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Quality of Life, Socioeconomic Well-Being and Heart Rate Variability in 16-18-Year-Old Girls Living in the Russian Arctic

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Abstract

Background: 16-18-year-old girls represent the country's reproductive and employment potential, which is the basis for its future demographic and socioeconomic development. The study aimed to determine the heart rate variability (HRV) indicators that can be most interrelated with quality of life (QoL) and socioeconomic well-being in 16-18-year-old girls living in the Russian Arctic.

Methods and Results: The study involved 53 girls aged 16-18 living in Arkhangelsk. The World Health Organization Brief Quality of Life Questionnaire (WHOQOL-BREF), Family Affluence Scale (FAS II), Family Financial Satisfaction Questionnaire, and Chen Internet Addiction Scale (CIAS) were used. HRV parameters were determined at rest and during slow-paced breathing with a frequency of 6 respiratory cycles per minute (6SPB).

In girls with HR 90 bmp and below, the increase of "Psychological Health," "Social Relationship," and "Environmental health" scores of WHOQOL-BREF was correlated with the decrease of sympathetic activity and with the increase of vagal activity during the 6SPB test. CIAS scores were positively correlated with sympathetic activity. The number of family vacations in the last year was correlated with a decrease in sympathetic activity.

Conclusion:16-18-year-old girls with optimal resting HR living in the Russian Arctic have more significant correlations of HRV indicators with social, psychological, and environmental aspects of QoL, as well as with the risk of Internet addiction, and, to a lesser extent, with economic living conditions. The opportunity for young people in the Arctic region to spend vacations with their families several times during the year helps reduce cardiac stress.**(International Journal of Biomedicine. 2024;14(3):492-496.)**

Keywords: quality of life • socioeconomic well-being • heart rate variability • girls • Arctic region

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Abbreviations

BMI, body mass index; **HR**, heart rate; **HRV**, heart rate variability; **QoL**, quality of life; **SPB**, slow-paced breathing; **SI**, Stress Index.

Introduction

The age of 16-18 is a very important period of human development, both physiologically and psychologically.[1] By this age, girls have completed puberty, finished the process of body growth, and formed all of the organism's regulatory systems. At the same age, young people's professional interests are determined, they desire serious relationships, and the formation of basic human values, worldviews, and moral guidelines are completed.[2] Thus, 16-18-year-old girls represent the country's reproductive and employment potential, which is the basis for its future demographic and socioeconomic development. The search for modern tools to assess the state of the cardiovascular system, which is most sensitive to the processes of adaptation to the environment in girls living in the Arctic region, seems to be an important task.[3] The study aimed to determine the heart rate variability

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(HRV) indicators that can be most interrelated with quality of life (QoL) and socioeconomic well-being in 16-18-year-old girls living in the Russian Arctic (the Arkhangelsk region).

Materials and Methods

This cross-sectional analytical study was carried out in three educational facilities of Arkhangelsk [Northern (Arctic) Federal University named after M.V. Lomonosov (NArFU), Arkhangelsk Trade and Economic College (ATEC), secondary school No. 45] between January and March 2023. The choice of facilities was determined by the desire to cover all three levels of education available to 16-18-year-old girls: higher education, vocational secondary education, and general secondary education. Inclusion criteria were age between 16 and 18 years, signed voluntary informed consent for participation in the study, I or II clinical groups of dispensary observation (without chronic pathology of internal organs), height and body mass index (BMI) not higher than the 97th and not lower than the 3rd percentile (height-for-age and BMI-for-age scales for the respective age and gender).[4] Exclusion criteria were acute infectious diseases at the time of the study, chronic diseases in the history (III-V clinical groups of dispensary observation), and high blood pressure (above 140/90 mmHg). Seventy-eight girls agreed to participate in this study. After applying the eligibility criteria, 53 individuals were included in the sample: NArFU (n=16, mean age of 17.94±0.24 years), ATEC (n=24, mean age of 17.96±0.20 years), secondary school No. 45 (n=13, mean age of 16.38 ±0.62 years).

Girls were invited to the study on days corresponding to the first half of their menstrual cycles. The research was approved by the Ethical Committee of N. Laverov Federal Center for Integrated Arctic Research of the Ural Branch of RAS (Protocol No. 10, 11.21.2022) and performed in accordance with the ethical principles of the World Medical Association Declaration of Helsinki.

The brief version of the World Health Organization Quality-of-Life Scale (WHOQOL-BREF) was used. The overall QoL, the general perception of health, and four domains of the QoL were determined:[5]

- The "Physical Health" domain includes assessment of physical pain, daily activities, functional capacity, energy, sleep, etc.).
- The "Psychological Health" domain includes assessment of self-image, attention, negative experiences, mentality, learning ability, memory concentration, life satisfaction, appearance, etc.).
- The "Social Relationship" domain contains questions on personal relationships with friends and relatives
- The "Environmental Health" domain covers issues related to financial resources, transport accessibility, safety, and access to medical care.

Each question in this questionnaire was rated on a five-point scale from 1 to 5, where 5 points correspond to the best QoL. Item #21 was excluded from the questionnaire: "How satisfied are you with your sex life?" taking into account the confidentiality of the personal lives of young girls. According to researchers, less than half of adolescents (41%) under the age of 18 in the Russian Federation have had sexual experience. Given the significant gender gap in the proportion of Russian youth with sexual experience, it can be assumed that the proportion of girls who are sexually active at the age of 16-18 is significantly lower than those presented in the literature.[6] In some studies using the WHOQOL-BREF to assess the QoL, a similar exclusion of the question about sexual life was performed, which was approved by WHO.[7] The socioeconomic status of the girls' family was assessed using the Family Affluence Scale (FAS II),[8,9] which includes four questions: 1) Do you have your own bedroom? 2) How many cars are there in your home? 3) How many vacations did your family have last year? and 4) How many computers does your family own? 0-2 points indicate low family affluence, 3-5 points correspond to average family affluence, and 6-9 points indicate high family affluence. The main advantages of the FAS are its high reliability and its simplicity and accessibility for adolescents, who often do not have a clear idea of the level of family income.[8,9]

The Chen Internet Addiction Scale (CIAS), in its Russian version by Malygin and Feklisov, was used to assess Internet addiction in girls. The complex score CIAS was calculated.[10,11]

The study participants also completed a questionnaire developed by the Federal State Statistics Service of the Russian Federation (Rosstat).[12] This Family Financial Satisfaction Questionnaire indicated the financial situation of their family on a scale from 1 to 5, where 1 means there is not enough money even for food and 5 means there is enough money to buy everything you need. It also asked about the number of children in the family and the presence of parents (one or two parents, an unrelated parent, or no parents).

A "Varicard" device (LLC "Ramena," Ryazan, Russia) was used to analyze HRV parameters. HRV parameters were analyzed in the rest state (session 5 minutes) and during the slow-paced breathing (session 5 minutes) with the frequency of 6 respiratory cycles per minute (6SPB) in the sitting position.[13] The following HRV parameters were determined: heart rate (HR, bmp), Stress Index (SI, units), the amplitude of mode (AMo50, %), pNN50 (percentage of neighboring NN intervals in the recording differing by more than 50 ms, %), RMSSD (root mean sum successful deviation, ms), MaxRMin (variation range as the ratio of maximum cardio-interval to minimum cardio-interval), SDNN (standard deviation of NN-interval, ms), total spectral power of HRV (TP, ms^2). SI was calculated by the formula $SI = AMo50/2 \times VAR \times Mo$, where Mo(ms) is the cardio-interval value dividing the cardio-interval series in half, VAR is the variation range between the minimum and maximum values in the cardio-interval series, and AMo50 (%) is the amplitude of mode (the most frequent RR intervals).[14]

Statistical processing of data was performed using the statistical software «Statistica» (v. 13.0, StatSoft, USA). The median values (Me) with interquartile range (IQR; 25th to 75th percentiles) and Min-Max range was used to characterize the sample. The Wilcoxon test was used to compare the dependent groups (Rest and 6SPB). The Spearman correlation coefficient (r_s) was used to assess the relationships between variables. A probability value of $P<0.05$ was considered statistically significant.

Results

The median value of self-assessment of general health and perception of general health were 4 points out of 5 (Table 1). The median parameter of physical health was 27 points, with a maximum of 35 points. The median self-assessment of psychological health was 23 out of a possible 30 points, social relationship was 8 out of a maximum of 10, and environmental assessment was 32 out of a possible 40. The median FAS score was 5 points, which is the upper limit of the average level. The median CIAS score was 47 points, which corresponds to a pronounced risk of developing Internet addiction. At the same time, 4 girls (5.7%) showed symptoms of a stable pattern of Internet addictive behavior.

Table 1.

Parameters of quality of life, risk of Internet addiction, and socio-economic well-being in 16-18–year–old girls living in the Russian Arctic (in scores).

Parameter	Me	Min-Max
Overall QoL	4	(2; 5)
General health	4	(3; 5)
Physical health	27	(19; 35)
Psychological health	23	(14; 30)
Social relationship	8	(3; 10)
Environmental health	32	(17; 40)
CIAS	47	(30; 73)
FASII	5	(1; 8)
Family Financial Satisfaction Questionnaire (according to the questionnaire of Rosstat)	3	(1; 4)

Thirty-five persons (66 %) were brought up in a complete family (with both parents), 41 persons (77.4 %) had their own private room, and 44 persons (83%) had comfortable housing with electricity, central heating, centralized water supply, and sewage systems. Most of the participants were raised in families with only one child (24/4.3%), 21(39.6%) persons were raised in families with two children, and 8(15.1%) girls were raised in large families (with three or more children). The most significant number of girls (26/49%) was from families owning one car. Eleven (21%) girls indicated their family had no car. Most of those surveyed (28/52.8%) had two computers in the family. Twenty-two (41.5%) girls indicated they had never gone on vacations with their family in the last year. Nineteen (35.9%) girls went on vacations with their parents once a year. The girls surveyed most often highly assessed their families' financial situation, noting that the financial resources available in the family were sufficient to buy everything they needed (25/47.2%). Nevertheless, 6(11.3%) persons noted that the financial resources in their family are not enough to buy clothes and pay for housing and utilities. Another one (1.9%) person indicated that the available funds are not enough even for food.

The average HRV parameters in girls correspond to normotonic: the median HR was 83 bmp, and the upper quartile SI was 150 units (Table 2). Nevertheless, 17(32.1%) persons had HR ≥90 bpm, indicating resting tachycardia.[15]

Table 2.

HRV parameters in rest state and in 6SPB [Me (25p;75p)]

Parameter	Rest	6SPB	*P*-value
HR, bmp	83 (76;92)	85 (80;91)	0.001
MxRMn, ms	1.49 (1.39;1.58)	1.65 (1.52;1.76)	<0.001
RMSSD, ms	34.35 (24.41;54.37)	47.27 (30.08;63.82)	<0.001
pNN50,%	12.75 (5.36;32.21)	23.2 (8.54;34.63)	0.01
SDNN, ms	56.97 (45.16;67.85)	97.74 (64.93;114.52)	<0.001
Amo50, %	30.4 (22.24;37.0)	25.3 (22.8; 32.8)	<0.001
SI, units	83.36 (54.93;150.58)	62.26 (39.90;105.04)	0.009
TP, $ms^2 \times 1000$	2.54 (1.80;4.07)	8.20 (3.97;12.5)	<0.001

6SPB - slow-paced breathing with the frequency of 6 respiratory cycles per minute

When performing 6SPB, there was a significant decrease in the parameters of sympathetic activity (AMo50, SI) and an increase in the parameters reflecting vagal regulation (MxRMn, RMSSD, pNN50, SDNN). In most cases (41/77.4%), MxRMnwas increased during 6SPB. This data indicates the strengthening of the vagal influences on the heart rhythm during 6SPB, i.e., preservation of the vagal reserve of autonomic regulation of the heart rhythm.

Correlation analysis of QoL indicators, socioeconomic well-being, and HRV parameters in the total sample of individuals did not reveal statistically significant relationships, or the relationships had contradictory interpretations.

Preliminary analyses showed a change in the nature of the interrelationships of QoL, socioeconomic well-being, and HRV in individuals with different baseline HR. Therefore, it was decided to identify a subgroup of girls with HR<90 bpm, which included 36 persons. HR ≥ 90 bpm represents the risk of heart rhythm disorders in young people.[15]

Table 3 presents the results of the correlation analysis, including socioeconomic well-being parameters that were statistically significantly correlated with HRV parameters in at least one of the states ("Rest" or 6SPB). The increase of the self-esteem score on the "Social Relationship» was correlated with the decrease of sympathetic activity parameters (Amo50, SI) and with the increase of vagal activity parameters (RMSSD, pNN50, SDNN, TP) during the 6SPB test. An increase in the "Environmental Health" parameter was accompanied by decreases in HR (r_s = -0.45), SI (r_s = -0.43), and AMo50 (r_s = -0.43) and increases in pNN50 (r_s = 0.40), and SDNN (r_s = 0.33). Sympathetic parameters (AMo50 and SI) were negatively correlated with "Psychological Health» scores in girls during the 6SPB test. At the same time, a positive correlation between Amo50, SI, and CIAS scores was noted with an increased risk of Internet addiction in persons with high sympathetic activity. A decrease in "Physical Health" and "Environmental Health" parameters was accompanied by an increase in HR during the 6SPB test (r_s = -0.35).

Table 3.

Rank correlations of HRV parameters with the parameters of QoL and socio-economic well-being in 16-18-years-old girls with HR <90 bmp (n=36).

Rank correlations	Rest		6SPB	
	r_s	*P*	r_s	*P*
HR – Physical Health	-0.13	0.42	-0.35	0.036
HR – Environmental Health	-0.27	0.11	-0.45	0.006
RMSSD – Social Relationship	0.22	0.20	0.43	0.009
pNN50 – Social Relationship	0.29	0.08	0.39	0.019
pNN50 – Environmental Health	0.26	0.11	0.40	0.015
SDNN – Social Relationship	0.22	0.21	0.35	0.034
SDNN – Environmental Health	0.15	0.38	0.33	0.049
AMo50 – Number of family vacations in the last year	-0.39	0.018	-0.02	0.91
AMo50 – Internet addiction (CIAS)	0.25	0.15	0.36	0.029
AMo50 – Psychological Health	-0.12	0.50	-0.36	0.032
AMo50 – Social Relationship	-0.19	0.26	-0.35	0.039
AMo50 – Environmental Health	-0.19	0.26	-0.43	0.009
SI – Internet addiction (CIAS)	0.21	0.22	0.36	0.032
SI – Psychological Health	-0.23	0.18	-0.38	0.022
SI – Social relationship	-0.28	0.10	-0.42	0.011
SI – Environment	-0.25	0.15	-0.43	0.009
TP – Social relationship	0.07	0.70	0.41	0.014

Notably, most of the studied QoL and socioeconomic well-being parameters were significantly correlated with HRV parameters during 6SPB. Only one parameter reflecting economic well-being according to the FAS ("Number of family vacations in the last year") was significantly correlated with HRV parameters. This parameter had an inverse correlation with AMo50 (r_s = -0.39), which was recorded at the state of rest.

Discussion

The study results suggest that in 16-18-year-old girls with optimal heart rate (below 90 bmp) living in the Russian Arctic, social indicators are more correlated with HRV parameters, in contrast to indicators of economic well-being. High self-assessment of the QoL parameters, including personal relationships, support of friends, satisfaction with their appearance and life, as well as relatively rare occurrence of negative feelings (bad mood, despair, anxiety, depression) are correlated with a decrease in sympathetic and increase in vagal influences on heart rhythm. These findings are in accordance with international studies that show low social support,[16] high levels of stress in social life,[17] and an underdeveloped ability to regulate their emotional and behavioral reactions towards other members of society [18,19] are associated with low heart rate variability.

The interdependence of the "Environmental Health" parameter of QoL and HRV indicators seems significant. The "Environmental Health" parameter in the WHOQOL-BREF questionnaire assesses satisfaction with conditions in the place of residence: medical care, transport, safety, and recreational opportunities. Our result helps to explain the revealed tendency of higher risk of cardiovascular disease morbidity in those living in less favorable areas (with low access to places of physical activity, low number of recreational facilities, low transport accessibility, high crime rate, etc.).[20,21] It is especially important to note the importance for the female population of living conditions in the Arctic territories, where there are difficulties in the development of social infrastructure.[22] In the northern regions of Russia, which have the least developed social and housing infrastructure (primarily rural areas), there is a so-called "female exodus" (out-migration of young women to more favorable areas in terms of comfort, resulting in an imbalance in the gender structure of the population of the territory with a pronounced predominance of men).[23,24] Studies by a group of Taiwanese scientists led by P.C. Lin showed an association between Internet addiction and higher sympathetic and lower parasympathetic activity of the autonomic nervous system in school-aged children.[25] A sample of people in China showed that people with problematic Internet use had significantly lower resting HRV.[26] Our results confirm the above-mentioned trends: girls with a higher CIAS score were also characterized by higher indices of the sympathetic part of the autonomous nervous system. Living in the discomforting climatic conditions of the Arctic also contributes to a more pronounced risk of Internet addiction in young people compared to more southern regions, [27] especially in girls.[28]

Our study provides a basis for further investigation of the mechanisms of HRV correlation with the parameters of QoL and socioeconomic well-being in female residents of the Russian Arctic using more representative samples in terms of the number of people, as well as in girls with an increased risk of cardiac regulation disorders (resting tachycardia and the presence of arterial hypertension).

Conclusion

In girls aged 16-18 years with optimal HR at rest (<90 bpm) living in the Russian Arctic, there are more significant correlations of HRV indicators with social, psychological, and environmental aspects of QoL, as well as with the risk of Internet addiction, and, to a lesser extent, with economic living conditions. However, such an economic factor as the opportunity for young people in the Arctic region to spend vacations with their families several times during the year helps reduce cardiac stress.[3] HRV parameters during the 6SPB test are more sensitive than resting HRV parameters in identifying relationships between HRV parameters and indicators of QoL and socioeconomic well-being. The results obtained are important for the formation of socioeconomic programs to support young people in the Arctic region and to determine the priority parameters of socioeconomic well-being that make the maximum contribution to the preservation of the cardiovascular health of young girls living in the Arctic region.

Competing Interests

The authors declare that they have no competing interests.

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