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Cardiovascular Responses of Patients with Obesity Submitted to a Proof of Effort

Pereira-Rodríguez JE[*1], Peñaranda-Florez DG[2], Pereira-Rodríguez R[3], Pereira-Rodríguez P[4], Landaeta-Sequera AD[5], Quintero-Gómez JC[6], Santamaría-Perez KN[7] and Sánchez-Cajero OA[7]

[1]Magister in Health Sciences, Toltec University, Puebla, Mexico
[2]Physiotherapist, Independent Private Office, Puebla, Mexico
[3]General physician, FUCS - University Foundation of Health Sciences, Bogota Colombia
[4]General doctor, Rafael Núñez University, Cúcuta-Colombia
[5]Physiotherapist, Professional Institute of Therapies and Humanities, Puebla, Mexico
[6]Physiotherapy student, University of Santander, Cúcuta-Colombia
[7]Physiotherapy students, Puebla, Mexico

[*]**Corresponding author:** Pereira-Rodríguez JE, Magister in Health Sciences, Toltec University, Puebla, Mexico, E-mail: jepr87@hotmail.com

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Abstract

Introduction and Objectives: Obesity is a multisystemic disease. It is a coronary risk factor, that promotes or is associated with other components such as hypertension, diabetes, dyslipidemia, etc. The objective of this study was to determine the cardiovascular response of patients with obesity after being subjected to an exercise test.

Methods and Materials: Observational, descriptive and cross-sectional study with 67 participants (45 women and 22 men), with a mean ± SD age of 35 ± 12.6 years. For the purpose of this research anthropometry, vital signs, Borg scale, questionnaire for cardiovascular risk factors (CRF) and exercise test were obtained.

Result: An average FCM (Maximun Heart Rate) of 172.82 ± 18.81 bpm was obtained in the exercise test. Being higher in women compared to men (M: 173.9 ± 17.5 vs H: 168.9 ± 22.1). In addition, the most usual CRFs found were obesity (100%), sedentary lifestyle (100%) and family history (76%), and when comparing FCM with CRF, it was found higher in patients with less than 4 CRFs (179.4 ± 17.7 vs 167.1 ± 18.6).

Conclusion: The results of the present study, show a decrease in the cardiovascular response compatible with the expected effort for the test in patients with more than 4 CRFS. Lower FCM is connected with presence of CRFs.

Keywords: Heart Rate; Cardiology; Stress Test; Exercise

Introduction

Currently, obesity is one of the biggest public health problems. It is known as an imbalance between the amount of calories ingested through foods rich in fats and sugars and poor physical activity [1]. According to the World Health Organization (WHO), obesity has doubled worldwide since 1980, reaching in 2014 more than 1,900 million adults over 18 years of age with overweight and / or obesity [2,3].

Obesity is related to other pathologies like diabetes mellitus, hypertension, dyslipidemia, hyperinsulinemia, cardiovascular disease4 which constitute main causes of morbidity in older adults [5,6] (Table 1).

Given this situation, multiple measures can be taken to prevent and above all, control obesity. Physical exercise is one of them and plays a very important and fundamental role in the treatment and control of this pathology [7]. Planned physical exercise must have certain characteristics such as: intensity, duration, structure and specific individualization. As a result physical activity is different for the overweight and / or obese patients, in addition to having a clear objective to achieve positive effects for health [8]. Moderate exercise corresponds to 50 - 75% of VO2 max. (Maximal oxygen uptake) or maximum heart rate [9].

However, the performance of physical activity on a regular basis has several advantages: it avoids the decrease of basal metabolic rate accompanied by diet, decreases the associated risk factors, protects lean mass, reduces anxiety, depression and improves body composition [10]. At the beginning of exercise, lipolysis increases rapidly by almost 3 times, thus increasing the availability of free fatty acids [11]. This is one of the reasons why there are multiple metabolic adaptations that can be advantageous for the treatment of obesity; among them, the increase of the oxidative potential of fats that generates the obtaining of metabolic energy (adenosine triphosphate - ATP) during physical exercise; and therefore, the loss of body weight [12,13].

Functional alterations
Impaired filling / diastolic relaxation of the left ventricle
Weakness of the heart for ventricular contraction
Decrease in muscle contractility
Abnormal radial distortion of the left ventricle
Low myocardial resistance
Reduced tricuspid annular velocity
Abnormal tension of the right atrium
Abnormal left atrial distortion
Alterations of dromotropism
Reduction of diastolic mitral annular velocity
Hemodynamic alterations
Increase in total and central blood volume
Increased left ventricular stroke volume
No changes or slight increase in heart rate
Increase preload and afterload
Increase in cardiac output
Increased oxygen consumption in the myocardium
Increase in arteriovenous oxygen difference
Increase in systolic and diastolic blood pressure in some people
Increase in cardiac work
Increased wedge pressure in the pulmonary artery
Decrease in maximum speed of contraction of the left ventricle
Increase in the final diastolic pressure of the left ventricle
Increase in right ventricular pressure
Increase in pulmonary artery pressure
Normal or increased pulmonary vascular resistance
Increase in right atrial pressure
Morphological alterations
Increase in left ventricular mass
Ventricular remodeling
Dilation of the left ventricle chamber
Eccentric hypertrophy of the left ventricle
Hypertrophy or concentric remodeling of the left ventricle
Left atrial enlargement
Right ventricular hypertrophy
Right atrial enlargement
Excessive epicardial adipose tissue

Modified from Alpert MA, Lavie CJ, Agrawal H, Kumar A, Kumar SA (2016) Cardiac Effects of Obesity. Journal of Cardiopulmonary Rehabil and Prev 36: 1-11.
Table 1: Cardiovascular Effects of Obesity.

However, to obtain these results it is necessary to know the cardiovascular status of patients with obesity; hence, stress tests in this type of patients are essential for an adequate prescription of exercise and guarantee a moderate intensity training which is able to obtain the benefits mentioned.

Stress Test

It is one of the most important non-invasive tools in the exploration of the heart by means of a cardio-respiratory sample, mainly in three aspects: Diagnosis of ischemic heart disease (IC), determination of functional capacity (CF) and perception of dyspnea and fatigue at a maximum effort [14,15]. There are two types of tests for all these findings: conventional and unconventional stress test (PE) [14]. In addition, there is a variety of protocols: Bruce, modified Bruce, Naughton, Balke and Sheffield. It should be noted that the Bruce protocols are better for the diagnosis of ischemia and are the most commonly used in conventional Pes [16]. On the other hand, the remaining protocols are not as effective for the diagnosis of ischemia, but they have a better value for CF in certain cases [15]. These protocols vary according to the characteristics of the study population.

Methodology

Bruce's protocol consists of increasing the tilt and speed every three minutes. The periods of time in which the speed and slope remain constant are called stages and the duration of the exercise, with the Bruce protocol, for a normal person is approximately 8-12 minutes [17,18]. This may vary according to the characteristics of the patient that could generate times lower or higher than those mentioned.

In PE, it is necessary to control and monitor vital signs pre, peri and post. Therefore, it is necessary to have records of these measures at each stage; in addition, to perceive the degree of tiredness and dyspnea of the patient during the test. Of course, if for any reason you wish to interrupt the test, your decision must be respected [19]. Otherwise, the test will stop when the patient is quite exhausted, no longer able to report, relevant clinical abnormalities appear (angina, electrocardiographic alterations, abnormal blood pressure behavior) or when a sufficient level of effort is reached for diagnosis [20]. However, one of the purposes of the stress test is to reach the submaximal heart rate, which is altered above 85% of the maximum heart rate; on the contrary, the diagnostic reliability of the test is not as objective and it would be called inconclusive test [17].

Equipment and Implements

The most commonly used devices for these tests are the ergometer bicycle and the treadmill or endless belt; which, present their advantages and disadvantages either by the mode of use or space [14]. The bicycle ergometer, occupies less space, is not noisy, but needs a greater collaboration of the patient, since not everyone is familiar with a bicycle; on the other hand; endless tape, requires less collaboration on the part of the patient and submaximal HR can be easily achieved, but requires more space [21]. In addition, the respective implements are required to control and monitor vital signs.

Contraindications and Indications

Contraindications to these tests are: acute myocardial infarction (AMI) in the last 5-7 days, severe cardiac arrhythmias, acute pericarditis, endocarditis, severe aortic stenosis, embolism or acute pulmonary infarction, unstable angina and severe physical disability [16]. Indications include: symptomatic patients who present with chest pain, arrhythmias and/or ventricular dyskinesia whose etiology is unknown, some typical angina with normal basal electrocardiogram (ECG), patients with symptoms suggesting coronary disease, without chest pain; and asymptomatic patients with high coronary risk, when there is a baseline ECG and/or a study by Holter suspected of ischemia, but without any symptoms, or simply sedentary people over 30 who want to start sports [16,18]. Having said all of the above, this research proposes as a research question: What is the cardiovascular response of patients with obesity after performing a stress test? And therefore, the main objective is to determine the cardiovascular response in patients with obesity subjected to an exercise test.

Materials and Methods

An observational, descriptive and cross-sectional study was carried out that quantified the cardiovascular risk factors, anthropometry, pre, peri and post-stress cardiovascular response in participants with obesity.

Sample

In the present investigation, tests and measurements were performed on participants whose ages were 35.58 ± 12.6 years old from the city of Cúcuta, Colombia. Participants were 67, 45 women and 22 men. The eligibility criteria of the patients were: to be over 18 years of age, have a body mass index greater than 30, weight more than 65Kg and sign an informed consent endorsed by the ethics committee of the institution.

Exclusion criteria were: presentation of pain in the lower limbs, dyspnea and / or fatigue at rest greater than 3, history of beta-blockers medication, cardiovascular disorders, surgical history of this type and / or acute myocardial infarction. As withdrawal criteria, hemodynamic instability during the test and the manifestation of not wanting to continue were taken into account.

Data Collection

A questionnaire was used for the collection of personal, family and sociodemographic data. To measure the morphological, anthropometric and vital signs variables; we used the Adult Acrylic Halter Wall Kramer 2104 (stadiometer), Asmico 150 cm 60" Gree (tape measure), Balance Tezzio Digital Balance TB-30037 (bioelectrical impedance), Nellcor Puritan Bennett (portable pulse oximeter) and manual tensiometer.

An effort test was performed for each participant in an endless band with the Bruce protocol. In the 12 hours prior to the stress test, participants were instructed to avoid alcohol, caffeine, smoking, vigorous exercise and some type of drug or medication that could interfere with HRmax. Or performance during the test; also, it was explained to them that they could make their morning intake (breakfast).

The subjective lack of air and perceived effort were estimated according to the modified Borg scale; which helps us to determine the effort perceived by patients, This consists of 10 items for the evaluatione of the intensity settings and/or workloads.

However, using the Polar RS800CX Multisport system, heart rate (HR) was obtained before, during and after the test in real time. Regarding arterial oxygen saturation, we used a portable pulse oximeter (Nellcor Puritan Bennett); These measurements were taken pre, peri and post stress test. Systolic (SBP) and diastolic (DBP) blood pressure were obtained, manually pre, post and after 5 minutes of having finished the stress test.

Ethical Considerations

The design and development of the research was carried out under the ethical considerations of the Declaration of Helsinki and Resolution No. 008430 of the Ministry of Health of Colombia.

Statistic Analysis

For the description of quantitative variables, it was necessary to express as the arithmetic measure and standard deviation. Regarding the comparison of pre and post data to the FCM the ANOVA (analysis of variance one-way) was performed to compare the differences of gender and CRF in the different variables studied. In all cases the level of significance was established at 5% ($p < 0.05$) and were performed in Stata 12 (Data Analysis and Statistical Software) program.

Results

The initial characteristics of the participants are summarized in Table 2 and in Table 3, the pre and post changes of all participants can be visualized, including their respective comparison according to gender, systolic and diastolic blood pressure; as well as arterial oxygen saturation, dyspnea and fatigue (Table 2 and 3).

	Total	%	Male	%	Female	%
Gender	67	100	22	32.8	45	32.8
Age						
Under 30	24	35.8	11	50	13	28.8
Older than 30	43	64.1	11	50	32	71.1
Weight	67	100	95.3kg ± 20.6	---	95.7 ± 13.9	---
Height	67	100	1.57 ± 0.06	---	1.69 ± 0.06	---
Ethnicity						
White	26	38.8	11	50	15	33.3
Half Blood	38	56.7	9	40.9	29	64.4
Afro-Colombian	3	4.4	2	9.1	1	2.2
Education level						
Primary	1	1.4	1	4.5	0	0
High school	9	13.4	4	18.1	5	11.1
Bachelor	26	38.8	7	31.8	19	42.2
Tech. O Tecnol.	4	5.9	1	4.5	3	6.6
Undergraduate	25	37.3	9	40.9	16	35.5
Postgraduate	2	2.9	0	0	2	4.4
Smoking						
Exhamers	20	29.8	10	22.2	10	45.4
3-7 Cigarettes	2	2.9	0	0	2	9
9-15 Cigarettes	1	1.4	1	2.2	0	0
Do not Consume	44	65.6	11	24.4	33	73.3

Alcoholism						
Consumers	39	58.2	13	59	26	57,7
1 x Week	16	23.8	7	31.8	9	20
1 or 2 x Week	20	29.8	3	13.6	17	37.7
2 x Week	3	4.4	2	9	1	2.2
4 x Week	1	1.4	1	4.54	0	0
Do not Consume	27	40.2	9	40.9	18	40
Inadequate diet						
1 time x Month	20	29.8	2	9	18	40
1 time x Week	15	22.3	7	31.8	8	17.77
2 times per week	12	17.9	3	13.6	9	20
3 times per week	11	16.4	2	9	0	0
4 or more x Week	3	4.4	1	4.5	2	9
They do not consume	15	22.3	7	31.8	8	17.7
Arterial hypertension						
Yes	19	28.3	6	27.2	13	28.8
Do not	48	71.6	16	72.7	32	71.1
Diabetes						
Yes	9	13.4	3	13.6	6	13.3
Do not	58	86.5	19	86.3	39	86.6
Obesity						
I	37	55.2	16	72.1	21	46.6
II	21	31.3	3	13.6	18	40
IMC	100	100	38.6 ± 8.07	---	33.6 ± 3.94	---
Sedentary						
Yes	67	100	45	67.1	22	32.8
Do not	0	0	0	0	0	0
Family background						
Yes	51	76.1	16	72.7	35	77.7
Do not	16	23.8	6	27.2	10	22.2

Table 2: Characteristics of the population

	Average		**SD**		**Minimum**		**Maximum**	
	M	F	M	F	M	F	M	F
$SatO_2$ (pre)	97.31	97.26	1.12	1.05	94	95	99	98
$SatO_2$ (post)	91.31	95.57	1.57	1.77	92	90	98	98
PAS (pre)	125.18	120.44	13.8	13.89	100	97	160	160
PAS (post)*	131.95	128.17	14.25	17.31	100	100	160	180
PAD (pre)	80.13	78.24	12.06	11.28	60	60	100	100
PAD (post)*	83.5	79.35	6.49	11.26	75	60	100	100
Dyspnoea (pre)	0.13	0.26	0.35	0.49	0	0	1	2
Dyspnoea (post)	8.31	7.42	1.17	2.6	6	0	10	10
Fatigue (pre)	0.18	0.24	0.39	0.6	0	0	1	2
Fatigue (post)	8.36	7.66	1.43	2.27	6	1	10	10

*PAS and PAD post training was take in just momento when the patient finish his test.$SatO_2$: Arterial oxygen saturation; PAS: Systolic blood pressure; PAD: Diastolic blood pressure; SD: Standard deviation; M: Male; F: Female.

Table 3: Blood pressure and arterial oxygen saturation before and after stress test

On the other hand, It should be noted that on average there was no gender difference with respect to weight (H: 95.3kg ± 20.6 vs 95.7 ± 13.9) but in the size of the participants (H: 1.57 ± 0.06 vs. M: 1.69 ± 0.06). As also, a higher index of corporal mass on the part of men in comparison with the women (H: 38.6 ± 8.07 vs M: 33.6 ± 3.94) (Table 2). Also, it was possible to record the response of the heart rate at the beginning, after the test and in recovery times at 1, 3 and 5 minutes. The average maximum heart rate was 172.8 ± 18.8 beats per minute (bpm), being higher in women compared to men (M: 173.9 ± 17.5 vs H: 168.9 ± 22). In addition, we compared the patients with obesity and more or less than 4 cardiovascular risk factors; finding, much higher FCM figures in patients with less than 4 CRF compared to those who had more than 4 (179.4 ± 17.7 vs. 167.1 ± 18.6; p= <0,001) (Table 4).

	PRE		POST		Minimum		Maximum		Value of *p*
	Mean	SD	Mean	SD	Pre	Post	Pre	Post	
Men	90.7	12.9	168.9	22.1	66	117	110	199	0,002
Women	98.8	21.3	173.9	17.5	70	133	140	199	0,005
FC <4 FRC (Men)	93.2	17.1	178.7	19.4	66	141	110	199	<0,001
FC >4 FRC (Men)	95.2	15.3	167.1	18.6	74	117	110	189	0,010
FC <4 FRC (Women)	94	14.6	179.4	17.7	70	133	140	199	<0,001
FC >4 FRC (Women)	95.9	15.5	168	18.2	74	144	139	199	<0,001
	Men		**Women**		**Minimum**		**Maximum**		
	Mean	**SD**	**Mean**	**SD**	**M**	**W**	**M**	**W**	
FC 1 min.	148.2	17.5	150.7	20	115	111	178	182	0,121
FC 3 min.	127.2	16.1	131.3	15.2	95	105	160	165	0,113
FC 5 min.	116.1	13.6	121.4	13.7	86	95	140	158	0,256

FC: Heart Rate; FRC: Cardiovascular Risk Factors; SD: Standard Deviation; M: Male; F: Female.
Table 4: Pre-post heart rate and recovery times in patients with obesity

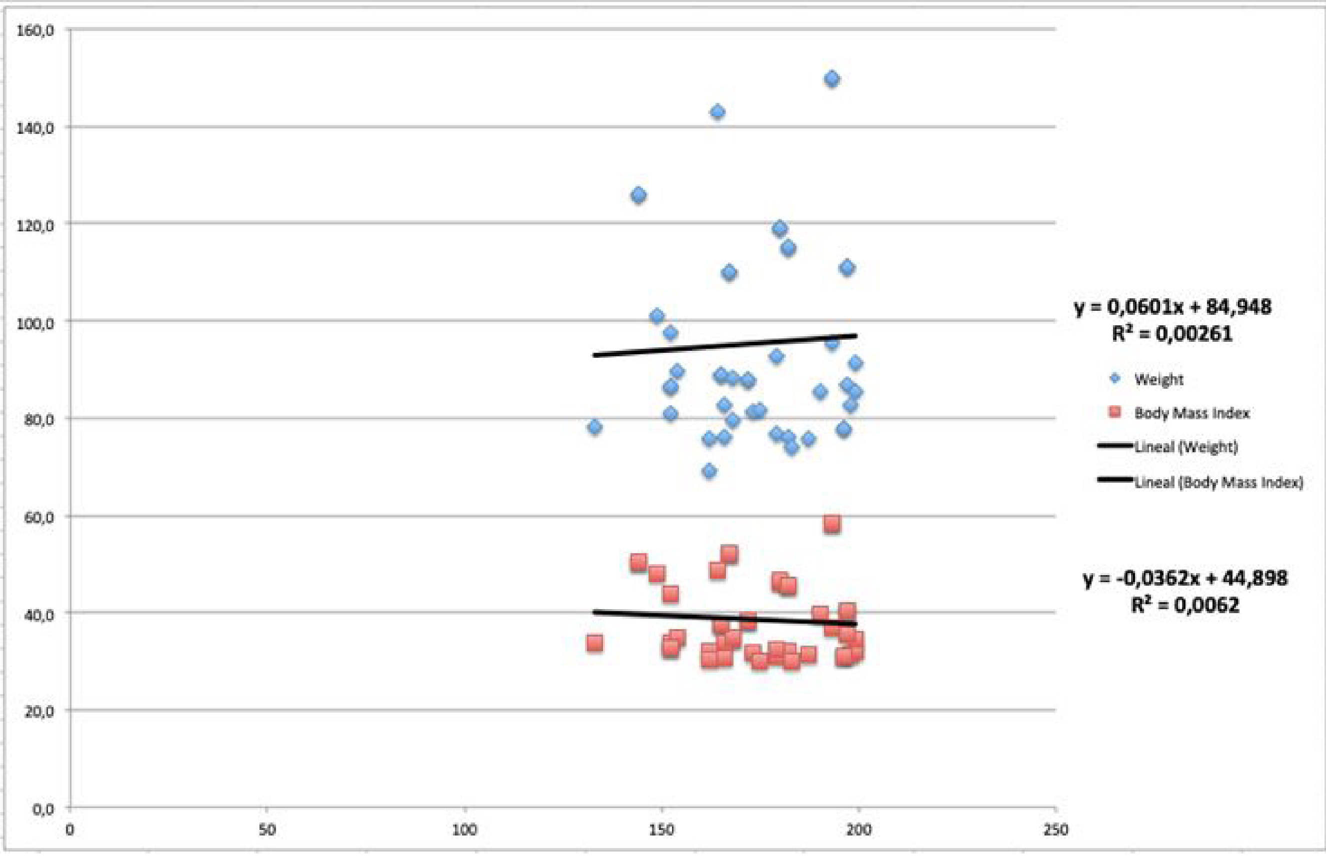

Figure 1: Dispersion graph and Pearson's r in the female sex

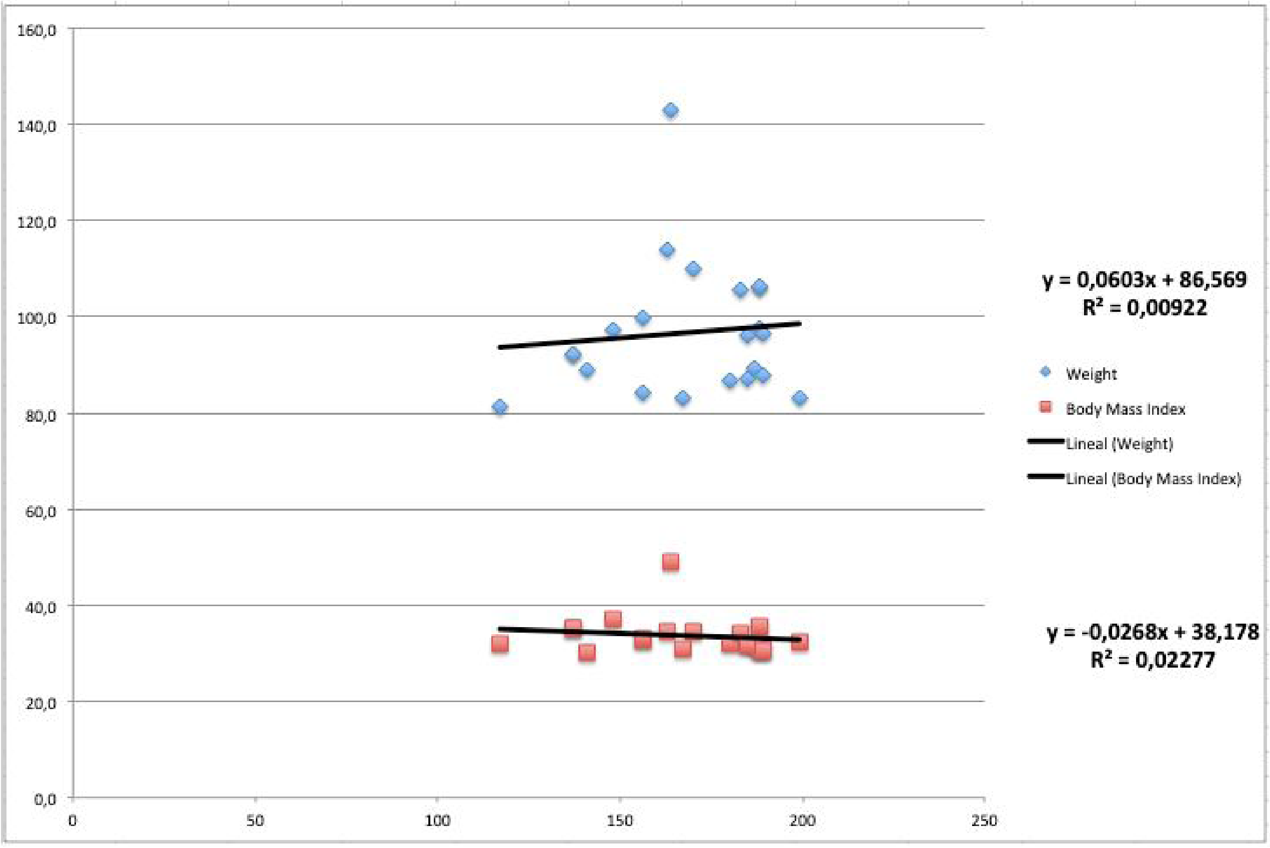

Figure 2: Dispersion graph and Pearson's r in the male sex

Discussion

Obesity is a main cardiovascular risk factor (CRF) associated with multiple pathologies of the cardiovascular system. It has a direct relationship with high LDL cholesterol levels and a high percentage of coronary risk, diabetes mellitus and hypertension, which are direct variables that affect myocardial perfusion, predisposing the patient to myocardial infarction. In this work, we examined cardiovascular responses of patients with obesity when subjected to an exercise test. This could be correlated with the study conducted by Guzmán J, Sánchez A, Montez Ma, *et al*. Where they studied the cardiovascular capacity of obese patients subjected to an ergometry with the Bruce protocol [22]. They found that heart rate rises but not according to the values established for the age of the patient and the effort made. Furthermore, a high percentage of patients had an inability to raise their heart rate above 80% of capacity.

Likewise, a study conducted by Urquiaga J, Negron S, Gil M, *et al*. Shows that a deficit in the ability to raise the heart rate over 80% is directly related to risks of ischemia of myocardial perfusión [23]. At present we have a problem to determine the maximum heart rate and to be able to determine its percentage reached in a stress test; since the methods used to obtain this result are the predictive equations such as 220-age, Tanaka, Karvonen, Cooper, Ellestad and among 40 other formulas.

However, multiple investigations do not recommend its use since it overestimates FCM by approximately more than 10 beats per minute (bpm) [13,24-26]. In another study of our authorship, with population of obesity in both genders, we compared the predictive equations versus the maximal stress test and it was possible to show that these formulas in obese patients differ from 2 to 18 bpm, compared to a test of maximum effort.

On the other hand, the research by Marino F, Vidal R, Parada F, *et al.* carried out on a group of women with morbid obesity by means of an ergometer adapted to upper limbs, comparing it with one of lower limbs, showed that there are changes in the increase of systolic blood pressure during the test, similar to the present study where changes in SBP and DBP are observed during the test. However, they observed that these changes are not significant according to parameters such as age, sex and level of physical activity [27].

In turn, no other studies have demonstrated changes related to oxygen saturation before, during and after the development of an exercise test in patients with obesity. Our study shows that there is an early decrease in peri-effort tissue perfusion levels, hypothetically caused by obesity, cardiovascular alterations or comorbidities in the beginning. Furthermore, when comparing the cardiovascular response of obese participants with a published study on stress test in apparently healthy patients with age ranges similar to those of the present study, we found that these are very inferior to the cardiovascular response found in patients apparently healthy [28,29].

In all patients there was a linear increase in heart rate and none stopped the test due to an increase in hemodynamic values, and this is due to the increased cardiac output and the muscle mass involved. At the beginning of the exercise, the autonomic nervous system promotes the elevation of the return of blood to the heart, causing greater distension of the right ventricle to receive the greater number of blood, added to the tachycardia that occurs later and to the increase of the cardiac debit [30].

All the patients reached 85% of the maximum heart rate, but the majority did not reach the maximum expected for the test due to fatigue of the upper limbs, test specificity and sedentary lifestyle. A reduction in the heart rate of more than 20% was observed in the first minute of recovery, compared with the peak frequency, an important fact, since the reduction of the heart rate in the first minute of recovery makes it possible to infer the cardiac vagal modulation: equal reductions or lower than 12 beats per minute have an association with higher prevalence of mortality [30].

Conclusion

The patients had good tolerance to the stress test. The SBP and DBP increased with the effort and after the recovery time, as well as the arterial oxygen saturation, and values do not differ significantly from each other. Finally, it is important to make an initial evaluation of the obese patient that includes his pathological antecedents, complete physical examination, anthropometry and measurement of his aerobic capacity, flexibility and strength, in order to be able to carry out an individualized and accurate exercise program.

Limitations

The authors of the present investigation considers that for future investigations it would be interesting to include echocardiogram tests and analyze each of the comorbidities present in the obese population, which inevitably play a fundamental role in the cardiovascular manifestations of patients with obesity.

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