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PHOTOPERIODIC CHRONOTYPE STABILITY IN STUDENTS OF KHANTY-MANSI AUTONOMOUS AREA – YUGRA AND VLADIKAVKAZ

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ФОТОПЕРИОДИЧЕСКАЯ УСТОЙЧИВОСТЬ ХРОНОТИПА У СТУДЕНТОВ ХМАО – ЮГРЫ И ВЛАДИКАВКАЗА

Abstract. The aim of the work is to establish the peculiarities of the organization of various aspects of life in the dynamics of the *winter/summer* seasons among students studying in the conditions of the photoperiod of the northern region (Khanty-Mansi Autonomous Area – Yugra) and the temperate climatic zone (Vladikavkaz). In the Khanty-Mansi Autonomous Area, among students of both sexes, the proportion of persons with *evening* chronotypes was higher than in Vladikavkaz. Among thenorthernyoung men, there were no persons with a *definite morning* chronotype, and among the Vladikavkaz students there was noone with a *definite evening* chronotype; in the southern region, the share of "larks" was higher. In the dynamics of *winter/summer* in all groups, an increase in the proportion of "larks" was found, less pronounced in young men. Among the students of Vladikavkaz in both seasons, young men predominated among *morning* chronotypes, the percentage of persons with an *arrhythmic* chronotype was higher among young women. The values of *the index of photoperiodic stability*, in general, characterize the chronotype of the examined students as rigid. In the organization of life in the social group of students, social generators of rhythm prevail over natural factors.

Keywords: photoperiod, chronotype, north.

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Аннотация. Цель работы – установить особенности организации различных аспектов жизнедеятельности в динамике сезонов года *зима/лето* у студентов, обучающихся в условиях фотопериода северного региона (ХМАО – Югра) и умеренного климатического пояса (г. Владикавказ). В ХМАО у студентов обоего пола доля лиц с *вечерними* хронотипами была больше, чем во Владикавказе. Среди юношей у северян не было лиц с *определенно утренним*, а у владикавказских студентов – с *определенно вечерним* хронотипом; в южном регионе была выше доля «жаворонков». В динамике *зима/лето* во всех группах обнаружили прирост доли «жаворонков», менее выраженный у юношей. Среди студентов г. Владикавказа в оба сезона среди *утренних* хронотипов преобладали юноши, процент лиц с *аритмичным* хронотипом был выше у девушек. Значения *индекса фотопериодической устойчивости* в целом характеризуют хронотип обследованных студентов как ригидный. В организации жизнедеятельности у социальной группы студенчество социальные

Ключевые слова: фотопериод, хронотип, север.

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Introduction. Illumination is one of the most natural and definite geophysical characteristics of the territory [1]. The circadian rhythm of illumination varies greatly with the season of the year, except for the tropics. At high latitudes, the ratio of light and dark time of day undergoes significant changes throughout the year: in winter, dark prevails, in summer - light, which does not meet the physiological needs of humans [1]. According to I.I. Zamorsky et al., the need to adapt to the pronounced daily and annual dynamics of illumination led to the emergence of a functional system that synchronizes chronorhythms. Circadian rhythms are organized by the circadian system and circannual rhythms by the circannual system. Since these systems include the same structures, it was proposed to combine them into a chronoperiodic system [2]. The rhythm of physiological functions is one of the qualities of living matter [3-5]. The state of the chronobiological structure of the body depends on the light regime. Thus, under the conditions of a changed seasonal photoperiod, an inconsistency in the spatiotemporal perception of the chronotype was revealed in patients with psoriasis living in the Khanty-Mansi Autonomous Area – Yugra [6]. Chronobiological features of the structure of exacerbations of depressive states in the northern region have been established, the influence of desynchronosis of biological rhythms on the pathogenetic mechanism of development and dynamics of exacerbations has been revealed [7]. The ecophysiological role of the photoperiod in female reproductive function was investigated by changing the synthesis of melatonin, which controls its activity, according to the dynamics of conception [8].

The preservation of the chronostructure of functions is a universal criterion for the functional state of an organism. The chronotype refers to the individual characteristics of the organization of circadian rhythms. In 1976, based on the modification of the questionnaire by O. Öquist, J. Horne and O. Ostberg developed a test that is widely used at present to determine the chronotype (Horneand Ostberg Morningness-Eveningness Questionnaire, MEQ) [9]. The biorhythmological stereotype affects the body's ability to adapt [10], depends on endogenous and exogenous parameters [11].

Proceeding from the fact that the illumination mode acts as a natural generator of biorhythms, the aim of the study was to establish the peculiarities of the organization of various aspects of life in the dynamics of the *winter/summer* seasons among students studying in the conditions of the photoperiod of the northern region (Khanty-Mansi Autonomous Area-Yugra) and the temperate climatic zone (Vladikavkaz).

Objects and research methods. Khanty-Mansiysk Autonomous Area – Yugra is located in the center of the West Siberian Plain, between 58° and 62° north latitude, according to natural and climatic factors it is equated to the regions of the Far North. The climate varies from temperate to sharply continental [12; 13]. On the territory of the Khanty-Mansi Autonomous Area, significant changes in illumination are traced: the shortest daylight hours are recorded in the second half of December (05 hours 32 minutes), the largest – in the second half of June (more than 19 hours). Vladikavkaz city is located at 43°01′00″N, 44°41′00″E, the climate is moderately continental. The

length of the day on the winter solstice (December, 22) is 08 hours 59 minutes, in the second half of June – 15 hours 22 minutes. Thus, the seasonal range of daylight hours in the Khanty-Mansiysk Autonomous Area – Yugra is much greater than in Vladikavkaz.

The study involved 153 students studying in the Khanty-Mansi Autonomous Area – Yugra (young women n=100, young men n=53), and 121 students from Vladikavkaz (young women n=83, young men n=38). The dynamics of the chronotype was investigated using the mobile application "Index of photoperiodic stability" [14] in 2020-2021. The mobile application includes the Horneand Ostbergquestionnaire, to which the respondents answer the questions in two versions: taking into account the preference of the time intervals for various activities in the winter and summer seasons of the year. The results of the Horneand Ostbergquestionnaire are interpreted as follows: the scores 16-30 – *definitely evening type* (DET), 31-41 – *moderate evening type* (MET), 42-58 – *arrhythmic (intermediate) chronotype* (AT), 59-69 – *moderate morning chronotype* (MMT), 70-86 – *definitely morning chronotype* (DMT).

Statistical data processing. The mobile application "Index of photoperiodic stability" [14] contains a computer program "Calculator of photoperiodic stability of the chronotype" [15], which makes individual calculations for subjective assessment of the chronotype with the most contrasting parameters of the photoperiod (winter and summer).

The program "Calculator of photoperiodic stability of the chronotype" calculates the Photoperiodic Stability of the Chronotype (PSC) by the formula:

$$PSC = \frac{(\Sigma|Si - Wi|) - (\Sigma Wi - \Sigma Si)}{2}, \text{ where:}$$

Σw_i –total points when answering 19 questions of the Horne and Ostberg questionnaire for morning-evening preferences in *winter*; Σs_i –total points when answering 19 questions of the Horne and Ostbergquestionnaire for morning-evening preferences in *summer*; d_i –difference in points in *summer and winter* for i questions; $\Sigma|d_i|$ –sum of the absolute differences in points in *summer and winter* for all questions.

Normal values of photoperiodic stability of the chronotype are in the range of 4 conditional unit (cu) (5% probability) up to 16 cu (95% probability). When PSC<4 cu the chronotype is *rigid*, without obvious adaptive behavioral responses to exogenous factors. PSC>16 cu characterizes the chronotype as *labile*, significantly dependent on external influences. The study is single-step cross-sectional study. The sampling method is non-randomized. Descriptive statistics are represented by mean value (M) and mean error (m). Excel 2013 was used for statistical data processing. Data is presented in percent (%).

Research results and discussion. The data on the representation of various chronotypes in populations differ significantly. So, in the studies of N.A. Aghajanyan et al. (2013) established the following approximate frequency of distribution of chronotypes: 15% – morning type, 20% – eveningtype and 65% – arrhythmic type [3].

According to other sources, the number of "larks" ranges from 15 to 25% [16]. In a study with the participation of lyceum students from Votkinskcity (the Udmurt Republic), more than half were "doves", the share of "larks" was quite significant — about a third of those surveyed; the smallest was the representation of "owls" [17].

On the territory of the Khanty-Mansiysk Autonomous Area – Yugra, a different representation of chronotypes is revealed: the percentage of "larks" is significantly reduced – to 2-4%, with an increase in the contribution of persons with the *evening* chronotype to 38-40%; representatives of the *arrhythmic* (intermediate) chronotype prevail (56-58% and more) [10; 18; 19].

In our study, the analysis of the data obtained showed that there are differences in the representation of different chronotypes depending on the geographic location of the place of residence (tabl. 1). As it turned out, among the students of both genders in the Khanty-Mansi Autonomous Area -Yugra, which is characterized by a significant off-season range of the ratio of daylight to dark, there was a greater proportion of persons with *evening* chronotypes (%). So, in total (DET + MET) in the *winter/summer* season among the northern young men, there were 33.9%/17.0% of "owls" against, respectively, 21.0%/13.1% among students of Vladikavkaz, in the absence of persons with DET among the latter. In the women's groups, the representation of *evening* chronotypes in *winter/summer* was, respectively, 35.0%/32.0% among the northern young women and 19.2%/16.8% among female students of Vladikavkaz.

Table 1

Distribution of chronotypes (%) among young men and young women of the Khanty-Mansi Autonomous Area-Yugra and Vladikavkaz

Chronotypes		Young men, n/%				Young women, n/%			
		Khanty-Mansi Autonomous Area – Yugra (n=53)		Vladikavkaz (n=38)		Khanty-Mansi Autonomous Area – Yugra (n=100)		Vladikavkaz (n=83)	
		winter	summer	winter	summer	winter	summer	winter	summer
Evening	Total	**18/33,9**	**9/17,0**	**8/21,0**	**5/13,1**	**35/35,0**	**32/32,0**	**16/19,2**	**14/16,8**
	Definitely evening type	4/7,5	2/3,8	0/0	0/0	4/4,0	6/6,0	2/2,3	2/2,4
	Moderate evening type	14/26,4	7/13,2	8/21,0	5/13,1	31/31,0	26/26,0	14/16,9	12/14,4
Arrhythmic (intermediate) chronotype		**32/60,4**	**39/73,6**	**22/57,9**	**24/63,1**	**59/59,0**	**54/54,0**	**62/74,7**	**60/72,3**
Morning	Total	**3/5,7**	**5/9,4**	**8/21,0**	**9/23,7**	**6/6,0**	**14/14,0**	**5/6,0**	**9/10,8**
	Moderate morning chronotype	3/5,7	5/9,4	7/18,4	6/15,8	5/5,0	12/12,0	5/6,0	7/8,4
	Definitelymorning chronotype	0/0	0/0	1/2,6	3/7,9	1/1,0	2/2,0	0/0	2/2,4

The total ratio of the representation of young people with the morning chronotype (MMT + DMT) was different. Among the young men of the Khanty-Mansi Autonomous Area – Yugra, the percentage of larks was 5.7%/9.4%, respectively, in *winter/summer*, in the absence of persons with a *definitely morning* chronotype. Among Vladikavkaz male students, the proportion of *morning* types was significantly higher: 21.0%/23.7%. In the groups of young women, the differences were less pronounced: 6.0%/14.0% among the northern young women and 6.0%/10.8% among female students from Vladikavkaz.

In the study of I.N. Konareva (2016), with the participation of school-age children from Simferopol, the dynamics of the representation of persons with different chronotypes in the schooling process was discovered: the percentage of "larks" and "doves" decreased with age, "owls" were found starting from the age of 13. The author suggests that the reason is a rigid daily routine that does not allow younger students to focus on their internal biological needs. The biorhythmological characteristics of "doves" are more consistent with the organization of the educational process [20]. At the same time, the level of cortisol after waking up in the morning type is significantly higher than that of the evening type [21]. In a study with the participation of residents of Omsk city at the age of 18-35 years, representatives of the morning chronotype were mainly female, and the evening chronotype were male [22].

In our study, the share of students with an *arrhythmic* chronotype among northern young men in *winter/summer* was 60.4%/73.6% and 57.9%/63.1% among Vladikavkaz students, among young women, respectively, 59.0%/54.0% and 74.7%/72.3%.

Thus, the representation of chronotypes among students differed depending on the geographical characteristics of the place of residence. Representatives of the *arrhythmic* chronotype are leading in number, with a pronounced positive *winter/summer* dynamics in young men of the Khanty-Mansi Autonomous Area and a slight decrease in the proportion of young women in both groups. In the male groups of the northerners in both seasons of the year there were no persons with a *definitely morning* chronotype, among the Vladikavkaz youths there were no persons with a *definitely evening* chronotype. Differences related to gender were also found. Thus, among the students of Vladikavkaz in both seasons, young men prevailed among the "larks", and among the representatives of the *arrhythmic* chronotype, the percentage of young women was higher. In general, there was a tendency towards an increase in the manifestations of the *morning* chronotype in the summer season of the year for students of both territories, with its less pronounced in young men.

The *photoperiodic stability of the chronotype* (PSC) was calculated (tabl. 2). In the general groups (included all the presented chronotypes) in young men, this indicator was 2.89±0.72 cu northerners and 2.58±0.64 cu among the students of Vladikavkaz, that is, it differed slightly geographically and corresponded to a *rigid* type, independent of external factors. In the young women of the Khanty-Mansi Autonomous Area –Yugra, the average PSC value was within the normal range – 4.19±1.02 cu, among the female students of Vladikavkaz corresponded to the *rigid* type – 3.67±0.91 cu.

Analysis of PSC values by chronotypes did not reveal general patterns in terms of territorial and gender characteristics (tabl. 2). So, the lower limits of normal values, which correspond to natural physiological reactions to changes in the ratio of dark and light time of day, in the male groups of northerners corresponded to the average PSC values in larks, and in Vladikavkaz students the indicators of persons with an *arrhythmic* chronotype were closest to them. In both female groups, the doves showed normal reactivity.

Table 2

Photoperiodic stability of the chronotype (PSC) (cu) in young men and women Khanty-Mansi Autonomous Area – Yugra and Vladikavkaz, *winter / summer seasons*

Groups	Photoperiodic stability of the chronotype (PSC), cu			
	Youngmen		Youngwomen	
	Khanty-Mansi Autonomous Area – Yugra (n=53)	Vladikavkaz(n=38)	Khanty-Mansi Autonomous Area – Yugra (n=100)	Vladikavkaz (n=83)
	M±m	M±m	M±m	M±m
General (all CT)	2,89±0,72	2,58±0,64	4,19±1,02	3,67±0,91
Evening CT	3,1±0,5	2,5±1,2	3,9±0,5	2,6±0,5
ArrhythmicCT	2,7±0,4	3,3±0,7	4,5±0,4	4,0±0,4
Morning CT	4,0±2,1	0,6±0,4	2,3±1,2	3,2±0,8

*Note:*CT – chronotype

D.G. Gubin and S.N. Kolomeichuk (2019) suggested that the lengthening of the dark period of the day is more unfavorable for the representatives of the evening chronotype, due to the even greater inhibition of the biological clock, and the opposite thesis is correct for the morning chronotypes, since the addition of the light phase accelerates the biological time [23].

The authors point to a deficiency or excess of a synchronizing factor, such as light, temperature and food intake, as one of the reasons for the decline in vitality. At the same time, there is no clarity about the optimal duration of the light phase and the frequency of food intake at the moment.

Conclusion. Thus, territorial and sex differences were found in the representation of chronotypes: in the Khanty-Mansi Autonomous Area – Yugra, characterized by a changed photoperiod, the proportion of

persons with evening chronotypes was greater than in Vladikavkaz, among students of both sexes. For the male groups, the prevalence of morning chronotypes was also noted in the southern region. At the same time, among the northern young men, it was not revealed persons with a *definitely morning* chronotype, and among the Vladikavkaz students, it was not revealed persons with a *definitely evening* chronotype. In the seasonal *winter/summer* dynamics, an increase in the proportion of larks was found in all groups, less pronounced in young men. Among the students of Vladikavkaz in both seasons, young men predominated among the *morning* chronotypes, and the percentage of persons with an *arrhythmic* chronotype was higher among young women.

The values of *the index of photoperiodic stability* in general characterize the chronotype of the examined students as rigid, regardless of their territorial affiliation. At the same time, the average PSC values of larks in northerners corresponded to the lower limits of the values corresponding to natural physiological reactions to changes in the ratio of dark and light time of day, while in Vladikavkaz residents and in both groups of young women, indicators of "doves" approached them. The data obtained demonstrate the prevalence of social circumstances over natural time generators in the organization of life among students as a social group.

The question of the discomfort of the changed photoperiod, depending on the latitude of the place of stay, remains relevant, including in connection with the development of programs to preserve the health of student youth and the prevention of seasonal exacerbations of various diseases. The more significant the seasonal differences (winter – summer) in the intensity of such a generator of biorhythms as light, the less likely it is that throughout the entire calendar year the body will be able to organize its life activity according to its biological needs. In this case, in order to develop the optimal daily routine, a strictly regulated social rhythm should be a determining factor, taking into account biorhythmological preferences, but having the ability to compensate for the lack of a factor – a generator of time. This question is especially acute for higher education in high latitudes when organizing distance learning. Difficulties and mistakes in the selection of the *wakefulness-sleep* mode during the period when the student independently organizes his daily routine, often leads to the formation of desynchronosis of the physiological functions of the body. It was previously found that during distance learning, young women retained the classic type of dynamics of working capacity with a maximum in the daytime, while young men showed several peaks of activity, while the vital activity of junior students was less synchronized with the day-night cycle [24].

It is necessary to develop and implement methods aimed at organizing independent educational and other student activities, as well as leveling off-season differences in the magnitude of factors – generators of time. The most effective in this regard is the normalization of the light regime, with the help of additional lighting, spectral characteristics close to sunlight (winter season), and the reduction of "light pollution" through the use of thick curtains, blinds (summer).

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