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Seasonal fluctuations of heart rate variability parameters in children aged 7-12 years

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Introduction.

Adaptation or maladaptation of the body can be assessed by activity of its regulatory systems. One of the manifestations of such activity is heart rate variability (HRV) as a correlate of autonomous regulation of the cardiovascular system. HRV parameters are sensitive to the influence of the physical environment (climatic, geographic, and chronobiological factors) and social innovations.

Aim: to study seasonal fluctuations of HRV indicators in primary school students (7-12 years, 1st–5th grades). We were interested in a retrospective analysis of this phenomenon (comparison of current results with similar data from 2004-2007) and the correlation with body mass index (BMI).

Methods.

We analyzed the dynamics of semi-annual changes of HRV indicators (the "delta" of indicators, in % of the initial level), as well as blood pressure (BP) and its variability (BPV).

Testing was performed twice a year: in late March–early April, which corresponds to the beginning of the school year, and in late September–early October, i.e. at the end of the school year.

The volume of samples in 2004-2007 (School 1) was 317 people, 810 repeated measurements,
in 2016-2019 (School 2) was 214 people, 701 repeated measurements.

The School 1 and School 2 are different organizations, but both are elementary schools, located on the outskirts of Moscow. The ethnic composition in both cases is mixed, with a predominance (85–90%) of the indigenous population (both Russians and representatives of other nationalities). All children were assigned to the 1st and 2nd health groups and to the main physical culture group.

Enter the School
(7-8 years)

Measurements
(every autumn and every spring)

2004	Sen	Oct	No	Dec									
2005					Jan	Fev	Mar	Apr	May	Jun	Yul	Aug	
	Sen	Oct	No	Dec									
2006					Jan	Fev	Mar	Apr	May	Jun	Yul	Aug	
	Sen	Oct	No	Dec									
2007					Jan	Fev	Mar	Apr	May	Jun	Yul	Aug	

School 1 (2004-2007)

3 school parallel
classes,
434 boys and
376 girls in
dynamics,
810 repeated
measurements

The volume of examined samples of School 1 primary schoolchildren
(2004–2007) in different time periods

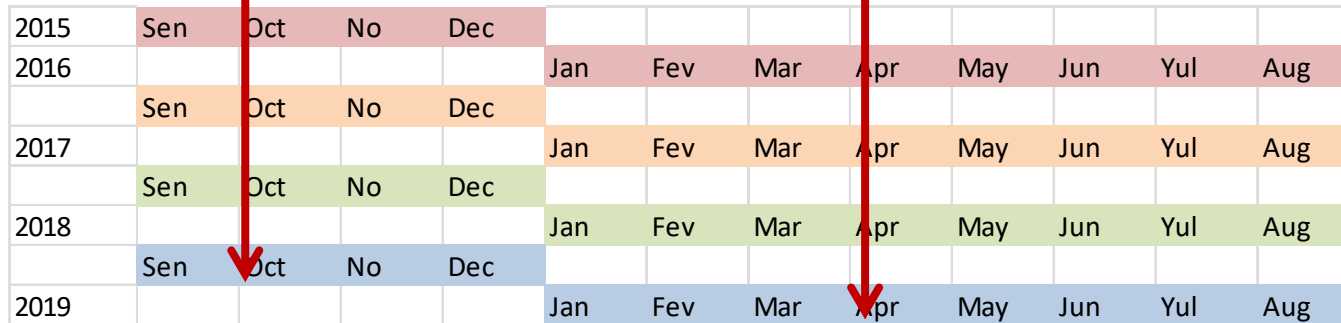
Time period	girls	boys
autumn 1 – spring 1	70	51
spring 1 – autumn 2	40	33
autumn 2 – spring 2	54	50
spring 2 – autumn 3	30	44
autumn 3 – spring 3	38	72
spring 3 – autumn 4	28	47
autumn 4 – spring 4	45	65
spring 4 – autumn 5	38	42
autumn 5 – spring 5	33	30

The numbers
indicate the class;
seasons: autumn –
October, spring –
March-April.

Enter the School
(7-8 years)

School 2 (2016-2019)

Measurements
(every autumn and every spring)



2015	Sen	Oct	No	Dec								
2016					Jan	Fev	Mar	Apr	May	Jun	Yul	Aug
	Sen	Oct	No	Dec								
2017					Jan	Fev	Mar	Apr	May	Jun	Yul	Aug
	Sen	Oct	No	Dec								
2018					Jan	Fev	Mar	Apr	May	Jun	Yul	Aug
	Sen	Oct	No	Dec								
2019					Jan	Fev	Mar	Apr	May	Jun	Yul	Aug

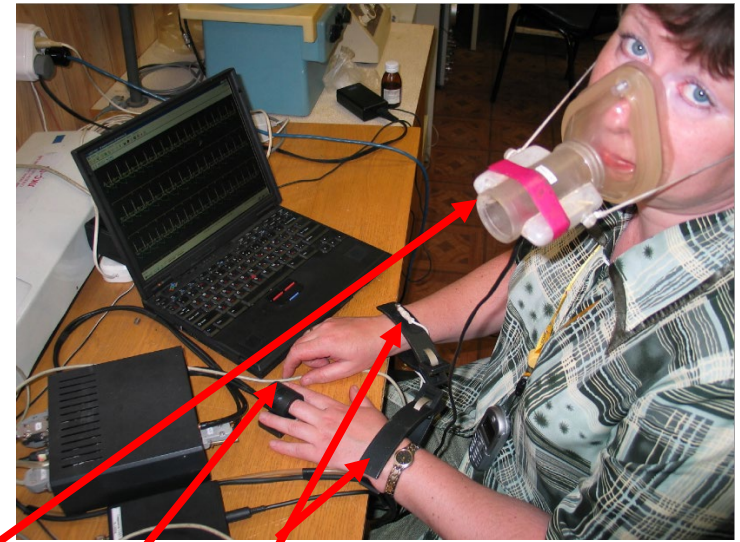
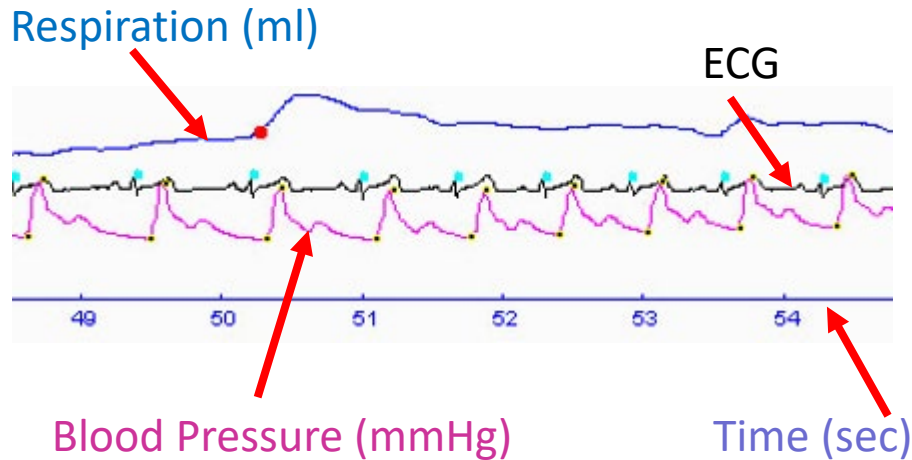
2 school parallel
classes,
111 boys and
113 girls
in dynamics,
701 repeated
measurements

The volume of examined samples of School 2 primary schoolchildren
(2016–2019) in different time periods

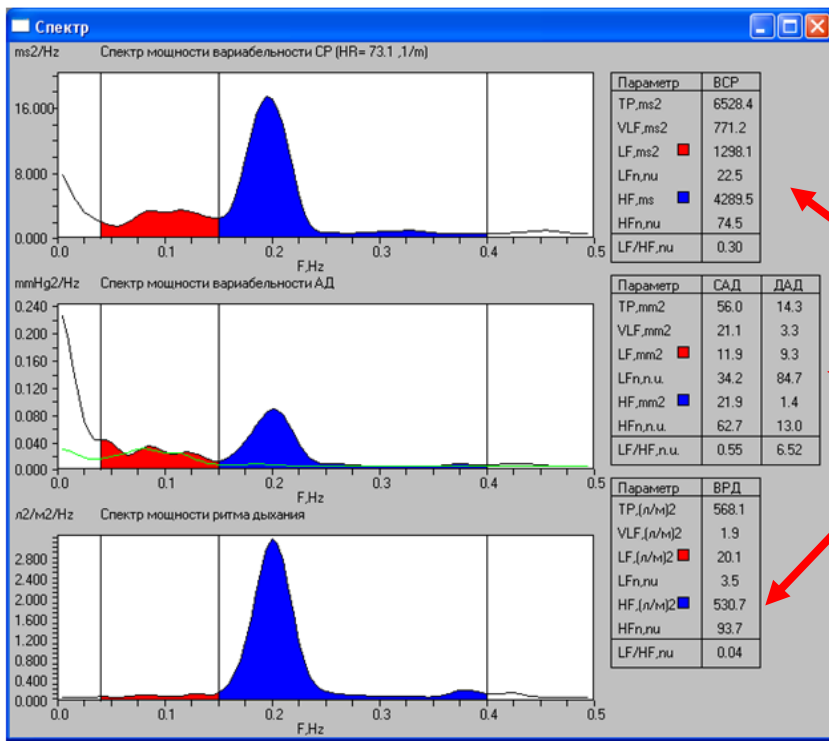
Time period	girls	boys
spring 1 – autumn 2	53	41
autumn 2 – spring 2	57	43
spring 2 – autumn 3	56	46
autumn 3 – spring 3	63	51
spring 3 – autumn 4	55	49
autumn 4 – spring 4	59	49
spring 4 – autumn 5	9	15
autumn 5 – spring 5	10	16

The numbers
indicate the class;
seasons: autumn –
October, spring –
March-April.

Equipment: spiroarteriocardiorhythmograph



Spiro Arterio Cardio Rhythmograph



Spectrum of Heart Rate Variability

Spectrum of Blood Pressure Variability (systolic and diastolic)

Spectrum of Respiration (air velocity)

Parameters: Total Power, absolute and relative power of VLF, LF and HF ranges (ms², mmHg², l/m²)

Results.

Of all the HRV and BPV parameters, seasonal fluctuations were revealed only for systolic BP and the LF/HF ratio in the HRV spectrum. In 2016-2019, an increase in systolic BP over the school year (fall – spring) and a decrease in LF/HF (from 2nd to 5th grade) were revealed in the examined primary school students.

However, in 2004-2007, seasonal changes in children of the same age were opposite: a decrease in systolic BP during the school year and an increase in LF/HF (from 1st to 5th grade).

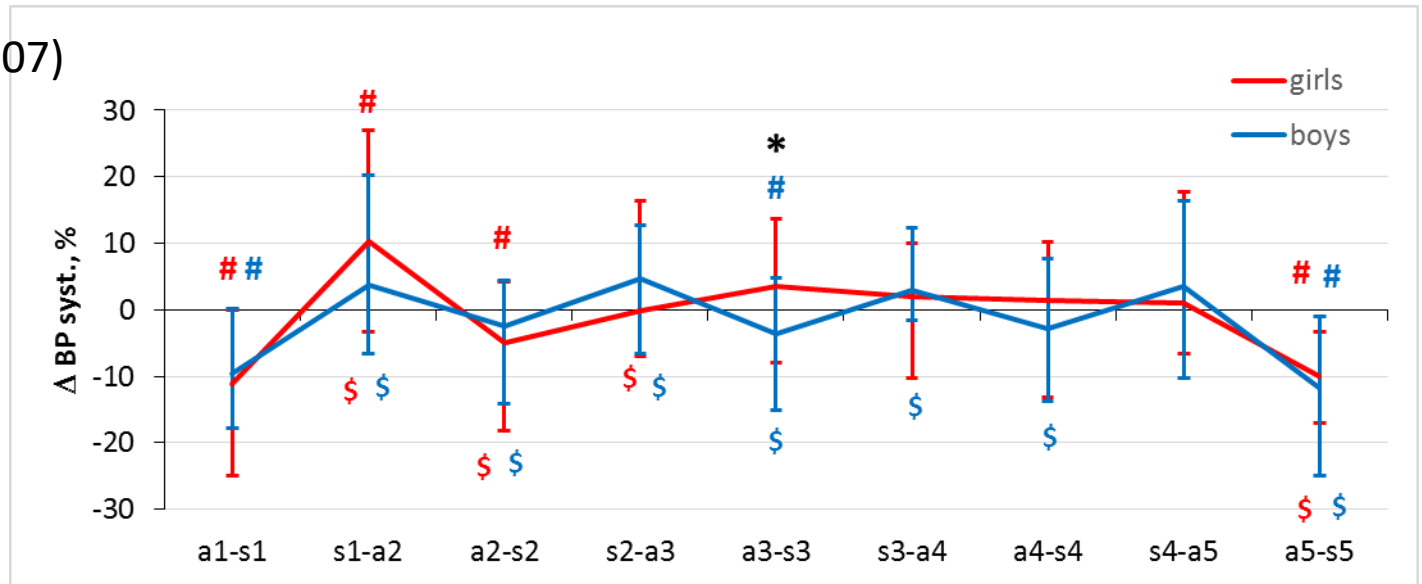
Figures legend.

Girl's data are marked with a red line, boys' data are marked with a blue line. The designations of time periods: "a" - autumn, "s" - spring, numbers denote class. Statistically significant changes over the time interval (according to the Wilcoxon paired criterion) are indicated by the red "#" for girls, and the blue "#" for boys. Statistically significant differences between girls and boys (according to the Mann-Whitney test) are marked with black asterisk (*). The "\$" signifies statistically significant differences from the previous interval in its group (according to the Mann-Whitney test).

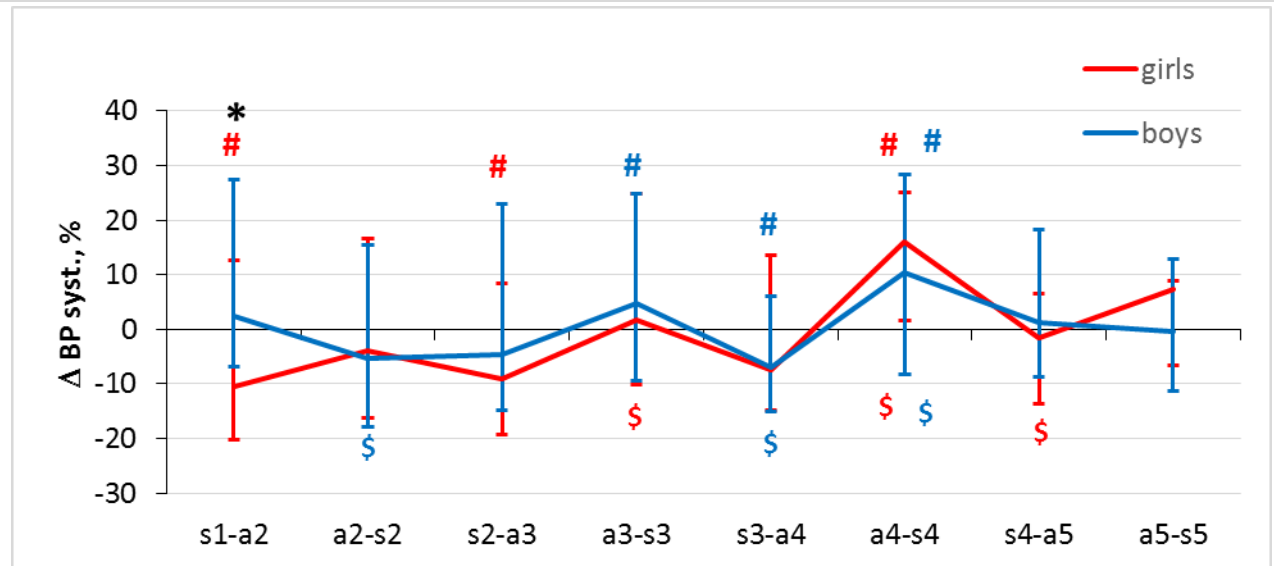
All data are presented as a median and interquartile range.

BP systolic seasonal fluctuations, delta in %

School 1 (2004-2007)

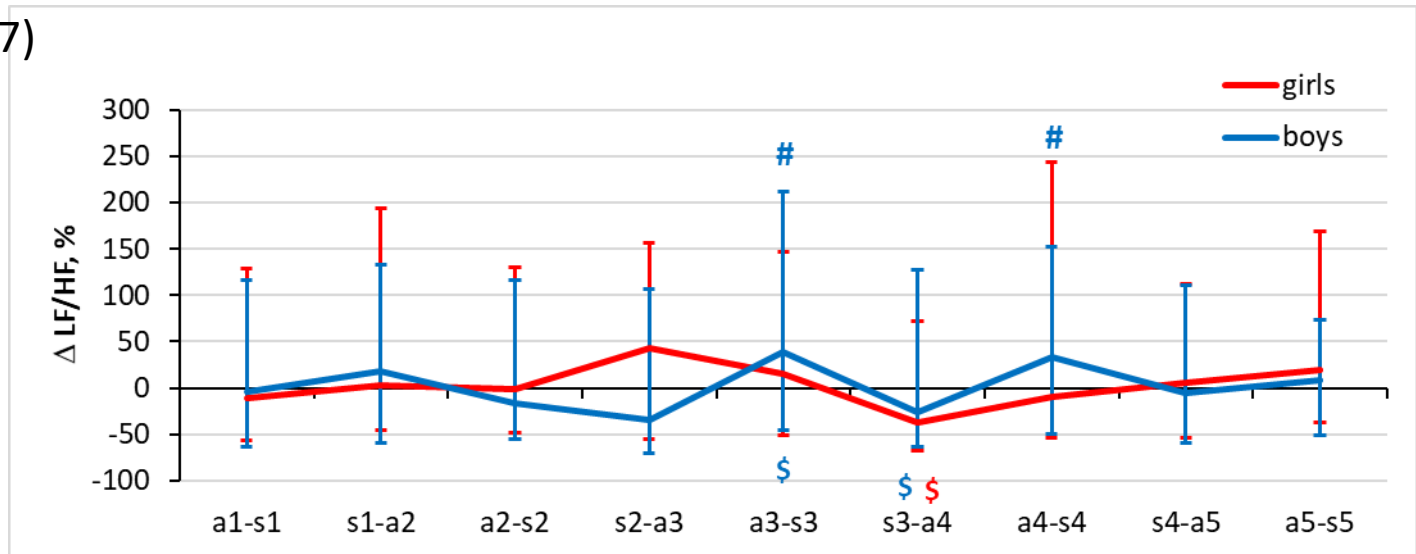


School 2 (2016-2019)

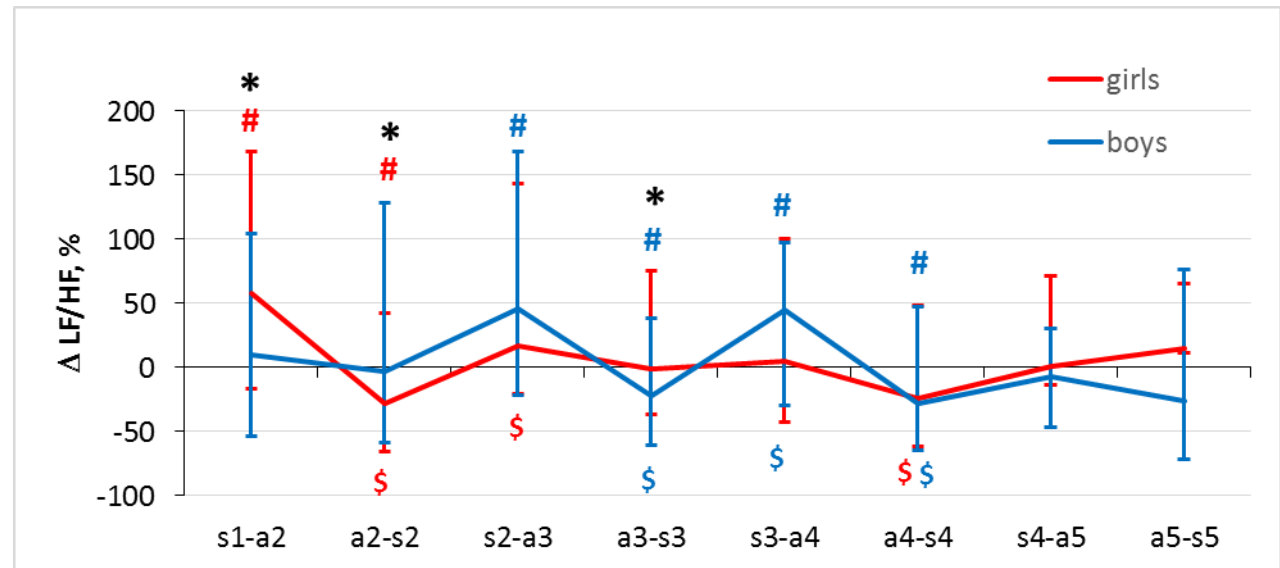


LF/HF seasonal fluctuations, delta in %

School 1 (2004-2007)



School 2 (2016-2019)



When the children (**School 2**) were divided into subgroups by BMI values, testing at the end of the fourth grade showed that seasonal fluctuations in HRV and BPV parameters were most pronounced in the group with BMI values ranging from the 15th to the 84th percentile.

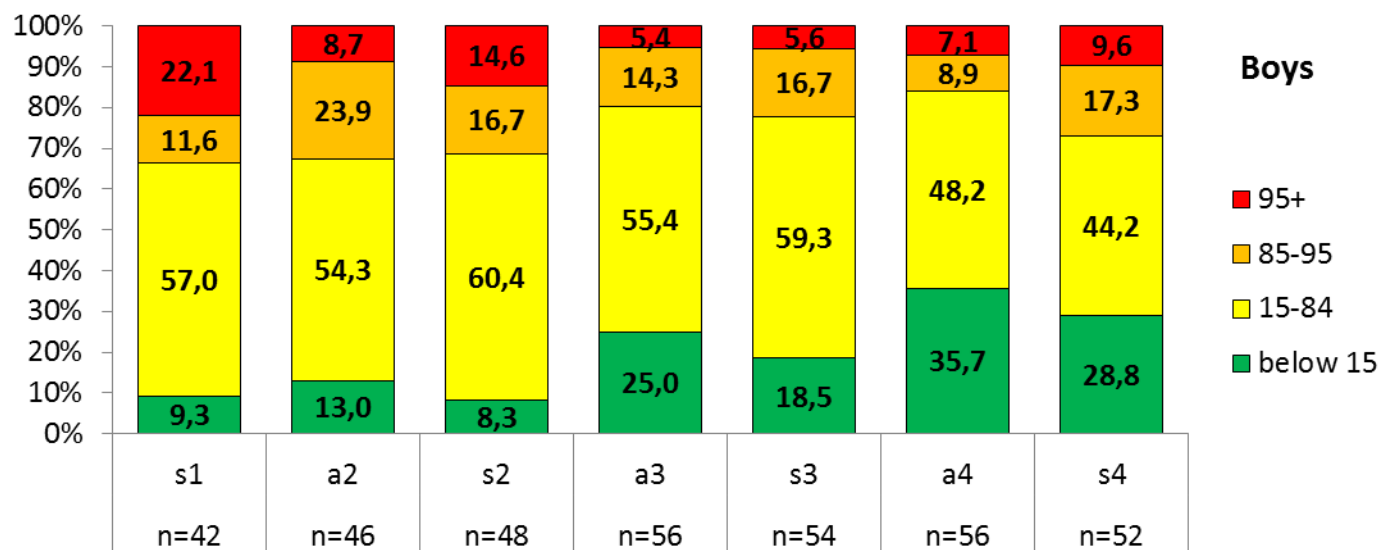
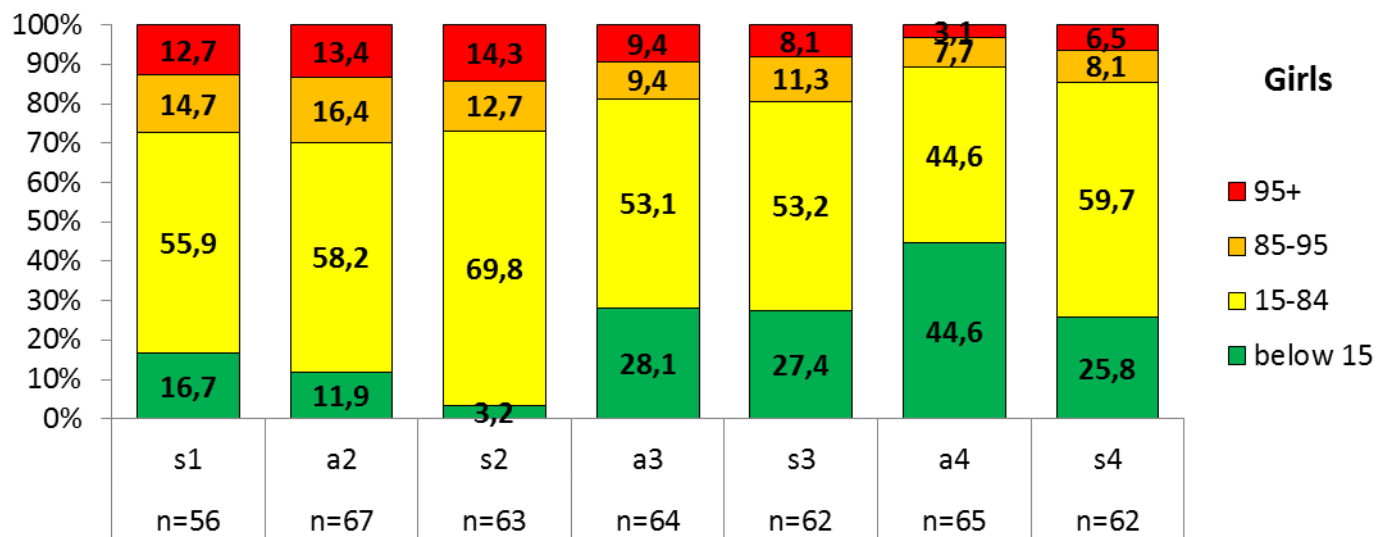
However, there were no significant differences between children from groups with different BMI (underweight in the range below the 15th percentile, overweight in the range of 85-95%, obesity in the range above the 95th percentile).

Figures legend.

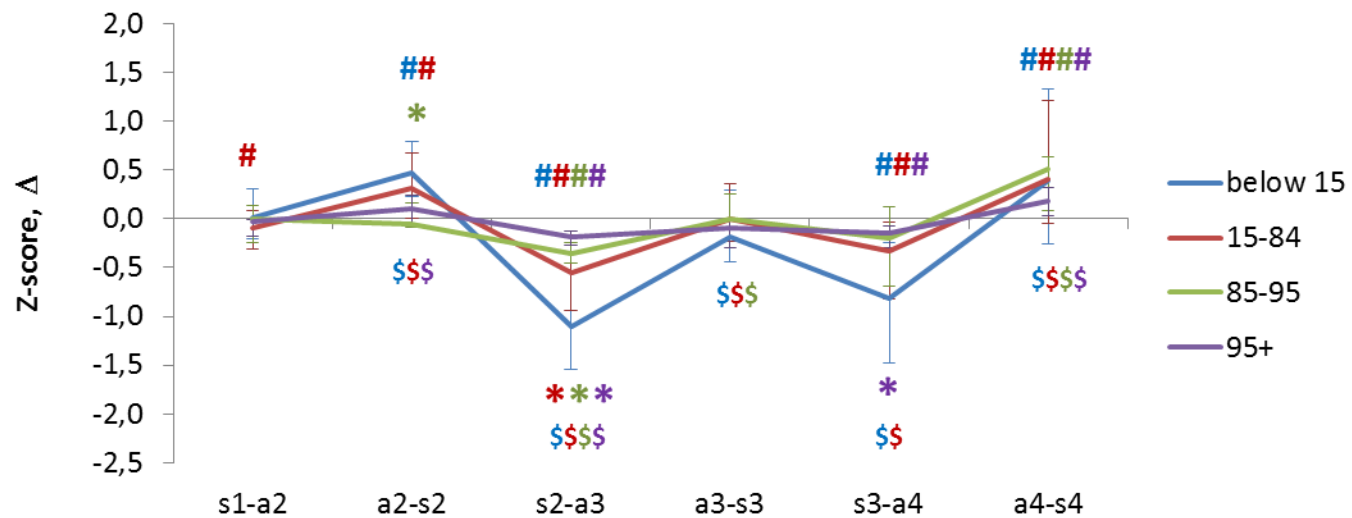
The designations of time periods: “a” - autumn, “s” - spring, numbers denote class. Statistically significant differences from the previous test point (according to the Wilcoxon paired criterion) are indicated by the “#” mark of the corresponding color. Statistically significant differences from other groups at the same testing point (according to Kruskal-Wallis test) are indicated by an asterisk of the corresponding color. The “\$” signifies statistically significant differences from the previous interval in its group (according to the Mann-Whitney test).

All data are presented as a median and interquartile range.

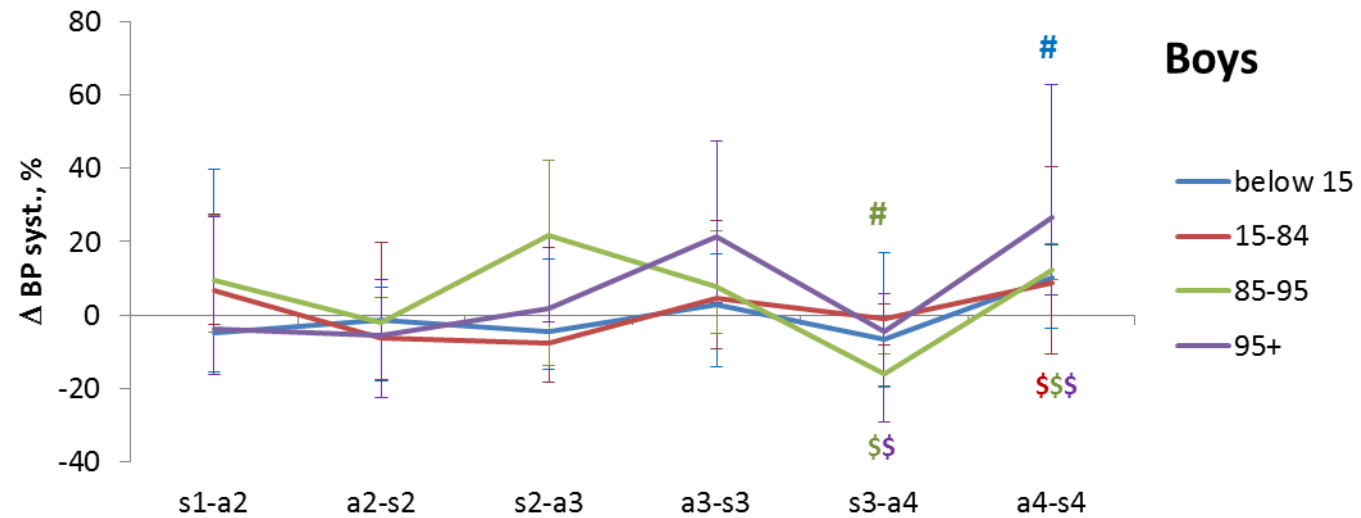
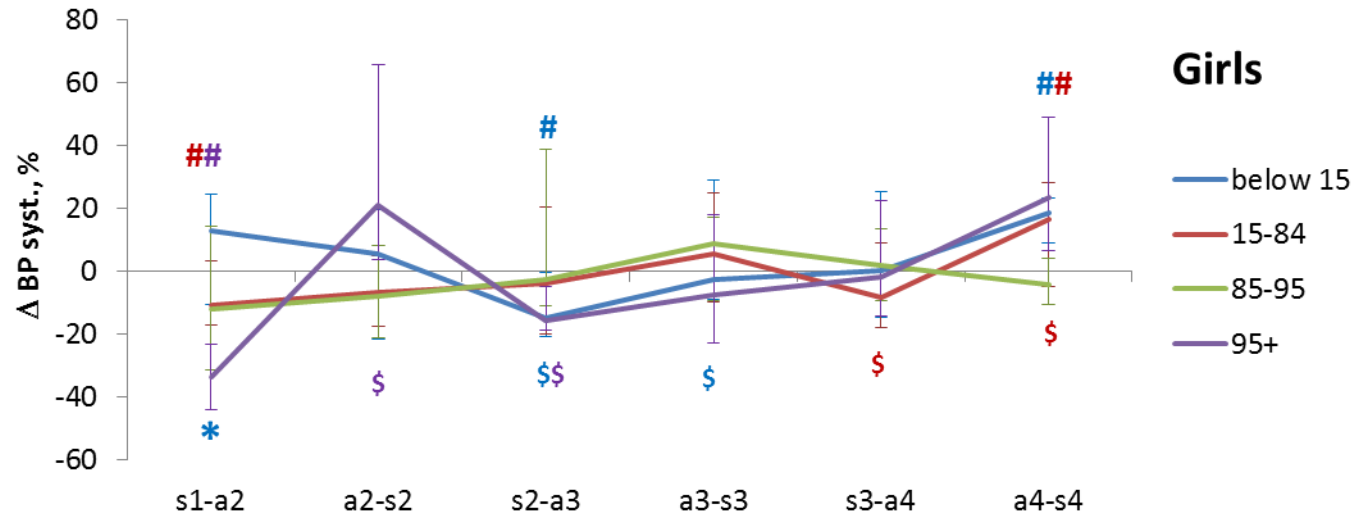
Proportion of children with different BMI (percentiles), School 2 (2016-2019)



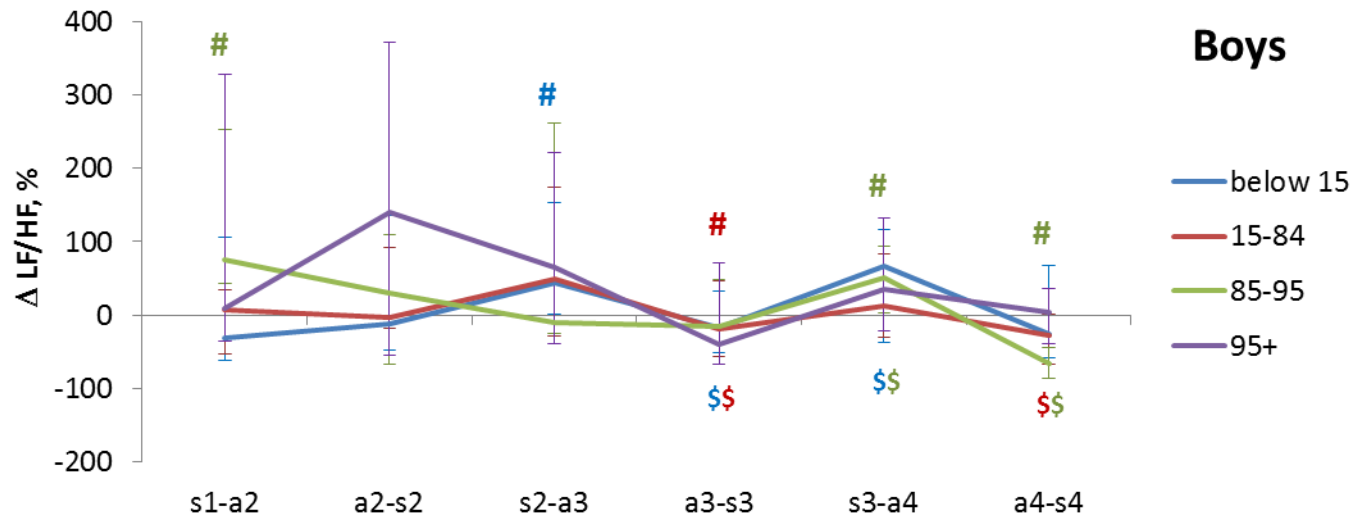
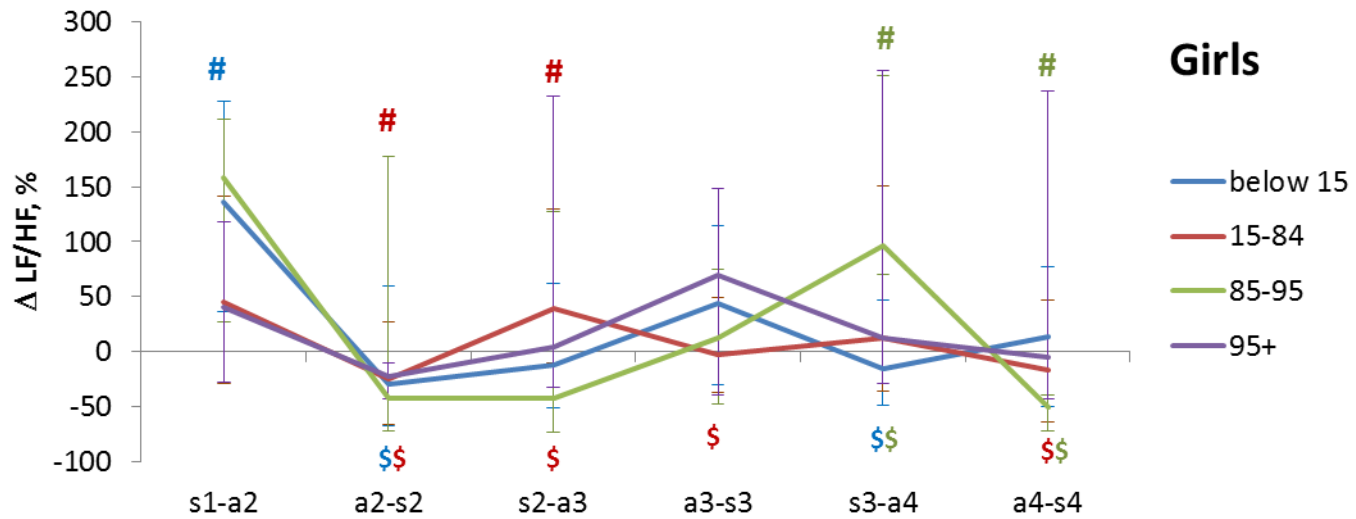
Seasonal fluctuations of BMI (Z-score) in children, divided into subgroups by BMI values, testing at the end of the fourth grade



BP systolic seasonal fluctuations, delta in %



LF/HF seasonal fluctuations , delta in %



Conclusion.

The obtained data attest to the presence of seasonal fluctuations in HRV and BPV parameters in children aged 7-12 years. These fluctuations do not depend on BMI value, but their pattern inverted from 2004-2007 to 2016-2019.

We hypothesized that these changes are related to evolution of the educational environment, its intensification, and introduction of computer technologies, but this assumption needs additional verification.

Linked publications:

Pankova N. B., Karganov M. Yu. [Seasonal and secular variations in selected indicators of the cardiovascular system among 7-11 years old children]. *Ekologiya cheloveka* [Human Ecology]. 2020; 12: 37-44. – DOI: [10.33396/1728-0869-2020-12-37-44](https://doi.org/10.33396/1728-0869-2020-12-37-44) (in Russian)

Pankova N.B. [Seasonal variability of cardiovascular parameters in elementary schoolchildren with various body mass indexes]. *Patogeneza* [Pathogenesis]. 2021; 19(1): 60-70. DOI: [10.25557/2310-0435.2021.01.60-70](https://doi.org/10.25557/2310-0435.2021.01.60-70) (in Russian)

Continuation of the research:

Pankova N., Alchinova I., Kovaleva O., Lebedeva M., Khlebnikova N., Cherepov A., Noskin L., Karganov M. The use of computers in the educational process affects the psychophysiological and somatic indicators in children aged 7-12 years (this Conference)

Pankova N.B., Alchinova I.B., Kovaleva O.I., Lebedeva M.A., Khlebnikova N.N., Cherepov A.B., Noskin L.A., Karganov M.Yu. Effects of screen time and seasons on the cardiovascular system indicators in primary schoolchildren. *Human Physiology* (accepted for publication).