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ORIGINAL ARTICLE

Relationship Between Body Composition Components and Functional State of the Autonomic Nervous System in Primary School Children with Overweight

PETRIK KYU[1], KOSTENCHAK-SVYSTAK OE[2]
[1,2]Uzhhorod National University, Uzhhorod, Ukraine Department of Physiology and Pathophysiology
Correspondence to: Olha Kostenchak-Svystak, Email: olha.kostenchak@uzhnu.edu.ua, Cell: +380630252660

ABSTRACT
Objective: Obesity and overweight in children is a socio-economic and medical problem around the world. [1] Target organs for the influence of excess fat are the heart, blood vessels, kidneys, liver and others. Therefore, more and more scientists and health professionals try to detect, prevent and control childhood obesity. [2]
Methods: 72 children aged 10-11 years were examined by body composition parameters using the bioimpedance method on Tanita BC-601 analyzer scales. Heart rate variability and autonomic nervous system status were assessed using a “CardioLab” electrocardiograph.
Results: Both BMI and total body fat, visceral fat and fat free mass were statistically significantly correlated with the activity of the sympathetic and parasympathetic systems. As the total fat content of the body increased, the total power of the regulatory systems decreased. Visceral fat content was statistically significantly affected by both ANS systems, but there was a stronger association between visceral fat and the sympathetic nervous system.
Conclusion: The data obtained can serve as an impetus for the identification of children with autonomic dysfunction and overweight to develop corrective and preventive programs for the prevention of CVD by normalizing the body composition.
Keywords: fat content, heart rate variability, obesity, BMI.

INTRODUCTION

For many years, obesity has been a leading disorder affecting children and adolescents worldwide and in Ukraine in particular. Thus, according to the World Health Organization (WHO), in almost all regions of the world, the percentage of overweight children with signs of obesity is steadily increasing, doubling every decade [3-6]. It was noted that excess body weight in childhood is a predictor of likely obesity in adulthood [7,8]. That is why finding out the social, behavioral and pathophysiological mechanisms of obesity in children is a very important task in the effort to prevent premature death and disability caused by diseases and complications from obesity-related disorders in adulthood. First of all, we are talking about such pathologies as type 2 diabetes, coronary heart disease, myocardial infarction, and acute cerebrovascular disorders.

It is believed that obesity in both children and adults has a multifactorial etiology and pathogenetic mechanisms. Among them, the most significant are genetic, environmental, and psychological factors, and lifestyle [9,10]. At the same time, the pathophysiological mechanisms of metabolic disorders that lead to the accumulation of fat in the body remain less studied. In particular, the role of autonomic dysfunctions in the pathogenesis of childhood obesity remains not fully understood, although the prevalence of such dysfunctions among school-age children is quite high [11-13]. Therefore, the aim of this study was to determine the relationship between the functional state of the autonomic nervous system (ANS) and the ratio of adipose and muscle tissue in the body of primary school children. The development of modern diagnostic technologies has made it possible to quantify the function of various parts of the ANS according to heart rate variability (HRV), which serves as a "window" into autonomous regulation of other organs and systems.

MATERIALS AND METHODS

The study, with the written consent of parents and in accordance with the ethical standards of the responsible committee on human experimentation as outlined in the Helsinki Declaration, involved 72 children aged 10 to 11, including 31 boys and 41 girls. All subjects were in good health at the time of the study according to physical examination and body temperature and blood pressure. Subjects who showed signs of increased psychological activity and those who had been involved in sports for at least 6 months were excluded from the study.

Body composition was studied using a bioimpedance analyzer Tanita BC-601 (Japan). In particular, indicators such as body mass index (BMI, kg / m^2), total body fat content (TBF,%), visceral fat content (VF, kg), and fat free mass (FFM,%) were used.

The functional state of the ANS was assessed by the method of registration of cardiointervals by graphical reproduction, using the computer complex "Cardiolab" (KHAI "Medica", Ukraine), which provides spectral indicators of heart rate variability (HRV), characterizing the functional activity of ANS systems. In particular, the tone of the sympathetic link was analyzed by the power of low-frequency waves (LF, ms^2), parasympathetic link - high-frequency waves (HF, ms2), and suprasegmental parts of ANS - ultra-low frequency waves (VLF, ms2). In addition, we calculated the sympathetic-vagal balance (LF / HF), and also the relative power indices of different frequencies in the structure of total heart rate power (TP, ms^2) as a percentage (LF%, HF%, VLF%). An example of a graphical HRV research protocol is shown in Figure 1.

RESULTS AND DISCUSSIONS

Due to age specific categorization, the children were not divided into groups by gender. The mean BMI was 25.04 ± 4.42 (kg / m^2), TBF (%) was 28.97, VF (kg) was 8.14 ± 2.38, and FFM (%) was 62.89 ± 4.83. The mean values of heart rate variability in children were: TP -2992,49 ± 519,30; VLF - 728,08 ± 145,87; LF - 1678,50 ± 632,33; HF - 585,91 ± 124,69; LF / HF - 3,09 ± 1,57; VLF% - 25,72 ± 9,51; LF% - 54,00 ± 13,80; HF% - 20,27 ± 5,87; PARS - 3,41 ± 2,09. The tension of the regulatory systems generally corresponded to the green color, indicating normal tension of the regulatory systems (TRS).

After statistical processing of data, we obtained a correlation between body composition and heart rate variability (Table №1).

BMI negatively correlates with TP, LF, LF / HF, LF% and positively correlates with VLF, VLF%, HF%. With increasing BMI, the power of regulatory systems (RS) and the activity of the sympathetic link decreased, and the activity of the parasympathetic, on the contrary, increased.

The TBF indicator showed a negative correlation with TP, LF, LF / HF, LF%, and a positive correlation with VLF, VLF%, HF%. These data corresponded to the same statistical results as when processing the correlation of BMI and HRV.

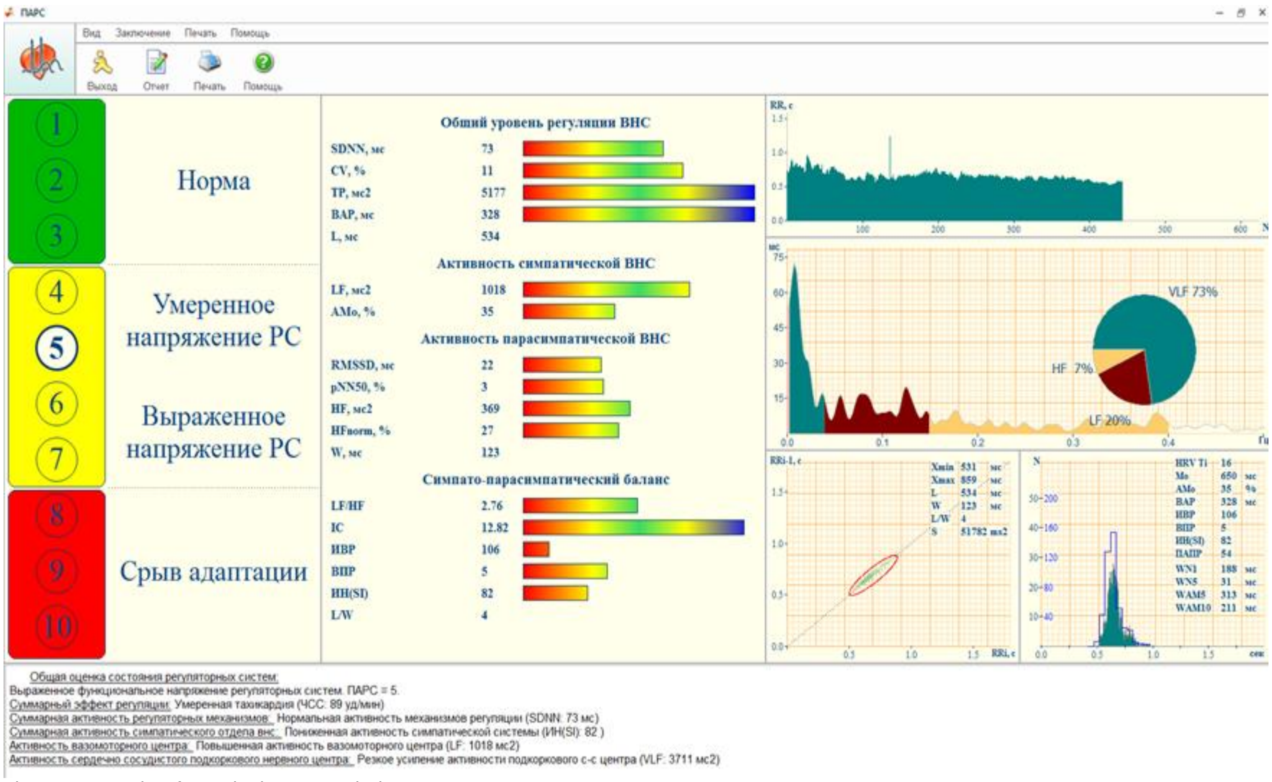

Figure 1: Example of standard HRV analysis

Table 1:

Correlations between body composition parameters and parameters of heart rate variability $p < ,05000$ N=74									
	TP	VLF	LF	HF	VLF %	LF/HF	LF%	HF%	ARS
BMI, kg/m^2	-0,53	0,52	-0,54	-0,06	0,57	-0,34	-0,52	0,30	0,17
TBF, %	-0,69	0,48	-0,68	0,02	0,59	-0,50	-0,59	0,41	0,13
VF, kg	0,09	-0,43	0,12	-0,10	-0,29	0,22	0,27	-0,15	-0,16
FFM, %	0,62	-0,25	0,56	0,03	-0,43	0,38	0,43	-0,33	-0,05

Table 2:

Regression Summary for Dependent Variable: TP (Total Power) R= ,68744379 R^2= ,47257896 Adjusted R_a^2= ,45772203 F(2,71)=31,809						
	b*	Std.Err. - of b*	b	Std.Err. - of b	t(71)	p-value
TBF, %	-0,62	0,18	-68,07	19,72	-3,46	0,00
FFM, %	0,08	0,17	8,62	19,16	0,44	0,65

Table 3:

Regression Summary for Dependent Variable: VF, kg. R= ,52424165 R^2= ,27482930 Adjusted R_a^2= ,24375056 F(3,70)=8,8430						
	b*	Std.Err. - of b*	b	Std.Err. - of b	t(70)	p-value
VLF	-0,73	0,15	-0,01	0,00	-4,72	0,00
HF	-0,29	0,11	-0,00	0,00	-2,57	0,01

The VF indicator had a negative correlation with VLF, VLF%, and a positive correlation with LF%. With increasing content of internal fat, the sympathetic-vagal balance decreased proportionally.

And the FFM indicator showed a positive correlation with TP, LF, LF / HF, LF% and a negative correlation with VLF, VLF%, HF%. Increase in fat content corresponded to an increase in total RS capacity, sympathetic activity and a decrease in the activity of the cardiovascular subcortical nerve center.

Through multifactorial regression analysis, we were able to determine that the total power of RS depends on the percentage of fat in the body - the higher the power of RS, the lower the content of total fat in children. (Table №2)

It should be noted that the content of visceral fat is affected by the activity of both the sympathetic and parasympathetic links of the ANS, and the strongest relationship is observed between the activity of the sympathetic link and the parameter of visceral fat. (Table №3)

Heart rate variability corresponds to changes in heart rate during inhalation and exhalation, and therefore reflects changes in the autonomic regulation of the heart. HRV is affected by changes in both parasympathetic and sympathetic nervous systems. However, the dynamics of HRV differ in children and adults. Studies show that cholinergic activity increases with age and the effect of adrenergic modulation decreases. The study of HRV to identify high-risk CVD groups, as well as to optimize treatment in relevant pediatric groups, has attracted the attention of many researchers. [14,15] HF and LF / HF ratios are used to predict the risk of stroke, epilepsy, heart attack and other cardio-vascular events. In addition to assessing sympathetic-vagal balance, VLF has a strong correlation with metabolic syndrome and physical endurance, as well as the association with mental stress. [16] In our study, we obtained data that the content of both fat and lean body mass affects the activity of both the parasympathetic nervous system, which is reflected by HF, and the sympathetic nervous system, which is assessed by LF, and, accordingly, affects the balance between these two links of the ANS.

Analyzing the data obtained, we can assume that the adaptive capacity of children depends on the ratio of adipose and muscle tissue. Assessment of HRV and control of eating behavior and physical activity in school-age children can be an important preventive step against CVD and obesity.

CONCLUSIONS

Thus, in children of primary school age with excess body weight, there is a close relationship between the indicators of component body composition and the functional state of the ANS, as assessed by heart rate variability. In particular, increased content of total fat has the greatest effect on the activity of the sympathetic ANS link, inducing a shift towards sympathicotonia. This is confirmed by the results of both correlation and regression analysis. In turn, this leads to a decrease in adaptation reserves according to the total power of the heart rate spectrum and the percentage of ultra-low frequency wave power.

The obtained data provide grounds for the correction of autonomic dysfunctions in overweight children by normalizing the fat content in their body.

REFERENCES

1. Brown CL, Halvorson EE, Cohen GM, Lazorick S, Skelton JA. Addressing Childhood Obesity: Opportunities for Prevention. Pediatr Clin North Am. 2015 Oct;62(5):1241-61.
2. Yang LL, Xi B. Childhood obesity and early target organ damage. Zhonghua Yu Fang Yi Xue Za Zhi. 2019 Jul 6;53(7):731-736.
3. Rodenburg G et al. Associations of Children's Appetitive Traits with Weight and Dietary Behaviours in the Context of General Parenting. PLoS One. 2012; 7(12):1
4. Ghergherechi R, Tabrizi A. Prevalence of impaired glucose tolerance and insulin resistance among obese children and adolescents. Ther. Clin. Risk Manag. - 2010; 6:345-349.
5. Raj M. Obesity and cardiovascular risk in children and adolescents Indian. J. Endocrinol. Metab. 2012; 16(1):13-19.
6. Sypniewska G. Laboratory assessment of cardiometabolic risk in overweight and obese children. Clin. Biochem. 2015; 48(6):370-376.
7. World Obesity Federation. Obesity and overweight. 9 June 2021. - Available from: URL: https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight
8. Kumar S, Kaufman T. Childhood obesity. Panminerva Med. 2018 Dec;60(4):200-212.
9. Liberali R, Kupek E, Assis MAA. Dietary Patterns and Childhood Obesity Risk: A Systematic Review. Child Obes. 2020 Mar;16(2):70-85.
10. Tanvig M. Offspring body size and metabolic profile - effects of lifestyle intervention in obese pregnant women. Dan. Med. J. 2014; 61(7).
11. DeBoer MD. Assessing and Managing the Metabolic Syndrome in Children and Adolescents. Nutrients. 2019 Aug 2;11(8):1788.
12. Adan RAH, van der Beek EM, Buitelaar JK, Cryan JF, Hebebrand J, Higgs S, Schellekens H, Dickson SL. Nutritional psychiatry: Towards improving mental health by what you eat. Eur Neuropsychopharmacol. 2019 Dec;29(12):1321-1332.
13. Engin A. The Definition and Prevalence of Obesity and Metabolic Syndrome. Adv Exp Med Biol. 2017;960:1-17
14. Cysarz D, Linhard M, Seifert G, Edelhäuser F. Sleep Instabilities Assessed by Cardiopulmonary Coupling Analysis Increase During Childhood and Adolescence. Front Physiol. 2018 May 8;9:468.
15. Massin M, von Bernuth G. Normal ranges of heart rate variability during infancy and childhood. Pediatr Cardiol. 1997 Jul-Aug;18(4):297-302.
16. Usui H, Nishida Y. The very low-frequency band of heart rate variability represents the slow recovery component after a mental stress task. PLoS One. 2017 Aug 14;12(8):e0182611.