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Original article

Indices of heart rate variability are not associated with obesity in patients 30-60 years of age without chronic noncommunicable diseases

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Abstract: *Objective* — to compare heart rate variability (HRV) in patients aged 30-60 years without chronic noncommunicable diseases (CNCDs) with and without obesity.
Methods — The groups of obese (n=43) and nonobese (n=28) patients without CNCDs ranged 30 through 60 years of age. We assessed the conventional HRV indices according to the clinical guidelines, as well as the synchronization index (S) for low-frequency (LF) oscillations evaluated from HRV and photoplethysmogram (PPG).
Results — No statistically significant differences in HRV indices and S index were detected between the study groups.
Conclusion — HRV indices and synchronization of LF oscillations detected from HRV and PPG were not significantly associated with obesity in patients aged 30-60 years without CNCDs.

Keywords: obesity, heart rate variability, chronic noncommunicable diseases.

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Introduction

The association between the dysfunction of autonomic regulation and the pathogenesis of obesity is a highly debated issue in the medical community [1–4]. In particular, the parasympathetic part of the autonomic nervous system modulates feeding behavior, the glucose and free fatty acids metabolisms, and insulin sensitivity of adipocytes [5, 6]. Researchers concluded that potential health risks in obese individuals were to a greater extent associated with autonomic dysfunction [5]. A variety of pathogenetic processes linking autonomic dysfunction to obesity have launched the development of methods for excess body weight correction via affecting the mechanisms of autonomic regulation (e.g., by stimulating the vagus nerve) [7].

Traditionally, the state of autonomic regulation in the human body is assessed by analyzing heart rate variability (HRV) indices [8]. In childhood and adolescence, a decrease in HRV indices caused by autonomic dysfunction is significantly associated with obesity [9]. Studies conducted on middle-aged people showed that body mass index (BMI) per se has a weak connection with HRV indices, while visceral obesity is closely related to changes in autonomic regulation [10]. The positive effect of weight loss in young and middle-aged people on the state of autonomic regulation assessed by HRV indices is well known [11].

Metabolic aging processes are accompanied by an age-related decrease in values of HRV indices [12, 13], which may complicate the analysis of the association of autonomic dysfunction with obesity. Obese patients of the older age group are often characterized by the presence of comorbid conditions, also to a certain extent associated with autonomic disorders. Such heterogeneity in clinical groups of patients causes high variability in the detected differences and associations between HRV indices, obesity and other factors [3, 14]. Often, researchers find differences in HRV indices only in individuals with extremely high BMI or waist circumference values [14]. We can assume that HRV, albeit characterizing the autonomic regulation of blood circulation, is not the optimal marker for assessing changes in the autonomic regulation of metabolism in general for substances involved in the pathogenesis of obesity.

The objective of our study was to compare the values of HRV indices between obese and nonobese 30-60 years old patients without chronic noncommunicable diseases (CNCDs).

Material and Methods

Research design

This article is a subanalysis of the Auricular Vagus Stimulation in Obesity project (ClinicalTrials.gov Identifier: NCT05230628) performed at the National Medical Research Center for Therapy and Preventive Medicine of the Russian Federation Ministry of Healthcare. The study was approved by the local ethics committee and was conducted in accordance with international standards of good clinical practice. Written informed consent was obtained from each patient prior to the inclusion in the study.

The inclusion criteria were as follows:

– patients from 30 to 60 years of age who gave consent to participate in the study;
– obesity (BMI ≥30 kg/m^2).

The exclusion criteria were as follows:

– diagnosed CNCDs (coronary artery disease, chronic heart failure, etc.);
– heart valve disorders;
– history of any form of atrial fibrillation or flutter;
– history of any form of supraventricular arrhythmias;
– frequent ventricular or supraventricular extrasystoles;
– first- and second-degree atrioventricular blocks;
– intake of glucocorticoids and any antiarrhythmics including beta blockers in the last month;
– obesity of endocrine nature;
– anticipated technical difficulties when using the device on the part of the patient;
– existing or anticipated pregnancy or breastfeeding during the study period;
– patient participation in another clinical trial.

Study subjects

The presented subanalysis included data on patients who were involved in the observational phase of the study. We analyzed their baseline HRV indices vs. the presence or absence of obesity. A total of 71 patients were included in our study, their median age was 45 years with an interquartile range of 36 to 53 years. In terms of gender distribution, the pool of patients was dominated by females (n=51, 72%). The group of obese patients comprised 43 individuals, while the group of nonobese subjects encompassed 28 patients.

Analysis of heart rate variability indices

The study was conducted in early evening hours (17.00-18.00) before meals, which made it possible to exclude the influence of daily fluctuations and postprandial effects in the autonomic regulation of the cardiovascular system and create similar conditions for all patients. The recording of the studied signals took place in a specialized functional diagnostics room that met the medical requirements (temperature of 21-24 °C, required humidity, lighting, wall covering, etc.), in the presence of a clinical research physician without unauthorized individuals. The effects of noise, various sounds, etc., were excluded. All subjects were in a horizontal position at the time of the study. At all stages of the study, their breathing was voluntary.

All patients were simultaneously subjected to an electrocardiogram (ECG) in standard lead II *sensu* Einthoven and a photoplethysmogram (PPG) from the distal phalanx of the index finger of the right hand using an infrared reflected light sensor of the plethysmograph. Signals were recorded using a multichannel polyrecorder electronic unit (electroencephalograph analyzer *EEGA-21/26 Encephalan-131-03*, model 10 with a set of standard sensors, Medicom MTD, Russia) with a sampling frequency of 250 Hz and a resolution of 14 bits. For further analysis, we selected signal recordings without interference, extrasystoles, noticeable linear trends and transient processes.

Conventional HRV indices were assessed according to clinical guidelines [8]. The list of these indicators is presented in *Table 1*. The value of the synchronization index (S) was calculated as well for low-frequency oscillations detected from HRV and PPG, according to the previously described original method [15].

Statistical data processing

Statistical data processing was performed using STATISTICA® Statsoft and SPSS® Statistics 25.0 software. Our results are presented as median and interquartile range [Me (Q1; Q3)], and frequencies. To compare two independent samples, we employed the Mann-Whitney U test for quantitative variables and the Pearson's chi-squares test or Fisher's exact test for categorical variables. The difference between groups was considered statistically significant at $p < 0.05$.

Results

The analysis included 71 individuals: 43 obese patients vs. 28 nonobese (control) subjects. The groups had comparable distributions in terms of age and gender (*Table 2*) and differed in both absolute values of body weight and BMI.

The comparisons of various HRV indices yielded no statistically significant differences between the groups (*Table 2*).

Table 1. Indicators of autonomic regulation assessed in this study

HF	Power of the high-frequency band in the heart rate spectrum, absolute value
LF	Power of the low-frequency band in the heart rate spectrum, absolute value
LF/HF	Ratio of high-frequency to low-frequency oscillations in the heart rate spectrum
VLF	Power of the very low-frequency band in the heart rate spectrum, absolute value
ULF	Power of the ultra-low-frequency band in the heart rate spectrum, absolute value
TP	Total power of the heart rate spectrum
SDNN	Standard deviation of NN (normal-normal interbeat interval)
V	Variance of the array of normal interbeat intervals
CV	Coefficient of variation of the full array of interbeat intervals
RMSSD	Root mean square of successive differences between adjacent NNs
pNN50	Proportion of NN50 (number of pairs of interbeat intervals with a difference of more than 50 ms) of the total number of NNs
S (ECG-PPG)	Degree of synchronization of low-frequency oscillations between heart rate variability and photoplethysmogram

Table 2. Comparison of patient groups with and without obesity according to initial data

Indicators	*Obese (n=43)*	*Nonobese (n=28)*	*p*
Clinical data			
Age, years	46 (35; 54)	40 (38; 49)	0.534
Male gender, %	24	33	0.390
Weight, kg	97 (88; 113)	74 (64; 87)	<0.001*
BMI, kg/m^2	34 (32.5; 38.5)	27 (24; 28)	<0.001*
HRV indices			
HR, beats/min	70 (64; 78)	68 (63; 75)	0.352
HF*, ms^2	199 (100; 458)	155 (93; 366)	0.423
LF*, ms^2	243 (131; 440)	228 (132; 364)	0.991
LF/HF	0.9 (0.6; 1.6)	1.3 (0.7; 2.3)	0.371
VLF*, ms^2	117 (61; 223)	93 (48; 198)	0.465
ULF*, ms^2	160 (82; 301)	148 (91; 217)	0.346
TP*, ms^2	835 (448; 1294)	705 (506; 1116)	0.605
SDNN*, ms	33 (24; 41)	32 (28; 39)	0.943
V*	1,112 (594; 1725)	1,011 (761; 1520)	0.943
CV*	3.7 (3; 4.6)	3.6 (3; 4.2)	0.706
RMSSD*, ms	24 (17; 34)	23 (17; 32)	0.841
pNN50*, %	2.92 (0.31; 12.6)	3.4 (0.13; 9)	0.558
S (ECG-PPG)*	48 (42; 59)	54 (43; 64)	0.233

BMI, body mass index; HRV, heart rate variability; HR, heart rate; *, defined in *Table* 1.

Discussion

The obesity is a widespread condition, and therefore new methods of its diagnosis and treatment are relevant and currently being sought. Our study demonstrated that there were no significant differences in HRV of obese patients vs. individuals with normal anthropometric indicators.

We compared the results of our study with published data. In 1999, Kristjan Karason et al. [16] examined a group of obese patients referred for bariatric surgery, a group of obese patients with dietary advice, and a control group. Initially, SDNN and HF values were reduced in obese patients, compared with the control group (p<0.01). At follow-up, in the group of patients who lost weight, an increase of SDNN and HF values was observed (p<0.05). Hence, that study supported the hypothesis that obese patients exhibited increased sympathetic activity and reduced vagal activity, and that these autonomic disorders improve after weight loss.

Ram Lochan Yadav et al. compared autonomic regulation in 30 obese adults and 29 healthy people with a normal weight. Waist circumference, hip circumference, waist-hip ratio, and BMI were measured/calculated and compared with HRV indices [10]. Some HRV indices exhibited a significant direct correlation with obesity: e.g., between the waist-hip ratio and LF (r=0.478, p<0.01) and the waist-hip ratio and LF/HF (r=0.479, p<0.01). However, BMI per se had a weak association with HRV. Similar results were obtained in the study by S. Niveatha et al. The relationship between BMI and HRV indices was weaker than between the waist circumference or percentage of visceral fat with HRV indices [17].

The results of a study by a team of scientists from Indonesia demonstrated differences in HRV indices in subjects with different BMIs [18]. However, the difference was determined only in the group of young people, and not in older age groups. Such trend may indicate that the properties of HRV decrease as they undergo physiological changes and metabolic aging. When comparing indices of autonomic regulation between ages, older people exhibit lower HRV indices than young subjects within the same BMI category. Besides that, the number of concomitant pathologies increases with age, which can also affect autonomic regulation.

Such heterogeneity of clinical groups causes high variability in the detected differences and associations between HRV indices, obesity and other factors [3, 14]. Hence, the results of our study differ from previously published sources, probably due to the lack of proper consideration of age-specific differences in these sources and comparison of groups solely in terms of BMI, without taking into account the waist-hip ratio, waist circumference or other parameters of visceral obesity. Considering our results, it becomes obvious that additional research is needed to further investigate the variability of autonomic status in obese individuals.

Conclusion

We found no differences in indicators of autonomic regulation of blood circulation between obese and nonobese 30-60 years old patients.

Study limitations

Limitations of the study include small sample sizes in groups with and without obesity, as well as a fairly wide age range for the study, which could potentially affect the values of HRV indices. However, we believe that age- and gender-specific variability of HRV indices was similar across the groups, given the absence of statistically significant differences in their values.

Small sample sizes did not allow performing a comprehensive multivariate analysis of the data, which also limited the results of our study to solely reporting the results of a comparative analysis of HRV indices between the groups of obese and nonobese subjects.

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Conflict of interest

The authors declare no conflicts of interest.

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