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Cardiovascular responses of obese patients to exercise stress test

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Abbreviation
HR: heart rate

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ABSTRACT

Introduction: Obesity is a multisystemic disease and a coronary risk factor that is frequently associated with others, such as high blood pressure, diabetes and dyslipidemia. These all increase the risk of heart disease.
Objective: We aimed to determine the cardiovascular response of obese patients during a stress test.
Methods: An observational, descriptive and cross-sectional study was conducted with 67 obese participants (45 women and 22 men) aged 35±12.6 years on average. To develop our research, we analyzed anthropometric variables and vital signs. The Borg scale, a cardiovascular risk factor interview and a Bruce treadmill stress test protocol were also applied.
Results: The main cardiovascular risk factors found were sedentary lifestyle (100%) and family history of disease (76%). An average maximum heart rate of 172.82± 18.81 beats per minute was obtained, which was higher in women (173.9±17.5 vs. 168.9±22.1). It was found to be higher in patients with less than four cardiovascular risk factors (179.4±17.7 vs. 167.1±18.6) when associated with cardiovascular risk factors.
Conclusions: A decrease in cardiovascular response was found in relation to the expected test effort. The greater the number of cardiovascular risk factors, the lower the maximum heart rate achieved.
Keywords: Obesity, Exercise stress test, Exercise, Heart rate, Risk factors, Cardiology

Respuestas cardiovasculares de pacientes con obesidad en la prueba de esfuerzo

RESUMEN

Introducción: La obesidad es una enfermedad multisistémica que constituye un factor de riesgo coronario y se asocia frecuentemente a otros, como la hipertensión arterial, la diabetes y la dislipidemia, todo lo cual aumenta el riesgo de enfermedad cardiovascular.
Objetivo: Determinar la respuesta cardiovascular de los pacientes con obesidad durante una prueba de esfuerzo.
Método: Estudio observacional, descriptivo y transversal con 67 participantes

Contribución de los autores
JEPR: Proposal and sample of results to patients, idea and design of the research; obtaining, analyzing and interpreting the data, as well as writing the manuscript. DGPF: Idea and design of the research; obtaining, analyzing and interpreting the data, as well as writing the manuscript. RPR y PPR: Idea of the research, analyzing and interpreting the data. KNSP y OASC: Obtaining the primary data and helping in writing the manuscript.
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obesos (45 mujeres y 22 hombres), con promedio de edad de 35±12,6 años. Para el desarrollo de esta investigación se obtuvieron variables antropométricas, signos vitales, escala de Borg, cuestionario para factores de riesgo cardiovascular, y se realizó una prueba de esfuerzo en tapiz rodante con protocolo de Bruce.
Resultados: *Los principales factores de riesgo cardiovascular encontrados fueron el sedentarismo (100%) y los antecedentes patológicos familiares (76%). Se obtuvo una frecuencia cardíaca máxima promedio de 172,82±18,81 latidos por minuto, que fue superior en las mujeres (173,9±17,5 vs. 168,9±22,1) y al asociarla con los factores de riesgo cardiovascular se encontró que fue mayor en los pacientes con menos de 4 factores de este tipo (179,4±17,7 vs. 167,1±18,6).*
Conclusiones: *Se encontró una disminución de la respuesta cardiovascular en relación con el esfuerzo esperado para la prueba de esfuerzo. A mayor número de factores de riesgo cardiovascular presentes, menor fue la frecuencia cardíaca máxima alcanzada.*
Palabras clave: *Obesidad, Prueba de esfuerzo, Ejercicio físico, Frecuencia cardíaca, Factores de riesgo, Cardiología*

INTRODUCTION

One of the biggest problems of public health nowadays is obesity, which is known as an imbalance between the amount of calories ingested through foods rich in fats and sugars, and reduced physical activity[1]. Moreno-Martínez[2] defines it as the excess of adipose tissue that is caused by the progressive accumulation of fat in the reservoirs, due to an imbalance of caloric homeostasis, where the ingest exceeds the energy expenditure. According to the World Health Organization (WHO), obesity has doubled worldwide since 1980 and in 2014, more than 1900 million adults over 18 years old suffer from overweight or obesity[3-5].

Likewise, obesity is linked to other diseases such as: diabetes mellitus, high blood pressure, dyslipidemia, hyperinsulinemia, stroke and cardiovascular disease, among others[5], which are the leading cause of morbidity in the elderly[5,6]. The main damage that generates this disease in function, structure and capacity of the heart, is shown in the following **box**[1-6].

Given this situation, multiple alternatives have been created to prevent and, above all, control obesity; among them, physical exercise, which plays a very important and vital role for the treatment and control of this disease[7]. That is why the planned physical exercise must have certain characteristics such as: intensity, duration, structure and specific individualization, which is what makes physical activity different, in addition to having a clear objective to achieve positive health effects in overweight or obese patients[8], where moderate exercise is 50-75% of the volume (consumption) maximum oxygen (VO_2 max) or maximum[9] heart rate (HR).

Performing physical activity regularly has several advantages: prevents the reduction of the basal metabolic rate together with a diet, reduces the associated risk factors, protects lean body mass, decreases anxiety and depression, and improves body composition[10]. It is important to highlight that, at the beginning of the exercise, the lipolysis increases rapidly in almost three 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, including the increased oxidative potential of fats[12,13], which generates obtaining metabolic energy (adenosine triphosphate-ATP) during physical exercise, and –therefore–, the loss of body weight.

However, for obtaining these results, it is necessary to know the cardiovascular state of patients with obesity, hence, the importance of the exercise stress tests in such patients, which are indispensable for prescribing exercise adequately, ensure training of moderate intensity and for being able to obtain the mentioned benefits. For these reasons, the main objective of this research has been to determine the cardiovascular response of obese patients during an exercise stress test.

METHOD

An observational, descriptive and cross-sectional study was carried out, which quantified cardiovascular risk factors, anthropometry, and cardiovascular response before, during and after the exercise stress test in obese participants from the city of Cúcuta, Colombia.

Sample

An intentional sample of 67 participants (45 women and 22 men) who met the eligibility criteria was selected:

1. To be older than 18 years old.
2. To have a body mass index higher than 30, weighing more than 65 kg.
3. To sign an informed consent endorsed by the ethics committee of the institution.

Box. Cardiovascular effects of obesity[1-7].

Functional alterations
Impaired LV diastolic filling/relaxation
Weakness of the heart for ventricular contraction
Decreased muscle contractility
Abnormal radial LV distortion
Low myocardial resistance
Reduced tricuspid annular velocity
Abnormal tension of the right atrium
Abnormal left atrial distortion
Dromotropic disorders
Diastolic reduction in mitral annular velocity
Hemodynamic alterations
Increase in total and central blood volume
Increased LV systolic volume
No change or mild increase in the heart rate
Increased preload and postload
Increased cardiac output
Increased oxygen consumption in the myocardium
Increased arteriovenous oxygen difference
Increased systolic and diastolic blood pressure
Increased cardiac work
Increased pulmonary artery wedge pressure
Decreased maximum velocity of LV contraction
Increased LV end diastolic pressure
Increased pressure in the right ventricle
Increased pulmonary artery pressure
Normal or increased pulmonary vascular resistance
Increased right atrial pressure
Morphological alterations
Increased left ventricular mass
Ventricular remodeling
LV chamber dilation
Eccentric LV hypertrophy
LV hypertrophy or concentric remodeling
Left atrial enlargement
Right ventricular hypertrophy
Right atrial enlargement
Excessive epicardial adipose tissue

LV, left ventricle

Patients who had pain in lower limbs with difficulty for walking, dyspnea and fatigue at rest, or both, previous cardiovascular disorders, history of cardiac surgery or myocardial infarction were excluded, as well as those who had medication with beta-blockers. The express statement of the patient to not wanting to continue the test was considered as a withdrawal criterion.

Procedure

In order to determine the morphologic and anthropometric variables, as well as the vital signs, there were used: a measuring rod (Adult Acrylic Halter Wall Kramer 2104), a measuring tape (Asámico de 150 cm 60"Gree) a weighing scales (Tezzio Digital Balance TB-30037) for electric bioimpedance, a portable pulse oximeter (Nellcor Puritan Bennett) and a manual tensiometer, with which the systolic and diastolic blood pressure was obtained, before, during and after 5 minutes of having finished the exercise test. In those same three times was obtained the heart rate in real time, through the Polar RS800CX Multisport system.

All participants underwent an exercise stress test on a treadmill, with the Bruce protocol, who were instructed that, in the 12 hours prior to the exercise stress test, they should avoid alcohol, caffeine, tobacco, vigorous exercise or the use of any type of drug or medication that could interfere with the maximum HR or physical performance during the test; it was also explained to them that they could have their morning meal.

The characteristics of the exercise stress tests, their methodology, indications and contraindications[14-21] are shown in the **appendix**.

The subjective shortness of breath and the effort perceived by the patients were estimated according to the modified Borg scale[22], which consists of ten items. The purpose of this tool in the area of health sciences is to evaluate adjustments in intensity and the workload.

Data collection

The data collection was done manually, and an in-

Table 1. Basal characteristics of the population.

Variables	Sex				Total (N=67)	
	Female (n=45)		Male (n=22)			
	Nº	%	Nº	%	Nº	%
Age (years)						
Equal/younger than 30	13	28.88	11	50.00	24	35.82
Older than 30	32	71.11	11	50.00	43	64.17
Ethnicity						
White	15	33.33	11	50.00	26	38.8
Mestizo	29	64.44	9	40.9	38	56.71
Afro-Colombian	1	2.22	2	9.1	3	4.47
Education level						
Primary school	0	0	1	4.54	1	1.49
Secondary school	5	11.11	4	18.18	9	13.43
High school	19	42.22	7	31.82	26	38.81
Technician	3	6.67	1	4.54	4	5.97
Undergraduate	16	35.55	9	40.91	25	37.31
Postgraduate	2	4.44	0	0	2	2.98
Smoking						
Ex-smoker	10	45.45	10	22.22	20	29.85
3-7 cigarettes/day	2	9.09	0	0	2	2.98
9-15 cigarettes/day	0	0	1	2.22	1	1.49
Non smoker	33	73.33	11	24.44	44	65.67
Alcoholism						
Regular consumer	26	57.77	13	59.09	39	58.20
Once a week	9	20.00	7	31.81	16	23.88
Once or twice a week	17	37.77	3	13.63	20	29.85
Twice a week	1	2.22	2	9.09	3	4.47
Four a week	0	0	1	4.54	1	1.49
Non consumer	18	40.00	9	40.90	27	40.29
Inappropriate diet						
Once a month	18	40.00	2	9.09	20	29.85
Once a week	8	17.77	7	31.81	15	22.38
Twice a week	9	20.00	3	13.63	12	17.91
Three a week	0	0	2	9.09	11	16.41
Four or more a week	2	9.09	1	4.50	3	4.40
Non consumer	8	17.77	7	31.81	15	22.38
High blood pressure						
Yes	13	28.88	6	27.27	19	28.36
No	32	71.11	16	72.72	48	71.64
Diabetes						
Yes	6	13.33	3	13.63	9	13.43
No	39	86.66	19	86.36	58	86.56
Obesity						
I	21	46.67	16	72.12	37	55.22
II	18	40.00	3	13.64	21	31.34
Sedentary lifestyle						
Yes	22	32.84	45	67.16	67	100
No	0	0	0	0	0	0
Family history						
Yes	35	77.77	16	72.72	51	76.11
No	10	22.22	6	27.27	16	23.88

strument was used, self-created, aimed at doing the interrogation of patients and the incorporation of the measurements that were obtained before, during and after the exercise stress test.

Statistical analysis

Quantitative variables are expressed as arithmetic mean, minimum, maximum values and variability (standard deviation). Furthermore, an analysis of the Pearson's correlation coefficient between the different variables was carried out. In all cases, the level of significance was established at 5% ($p < 0.05$) and the analyses were performed in the Stata program (Data Analysis and Statistical Software).

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 Colombian Ministry of Health.

RESULTS

A total of 67 individuals (45 women and 22 men) were studied, with a mean age of 35.58 ± 12.6 years. Their basal features are summarized in **table 1**.

It may be noted (non tabulated data) that there was no significant difference compared to the body weight between men and women (95.3 ± 20.6 *vs.* 95.7 ± 13.9 kg), but there were in height (1.57 ± 0.06 *vs.* 1.69 ± 0.06 m) which was higher in females, what made the body mass index higher in men (38.6 ± 8.07 *vs.* 33.6 ± 3.94 kg/m^2).

In **table 2** is displayed the behavior of some of the studied variables (oxygen saturation, blood pressure, dyspnea and fatigue) in relation to the exercise stress test and gender. The response of the HF was registered (**Table 3**) at the start of the test, at peak exercise and during the minutes 1, 3 and 5 of the recovery, and it was higher in women (173.91 ± 17.57 *vs.* 168.9 ± 22.1). In addition, the values of this variable in patients with obesity and the presence of more or less four factors of cardiovascular risk were compared, resulting that the maximum HR reached was much higher in patients with less than four risk factors compared to those having four or more (179.4 ± 17.7 *vs.* 167.1 ± 18.6).

In the dispersion graphs (**Figure**) is displayed the behavior of maximum HR in relation to weight, body mass index and sex of the participants; to which its corresponding Pearson´s correlation was added for a better analysis.

DISCUSSION

Among the cardiovascular risk factors, obesity stands out as one of the main factors associated with multiple diseases of the cardiovascular system, both

Table 2. Blood pressure and arterial oxygen saturation before and after the exercise stress test.

Variable	Women				Men			
	Average	SD	Minimum	Maximum	Average	SD	Minimum	Maximum
$SatO_2$ (pre)	97.26	1.05	95	98	97.31	1.12	94	99
$SatO_2$ (post)	95.57	1.77	90	98	91.31	1.57	92	98
SBP (pre)	120.44	13.89	97	160	125.18	13.80	100	160
SBP (post)	128.17	17.31	100	180	131.95	14.25	100	160
DBP (pre)	78.24	11.28	60	100	80.13	12.06	60	100
DBP (post)	79.35	11.26	60	100	83.50	6.49	75	100
Dyspnea (pre)	0.26	0.49	0	2	0.13	0.35	0	1
Dyspnea (post)	7.42	2.60	0	10	8.31	1.17	6	10
Fatigue (pre)	0.24	0.60	0	2	0.18	0.39	0	1
Fatigue (post)	7.66	2.27	1	10	8.36	1.43	6	10

DBP, diastolic blood pressure; SatO2, peripheral arterial oxygen saturation; SBP, systolic blood pressure; SD, standard deviation

Table 3. Heart rate before, after and during recovery times in patients with obesity.

Variable	Women				Men			
	Average	SD	Minimum	Maximum	Average	SD	Minimum	Maximum
HR (pre)	98.88	21.35	70	140	90.77	12.95	66	110
HR (post)	173.91	17.57	133	199	168.95	22.16	117	199
HR 1 minute	150.75	20.05	111	182	148.28	17.53	115	178
HR 3 minutes	131.31	15.22	105	165	127.23	16.16	95	160
HR 5 minutes	121.44	13.70	95	158	116.19	13.62	86	140
HR <4 CRF (pre)	94.07	14.69	70	140	93.25	17.18	66	110
HR <4 CRF (post)	179.46	17.75	133	199	178.7	19.43	141	199
HR >4 CRF (pre)	95.97	15.55	74	139	95.20	15.38	74	110
HR >4 CRF (post)	168	18.24	144	199	167.12	18.68	117	189

CRF; cardiovascular risk factors; HR, heart rate; SD, standard deviation.

because it has a direct relationship with high levels of LDL (low-density lipoproteins) cholesterol and a high percentage of coronary risk, diabetes mellitus and high blood pressure, which are direct variables that affect myocardial perfusion and predispose the patient to suffer any of the manifestations of ischemic heart disease, including myocardial infarction.

In this article are shown the cardiovascular responses of the obese patients that underwent an exercise stress test. Our results are similar to those found by Guzmán *et al*[23], who studied the cardiovascular capacity of obese patients using exercise stress testing with the Bruce protocol and found that HR rises, but not in accordance with the values established for the patient's age and effort made. In this study is also noticeable that a high percentage of the patients were unable to increase their HR above 80% of the maximum estimated for their age.

Likewise, a study conducted by Urquiaga *et al*[24] shows that a deficit in the ability to raise HR above 80% of the theoretical maximum is directly related to the risk of ischemia in the myocardial perfusion study. However, nowadays, there is controversy to determine the maximum HR and calculate its percentage achieved in an exercise stress test, since the methods used to obtain this result are the

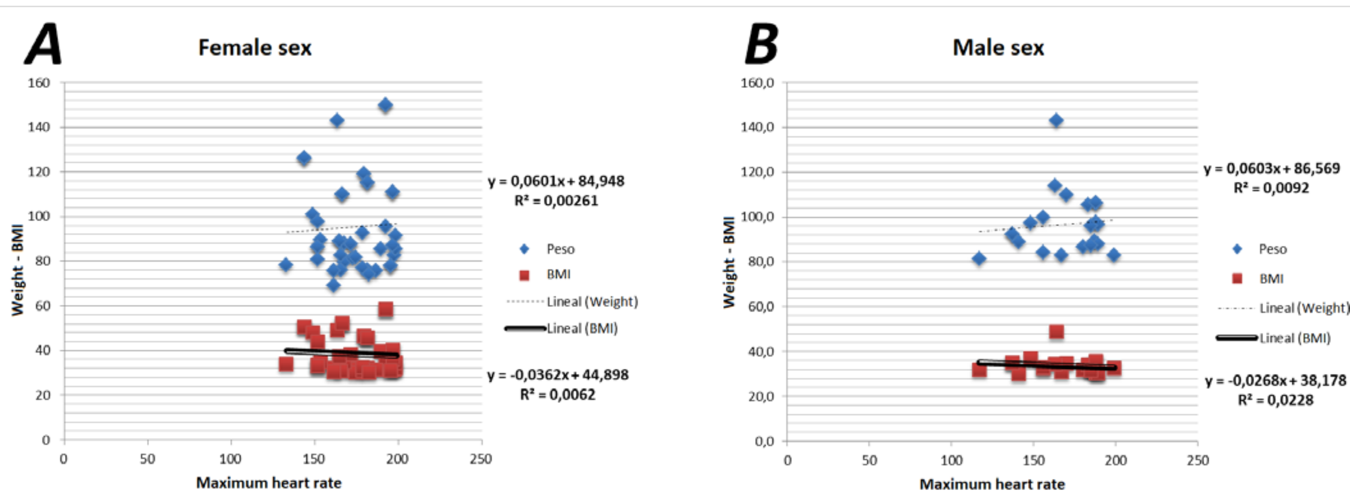

Figure. Dispersion graph and Pearson's r, according to maximum heart rate reached during the exercise stress test and its relationship with weight, body mass index and gender. **A.** Female sex. **B.** Male sex. BMI, body mass index.

predictive equations such as 220 - age, Tanaka, Karvonen, Coop-er and Ellestad, among 40 more formulas. Nonetheless, in multiple studies[13,25-27] is not recommended to calculate it, since some of them overestimate the maximum theoretical HR in approximately 10 beats per minute. In addition, in other studies of our work group[27, 28] with an obese population of both sexes, the predictive equations were compared with the maximal stress test and it was evidenced that these formulas differ from 2 to 18 beats per minute, compared to a maximal stress test in this type of patient; which has also been studied by Bouzas *et al*[29].

On the other hand, the research by Marino *et al*[30], carried out in a group of women with morbid obesity using an ergometer adapted to the upper limbs, when compared with one of the lower limbs, showed that there are changes in the increased systolic blood pressure during test, which is related to the present study, where differences in systolic and diastolic blood pressures are observed during the test, although they were not statistically significant with respect to parameters such as age, sex, and level of physical activity.

No studies were found that demonstrate changes in relation to oxygen saturation before, during and after the development of an exercise stress test in obese patients; however, our study shows that there is an early decrease in the levels of exertional tissue perfusion, hypothetically caused by obesity and the consequent cardiovascular alterations or their comorbidities. Also, when comparing the cardiovascular response of the obese participants with other studies published[28,30] on exercise stress test in patients apparently healthy with similar age ranges to those of the present study, these were found to be much lower to the cardiovascular response found in patients supposedly healthy.

CONCLUSIONS

A decreased cardiovascular response was found in relation to the effort expected for the exercise stress test. The greater the number of cardiovascular risk factors, the lower the maximum heart rate achieved. It is very important to carry out an initial evaluation of the obese patient that includes the pathological history, complete physical examination, anthropometry and measurement of the aerobic capacity, flexibility and strength, for being able to carry out the prescription and the exercise program in the most individualized and accurate way as possible.

LIMITATIONS

After the present research, it is considered that, for future studies, it would be interesting to include echocardiography tests and analyze each of the comorbidities present in the obese population, which inescapably play a core role in the cardiovascular manifestations of patients.

REFERENCES

1. Barroso Camiade C. La obesidad, un problema de salud pública. Espacios Públicos. 2012;33:200-15.
2. Moreno-Martínez FL. Obesidad y distribución regional de la grasa: viejos temas con nuevas reflexiones. CorSalud [Internet]. 2011 [cited 26 May 2019];3(1). Available at: http://www.corsalud.sld.cu/sumario/2011/v3n1a11/distribucion.htm
3. Malo-Serrano M, Castillo N, Pajita D. La obesidad en el mundo. An Fac Med. 2017;78(2):173-8.
4. Dávila-Torres J, González-Izquierdo JJ, Barrera-Cruz A. Panorama de la obesidad en México. Rev Med Inst Mex Seguro Soc. 2015;53(2):240-9.
5. James WPT, Jackson-Leach R, Ni Mhurchu C, Kalamara E, Shayeghi M, Rigby NJ, *et al*. Overweight and obesity (high body mass index). En: Ezzatti M, Lopez AD, Rodgers A, Murray CJL, eds. Comparative Quantification of Health Risks: Global and Regional Burden of Disease Attributable to Selected Major Risk Factors. Vol. 1. Part: Other nutrition-related risk factors and physical inactivity. Geneva: WHO; 2004. p. 497-596. Available at: https://www.who.int/publications/cra/chapters/volume1/0497-0596.pdf
6. Warren TY, Barry V, Hooker SP, Sui X, Church TS, Blair SN. Sedentary behaviors increase risk of cardiovascular disease mortality in men. Med Sci Sports Exerc. 2010;42(5):879-85.
7. Williams MH. Nutrición para la salud, condición física y deporte. 7ª ed. México DF: McGraw-Hill; 2005.
8. Elias MF, Goodell AL. Diet and exercise: blood pressure and cognition: to protect and serve. Hypertension. 2010;55(6):1296-8.
9. Pollock ML. Wilmore JH. Exercise in health and disease: Evaluation and prescription for prevention and rehabilitation. 2ª ed. Philadelphia: W.B.

Saunders; 1990.
10. Barbany JR. Adaptaciones Fisiológicas al entrenamiento. En: Barbany JR, ed. Fisiología del ejercicio físico y del entrenamiento. Barcelona: Editorial Paidotribo; 2002. p. 155-67.
11. Yoshioka M, Stpierre S, Richard D, Labrie A, Tremblay A. Effect of exercise intensity on post-exercise energy metabolism (A375). FASEB J. 1996;10(3):2171.
12. Janiszewski PM, Ross R. The utility of physical activity in the management of global cardiometabolic risk. Obesity (Silver Spring). 2009;17(Suppl 3):S3-S14.
13. Slentz CA, Duscha BD, Johnson JL, Ketchum K, Aiken LB, Samsa GP, *et al*. Effects of the amount of exercise on body weight, body composition, and measures of central obesity: STRRIDE – A randomized controlled study. Arch Intern Med. 2004;164(1):31-9.
14. Ellestad M. Pruebas de Esfuerzo: Bases y aplicación clínica. En: Ellestad M, ed. Las pruebas de esfuerzo. Barcelona: Ediciones Consulta; 1988.
15. Wasserman K, Hansen JE, Sue DY, Stringer WW, Whipp BJ. Principles of Exercise Testing and Interpretation: Including Pathophysiology and Clinical Applications. Philadelphia: Lippincott Williams & Wilkins; 2004.
16. Sosa V, De Llano J, Lozano JA, Oliver A, García Alarcón P. Rehabilitación cardíaca: Generalidades, indicaciones, contraindicaciones, protocolos. Monocardio. 1991;28:44-60.
17. American Thoracic Society, American College of Chest Physicians. ATS/ACCP Statement on cardiopulmonary exercise testing. Am J Respir Crit Care Med. 2003;167(2):211-77.
18. Piscatella J, Franklin BA. Take a load off your Heart: 109 things you can actually do to prevent, halt and reverse heart disease. Nueva York: Workman Publishing Company; 2003.
19. Milani RV, Lavie CJ, Mehra MR. Cardiopulmonary exercise testing: how do we differentiate the cause of dyspnea? Circulation. 2004;110(4):e27-31.
20. Nishime EO, Cole CR, Blackstone EH, Pashkow FJ, Lauer MS. Heart rate recovery and treadmill exercise score as predictors of mortality in patients referred for exercise ECG. JAMA. 2000; 284(11):1392-8.
21. Froelicher VF, Myers J. Exercise and the Heart. 5ª ed. Filadelfia: W.B. Saunders; 2006.
22. Jakobsen MD, Sundstrup E, Persson R, Andersen CH, Andersen LL. Is Borg's perceived exertion scale a useful indicator of muscular and cardiovascular load in blue-collar workers with lifting tasks? A cross-sectional workplace study. Eur J Appl Physiol. 2014;114(2):425-34.
23. Guzmán JA, Sánchez AO, Montez ML, Díaz S, Vázquez J, Pérez I. Capacidad cardiovascular en pacientes obesos. Rev Mex Med Fis Rehab. 2001; 13(4):109-12.
24. Urquiaga J, Negron S, Gil M, Morales R, Cáceres M, Cabo R. Relación entre los parámetros de incompetencia cronotrópica y las imágenes de perfusión miocárdica mediante tomografía computada por emisión de fotón simple (SPECT). Rev Peru Cardiol. 2007;33(3):148-63.
25. Miragaya MA, Magri OF. Ecuación más conveniente para predecir frecuencia cardíaca máxima esperada en esfuerzo. Insuf Card. 2016;11(2):56-61.
26. Cruz-Martínez LE, Rojas-Valencia JT, Correa-Mesa JF, Correa-Morales JC. Maximum Heart Rate during exercise: Reliability of the 220-age and Tanaka formulas in healthy young people at a moderate elevation. Rev Fac Med. 2014;62(4):579-85.
27. Pereira-Rodríguez J, Boada-Morales L, Jaimes-Martin T, Melo-Ascanio J, Niño-Serrato D, Rincón-González G. Predictive equations for máximum heart rate. Myth or reality. Rev Mex Cardiol. 2016; 27(4):156-65.
28. Pereira Rodríguez JE, Boada Morales L, Niño Rios IM, Cañizares Pérez YA, Quintero Gómez JC. Frecuencia cardiaca máxima mediante 220 menos edad versus prueba de esfuerzo con protocolo de Bruce. Mov Científico. 2017;11(1):15-22.
29. Bouzas JC, Delgado M, Benito PJ. Precisión de las ecuaciones para estimar la frecuencia cardíaca máxima en cicloergómetro. Arch Med Deporte. 2013;30(1):14-20.
30. Marino FM, Vidal R, Parada LF, do Valle JC, Fares R, Ivar JR, *et al*. Respuestas cardiovasculares de mujeres con obesidad mórbida sometidas a un test ergoespirométrico con ergómetro de brazo. Rev Colomb Cardiol. 2017;24(5):532-6.

APPENDIX

Exercise stress test

It is one of the most important non-invasive records in the exploration of the heart using a cardio-respiratory sample[14], primarily due to three aspects: diagnosis of ischemic heart disease, determination of functional capacity[15] and perception of dyspnea and fatigue at maximum effort. For all these findings, there are two types of tests: the conventional stress test and the unconventional[14]. In addition, there is a variety of protocols, among them: Bruce, modified Bruce, Naughton, Balke, and Sheffield, among others. It should be noted that the Bruce protocols are better for the diagnosis of ischemia and they are the most used in conventional exercise stress tests[16]; moreover, the remaining protocols are not as effective for the diagnosis of this disease, but they have a better evaluation for functional capacity in certain cases[15]. In turn, these protocols vary according to the characteristics of the study population.

Methodology

Bruce protocol consists in increasing the inclination 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 shorter or longer than those mentioned.

In exercise stress tests, it is necessary to control and monitor vital signs before, during and after its performance; therefore, it is necessary to have records of these measurements at each stage, in addition to perceiving the degree of fatigue and dyspnea of the patient during the test. Of course, if for any reason it should be interrupted, the decision must be respected[19]. Otherwise, the test will stop when the patient: a) reaches a sufficient level of effort for the diagnosis, which is the submaximal HR (85% of the theoretical maximum HR), b) is exhausted and refers that cannot continue, or c) when relevant clinical (angina, abnormal behavior of blood pressure) or electrocardiographic changes appear[20]. This last possibility may be enough for diagnosis; nevertheless, if the exercise stress test is stopped due to fatigue before reaching the submaximal HR, the diagnostic reliability is not as objective as it should be and it would be considered an inconclusive test[17].

Equipment and implements

The most commonly used devices for these tests are the ergometric bicycle and the treadmill[14], each with its advantages and disadvantages, either due to the mode of use or space. The ergometric bicycle takes up less space, it is not noisy, but it needs more collaboration from the patient, since not everyone is familiar with a bicycle; on the other hand, the treadmill requires less collaboration from the patient and submaximal HR can be achieved more easily, but requires more space[21]. In addition, both devices require the respective implements to control and monitor vital signs.

Contraindications and indications

In general, these tests will be contraindicated in patients convalescing from an acute myocardial infarction in the last 5-7 days, severe cardiac arrhythmias, acute pericarditis, infective endocarditis, severe aortic stenosis, acute pulmonary embolism or infarction, unstable angina and limiting physical disability[22]; although some are relative contraindications, as in valve diseases and myocardial ischemia. On the contrary, they will be indicated mainly in symptomatic and asymptomatic patients for the diagnosis and evaluation of ischemic heart disease and cardiac arrhythmias, as well as for stratifying risk, assessing functional capacity, and inclusion in cardiac rehabilitation programs; in healthy people, also to stratify risk, start physical training programs and sports practice, as well as in high-performance athletes[18,22].