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HEART RATE VARIABILITY IN 7 YEARS OLD CHILDREN

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Abstract: The article presents data on heart rate variability (HRV) in 7 years old children. There are presented information of temporal, geometric, spectral analysis of HRV as well as data of variation pulse oximetry. There is given a comparative assessment of indicators depending on the gender and body mass index of children. An analysis of the results of the study showed a strong direct and inverse relationship between some of the indicators of HRV, as well as a difference in the indicators of HRV in 7 years old children, depending on gender and body mass index.

Keywords: 7-year-old children, physical development, heart rate variability.

Heart rate variability (HRV) is the simplest and informative method of assessing the status of the vegetative nervous system [5]. Also, HRV indicates the adaptive capacity of the body and helps to identify the risk of unexpected death [1]. Most often, HRV is used in cardiology practice in determination of the adequacy of therapy [4]. HRV is based on the determination of cardio intervals in the second standard lead of electrocardiography. [2,3]. HRV assesses the physiological functions of the body through the ratio of the activity of the different part of vegetative nervous system [1], and allows to evaluate the functional capabilities of the body and carry out preventive measures aimed at maintaining the health of the child [6]. For greater reliability, the minimum recording should be at least 5 minutes. Also, orthostatic test, Valsalva test are used for evaluation. To carry out these tests, it is necessary to adhere to the stationarity condition. Studies should be conducted under the same conditions and the length of the first and second records should be the same. Statistical data processing methods are used to analyze heart rate variability. Statistical methods based on the time difference between R-R intervals. These methods include HR (heart rate), RRNN, mean RR interval duration, which evaluates the balance in the

vegetative nervous system; SDNN is the square root of the cardio interval`s spread, RMSSD and pNN50% are indicators that assess the state of the parasympathetic link of the autonomic nervous system. Geometric methods are the least influenced by artifacts, these include the triangular index and the St. George index, TINN reflect the total HRV. In spectral analysis, the power is estimated depending on the oscillation frequency. The frequency spectrum is usually divided into: high-frequency (0.2-0.4 Hz), low-frequency (0.04-0.15 Hz) and very low-frequency (0.003-0.04 Hz). Power is measured in ms^2. Measure the power contribution of the spectrum depending on the frequency range. HF - high-frequency spectrum showing the activity of the parasympathetic system, LF – indicates the activity of the sympathetic system, VLF – reveals the activity of the suprasegmentally centers of the autonomic nervous system [3].

Purpose of the study. Determine the heart rate variability in 7 years old children.

Materials and research methods. The study involved 120 children. All children underwent anthropometric measurements. There were selected only children without acute and chronic diseases. The children were divided into 3 groups depending on the body mass index. The first group consisted of 66 children with BAZ (bmi for age) scores from -2 to +1 SDS; the second group included 29 children, with a BAZ range of +1 to +2 SDS. The third group consisted of 25 children with BAZ > +2 SDS. All children underwent ECG examination, cardiointervalography with orthostatic test. The following indicators were used for analyses of HRV: rrHRV, IQR, RRNN, HR, SDNN, RMSSD, pNN50%, TRI, ApEn, SD1, SD2, SD1/SD2, VLF, LF, HF, IC, CV, Mo (the most common interval RR), SI (stress index), RMI (respiratory modulation index), SAI (sympathoadrenal index), SWAI (slow wave arrhythmia index), VPR (vegetative parasympathetic range), ARPI (indicator of the adequacy of regulatory processes), VBI (vegetative balance index). The statistical significance of the obtained measurements was determined by

Student's t-test (t) with the calculation of the error probability (P). Significance level $p<0.05$ was taken as statistically significant changes.

Results and discussions. According to the results of the survey, correlations between the indicators were revealed. An indicator >0.7 was taken as a strong correlation. A strong direct correlation was found between: rrHRV - SDNN - RMSSD - pNN50% - TRI - SD1/SD2 - CV - RMI. A strong inverse correlation was found between the indicators: rrHRV and AMo (% of most common intervals RR), SI, SAI, SWAI, ARPI, VPR. HR has a high inverse correlation with pNN50%, RMSSD, SDNN and a high direct correlation with AMo, SI, SWI, ARPI. SI (stress index) and APRI (an indicator of the activity of regulatory processes) have a strong inverse correlation with rrHRV, SDNN, RMSSD, pNN50%, TRI. Correlation relationship between statistical, spectral and geometric indicators with indicators of variation pulse oximetry demonstrated in the table 1.

Table 1

Correlation relationship between statistical, spectral and geometric indicators with indicators of variation pulse oximetry.

Indicators	Mo	AMo	SI	RMI	SAI	SWAI	ARPI	VBI
rrHRV	0.50	-0.78	-0.75	0.71	-0.82	-0.65	-0.78	-0.74
RRNN	0.89	-0.59	-0.64	0.65	-0.63	-0.65	-0.73	-0.57
HR	-0.91	0.58	0.69	-0.61	0.65	0.64	0.75	0.61
SDNN	0.48	-0.73	-0.69	0.96	-0.77	-0.56	-0.7	-0.73
RMSSD	0.52	-0.68	-0.64	0.98	-0.75	-0.73	-0.67	-0.67
pNN50	0.61	-0.75	-0.69	0.90	-0.81	-0.79	-0.75	-0.70
TRI	0.48	-0.89	-0.67	0.78	-0.76	-0.50	-0.84	-0.71
SD1	0.52	-0.68	-0.64	0.98	-0.75	-0.73	-0.67	-0.67
SD2	0.43	-0.72	-0.71	0.90	-0.77	-0.42	-0.69	-0.75
SD1/SD2	0.53	-0.38	-0.42	0.73	-0.57	-0.99	-0.43	-0.4
LF%	-0.31	0.29	0.40	-0.58	0.52	0.70	0.32	0.41
HF%	0.31	-0.29	-0.40	0.58	-0.52	-0.70	-0.32	-0.41
LF/HF	-0.31	0.24	0.32	-0.47	0.44	0.63	0.29	0.32
VLF	-0.37	0.21	0.26	-0.54	0.35	0.64	0.26	0.26
LF	-0.17	0.18	0.24	-0.36	0.33	0.44	0.20	0.23
HF	0.25	-0.17	-0.23	0.40	-0.31	-0.36	-0.23	-0.24

According to the indicators of anthropometric measurements, it was revealed that the average height of boys is 131±7.4 cm., which corresponds to the 68th percentile, and for girls - 128.34±6.4 cm ($p<0.05$), which corresponds to the 49th percentile. The average weight of boys is 30.7±7.9 kg, and girls -29.10±6.5 kg ($p>0.05$). The rrHRV indicator in boys was 7.66±2.7 c.u., and in girls it was 8.85±3.4 c.u. ($p<0.05$). The average heart rate in girls was slightly higher (89.13±12.1 bpm.) than in boys (88.8±10 bpm), $p>0.05$. SDNN - an indicator reflecting the reserve capacity of the body, was higher in girls (65.81±5.48 msec.) compared to boys (54.88±3.51 msec.), $p<0.05$. Significant differences were also observed in RMSSD: boys - 60.42±4.10 msec., girls - 76.61±7.48 msec. ($p<0.05$) and pNN50%: boys - 22.74±2.0%, girls - 29.24±3.56% ($p<0.05$). According to the indicators of the non-linear evaluation method, a significant difference in the indicators was also determined: TRI, ApEn, SD1, SD2. According to the spectral analysis data, the power of the LF spectrum prevailed in boys, while the power of the HF spectrum prevailed in girls ($p<0.05$).

Table 2

Anthropometric parameters and indicators of HRV in 7 years old children.

Index	**Boys**	**Girls**
Height, cm	131.13±0.82	128.34±1.02
Weight, kg	30.70±0.88	29.10±1.02
rrHRV* c.u.	7.66±0.31	8.85±0.55
IQR c.u.	6.56±0.27	7.14±0.36
RRNN, msec.	682.86±8.45	685.92±15.52
HR, bpm	88.80±1.10	89.13±1.91
SDNN, msec *	54.88±2.63	65.81±5.09
RMSSD, msec *	60.42±4.10	76.61±7.48
pNN50, % *	22.74±2.0	29.24±3.56
TRI c.u.*	2.97±0.11	3.37±0.21
ApEn c.u.*	0.83±0.01	0.78±0.02
SD1*	42.73±2.90	54.18±5.29
SD2*	63.64±2.057	74.28±5.19
SD1/SD2	0.65±0.02	0.69±0.03
LF, %	43.28±1.74	41.16±2.59
HF, %	56.72±1.74	58.84±2.59
LF/HF	0.94±0.08	0.85±0.11

TP, ms2	1365.95	1302.23
VLF, ms2	531.71±22.52	476.25±33.53
LF, ms2 *	450.43±13.38	405.88±14.98
HF, ms2 *	383.82±10.89	420.10±18.0
IC	1.90±1.90	2.16±0.18
CV *	7.89±0.30	9.30±0.57
Δ×	262.68±11.63	296.00±22.13
Mo, msec	669.76±8.0	664.00±11.71
Amo, msec	36.82±1.21	34.05±1.89
SI, c.u.	137.24±11.61	128.47±16.49
SAI, c.u.	1106.73±73.86	946.83±116.94
SWI, c.u. *	43.64±0.57	42.53±0.88
VPR, c.u.	6.86±0.57	6.61±0.57
ARPI, c.u.	56.35±2.34	53.30±3.61

Note * - p <0.05

According to the results of the temporal analysis of HRV, there were no significant differences in heart rate in children both at rest and during the orthostatic test. The lowest total indicator of HRV (SDNN - an indicator of restoration of body reserves) both at rest and during the orthostatic test was observed in obese boys - 51.05±8.0 msec., and 41.69±5.46 msec., respectively. In girls, there were no significant differences depending on the body mass index. This indicates a higher reserve potential of the autonomic nervous system in girls compared to boys. In terms of pNN50%, the 1st group had the highest rate: boys – 24.49±2.8%; girls - 32.32 ± 4.32%, while the lowest indicator was observed in children of the 3rd group: boys - 20.87 ± 5.2%, girls - 24.97 ± 7.8%, which indicates a high activity of the sympathetic nervous system in obese children. In orthostatic test, the lowest indicators were observed in children of the 2nd group: boys - 4.75 ± 1.52%, girls - 4.75 ± 1.11%.

Table 3

HRV indicators in 7 years old children at rest.

Index	**1 group (n=66)**		**2 group (n=29)**		**3 group (n=25)**	
	Boys (n=42)	**Girls (n=24)**	**Boys (n=18)**	**Girls (n=11)**	**Boys (n=15)**	**Girls (n=10)**
HR, bpm.	87.8± 1.3	88.2± 2.2	89.9± 1.5	89.1± 4.5	90.5± 3.98	90.8± 4.5
RRNN	688.9±	687.98±	670.14±	689.4±	679.62±	679.2±

, msec.	10.3	17.4	11.57	35.11	29.5	38.2
SDNN, msec.	56.6± 3.5	65.97±5.48	53.45± 3.49	67.74± 10.9	51.05± 8.07	63.78± 13.28
RMSSD, msec.	63.27± 5.63	77.29±8.23	55.4± 5.08	78.8± 16.95	57.66± 11.99	73.47±18.59
pNN50, %	24.49± 2.80	32.32± 4.32	19.78± 2.78	28.08±8.30	20.88± 5.3	24.98± 7.8
CV, %	7.9± 0.42	7.95± 0.48	8.55± 0.61	7.94± 0.89	6.89± 0.68	7.57±3216 0.94
Mo, msec.	674.17± 9.67	667.37±15.3	661.05±13.11	668± 24.62	666.67± 26.95	654.54± 26.57
AMo, %	35.14± 1.39*	33.89± 2.6	37.37± 1.91	31.5± 4.04	41.47± 4.19*	36.64± 4.02
VBI, c.u.	173.29± 13.87*	146.48±27.92	167.88± 19.78	155.03± 42.44	228.26± 48.32*	189.42± 34.03
ARPI, c.u.	52.85±2.29*	52.41±4.87	57.06± 3.23	49.28± 7.63	66.63± 9.43*	58.49± 7.66
VPR, c.u.	6.66± 0.45	6.07± 0.78	6.60± 0.59	6.57± 1.30	7.81± 1.20	7.58± 1.05
SI, c.u.	123.08± 10.34*	115.95± 24.39	129.11± 15.90	125.42± 37.03	192.81±49.26*	152.87±28.20

Note * - p <0.05

As can be seen from Table 3, the highest rates of AMo, VBI, ARPI are observed in group 3 in children with obesity, and these rates are high in both boys and girls. SI (an indicator reflecting the influence of the sympathetic department on the autonomic nervous system): in boys of the 3rd group, with an orthostatic test, it increases from 192.87 ± 49.2 c.u. up to 205.43±42.68 c.u., and for girls from 152.87±28.2 c.u. up to 208.98±48.3 c.u.

Table 4

HRV indicators in 7 years old children during orthostatic test.

Index	**1 group (n=66)**		**2 group (n=29)**		**3 group (n=25)**	
	Boys (n=42)	**Girls (n=24)**	**Boys (n=18)**	**Girls (n=11)**	**Boys (n=15)**	**Girls (n=10)**
HR, bpm	103.0± 1.3	107.0± 2.6	105.0± 1.7	109.0± 4.65	104.0± 3.79	107.0± 4.66
RRNN, msec	582.87±	566.97±	571.98±	556.96±	584.72±	568.0±

	7.63	14.49	9.58	24.80	20.64	27.76
SDNN, msec	46.69± 2.82	45.82± 3.59	49.57± 4.04	44.22± 5.06	41.69± 5.46	44.7± 7.42
RMSSD, msec	32.11± 1.58	35.69± 3.47	32.62± 2.70	38.62± 7.53	31.95± 3.96	34.91± 6.17
pNN50, %	6.33± 1.01	8.08± 2.45	4.57± 1.11	4.75± 1.52	5.86± 2.10	8.54± 4.28
CV, %	7.90± 0.42	7.95± 0.48	8.55± 0.61	7.94± 0.89	6.89± 0.68	7.57± 0.94
Mo, msec	673.33± 14.32	648.42± 15.47	658.95± 14.46	644± 24.18	666.67± 26.67	654.55± 24.88
AMO, %	39.19± 1.18	36.32± 2.71	39.19± 1.18	39.90± 3.43	43.60± 3.24	41.18± 1.75
VBI, c.u.	173.29± 13.87*	168.41± 31.49	209.59± 48.99	165.11± 39.17	250.06± 43.99*	257.17± 55.97
ARPI, c.u.	44.51± 2.05*	46± 4.02	48.15± 2.57	42.90± 6.25	56.73± 7.17*	52.05± 6.61
VPR, c.u.	8.78± 0.63	8.43± 0.96	9.88± 2.11	9.46± 1.72	10.78± 1.60	11.34± 2.03
SI, c.u.	132.82± 11.50*	134.44± 27	166.78± 44.15	132.95± 33.67	205.43± 42.68*	208.98± 48.38

Note * - p <0.01

Conclusions. According to the results of the study, it can be concluded that there is a strong correlation between the indicators of heart rate variability, so there is no need to apply all methods of assessment. There is a high significance of differences between indicators in boys and girls. According to spectral analysis and statistical analysis, the parasympathetic division of the nervous system predominates in girls. However, when assessed according to the indicators proposed by R.M. Baevsky [7,8], (stress index), hypersympathicotonia is noted in both girls and boys. Based on this, it can be assumed that children aged 7 years are characterized by a higher stress index than adolescents and adults. This period is critical for children, and during the first year of education, children adapt to new environmental conditions. There is a correlation between the excessive influence of the central and sympathetic nervous systems on obese children, which is reflected in the indicators of ARPI and SI during the orthostatic test.

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