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Predictive equations for maximum heart rate. Myth or reality

Ecuaciones predictivas para la frecuencia cardiaca máxima. Mito o realidad

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Maximum heart rate, exercise prescription, stress test, exercise.

Palabras clave:
Frecuencia cardiaca máxima, prescripción del ejercicio, prueba de esfuerzo, ejercicio.

ABSTRACT

Introduction and objective: Maximum heart rate (MHR) is essential to establish the effort, intensity and strategies for physical activity. For this, there are more than 40 formulas; among the best known are 220-Age and Tanaka. The objective of this research is to determine the validity and effectiveness of the equations for MHR. **Material and methods:** Observational, descriptive and transversal study with a sample of 300 participants (181 women and 119 men) with a mean age of 26 ± 10 years. For the development of this research, we used anthropometry, vital signs, Borg scale and questionnaire for cardiovascular risk factors and a stress test and compare the data with 25 equations of MHR. **Results:** Maximum heart rate by stress test of the 300 participants was 179.6 ± 15 beats per minute; regarding 25 equations, was observed an overestimation up to 19 beats per minute. Only the formulas of Morris and Graettinger scored less than 4 beats per minute apart to stress test. **Conclusions:** No one is recommended equations evaluated for their significant difference in the stress test; especially 220-edad, Hossack y Bruce, Cooper and Lester whose difference mean were above 14 beats per minute (p = 0.000). The equation of Morris (p = 0.380) no were found significant differences and were the most successful to estimate the MHR for a minimum difference compared to a stress test.

RESUMEN

Introducción y objetivo: *La frecuencia cardiaca máxima (FCM) es un parámetro esencial para establecer el esfuerzo, intensidad y estrategias de la actividad física. Para ello, existen más de 40 fórmulas; entre las más conocidas son 220-edad y Tanaka. El objetivo de la presente investigación es determinar la validez y efectividad de las ecuaciones para la FCM.* ***Material y métodos:*** *Estudio observacional, descriptivo y transversal con 300 participantes (181 mujeres y 119 hombres), de edad promedio de 26 ± 10 años. Para el desarrollo de esta investigación, se obtuvo antropometría, signos vitales, escala de Borg, cuestionario para factores de riesgo cardiovascular y realización de prueba de esfuerzo para comparar datos con 25 ecuaciones de FCM.* ***Resultados:*** *La FCM por prueba de esfuerzo en los 300 participantes fue de 179.6 ± 15 latidos por minuto; en cuanto a las 25 ecuaciones, se observó una sobreestimación hasta en 19 latidos por minuto y sólo las fórmulas de Morris y Graettinger obtuvieron menos de cuatro latidos por minuto de diferencia a la prueba de esfuerzo.* ***Conclusiones:*** *No se recomienda alguna de las ecuaciones evaluadas por su diferencia significativa respecto a la prueba de esfuerzo; especialmente 220-edad, Hossack y Bruce, Cooper y Lester cuya diferencia de media estuvo por encima de 14 latidos por minutos (p = 0.000). Para la ecuación de Morris (p = 0.380) no se encontraron diferencias significativas y fue la más acertada para estimar la FCM comparada con una prueba de esfuerzo.*

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INTRODUCTION

The heart rate (HR) is the number of times the heart contracts for a minute, your cardiovascular measurement is easy to perform and adequate HR is essential for the proper functioning and evaluation of the heart.[1,2] Actually exist devices for making heart rate; including portable pulse oximeter and the Polar system that has proved more effective and accurate than manual take.

The maximum heart rate (MHR) is the maximum number of beats that can reach the heart at a high physical exercise, because the body responds to exercise increasing its MR and, if exercise is intense enough MHR will be obtained. This is very easy cardiovascular measurement, compared with invasive or noninvasive used to estimate stroke volume and cardiac output procedures. The MHR is used to determine, control and monitor training intensity and likewise know the limit of beats per minute that can reach the heart without compromising the health (ACSM 1994).

Consequently, the HR measurement routinely used to assess response and/or recovery of the heart to exercise, as well as to prescribe exercise intensities according to the MHR individual.[3] The MHR can be determined in two ways: the first is through a record of the highest HR obtained after a high-intensity effort;[4,5] the second, by means of equations that estimate a subject MHR.[6] The estimate of the MHR has been a feature of exercise physiology and applied sciences, since late 1938 Robinson[7] began raising the formula 212-0.77 * Age, which is very different from the widely accepted formula «220-Age» which, has long been the major reference in the estimation of the MHR. However, this equation is presented in books, sports medicine, and exercise physiology; without an explanation or citation of research.[8] Likewise, Tanaka et al. in 2001[9] suggest a formula very well received today (208.75-0.7 * Age) apparently healthy adult subjects. In addition, there are more than 45 equations to determine the MHR according to different variables such as age and gender; but there are other variables that can influence the response of the MHR and that have not been taken into account by these equations.[10]

Similarly, the stress test is an important clinical tool for assessing[11] from two points of view: a) protects the health through prevention and early diagnosis of coronary heart disease or ischemic heart disease (angina pectoris, myocardial infarction, sudden death), and b) support scientific physician training process.[12] And it is not limited to that, but allows conclusions about the functional capacity, the response of blood pressure (BP), maximum heart rate, arrhythmias, the result of a given medical or surgical treatment, among others. It is one of the tests that provide more information at a lower cost.[13]

Currently, the stress tests are performed through established protocols known multistage, ie comprise several phases or stages usually about 2-3 minutes, with progressive increase of the load requires increased physical effort, and is the highest degree of effort reached corresponding to the functional capacity of patients in the study, as with the Bruce protocol, one of the most used internationally (Maroto y De Pablo 2011). However, for some patients the Bruce protocol can be very demanding, so there are other protocols like Naughton, which is to increase a little softer load every two minutes. This protocol has been widely used in the assessment of patients with heart failure or elderly patients.

Therefore, during the approach of this research came the question: How valid and effective are the equations to find the maximum heart rate?, in order to perform this research, I set out to achieve identify the validity and effectiveness of existing formulas comparing them with the results obtained through a stress test according to the Bruce protocol.

MATERIAL Y METHODS

An observational, descriptive and cross-sectional study quantified the cardiovascular risk was performed, the maximum heart rate obtained through a stress test and theoretical equations in a population of 300 (181 women and 119 men) participants with an average age of 26 ± 10 years, who they attended the Rehabilitar Cucuta IPS located in the city of Cucuta-Colombia. The participants must be 18 years old, apparently healthy and to sign an informed consent, endorsed by the ethics committee of the institution. We excluded participants with lower limb pain, dyspnea and/or fatigue greater than 3, participants with cardiovascular disorders or a history of cardiovascular surgical type or acute myocardial infarction. As retirement criteria were taken into account hemodynamic instability during the test and the manifestation of not wanting to continue.

To collect sociodemographic, anthropometric and physiological data an instrument, which was used for the filled of questionnaire the patient. We proceeded first to perform measurements sociodemographic (gender, age, ethnicity, identifying risk factors, personal history, family history), physiological (blood pressure, heart rate, blood oxygen saturation) and anthropometric (weight, height, BMI) by the balance (Health o Meter) previously calibrated (accuracy = 0.1 g and 0.1 cm respectively), weight and height of patients was evaluated determined by placing the patient standing with Frankfort plane and shoulders relaxed to avoid lordosis. Was obtained Z score (Z-score) for BMI (kg/m2) through Excel, developed based on the WHO reference. The Z score of BMI allowed the sample group in underweight, normal weight, overweight and obesity. The stress test was performed on a treadmill with the Bruce protocol; patients could not drink alcohol, coffee, and smoke or use any drugs or medication that could interfere with the MHR. Perceived dyspnea and effort were assessed by the modified Borg scale *(Table I)*.[14]

Table I. Borg scale for dyspnea and fatigue.

0	Nothing
1	Very, very light
2	Very light
3	Light
4	Moderate
5	A little strong
6	Strong
7	
8	Very strong
9	
10	Extremely strong

Heart rate was obtained by the Polar RS800CX Multisport system, while blood oxygen saturation with portable pulse oximeter (Nellcor Puritan Bennett); both measurements were taken before, during and after the stress test. Systolic and diastolic blood pressure was taken manually at the start, end and after 5 minutes the stress test ended.

It was considered as a dependent variable (or result) the value of the MHR obtained after a maximum effort. As independent variables (or predictors) were taken the various equations formulated to calculate the MHR *(Table II)*.

Table II. Equations for calculating MHR.

#	Study	Formula
1	Astrang[14]	211-0.922* Year
2	Bruce (1974)[15]	210-0.662* Year
3	Cooper[16]	217-0.845* Year
4	Ellestad[16]	197-0.556* Year
5	Fernhall et al. (2001)[17]	205-0.64* Year
6	Froelicher y Myers (2000)[16]	207-0.64* Year
7	Graettinger et al. (1995)[18]	199-0.63* Year
8	Hossack y Bruce (1982)[19]	206-0.597* Year
9	Hossack y Bruce (1982)[19]	227-1.067* Year
10	Inbar et al. (1994)[20]	205.8-0.685* Year
11	Jones (1985)[21]	210-0.65* Year
12	Lester (1968) Trained[22]	205-0.41* Year
13	Lester (1968) Untrained[22]	198-0.41* Year
14	Morris[16]	200-0.72* Year
15	Rodeheffer et al (1984)[23]	214-1.02* Year
16	Robinson (1938)[16]	212-0.77* Year
17	Sheffield et al. (1978)[24]	216-0.88* Year
18	Tanaka et al. (2001)[9]	211-0.8* Year
19	Tanaka et al. (2001)[9]	207-0.7* Year
20	Tanaka et al. (2001)[9]	206-0.7* Year
21	Tanaka et al. (2001)[9]	208.75-0.73* Year
22	Whaley et al (1992)[25]	209-0.7* Year
23	Whaley et al (1992)[25]	214-0.8* Year
24		220-Year
25		210-Year

The design and development of the research was conducted 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 mean and standard deviation. Regarding the comparison of the MHR between theoretical equations versus that obtained in the stress test, it was performed by ANOVA (analysis of variance one-way) to compare the differences of gender and age in the different variables studied. Also, post hoc test by Tukey test, to see the differences between the different age groups and anthropometry. In all cases the level of significance was set at 5% ($p < 0.05$); like the variables were correlated by Pearson's R and all analyzes were performed in Stata (Data Analysis and Statistical Software).

RESULTS

After analyzing the data obtained during the fieldwork; which it was conducted with a total sample of 300 (181 women and 119 men) participants from the city of Cucuta, Colombia who attended the Rehabilitar Cúcuta IPS. Among the sociodemographic characteristics studied an average age for both genders of 26 ± 10 years identified; made up of 60% women and 40% men.

On the academic level, 58% were university graduates, 26% had studied up to high school, 9% were high school graduates, 6% were technical or technological and 1% had completed only primary. The risk factors identified were: blood pressure, overweight and/or obesity, diabetes, smoking, family history (diabetes, acute myocardial infarction and hypertension), alcohol intake and fatty foods; being most prevalent smoking, alcohol intake, overweight and/or obesity in men than in women and 93% of women eat many times month fast food, according to BMI the underweight, overweight and obesity was higher in men than women *(Table III)*.

Moreover, we note that the stress tests performed were significantly high intensity for participants, since 80% (M: 84.03% versus W:

Table III. Characterization of the population.

Variable	Quantity	Women	Men	Mean
Poblation total				300
Year	300	26.5 ± 10.3	26.15 ± 10.4	26 ± 10
Gender	300	181	119	100
Ethnicity				
White	170	114	56	56.66
Half blood	97	51	46	32.33
Afrocolombian	33	16	17	11
Risk factors				
Smoking	17	3 - 1.6%	14 - 11.7%	5.66
Ex smoking	28	11 - 6%	22 - 18.4%	9.33
Alcohol intake	206	114 - 62.9%	92 - 77.3%	10.35
Hypertension arterial	27	16 - 8.8%	11 - 9.2%	26.03
Diabetes mellitus	15	11 - 6%	4 - 3.3%	5
Intake of fatty foods	279	169 - 93.3%	110 - 92%	93
Family discovery: HTA, diabetes, HTA, IAM	91	49 - 27%	42 - 35.2%	30.33
BMI				
Underweight	12	6 - 3.3%	6 - 5%	4
Normopeso	167	109 - 60.2%	58 - 48.7%	55.66
Overweight	88	47 - 25.9%	41 - 34.4%	29.33
Obesity	33	19 - 10.5%	14 - 11.8%	11
Education				
Primary	3	1 - 0.55%	2 - 1.68%	1
High school	75	45 - 24.86%	30 - 25.21%	25
Bachelor degree	27	13 - 7.18%	14 - 11.76%	9
Technical	12	5 - 2.76%	7 - 5.88%	4
Technological	7	5 - 2.76%	2 - 1.68%	2.33
Undergraduate	164	105 - 58%	59 - 49.57%	54.66
Postgraduate	12	7 - 3.86%	5 - 4.20%	4

76%) mentioned an effort between strong and extremely strong (rating 5 to 10) after the stress test according to the Borg scale for fatigue; for the assessment of dyspnea 70% (M: 76% versus W: 63%) mentioned by the Borg scale dyspnea severe to extremely severe (grade 5 to 10) after the stress test.

Likewise, the results of the stress test show similar values for men compared to women (178.49 bpm ± 16.64 versus 180.46 bpm ± 14.10; p = 0.272) *(Table IV)*, and according to the BMI, the patients with underweight they reached a maximum heart rate of 186.9 bpm ± 14.2, normal weight 180.4 bpm ± 13.9, overweight 179.3 bpm ± 15.6 and obesity with 174.3 bpm ± 18.8 (p = 0.061) *(Table V)*.

Similarly, it was determined that the equations with less arithmetic difference between the predictive equations for participants with underweight were the formula Morris (1 bpm, p = 0.434) and Graettinger (2 bpm, p = 0.567). Normoweight the equations of Morris (3 bpm, p = 0.123). And the participants with overweight or obesity were the equations of Morris (p > 0.05), Graettinger (p > 0.05) and 210-Age (p > 0.05) with an arithmetic difference between the stress test of 1 bpm *(Table VI)*.

Similarly, by linking the age with maximum heart rate obtained in the stress test, it demonstrated in the study population that to older age less was his MHR obtained (18 to 30 years: 183 bpm ± 12; 31 to 40 years: 176 bpm ± 15; 41 to 50 years: 167 bpm ± 13; older to 50 years: 163 bpm ± 13; p < 0.001) *(Table V)*. And the equations with less arithmetic difference respect to the beats per minute (blp) was Morris and Graettinger with 1 and 2 bpm respectively for the ages between 18 to 30 years. For ages between 31 and 40 years were the equations of Graettinger (p = 0.863) and 210-Years (p = 0.807) with less of 1 bpm of difference. In the group of the participants with ages between 41 to 50 years and older of 50, existed less arithmetic difference in the equation of Morris (p > 0.05), Astrang (p > 0.05) and Graettinger (p > 0.05) *(Table VII)*.

At the same time, the MHR obtained in a stress test was compared and determined by the equations, showing an overestimation by the equations up to 19 beats for minute. The equation 220-Age was not found valid and effective in determining the MHR, this formula obtained a difference in average of 14 bpm (p = 0.000) and Tanaka et al. (1997) and (2001)

Table IV. Results obtained of the MHR in testing.

	Men	Women
Sample	119	181
Media	178.49 lpm	180.46 lpm
DT	16.64	14.10
Maximum value MHR*	210 lpm	206 lpm
Minimum value MHR	117 lpm	133 lpm

DT = standard deviation, bpm = beats per minutes.

Table V. Arithmetic mean and standard deviation of the MHR as anthropometry and age.

	Total (n = 300)	Men (n = 119)	Women (n = 181)
BMI			
Underweight	186.9 ± 14.2 (n = 12)	185.9 ± 14.5 (n = 6)	188.8 ± 12.8 (n = 6)
Normopeso	180.4 ± 13.9 (n = 167)	180.3 ± 14.0 (n = 58)	180.4 ± 13.9 (n = 109)
Overweight	179.3 ± 15.6 (n = 88)	179.3 ± 15.6 (n = 41)	179.5 ± 15.8 (n = 47)
Obesity	174.3 ± 18.8 (n = 33)	176.4 ± 17.8 (n = 14)	173.9 ± 19 (n = 19)
Year			
18-30 year	182.6 ± 13 (n = 233)	182.6 ± 13.1 (n = 97)	182.6 ± 13.1 (n = 136)
31-40 year	176.1 ± 15 (n = 27)	176.1 ± 15.8 (n = 10)	176.3 ± 15.8 (n = 17)
41-50 year	167.6 ± 17.2 (n = 27)	169 ± 17.7 (n = 7)	167.6 ± 17.2 (n = 20)
Older 50 year	159.6 ± 16 (n = 13)	159.6 ± 16.8 (n = 5)	163.6 ± 15 (n = 8)

differences obtained 10 (p = 0.000) and 9 (p = 0.000) beats for minutes respectively. Accordingly, it is considered that the equations currently used to estimate the MHR are not accurate to prescribe ranges of heart rate training. Therefore, it was advisable to make a more specific analysis of correlation according to Pearson's R for the characteristics of the study population; this being a weak positive correlation (r = 0.19959) *(Table VIII)*.

In reviewing the results of the analysis through ANOVA and by Tukey test was determined that only the formula of Morris (200-0.72 * Year) no significant differences with respect to a stress test with Bruce protocol in apparently healthy participants.

DISCUSSION

The analysis of the results corroborates the various investigations that question the applicability of formulas to determine maximum heart rate.[8,26-28] However, these equations are frequently used in hospitals, books and research. In addition, formulas and related concepts are included in most certification exams, exercise physiology and fitness. Despite more than 20 years that reveal the great error inherent in the estimation of the maximum heart rate (standard error of estimate 7-11 bpm)[8] through predictive formulas.

Our results correspond partially to those reported by Chiacchio[29] who compared the performance of formulas for MHR predicted by

Table VI. Difference of MHR between the equations and stress test according anthropometry.

Formula	Underweight 182.5 ± 13	Value of p	Normopeso 179.6 ± 15	Value of p	Overweight 179.7 ± 15	Value of p	Obesity 179.7 ± 15	Value of p
Tanaka 1997	193 ± 2.7 (11)	0.171	191 ± 6.7 (12)	0.000	187 ± 10.0 (8)	< 0.000	186 ± 8.8 (7)	0.002
Tanaka 2001☻	191 ± 2.3 (9)	0.348	190 ± 5.8 (11)	0.000	186 ± 8.7 (8)	< 0.000	185 ± 7.7 (6)	0.003
Tanaka 2001☻☻	190 ± 2.3 (8)	0.480	189 ± 5.8 (10)	0.000	185 ± 8.7 (6)	< 0.000	184 ± 7.7 (5)	0.008
Tanaka 2001☻☻☻	192 ± 2.4 (10)	0.253	191 ± 6.1 (12)	0.000	187 ± 9.1 (8)	< 0.000	186 ± 8.0 (7)	0.002
Robinson 1938	194 ± 2.6 (12)	0.091	193 ± 6.4 (14)	0.000	189 ± 9.6 (10)	0.000	188 ± 8.4 (9)	0.000
Inbar	190 ± 2.3 (8)	0.000	189 ± 5.7 (10)	0.000	185 ± 8.6 (6)	0.000	184 ± 7.5 (5)	0.000
Astrang	190 ± 3.1 (8)	0.000	188 ± 7.7 (9)	0.000	183 ± 11.5 (4)	0.000	182 ± 10.1 (3)	0.000
Bruce	195 ± 2.2 (13)	0.000	194 ± 5.5 (15)	0.000	190 ± 8.3 (11)	0.000	189 ± 7.2 (10)	0.000
Cooper	198 ± 2.8 (16)	0.000	196 ± 7.0 (17)	0.000	191 ± 10.6 (12)	0.000	190 ± 9.2 (11)	0.000
Ellestad	184 ± 1.9 (2)	0.001	183 ± 4.6 (4)	0.000	180 ± 6.9 (1)	0.000	179 ± 6.1 (1)	0.000
Fernhall	190 ± 2.1 (8)	0.421	189 ± 5.3 (10)	0.000	186 ± 8.0 (7)	0.001	185 ± 7.0 (6)	0.004
Froelicher	192 ± 2.1 (10)	0.207	191 ± 5.3 (12)	0.000	188 ± 8.0 (9)	0.000	187 ± 7.0 (8)	0.000
Graettinger	184 ± 2.1 (2)	0.567	183 ± 5.2 (4)	0.010	180 ± 7.9 (1)	0.798	179 ± 6.9 (1)	0.181
Jones	195 ± 2.2 (13)	0.060	194 ± 5.4 (15)	0.000	190 ± 8.1 (11)	0.000	189 ± 7.1 (10)	0.000
Lester-Trained	195 ± 1.4 (13)	0.054	195 ± 3.4 (16)	0.000	192 ± 5.1 (13)	0.000	192 ± 4.5 (13)	0.000
Lester-No trained	188 ± 1.4 (6)	0.735	188 ± 3.4 (9)	0.000	185 ± 5.1 (6)	0.000	185 ± 4.5 (6)	0.002
Morris	183 ± 3.4 (1)	0.434	182 ± 6.0 (3)	0.123	178 ± 9.0 (-1)	0.540	177 ± 7.9 (-2)	0.416
Rodeheffer	191 ± 3.4 (9)	0.375	189 ± 8.5 (10)	0.000	183 ± 12 (4)	0.069	182 ± 11.2 (3)	0.046
Sheffield	196 ± 3.4 (14)	0.042	194 ± 7.3 (15)	0.000	189 ± 11.0 (10)	0.000	188 ± 9.6 (9)	0.000
Whaley^	193 ± 3.4 (11)	0.165	192 ± 5.8 (13)	0.000	188 ± 8.7 (9)	0.000	187 ± 7.7 (8)	0.000
Whaley^^	196 ± 3.4 (14)	0.044	194 ± 6.7 (15)	0.000	190 ± 10.0 (11)	0.000	189 ± 8.8 (10)	0.000
Hossack‡	192 ± 3.4 (10)	0.000	191 ± 5.0 (12)	0.000	188 ± 7.5 (9)	0.000	187 ± 6.5 (8)	0.000
Hossack‡‡	203 ± 3.4 (21)	0.000	201 ± 8.9 (22)	0.000	195 ± 13.4 (16)	0.000	193 ± 11.7 (14)	0.000
220-Year	197 ± 3.4 (15)	0.846	195 ± 8.3 (16)	0.000	190 ± 12.5 (11)	0.000	189 ± 11 (10)	0.000
210-Year	187 ± 3.4 (5)	0.018	185 ± 8.3 (6)	0.000	180 ± 12.5 (1)	0.640	179 ± 11 (1)	0.218

The value in parentheses indicates the difference between the arithmetic mean of the formulas according to anthropometry.
☻ = 207-0.7* Year, ☻☻ = 206-0.7* Year, ☻☻☻ = 208.75-0.73* Year, ^ = 209-0.7* Year, ^^ = 214-0.8* Year, ‡ = 206-0.597* Year, ‡‡ = 227-1.067* Year.

the equations 220-Age, Tanaka and Gellish; finding an overestimation of the HR in the younger subjects, while tended to underestimate the values in subjects 50 to 70 years. Like, he observed coincidence of the three formulas to 40 years.

One study,[30] compared the MHR obtained through a tapestry, with estimated values by equations Jones[21] and Tanaka et al.[9] with a sample of 86 men, mean age 22.2 ± 3.9 years. The authors' conclusions are similar to those obtained in this research, not recommend the use of the equation Jones (MHR = 210-0.65 * Year).

But, the study considers acceptable equation of Tanaka et al. (MHR = 208.7-0.7 * Year), which is not recommended in this study for the population of this research, which showed a margin of error of 9 lpm. Also, a job[31] made the same comparison of a stress test on treadmill versus 220-year. The values of MHR were obtained in the test 185.3 bpm ± 11.3 versus 188.7 bpm ± 12.3 obtained by the equation. Observed that the MHR calculated is significantly higher than obtained. These results are consistent with data obtained in the present study, in which 220-age equation overestimates the MHR for men and women.

Studies conducted by authors like Engels H.,[32] Ricard R.[33] y Robergs R.[34] affirm and recommend in their research that should not be used 220-age equation as a means to calculate

Table VII. Difference of MHR between equations and stress test by age.

Formula	18-30 years 183.8 ± 12	Value of p	31-40 years 176.4 ± 15	Value of p	41-50 years 167.4 ± 12	Value of p	Older to 50 163.3 ± 13	Value of p
Tanaka 1997	194 ± 2.3 (11)	0.000	183 ± 2.2 (7)	0.029	174 ± 2.4 (7)	0.063	168 ± 2.5 (5)	0.231
Tanaka 2001☻	192 ± 2.0 (9)	0.000	182 ± 1.9 (6)	0.046	175 ± 2.1 (8)	0.043	169 ± 2.2 (6)	0.131
Tanaka 2001☻☻	191 ± 2.0 (8)	0.000	181 ± 1.9 (5)	0.093	174 ± 2.1 (7)	0.082	168 ± 2.2 (5)	0.188
Tanaka 2001☻☻☻	193 ± 2.1 (10)	0.000	183 ± 2.0 (7)	0.025	175 ± 2.2 (8)	0.034	170 ± 2.3 (7)	0.137
Robinson 1938	195 ± 2.2 (12)	0.000	185 ± 2.1 (9)	0.005	177 ± 2.3 (10)	0.012	171 ± 2.4 (8)	0.097
Inbar	191 ± 1.9 (8)	0.000	181 ± 1.8 (5)	0.000	174 ± 2.0 (7)	0.000	169 ± 2.1 (6)	0.000
Astrang	191 ± 2.6 (8)	0.000	178 ± 2.5 (2)	0.000	169 ± 2.8 (2)	0.000	162 ± 2.9 (-1)	0.000
Bruce	196 ± 1.9 (13)	0.000	186 ± 1.8 (10)	0.000	179 ± 2.0 (12)	0.000	174 ± 2.1 (11)	0.000
Cooper	199 ± 2.4 (16)	0.000	187 ± 2.3 (11)	0.000	178 ± 2.5 (11)	0.000	172 ± 2.6 (9)	0.000
Ellestad	185 ± 1.6 (2)	0.000	177 ± 1.5 (1)	0.000	171 ± 1.7 (4)	0.000	167 ± 1.7 (4)	0.000
Fernhall	191 ± 1.8 (8)	0.000	182 ± 1.7 (6)	0.041	175 ± 1.9 (10)	0.026	171 ± 2.0 (8)	0.078
Froelicher	193 ± 1.8 (10)	0.000	184 ± 1.7 (8)	0.007	177 ± 1.9 (10)	0.005	173 ± 2.0 (10)	0.033
Graettinger	185 ± 1.8 (2)	0.009	176 ± 1.7 (0)	0.863	170 ± 1.9 (3)	0.530	165 ± 2.0 (2)	0.507
Jones	192 ± 1.8 (9)	0.000	187 ± 1.7 (11)	0.000	180 ± 1.9 (13)	0.000	175 ± 2.0 (12)	0.010
Lester-trained	196 ± 1.2 (13)	0.000	190 ± 1.1 (14)	0.000	186 ± 1.2 (19)	0.000	183 ± 1.3 (20)	0.000
Lester-No trained	189 ± 1.2 (6)	0.000	183 ± 1.2 (7)	0.017	179 ± 1.2 (12)	0.000	176 ± 1.3 (13)	0.004
Morris	184 ± 2.0 (1)	0.051	174 ± 1.9 (-2)	0.581	167 ± 2.2 (10)	0.766	161 ± 2.2 (2)	0.900
Rodeheffer	192 ± 2.9 (9)	0.49	178 ± 2.8 (2)	0.000	167 ± 3.1 (10)	0.904	159 ± 3.2 (-4)	0.440
Sheffield	197 ± 2.5 (14)	0.000	185 ± 2.4 (9)	0.004	176 ± 2.6 (9)	0.026	169 ± 2.8 (6)	0.197
Whaley^	194 ± 2.0 (11)	0.000	184 ± 1.9 (8)	0.009	177 ± 2.1 (10)	0.010	171 ± 2.2 (8)	0.059
Whaley^^	197 ± 2.3 (14)	0.000	186 ± 2.2 (10)	0.002	177 ± 2.4 (10)	0.007	171 ± 2.5 (8)	0.077
Hossack‡	193 ± 1.7 (10)	0.000	185 ± 1.6 (9)	0.000	178 ± 1.8 (11)	0.000	174 ± 1.9 (11)	0.000
Hossack‡‡	204 ± 3.0 (21)	0.000	189 ± 2.9 (13)	0.000	178 ± 3.2 (11)	0.000	170 ± 3.4 (7)	0.000
220-Year	198 ± 2.8 (15)	0.000	185 ± 2.7 (9)	0.003	174 ± 3.0 (7)	0.056	166 ± 3.1 (3)	0.423
210-Year	188 ± 2.8 (5)	0.000	175 ± 2.7 (-1)	0.807	164 ± 3.0 (-3)	0.317	156 ± 3.1 (7)	0.248

The value in parentheses indicates the difference between the arithmetic mean of the formulas according to age.
☻ = 207-0.7* Year, ☻☻ = 206-0.7* Year, ☻☻☻ = 208.75-0.73* Year, ^ = 209-0.7* Year, ^^ = 214-0.8* Year, ‡ = 206-0.597* Year, ‡‡ = 227-1.067* Year.

Table VIII. Comparison of MHR general in stress test versus equations.

Study	Formula	Media	MHR*	DF	R of Pearson	Value de p
Astrang	211 - 0.922* Year	186.74 ± 9.66	179.68 ± 15	7.06	0.19959	0.007
Bruce (1974)	210 - 0.662* Year	192.58 ± 6.94		12.9		0.000
Cooper	217 - 0.845* Year	194.77 ± 8.86		15.09		0.000
Ellestad	197 - 0.556* Year	182.37 ± 5.83		2.69		0.019
Fernhall et al. (2011)	205 - 0.64* Year	188.16 ± 6.71		8.48		0.000
Froelicher y Myers	207 - 0.64* Year	190.16 ± 6.71		10.48		0.000
Graettinger et al. (1995)	199 - 0.63* Year	182.43 ± 6.61		2.75		0.019
Hossack y Bruce (1982)	206 - 0.597* Year	190.29 ± 6.26		10.61		0.000
Hossack y Bruce (1982)	227 - 1.067* Year	198.93 ± 11.17		19.25		0.000
Inbar et al. (1994)	205.8 - 0.685* Year	187.77 ± 7.18		8.09		0.000
Jones (1975)	210 - 0.65* Year	192.9 ± 6.81		13.22		0.000
Lester trained	205 - 0.41* Year	194.22 ± 4.3		14.54		0.000
Lester no trained	198 - 0.41* Year	187.22 ± 4.3		7.54		0.000
Morris	200 - 0.72* Year	181.06 ± 7.55		1.38		0.380
Rodeheffer et al. (1984)	214 - 1.02* Year	187.16 ± 10.69		7.48		0.001
Robinson (1938)	212 - 0.77* Year	191.74 ± 8.07		12.06		0.000
Sheffield et al. (1978)	216 - 0.88* Year	192.85 ± 9.22		13.17		0.000
Tanaka et al. (1997)	211 - 0.8* Year	189.95 ± 8.38		10.27		0.000
Tanaka et al. (2001)	207 - 0.7* Year	188.58 ± 7.33		8.9		0.000
Tanaka et al. (2001)	206 - 0.7* Year	187.58 ± 7.33		7.9		0.000
Tanaka et al. (2001)	208.75 - 0.73* Year	189.54 ± 7.65		9.86		0.000
Whaley et al (1992)	209 - 0.7* Year	190.58 ± 7.33		10.9		0.000
Whaley et al (1992)	214 - 0.8* Year	192.95 ± 8.39		13.27		0.000
	220 - Year	193.69 ± 10.48		14.01		0.000
	210 - Year	183.68 ± 10.48		4		0.002

* Overall average of maximum heart rate obtained in stress test, DT: Standard deviation, DF: Difference between results of equations and stress test. Value of p determined by ANOVA of one way with p < 0.05.

the MHR, as you could incur serious errors in prescribing exercise as much as in cardiac patients, as in apparently healthy people; suggestion is supported by the results presented in this research.

At the same time, Machado Fabiana y col.[35] concludes that the equation «220-age» is not valid or appropriate because overvalued in average. Thus, and despite its widespread application, the formula «220-age» need samples to know its origin, author and age range used for processing, because the date is unknown.[36,37]

CONCLUSIONS

For the study population of the city of Cucuta, Colombia in the 25 equations evaluated to determine the maximum heart rate, no significant difference was found in the formula of Morris (200-0.72 * Year) (p = 0.380), therefore it considered appropriate to calculate the MHR in this population. However, we suggests conducting a stress test with the Bruce's protocol or Naughton for older people or with some degree of alteration where the Bruce protocol is contraindicated; for true maximum heart rate and no serious mistakes in planning training.

Furthermore, we identified significant difference in other equations evaluated; especially 220-Year, Hossack y Bruce (227-1.067 * Year), Cooper (217-0.845 * Year) and Lester (205-0.41 * Year) (p = 0.000) whose arithmetic mean differences were above 14 beats per minute.

In turn, it is emphasized that in participants with lower BMI or younger, the MHR was much higher.

In addition, exist the need to continue this investigation in the coming years with a larger population to determine the most accurate and in effect creating an indigenous equation that meets the characteristics of the region is highlighted equation.

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Interest conflict

The authors declare no conflict of interest.

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