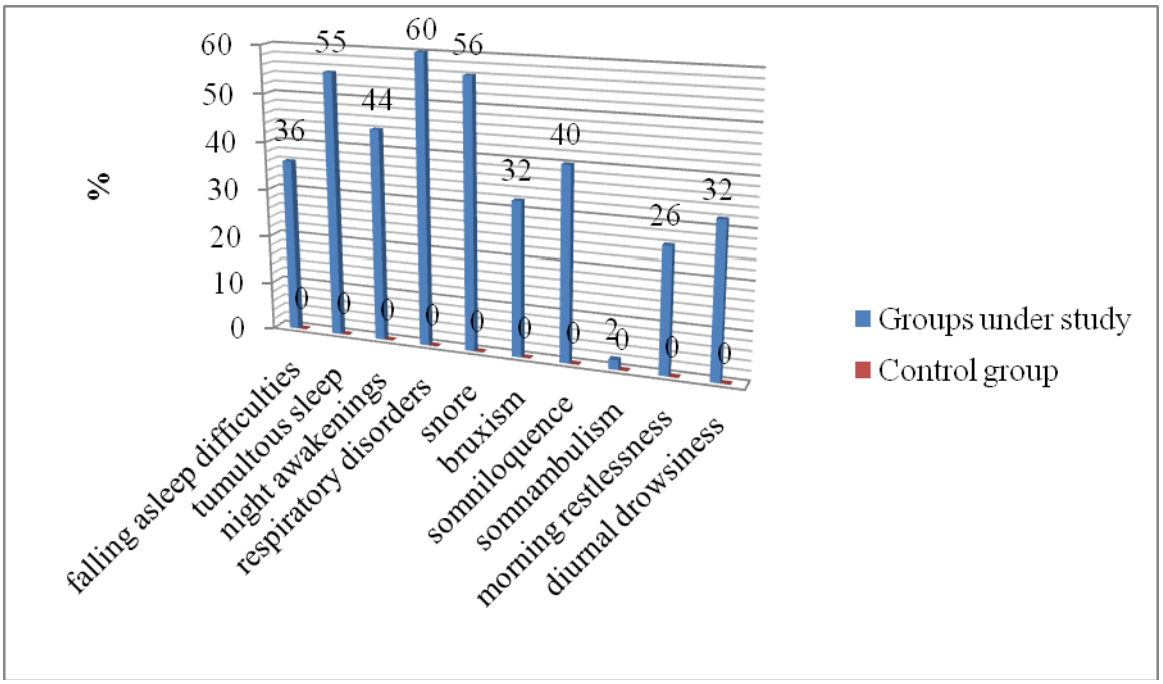
The most significant alteration in children with ENT-pathology, which distinguishes them from both apparently healthy children and patients with other chronic diseases, is the increase (6-20 times) in apnea/hypopnea index, which is why hypertrophy of tonsils and/or of adenoids together with complaints of respiratory distress and snore are indications to polysomnography in children. Polysomnographic study must be one of the compulsory paraclinic methods of examining children with ENT-pathology with obstructive sleep apnea syndrome, as it can accurately determine the pathogenetic character of sleep disorders and indications to operative intervention.

Children with sleep disorders should receive complex analysis of sleep-wakefulness cycle disorders including 2 stages: polling (quantitative assessment of subjective complaints connected with pre-, intra- and postsomnic disorders) and subsequent objective polysomnographic registration of night sleep parameters, which may be conducted outpatiently.

REFERENCES

1. National sleep foundation, 2004. Available at: http://www.sleepfoundation.org
2. Baranov A.A., Namazova L.S., Ignat'eva R.K., Kagramanov V.I. *Profilaktika rasstroistv sna u detei i podrostkov* [Prevention of Sleep Disorders in Children and Adolescents]. Moscow, 2006. pp. 9–11.
3. Namazova L.S., Abashidze E.A., Kozhevnikova E.V., Arshba S.K. Sleep disorder. *Pediatricheskaya farmakologiya – Pediatric pharmacology*. 2008; 5 (5): 69–73.
4. Owens J. A., Fernando S., Mc Guinn M. Sleep disturbance and injury risk in young children. *Behav Sleep Med*. 2005; 3 (1): 18–31.
5. Gozal D., SansCapdevila O., Kheirandish-Gozal L., McLaughlin Crabtree V. Apolipoprotein E _4 allele, neurocognitive dysfunction, and obstructive sleep apnea in school-aged children. *Neurology*. 2007; 69 (3): 243–249.
6. Meltzer L. J., Johnson C., Crossette J., Ramos M., Mindell J.A. Prevalence of diagnosed sleep disorders in pediatric primary care practices. *Pediatircs*. 2010; 125 (6): 1410–1418.
77. Efendieva K.E. *Vliyanie razlichnykh metodov lecheniya na kachestvo zhizni detei, stradayushchikh bronkhial'noi astmoi. Avtoref. dis. … kand. med. nauk* [Effects of Different Treatments on the Quality of Life of Children with Asthma. Author's abstract]. Moscow, 2005. p. 5.
8. Malow B. A., Levy K., Maturen K. et al. Obstructive sleep apnea is common in medically refractory epilepsy patients. *Neurology*. 2010; 55: 1002–1007.
9. International classification of sleep disorders, revised: Diagnostic and coding manual. *Rochester, Minnesota: American Sleep Disorders Association*. 1997.
10. Clark T. J. N., Hetzel M. R. Diurnal variation of asthma. *Br J Dis Chest*. 1977; 71: 87–92.
11. Montplaisir J., Walsh J., Malo J. L. Nocturnal asthma: features of attacks, sleep and breathing patterns. *Am Rev Respir Dis*. 1992; 125: 18–22.
12. Iglowstein I., Jenni O. G., Molinari L., Largo R. H. Sleep duration from infancy to adolescence: Reference values and generational trends. *Pediatrics*. 2003; 111 (2): 302–307.
13. Owens J. A., Dalzell V. Use of the «BEARS» sleep screening tool in a pediatric residents' continuity clinic: a pilot study. *Sleep Med*. 2010; 6 (1): 63–69.
14. Altunin V.V., Namazova-Baranova L.S., Kozhevnikova O.V. *Voprosy diagnostiki v pediatrii – Problems of diagnosis in pediatrics*. 2009; 1 (5): 30–35.

Pic. General structure of complaints in children of all groups under study



Note. p<0.05.

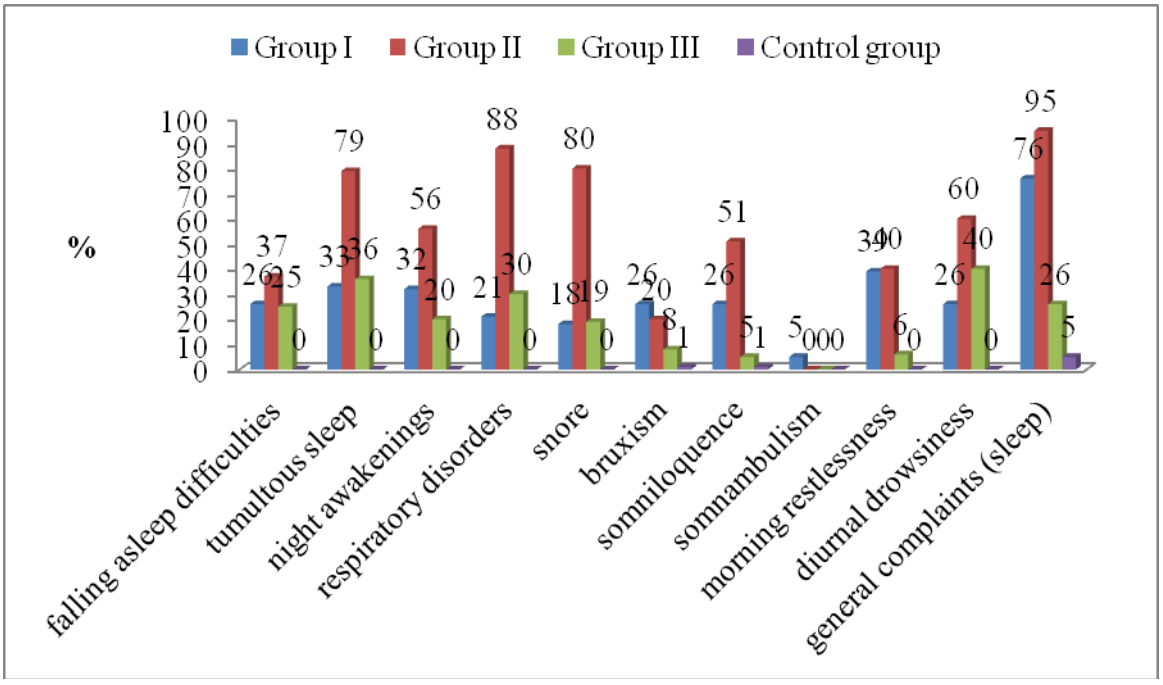


Table. Objective sleep structure parameters

Parameter	Median (interquartile range)			
	Group I	Group II	Group III	Control

				group
Age	9.0 (5.0; 12.0)	7 (6; 9)	13.5 (8.0; 16.0)	10 (8.0; 14.0)
Sleep stage I (S1), %	13.9 (5.5; 23.3)*	8.7 (4.4; 23.1)	18.7 (7; 24.2)*	6.9 (2.8; 9.0)
Sleep stage II (S2), %	37.4 (29.4; 45.8)	43.3 (34; 49.2)*	40.5 (34; 43.9)	30.6 (29.0; 41.4)
Slow sleep stages (S3+S4), %	22.9 (18.8; 32.0)*	23.0 (18.1; 29.1)*	22.4 (18.9; 28.0)*	36.5 (28.9; 38.0)
Rapid eye-movement sleep	14.8 (10.1; 19.0)*	14.5 (5; 19.7)*	14.9 (10.3; 18.0)*	24.0 (20.8; 27)
Wakefulness duration during sleep (minutes)	3.1 (0.8; 7.5)	4.4 (0.6; 7.8)	5.4 (2.9; 9.1)*	1.5 (0.6; 3.0)
Body weight index	17.5 (15.0; 22.2)	18.6 (16.5; 22.3)	19.3 (17.6; 21.3)	18.0 (16.7; 19.5)
Sleep duration (minutes)	462 (445.6; 517.0)	471.5 (405; 514.4)	495.1 (429; 551.7)	484 (477; 504)
Apnea and hypopnea index	1.5 (0.5; 2.3)	4.8 (3.3; 7.2)*	0.3 (0.0; 1.2)	0.3 (0.2; 0.4)
SpO_2	98.2 (98.0; 98.5)	97.6 (95; 98.4)	98.05 (97.5; 98.7)	98 (97.8; 98.7)
Heart rate (bpm)	72 (68.9; 81)	78 (70; 88.3)	66.5 (61; 78.7)	73 (68; 74.6)
Sleep effectiveness (%)	95.9 (90.5; 98.3)	94.3 (90; 99.4)	93.7 (90.9; 95.7)	98.5 (94; 99.9)
Latent period of the stage I (minutes)	14 (5.3; 29.0)	23.1 (5.1; 29.6)	8.4 (5.6; 18.7)	14 (13.2; 15.0)

Note. * - differences are significant ($p<0.05$) between groups I, II, III and control group. SpO_2 – blood hemoglobin oxygen saturation level.