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Trabajo Original

Obesidad y síndrome metabólico

Autonomic function and its relationship with central obesity and hemodynamic variables in obese and overweight adults

Función autonómica y su relación con la obesidad central y las variables hemodinámicas en adultos obesos y con sobrepeso

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Abstract

Introduction: central obesity is associated with an autonomic dysfunction characterized by an increase in sympathetic activity and a reduction in vagal tone, leading to a decrease in heart rate variability.

Objective: we aimed to analyze the relationship between the time and frequency domains of heart rate variability with central obesity, and its hemodynamic variables in normal-weight, overweight and obese adults.

Methods: a total of 65 adults were evaluated (25.4 ± 3.2 years old) and distributed in 3 groups: normal weight group (NW group), overweight group (OW group) and obese group (OB group). Heart rate variability parameters at rest and both anthropometric and hemodynamic variables were recorded.

Results: the results showed a positive correlation between waist circunference and LF/HF ratio in the OW ($p = 0.0008$; $r = 0.6607$; $r^2 = 0.4365$) and OB ($p = 0.0001$; $r = 0.8286$; $r^2 = 0.6866$) groups. The waist-to-height ratio showed significant differences with HF in the NW, OW, and OB groups. The variables related to the parasympathetic system (SDNN, RMSSD, pNN50, HF) in the OB and OW groups showed a decrease in values when compared to the NW group. Likewise, the variable related to the sympathetic system (LF) in the OB and OW groups increased its values when compared with the NW group. The LF/HF ratio increased from the NW group to the OW and OB groups (1.6 ± 0.7; 2.5 ± 1.8 and 3.3 ± 0.7).

Conclusion: overweight and obese adults present a modulation of sympathetic activity predominance at rest. This increased activity is represented by the time and frequency domains of heart rate variability, having an important correlation with waist circumference and waist-to-height ratio.

Keywords:

Autonomic nervous system. Heart rate variability. Central obesity. Hemodynamic variables. Waist circumference.

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Resumen

Introducción: la obesidad central se asocia con una disfunción autonómica caracterizada por una mayor actividad simpática y reducción del tono vagal, conduciendo a una disminución de la variabilidad de la frecuencia cardíaca (VFC).

Objetivo: analizar la relación entre los dominios de tiempo y frecuencia de la VFC con la obesidad central y sus variables hemodinámicas en adultos con peso normal, sobrepeso y obesidad.

Metodología: participaron 65 adultos (25,4 ± 3,2 años) distribuidos en 3 grupos: peso normal (grupo NW), sobrepeso (grupo OW) y obesidad (grupo OB). Se registraron los parámetros de la VFC y las variables antropométricas y hemodinámicas.

Resultados: se observó una correlación positiva entre la circunferencia de la cintura y la relación LF/HF en el grupo OW ($p = 0,0008$; $r = 0,6607$; $r^2 = 0,4365$) y OB ($p = 0,0001$; $r = 0,8286$; $r^2 = 0,6866$). La relacion cintura/altura mostró una diferencia significativa con la HF en los grupos NW, OW y OB. La actividad parasimpática (SDNN, RMSSD, pNN50, HF) de los grupos OB y OW evidenció una disminución de los valores en comparación con el grupo NW. La actividad simpática (LF) en el grupo OB y OW presentó mayores valores que en el grupo NW. La relación LF/HF aumentó del grupo NW hacia el OW y el OB (1,6 ± 0,7; 2,5 ± 1,8 y 3,3 ± 0,7).

Conclusiones: el sobrepeso y la obesidad presentan una predominancia de la actividad simpática en reposo. Este aumento de la actividad está representado en el dominio de tiempo y frecuencia de la VFC y, además, presenta una correlación importante con la circunferencia de la cintura y la relación cintura/altura.

Palabras clave:

Sistema nervioso autónomo. Variabilidad de la frecuencia cardiaca. Obesidad central. Variables hemodinámicas. Circunferencia de la cintura.

INTRODUCTION

Obesity is well known as a metabolic disorder of multifactorial origin with an increased incidence in developed and developing countries (1). It has led to non-communicable diseases such as arterial hypertension, hypercholesterolemia, insulin resistance and type-2 diabetes *mellitus* (2). Worldwide, according to the World Health Organization (WHO) in 2016, 39 % of adults ≥ 18 years (39 % of men and 40 % of women) are overweight, and 13 % of them (11 % of men and 15 % of women) are obese, the prevalence being a serious health problem (3). Obesity starts with an increase of free fatty acids in the organism. They accumulate initially in the subcutaneous adipose tissue and when this tissue is no longer able to store it, excess adiposity drains into the visceral fat deposits around the organs in the abdominal area (4), inducing an increase in inflammatory mediators from the fatty tissue. This inflammatory process establishes changes in both structure and function in the obese subjects (5).

Thus, scientific evidence indicates changes in autonomic function in overweight and obese people (6), since there is a deterioration of balance in autonomic nervous system (ANS) functioning. This unbalance is represented by an increase in sympathetic activity and a decrease in vagal tone leading to a reduction in heart rate variability (HRV) (7), which refers to the intervals between heartbeats in a specific time, and are a reflection of the balance between ANS, blood pressure (BP), and gut, heart, and vascular tone (8). In order to know if a person has overweight or obesity, we need to use the variables of BMI and WC. We define BMI as an indicator of the relationship between weight and height (9), and we understand WC as the amount of visceral adipose tissue in the abdominal region, measured in centimetres (10), which is considered an important cardiovascular risk factor (11).

Therefore, obese and overweight people have an imbalance in their ANS because of their visceral adipose tissue, expressed in their BP and their sympathetic function predominance (12). This imbalance in the ANS has been frequently mentioned related to an unhealthy lifestyle, sedentarism, and metabolic abnormalities (13). However, few studies have established a relationship between the time and frequency domain of HRV associated with central obesity. It is necessary to acknowledge that central obesity is a factor related to cardiovascular diseases, arrhythmias, hypertension, and cardiac death (14) because of the physiological and metabolic changes associated with cardiac function (15). The aim of this study was to analyze the relationship between the time and frequency domains of HRV and central obesity with its hemodynamic variables in obese and overweight people. We hypothesized that central obesity is associated with changes in the time and frequency domains of HRV that can negatively affect cardiac function.

MATERIAL AND METHODS

This study presents a non-experimental, cross-sectional correlation-causal design.

PARTICIPANTS

The present study considers 65 men adults, all sedentary college students aged from 20 to 30 years (25.4 ± 3.18 years). Participants were recruited through public announcement and social networks. Exclusion criteria were as follows: habit of physical exercises expressed as at least 3 times a week, smoking, subjects with hypertension, cardiopulmonary and morbid diseases, use of drugs or medicines that affect ANS. Before the evaluation, the participants were asked not to have consumed any alcoholic and/or stimulant drinks during 24 hours prior to the measurements, not to have carried out any physical activity of moderate or high intensity the previous day, and to have completed a 12-hour fasting period, in addition to signing the informed consent. All participants signed a written informed consent before undergoing research, and this study was evaluated and approved by the ethics committee of the university involved (CEC UST Nº52/2019).

PROCEDURE

The study was conducted at the exercise physiology laboratory. The room was air-conditioned, controlling temperature to range between 22 °C and 24 °C, relative humidity between 50 % and 60 %, and dim lighting. All 65 participants were distributed into three groups — the first group consisted of 24 adults, identified as NW group (BMI = 21.78 ± 1.38 kg/m^2), the second group was composed of 20 adults classified as overweight (OW group) (BMI = 27.4 ± 4.08 kg/m^2), and the last group included 21 adults classified as obese (OB group) (BMI = 33.79 ± 2.74 kg/m^2).

AUTONOMIC FUNCTION EVALUATION

Before the HRV evaluation the participants remained at rest in the supine position and the cardiac band (Polar brand, model H7) evaluated autonomic functions. The Cardiomood software recorded the R-R intervals of the QRS complex during a 10-minute period for data extraction and analysis. The analysis of the spectral method is based on fast Fourier transforms (FFT). We analyzed the frequency domain components such as high frequency (HF), range from 0.15 to 0.4 Hertz (Hz), and low frequency (LF), range from 0.04 to 0.15 Hertz. The LF component reflects a sympathetic modulation, while the HF component of vagal modulation and the LF/HF ratio are an indirect index of the vagal-sympathetic balance (16). All frequency domain parameters are expressed in normalized units (nu). Also, we analyzed the time-domain components such as SDNN (standard deviation for all R-R intervals), which describes short or long variations in the R-R intervals, NN50 (number of adjacent intervals varying by more than 50 ms, expressed in %), which is a variable derived from the difference in R-R intervals, and RMSSD (square of the mean root of the junction of the adjacent R-R intervals), which provides an indicator of the wandering cardiac control (8).

HEMODYNAMIC AND ANTHROPOMETRIC VARIABLE EVALUATION

After recording HRV, specialists using cardiac auscultation with the Omrom m6/comfort equipment measured blindly BP, systolic blood pressure (SBP), and diastolic blood pressure (DBP), in the seated position. In the same context, they evaluated heart rate (HR) by the heart band used before. With the information recorded they calculated the double product (DP) as HR (bpm) x SBP (mmHg), and the mean arterial pressure (MAP), which is the perfusion pressure for the body organs (16). On two occasions they measured SBP and HR at the same time at three-minute intervals.

In order to determine the BMI and categorize their level of obesity we measured and weighed the participants. With anthropometric tape (SECA – 203; accuracy, 0.1 cm) they recorded twice the WC using as midpoint the anatomical reference between the anterior superior iliac crest and the tenth rib and averaging both measures for the analysis (17). Also, we calculated the waist-to-height ratio (WHtR), which considers a better indicator of cardiometabolic risk than BMI and WC among adults, with a cut-off point at 0.5 cm, meaning that a value higher than 0.5 represents a higher risk of obesity-related diseases regardless of age, sex or ethnicity (18). We took into account these 3 anthropometric measurements and their averages for the analysis.

STATISTICAL ANALYSIS

For the statistics we used the GraphPad Prism 5 for Windows® software. The population profile data were described using descriptive statistics, and the results were presented as mean, standard deviation, coefficient of variation, and absolute number values. In the inferential analysis the Shapiro-Wilk normality test was performed to establish the distribution of the data. The comparison between groups was performed using a single-factor ANOVA and post hoc comparison with Bonferroni's test, depending on the normality and homoscedasticity tests. Pearson's or Spearman's correlation test was conducted, depending on normality and homoscedasticity. Differences in these tests were considered statistically significant when $p < 0.05$. In addition, a linear regression analysis was performed to model the relationship between the WC and ratio of LF-to-HF variables under study.

RESULTS

All participants completed the study and table I shows the anthropometric, hemodynamic and autonomic function characteristics of all groups. Of the 65 participants studied, 24 were women (63.09 %) and 41 men (36.9 %), with an average age of 25.4 ± 3.18 years (20 to 29 years), distributed as follows: 36.9 % in the NW group, 30.7 % in the OW group, and 32.3 % in the OB group. In relation to the anthropometric characteristics the average BMI was 27.22 ± 5.17 kg/m^2 for the entire studied group. The mean WC was 98.35 ± 20.57 cm for the individuals, distributed as 78.46 ± 7.22 cm in the NW group, 102.21 ± 11.14 cm in the OW group, and 120.83 ± 14.39 cm in the OB group. Hemodynamic results are presented in table I.

Regarding the HRV analysis, figure 1 shows the different HRV parameters in the frequency domains according to nutritional status. It is observed that there are significant differences in (A) LF, (B) HF and (C) LF/HF frequencies according to nutritional status. When analyzed, it is evident that people with NW have significantly less LF than the OW group ($p \leq 0.001$) and the OB group ($p \leq 0.001$). In addition, it was observed that people with NW have significantly higher HF than the OW group ($p = 0.002$) and OB group ($p \leq 0.001$). Additionally, figure 1 presents the highest predominance of autonomous sympathetic modulation (LF 81.61 ± 10.84 nu) in the OB group, as well as the lowest parasympathetic modulation (HF 25.50 ± 4.56 nu). Likewise, the LF/HF ratio increases from the NW and OW groups towards the OB group, with values of 1.57 ± 0.74 nu, 2.45 ± 1.79 nu, and 3.28 ± 0.86 nu, respectively.

Table I. Anthropometric, hemodynamic and autonomic function characteristics of the study groups

Parameters	Variables	NW Group (n = 24)	OW Group (n = 20)	OB Group (n = 21)
Anthropometric	Age (years)	22 ± 2.29	23 ± 2.07	22 ± 1.87
	Weight (kg)	60.75 ± 8.28	77.54 ± 17.54	93.57 ± 15.39
	Height (mts)	1.67 ± 0.09	1.67 ± 0.10	1.66 ± 0.10
	BMI (kg/m^2)	21.78 ± 1.38	27.40 ± 4.08	33.79 ± 2.74
	WC (cm)	78.46 ± 7.22	102.21 ± 11.14	120.83 ± 14.39
	WHtR	0.47 ± 0.03	0.59 ± 0.07	0.73 ± 0.10
Hemodynamic	SBP (mm Hg)	105.00 ± 13.51	113.14 ± 11.23	117.86 ± 11.02
	DBP (mm Hg)	60.42 ± 6.9	66.28 ± 8.9	77.38 ± 13.10
	MAP (mm Hg)	75.28 ± 7.73	80.33 ± 898	90.87 ± 10.82
	HR	75.67 ± 20.94	72.23 ± 10.54	74.76 ± 10.39
	DP	8015.00 ± 2851.85	8195.50 ± 1472.95	8811.9 ± 1472.53
Autonomic function	LF (nu)	56.04 ± 12.87	72.78 ± 22.45	81.61 ± 10.84
	HF (nu)	41.04 ± 13.23	30.56 ± 19.41	25.50 ± 4.56
	LF/HF (nu)	1.57 ± 0.74	2.45 ± 1.79	3.28 ± 0.68
	SDNN (ms)	65.00 ± 19.34	84,65 ± 36,90	74,97 ± 36,58
	RMSSD (ms)	55.16 ± 27.22	61.96 ± 48.03	64.22 ± 24.97
	PNN50 (%)	31.47 ± 17.99	31.28 ± 24.41	32.47 ± 20.85

Values expressed as mean ± standard deviation. NW: normal weight group; OW: overweight group; OB: obese group; BMI: body mass index; WC: waist circumference; WHtR: waist-to-height ratio; SBP: systolic blood pressure; DBP: diastolic blood pressure; MAP: mean arterial pressure; HR: heart rate; DP: double product; LF: low frequency; HF: high frequency; SDNN: standard deviation of NN intervals; RMSSD: root mean square of successive RR interval differences; PNN50: percentage of successive RR intervals that differ by more than 50 ms.

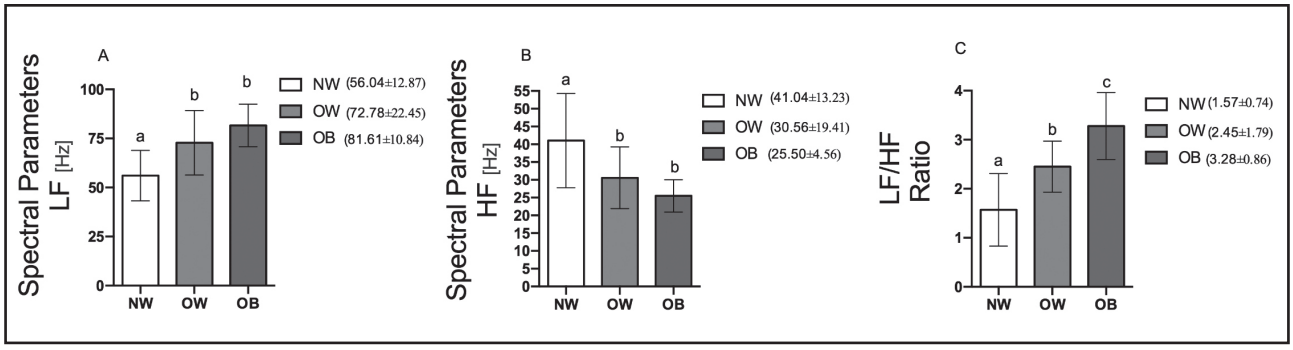

Figure 1.

Descriptive graph showing HRV parameters in the frequency domain across the NW, OW and OB groups: A. LF (low frequency); B. HF (high frequency); and C. LF/HF (LF-to-HF ratio). The statistical analysis was performed with a one-factor ANOVA (NW: normal weight group; OW: overweight group; OB: obese group; a,b,c within a column with a different letter indicates significant differences between groups [one-factor ANOVA and post hoc comparison with Bonferroni's test]. A p-value < 0.05 was considered for all analyses).

From the simple correlation analysis, the largest number of associations are found in the OB group, observing a positive correlation between WC, WHtR, HR and DP with LF and the LF/HF ratio ($p \leq 0.05$), and negative correlation between WC and WHtR with HF values ($p \leq 0.05$). Similarly, in the OW group a positive correlation is shown between the variables WC, WHtR and MAP and the LF/HF ratio ($p \leq 0.05$), and negative correlation between the values of WC and WHtR with HF ($p \leq 0.05$). Finally, a negative correlation is shown in the NW group between WC and WHtR with HF ($p \leq 0.05$), as shown in table II.

The time-domain component only exhibits a significant difference in the OB and OW group. The first group reveals a negative correlation between the variables SBP and DP with SDNN, also adding a negative correlation between SBP and RMSSD ($p \leq 0.05$), as shown in table IV. Likewise, for the OW group, a negative correlation is observed in the variables HR and DP with PNN50 ($p \leq 0.05$), as shown in table III.

Finally, a strong positive correlation is observed between WC and the LF/HF ratio in the OW group ($p = 0.0008$, $r = 0.6607$; $r^2 = 0.4365$) (Table III) and OB group ($p = 0.0001$, $r = 0.8286$; $r^2 = 0.6866$) (Table IV).

DISCUSSION

Central obesity is an important precursor of different metabolic diseases (5) and, for that reason, this study assessed the relationship between the time and frequency domains of HRV with central obesity and its hemodynamic variables, emphasizing an important sympathetic activity at resting conditions in obese and overweight adults compared to those of normal weight.

Table II. Correlation between HRV time and frequency domain measures with WC, SBP, DBP, HR and DP in the NW group

Variables NW Group (n = 24)									
Variables	**Frequency-domain measures**								
	LF (Hz)			**HF (Hz)**			**LF/HF (%)**		
	p	**r**	**r^2**	**p**	**r**	**r^2**	**p**	**r**	**r^2**
WC (cm)	0.3418	0.08774	0.007	*0.0175	-0.4320	0.1866	0.0734	0.305	0.093
WHtR (cm)	0.2754	0.1281	0.01642	*0.0428	-0.3583	0.1284	0.1093	0.2607	0.0679
SBP (mm Hg)	0.280	0.124	0,027	0.2416	-0.150	0.0187	0.2917	0.1179	0.02156
DBP (mm Hg)	0.349	-0.0831	0.0043	0.2428	0.1495	0.02818	0.2535	-0.1423	0.02153
MAP (mm Hg)	0.4431	0.0308	0.0032	0.407	0.0506	0.00039	0.4158	-0.0458	0.0951
HR (bpm)	0.322	0.0992	0.0325	0.305	0.1093	0.0177	0.4690	-0.01676	0.00958
DP	0.3065	0.108	0.00308	0.420	0.0435	0.00395	0.4795	0.0110	0.00084
Variables	**Time-domain measures**								
	SDNN (ms)			**RMSSD (ms)**			**PNN50 (%)**		
	p	**r**	**r^2**	**P**	**r**	**r^2**	**p**	**r**	**r^2**
WC (cm)	0.2605	0.1377	0.01896	0.4219	-0.0424	0.00180	0.2881	-0.1201	0.01442
WHtR (cm)	0.3100	0.1066	0.00113	0.3212	-0.0998	0.00997	0.1342	-0.2353	0.05535
SBP (mm Hg)	0.1608	-0.2113	0.1141	0.0858	-0.2885	0,1181	0.0710	-0.3088	0.0746
DBP (mm Hg)	0.3381	-0.0899	0.0053	0.410	0.0490	0,00024	0.2910	0.1183	0.01154
MAP (mm Hg)	0.1545	-0.2167	0.0575	0.2563	-0.1405	0.0363	0.3625	-0.0757	0.00905
HR (bpm)	0.4422	0.0313	0.00450	0.2103	0.1724	0.00466	0.0511	0.4179	0.1254
DP	0.3108	-0.1061	0.00117	0.4928	0.00391	0.0147	0.1913	0.1866	0.0406

*NW: normal-weight group; WC: waist circumference; SBP: systolic blood pressure; DBP: diastolic blood pressure; MAP: mean arterial pressure; HR: heart rate; DP: double product; LF: low frequency; HF: high frequency; LF/HF: LF-to-HF ratio; SDNN: standard deviation of NN intervals; RMSSD: root mean square of successive RR interval differences; PNN50: percentage of successive RR intervals that differ by more than 50 ms. *Value with statistical difference in HRV frequency and time domain measures of the NW group with anthropometrics and hemodynamics variables (Pearson´s test; $p < 0.05$).*

Table III. Correlation between HRV time and frequency domain measures with WC, SBP, DBP, HR and DP in the OW group

OW Group (n = 20)									
Variables	**Frequency-domain measures**								
	LF (Hz)			**HF (Hz)**			**LF/HF (%)**		
	p	**r**	**r^2**	**p**	**r**	**r^2**	**p**	**r**	**r^2**
WC (cm)	0.4643	-0.0214	0.0004	*0.0416	-0.3968	0.1574	*0.0008	0.6607	0.4365
WHtR (cm)	0.4423	-0.0346	0.0012	*0.0436	-0.3711	0.1377	*0.0061	0.5487	0.3010
SBP (mm Hg)	0.1717	0.2236	0.0500	0.1364	0.2576	0.01853	0.2121	0.1893	0.03582
DBP (mm Hg)	0.0738	0.3359	0.1291	0.2888	0.1325	0.01756	0.2924	0.1301	0.1643
MAP (mm Hg)	0.0648	0.3506	0.1229	0.2617	0.1517	0.0230	*0.0538	0.3708	0.1375
HR (bpm)	0.2045	0.1954	0.7145	0.3221	0.1100	0.0214	0.2374	0.1695	0.0287
DP	0.1164	0.3506	0.0780	0.2687	0.1466	0.02149	0.1246	0.2702	0.0730
Variables	**Time-domain measures**								
	SDNN (ms)			**RMSSD (ms)**			**PNN50 (%)**		
	p	**r**	**r^2**	**P**	**r**	**r^2**	**p**	**r**	**r^2**
WC (cm)	0.2344	-0.1718	0.02952	0.2015	-0.1979	0.0391	0.3790	-0.0735	0.0054
WHtR (cm)	0.3912	0.0659	0.00435	0.4074	0.05593	0.00312	0.3008	0.1243	0.01545
SBP (mm Hg)	0.4936	0.00384	0.00589	0.3215	-0.1105	0.01220	0.2440	-0.1646	0.0270
DBP (mm Hg)	0.1186	0.2770	0.0020	0.3791	0.0734	0.0033	0.2085	-.0.1922	0.0430
MAP (mm Hg)	0.3282	0.1060	0.01124	0.3600	-0.0855	0.0073	0.1798	-0.2164	0.0468
HR (bpm)	0.4401	-0.0360	0.0012	0.2761	-0.1414	0.01998	*0.0163	-0.4791	0.2296
DP	0.4620	-0.0228	0.0005	0.2344	-0.1718	0.02952	*0.0166	-0.4774	0.2279

*OW: overweight group; WC: waist circumference; SBP: systolic blood pressure; DBP: diastolic blood pressure; MAP: mean arterial pressure; HR: heart rate; DP: double product; LF: low frequency; HF: high frequency; LF/HF: LF-to-HF ratio; SDNN: standard deviation of NN intervals; RMSSD: root mean square of successive RR interval differences; PNN50: percentage of successive RR intervals that differ by more than 50 ms. *Value with statistical difference in HRV frequency and time domain measures of the OW group with anthropometrics and hemodynamics variables (Pearson´s test; $p < 0.05$).*

Table IV. Correlation between HRV time and frequency domain measures with WC, SBP, DBP, HR and DP in the OB group

OB Group (n = 21)									
Variables	**Frequency-domain measures**								
	LF (Hz)			**HF (Hz)**			**LF/HF (%)**		
	p	**r**	**r^2**	**p**	**r**	**r^2**	**p**	**r**	**r^2**
WC (cm)	*0.0033	0.5737	0.3291	*0.0093	-0.5084	0.2585	*0.0001	0.8286	0.6866
WHtR (cm)	*0.0014	0.6195	0.3838	*0.0326	-0.4096	0.1677	*0.0001	0.7981	0.6369
SBP (mm Hg)	0.3329	0.1001	0.01003	0.4647	-0.0206	0.00042	0.3897	0.0650	0.00422
DBP (mm Hg)	0.0926	0.3008	0.0904	0.4114	-0.0520	0.00270	0.1579	0.2300	0.0529

(Continues on next page)

Table IV (Cont.). Correlation between HRV time and frequency domain measures with WC, SBP, DBP, HR and DP in the OB group

OB Group (n = 21)									
Variables	**Frequency-domain measures**								
	LF (Hz)			**HF (Hz)**			**LF/HF (%)**		
	p	**r**	**r^2**	**p**	**r**	**r^2**	**p**	**r**	**r^2**
MAP (mm Hg)	0.1124	0.2766	0.0765	0.4165	-0.0489	0.00239	0.1832	0.2076	0.04311
HR (bpm)	*0.0035	0.5696	0.3245	0.4462	0.03146	0.00098	*0.0340	0.4057	0.1646
DP	*0.0059	0.5379	0.2894	0.4889	0.00644	0.00785	*0.0410	0.4057	0.1646
Variables	**Time-domain measures**								
	SDNN (ms)			**RMSSD (ms)**			**PNN50 (%)**		
	p	**r**	**r^2**	**P**	**r**	**r^2**	**p**	**r**	**r^2**
WC (cm)	0.2178	-0.1797	0.03230	0.2617	0.1475	0.02176	0.2319	-0.1690	0.00285
WHtR (cm)	0.2759	-0.1376	0.01894	0.1265	0.2611	0.06816	0.3510	-0.0887	0.00787
SBP (mm Hg)	*0.0029	-0.5799	0.3363	*0.0042	-0.3902	0.1523	0.3227	-0.1067	0.01138
DBP (mm Hg)	0.2041	-0.1905	0.03628	0.1983	0.1952	0.03809	0.4806	0.01130	0.00012
MAP (mm Hg)	0.0597	-0.3505	0.1228	0.4572	0.02496	0.00062	0.4535	-0.0271	0.00073
HR (bpm)	0.1226	-0.2652	0.0703	0.2750	0.1383	0.01912	0.3471	-0.0912	0.00831
DP	*0.0054	-0.5444	0.2964	0.3591	-0.0837	0.00701	0.3203	-0.1082	0.01171

*OB: obese group; WC: waist circumference; SBP: systolic blood pressure; DBP: diastolic blood pressure; MAP: mean arterial pressure; HR: heart rate; DP: double product; LF: low frequency; HF: high frequency; LF/HF: LF-to-HF ratio; SDNN: standard deviation of NN intervals; RMSSD: root mean square of successive RR interval differences; PNN50: percentage of successive RR intervals that differ by more than 50 ms. *Value with statistical difference in HRV frequency and time domain measures of the OB group with anthropometrics and hemodynamics variables (Pearson´s test; $p < 0.05$).*

Our main results showed that adults with obesity and overweight present a higher sympathetic modulation at rest through the time and frequency domains of HRV, and also present an important correlation with WC and waist-to-height ratio. Research protocols that measure health indicators that are easy to monitor, as HRV, are important because these people showed a delay in their recovery period because of arrhythmia and acute coronary pathology caused by their hypercoagulability state and their autonomic dysfunction as given by obesity and diabetes (19). Thus, such indicators can be used for the prevention and screening of cardiovascular diseases.

The evaluation of HRV in its frequency and time domains has been acknowledged as a non-invasive and low-cost method diagnostic tool for different cardiovascular diseases and dysautonomia in the ANS (20). In this regard, low levels of HRV are an important predictor for cardiovascular disorders and morbid diseases (21,22), but above all they are a predictor for mortality — people with autonomic unbalance are 5.3 times more likely to suffer sudden death (22).

The relationship between hyperactivity of the sympathetic system and underactivity of the parasympathetic system expresses the autonomic unbalance reflected in the results of this study, evidenced by the frequency domain behavior of the population studied (23,24) (Fig. 1). In this context, the time domain described in this study (Table I) presents a tendency towards a decrease of these values from the NW group to the OB group, as is described in the following scientific evidence (6) — comparing obese individuals with normal weight individuals the former present a decrease in vagal parameters (SDNN = 35.55 ms, RMSSD = 28.75 ms, pNN50 = 6.4 %), with a normal value in the NW group (SDNN = 46.15, RMSSD = 41.55, pNN50 = 25.65 %) (6). Likewise, Sant Anna Junior et al. (2015), also confirm the results found in our study, which evaluated 80 morbidly obese subjects and 30 normal weight subjects. The results showed low levels of HRV variables in morbidly obese subjects (SDNN = 40.0 ± 18.0 ms, RMSSD = 23.7 ± 13.0 ms, pNN50 = 14.8 ± 10.4%) compared to the NW group (SDNN = 70.0 ± 27.8 ms, RMSSD = 40.3 ± 22.4 ms, pNN50 = 25.9 ± 7.2 %) (24).

The frequency domain behavior observed in this work evidences that LF levels and the LF/HF ratio (Fig. 1) describe an important modulation on sympathetic predominance in the OB and OW groups, unlike the NW group where a vagal modulation predominance is observed and described in the HF levels, it being in autonomic equilibrium. Similar findings were described by Rossi et al. (2015), who evaluated 92 subjects divided into the NW and OB groups. The autonomic function of the OB group had a sympathetic nervous system predominance given by their frequency domain values (LF = 58.50 ± 12.93 Hz; HF = 41.49 ± 12.93 Hz), while in the NW group predominance was for parasympathetic function (LF = 48.65 ± 12.59 Hz; HF = 51.53 ± 12.56 Hz) (25). Similarly, in the study by Sant Ann Junior et al. (2015), the LF/HF ratio variable presented a sympathetic autonomic function predominance in the morbidly OB group (5.0 ± 2.8 nu/Hz) and sympathetic-vagal equilibrium in the control group (1.0 ± 0.9 nu/Hz) (24).

Also, a positive correlation was observed between sympathetic activity and the anthropometric variables, especially WC as represented in the OB group, while the NW group shows a vagal behavior (Table I). In this context, our findings are supported by Oliveira et al. (2020), who analyzed 64 obese subjects with elevated WC (118.83 ± 10.66 cm). The HRV variables showed a strong predominance sympathetic modulation (LF 56.44 ± 20.31 Hz) in contrast to a decrease in parasympathetic modulation (HF 42.52 ± 19.18 Hz) (26). Rastovi et al. (2017) obtained the same results in their study with 63 obese women, where the frequency domain variables of HRV (LF 55.09 ± 13.77 Hz / HF 44.91 ± 13.77 Hz) presented an imbalance in their ANS more favourable to the sympathetic function, corroborating the relationship between visceral adipose tissue and HRV parameters (27).

In the same way, the WHtR is a variable that quantifies more precisely central obesity due to its independence of age, sex and gender (18). Values greater than 0.5 cm are considered an indicator of cardiovascular diseases, and indicate a close relationship with sympathetic activity and an inverse relationship with vagal activity (28). In this sense, the OB and OW groups present values greater than 0.5 cm, showing a probability of suffering a cardiovascular disease whereas the NW group remains under 0.5 cm, showing that they have less probabilities of having a cardiovascular disease (Table I). Furthermore, scientific evidence shows that anthropometric variables such as body weight, body fat percentage, BMI, WC and waist-to-hip ratio have a close relationship with ANS unbalance. Accordingly, Grassi et al. (2019) in their meta-analysis, which included 45 studies and involved 1438 people, showed that the increase in sympathetic activity is detectable in obese and overweight people as related to body composition factors (29). Similarly, Pontiroli et al. (2013) observed and followed 24 obese people who reduced their body weight in 6 months, some through gastric banding surgery and others through diet-based caloric reduction, showing that both groups demonstrated significant changes in their frequency and time HRV variables (30). According to the results presented in this paper, it is possible to observe that by reducing central obesity there is a modification in ANS function.

Considering hemodynamic variables, we observed in our study that the parameters of SBP, DBP, MAP and DP have higher values in the OB and OW group than in the NW group (Table I). In fact, scientific evidence indicates that an increase in sympathetic activity is linked to an increment in BP, due to the modulation of autonomic control over arteriovenous vasomotor tone (7); and an increased sympathetic expression also could lead to early cardiac autonomic neuropathy in diabetics, which can lead to a therapeutic intervention with early-stage angiotensin 2 receptor antagonists (31). In this context, Indumathy et al. (2015) compared a group of obese people (n = 45) with a normal-weight group (n = 43), which showed that the variables SBP, DBP, MAP and DP were significantly high (114.53 ± 9.28 mm Hg, 76.67 ± 7.26 mm Hg, 89.29 ± 6.01 mm Hg, and 88.14 ± 13.11 mm Hg/min) when compared to the control group (108.05 ± 8.60 mm Hg, 67.88 ± 6.78 mm Hg, 81.27 ± 6.81 mm Hg, 76.29 ± 12.09 mm Hg/min), and at the same time all these variables were significantly correlated with the frequency domain of LF/HF ratio (7). Likewise, Oliveira et al. (2020), in their study, analyzed 64 obese subjects at rest who presented high BP (PAS 126.66 ± 17.02 mm Hg and PAD 84.33 ± 10.05 mm Hg) and an increase in the frequency domain variable related to the sympathetic system LF (56.44 ± 20.31 Hz), and a decreased value in the parasympathetic system component HF (42.52 ± 19.18 Hz) (26). This phenomenon could be explained by the relationship between high BP and increased free fatty acids, leading to a state of hyperinsulinemia and hyperleptinemia, caused by the sensitivity of the α1-adrenoceptor-mediated response, which increases BP by activation of the sympathetic nervous system, of the kidneys and of skeletal muscles (7,26).

The results and conclusions of this study on the HRV parameters with central obesity could be explained by the excess of energy that accumulates in the visceral fat deposits, establishing an increase of the adipocyte by a hypertrophy mechanism. This accumulation of inflammatory mediators from the fatty tissue induces an inflammatory process which is related to changes in structure and function (5). In this context, a higher energy balance generates greater activity of macrophages with pro-inflammatory characteristics (5), which are responsible for the secretion of pro-inflammatory cytokines such as tumor necrosis factor alpha (TNF-α). This cytokine participation represents a fundamental role in insulin resistance, affecting the sensitivity of insulin in adipocytes through inhibitors in the signalling pathway of this hormone, establishing a state of hyperinsulinemia and hyperleptinemia (32). Also, we have tried to explain that the peripheral signals transmitted by insulin to the hypothalamus are related to the activation of the proopiomelanocortin (POMC) pathway, which in the same way activates melanocortin receptors (MC4). In fact, the activation of the MC4 receptor modulates peripheral sympathetic activation, presumably by direct and indirect signaling processes. However, current evidence suggests that an increase in circulating TNF-α would produce a failure of intracellular signaling in sympathetic and parasympathetic efferent neurons in the brain stem, increasing cardiac and renal sympathetic discharge without improving thermogenesis (33).

There are some limitations to our study. The participants selected for this study were a generally healthy group of adults. Therefore, our findings may not be generalizable to the whole population in this age range, and this should be considered when examining HRV in people with certain illnesses or diseases such as metabolic syndrome. HRV is not an appropriate measure to assess sympathetic activity; further studies may use more precise methods.

CONCLUSION

The study reveals that adults with obesity and overweight present greater sympathetic modulation at rest through the time and frequency domains of HRV, and also present an important correlation with WC and the waist-to-height ratio. The findings of this study could be considered for a probable line of research oriented to delay the cardiovascular complications caused by an unbalanced sympathetic response in the long term.

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