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Predictability of predicted HRmax in Black Africans

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Abstract

HRmax is the heart rate that can be attained after maximum exertion. It is an index of the amount of stress the heart can take during exercise. For safety reason, it is usually predicted and reduced to a certain percentage when prescribing exercise. 220 – age and 208 – 0.7 x age are the common formulae used to predict HRmax. This study, using 40 young adults (22 male & 18 female) between the ages of 18-30 years, aims to validate the predictability of these formulae. They were subjected to maximum exertion on bicycle ergometer and the maximum heart rate measured. We then calculated the predicted HRmax and compare with the measured HRmax. The findings revealed that the measured HRmax is 135.70 ±3.80, Predicted HRmax using 220 – age is 197.83 ±0.45 and using 208 – 0.7 x age is 192.48 ±0.31. The 85% of Predicted HRmax, commonly used as submaximal HRmax was found to be 168.15 ±0.38. All these are significantly raised above the HRmax. The prediction error was found to be between 32 and 62 beats/minute (b/min) which is far above the acceptable 11 b/min. We then used 70% of Predicted HRmax and got means of 138.23 ±0.39 and prediction error of 3 b/min. In conclusion, caution should be taken in using these predictions and if we must, then we recommend values much below 85% Predicted HRmax; most especially in the elderly black Africans.

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Introduction

Heart rate is a very easily measurable cardiovascular parameter, especially in comparison to the invasive or non-invasive procedures used to estimate stroke volume and cardiac output. This is why Maximal heart rate (HRmax) is one of the most commonly used parameter in clinical medicine and physiology. The maximum heart rate is defined as the highest heart rate an individual can achieve without severe problems through exercise stress, and depends on age (Atwal *et al.,* 2002). For instance, a percentage of HRmax is used as a basis for prescribing exercise intensity in both rehabilitation and disease prevention programs (ACSM, 2000). Moreover, in some clinical settings, exercise testing is terminated when subjects reach an arbitrary percentage of their age-predicted maximal heart rate (e.g., 85% of HRmax) (Gibbons *et al.,* 2002). Maximal heart rate can also be used as a criterion for achieving peak exertion in the determination of maximal aerobic capacity (Tanaka *et al.,* 1997).

HRmax is often estimated because of the feasibility of performing the test in many settings and the risk in older patients, thus the equation 220-age is used. However the validity of this formula has not been established, especially in the elderly (> 60 years). The younger population may be subjected to HRmax test without much fear, but not so the elderly due to their susceptibility to physiological stress during strenuous exercise. Given that the increase in heart rate during incremental exercise mirrors the increase in cardiac output, maximal heart rate is often interpreted as the upper ceiling for an increase in central cardiovascular function, one that cannot be surpassed despite continued increases in exercise intensity or training adaptations (Robert and Roberto, 2002).

The purpose of this study is to compare the predicted HRmax using 220 - age and 208 - 0.7 x age with measured HRmax. We will also look at how these two methods deviate from the measured HRmax.

Material and methods

Subjects

Forty five (45) medical students of University of Abuja volunteered to participate in the study as subjects. Forty (40) students (22 males and 18 females) aged 18-30 years qualified to participate after the exclusion criteria were applied. The exclusion criteria were as follows:

I. Previous history of heart disease.
II. Ingestion of digitalis in preceding six months.
III. Fixed-rate pace maker in subjects.
IV. Uncontrolled metabolic disease (especially diabetes mellitus).
V. Neuromuscular, musculoskeletal or rheumatoid disorders.
VI. Hypertension and associated pulmonary disease (e.g. asthma, pneumonia etc.).
VII. Previous history of chest surgery.
VIII. Pregnancy.
IX. On any medication.

Procedures

Subject Preparation

Subjects were advices to be relaxed, wear light clothing and take their normal meals 2-3hrs before the study.

Anthropometric measurements were taken. Pre-exercise blood pressure, pulse rate and respiratory rates were recorded.

Supervising the test

There was a qualified medical personnel throughout the period of the exercise test to handle any emergency that may arise. There were also three technical staffs involved in the study. The procedure was demonstrated to all the subjects before the exercise.

Exercise Stress Testing

This was done using bicycle ergometer (RICHMORAL Sportscomputer). Subject sits comfortably on the bicycle with the seat adjusted in such a way that there is knee flexion when the contralateral knee is fully extended. The digital monitor is reset and the

resistance fixed at stage 2. As the subject places his/her hand on the handle, the pulse rate is recorded as is appears on the display monitor. The subject starts riding slowly and gradually increases the speed. Rides until exhausted and cannot continue due to fatigue (modified McArdle protocol) (McArdle *et al.,* 1994, Tanaka *et al.,* 2001). Before stopping, the subject is asked to ride slowly for about 30 seconds before finally dismounting the bicycle. The age-predicted maximal heart rate (HR_{Max}) was first calculated using the formula, Predicted HR_{Max} = 220 – age and 208 – 0.7x age (Robert and Roberto, 2002). Meanwhile, the duration of exercise, distance covered, calories burnt and the maximal heart rate attained are recorded from the digital monitor. HRmax prediction errors (HRmax – Predicted HRmax = error) is also calculated. The room temperature at the time of study was 34°C.

Statistical Analyses

All data obtained was interpreted using SPSS 16.0. The differences between HRmax and predicted HRmax values were evaluated using the pairwise t-test. All descriptive data was expressed as means ± standard error of means. Results were considered significant when p was ≤ 0.05.

Ethical Approval

The study was approved by the ethical committee of College of Health Sciences, University of Abuja. All subjects gave written informed consent to participate in the study in accordance with Helsinki Declaration of June 1964 and amended in Seoul in October 2008.

Results

The descriptive statistics: The ages of the subject range from 18 – 30 years, with average of 21 years among the males and 23 years among the female subjects. Their heights are between 1.5 – 2.0m with average in males being 1.77m and 1.58m in females. The subjects weigh between 44 – 92kg with the average weight in males being 67kg and in females 52kg. BMI of our subject range between 17.72 and 28.57, with males having an average of 21.46 and females 22.52.

Table 1. Means of Measured HRmax Compared to the Predicted HRmax using the two formulae and the prediction errors.

	HRmax	Predicted HRmax1	Predicted HRmax2	85% Predicted HRmax1	70% Predicted HRmax1
Mean	135.70 ±3.80	197.83 ±0.45*	192.48 ±0.31*	168.15 ±0.38*	138.23 ±0.39
HRmax Prediction Error	0	-62.13 ±3.89	-56.78 ±3.86	-32.45 ±3.87	-2.53 ±3.86

Values represent mean ± SEM *Significant (p<0.05).

Table 1. shows the means of HRmax compared to those predicted by using the formula 220 – age (Predicted HRmax1), 208 – 0.7 x age (Predicted HRmax2) and 85% of Predicted HRmax1 which is commonly used. We also used 70% of Predicted HRmax 1 to see how it defers from 85%. All the predicted values are significantly raised above the measured HRmax except 70% Predicted HRmax. The difference between the measured HRmax and the predicted values shows that it is much higher with the formula 220 – age compared to 208 – 0.7 x age.

Table 2. Correlation table of Age and HRmax.

	AGE	*HRmax*	*Predicted Hrmax 1*	*Predicted Hrmax 2*	*85% Predicted Hrmax1*
AGE	1.00				
HRmax	0.14	1.00			
Predicted Hrmax 1	-1.00	-0.14	1.00		
Predicted Hrmax 2	-1.00	-0.14	1.00	1.00	
85% Predicted Hrmax1	-1.00	-0.14	1.00	1.00	1.00

Table 2. shows the correlation between age and other HRmax variables. There is very strong negative correlation between age and all predicted HRmax. This is understandable as predicted HRmax is deducted by reduction in age. But is weakly positive when correlated with calculated HRmax.

From Fig. 1. it is clear that the predicted values are generally higher than the measured. 85% of the predicted HRmax1 is closer to the measured values compared to the unadjusted predicted values

When arranged from the lowest to the highest HRmax (Fig. 2), a clearer picture appears. The predicted values remain relatively the same while the HRmax slopes upward, naturally.

Discussion

One of the most important applications of the heart rate response to exercise has been the use of submaximal heart rate, in combination with resting and maximal heart rate, to estimate VO2max (maximal oxygen consumption). Often, maximal heart rate estimation is recommended by using the formula HRmax=220-age, and 85% of this as submaximal heart rate. Based on this application, heart rate responses to exercise have been used to calculate exercise intensities, especially in the elderly where you are careful about excessive stress on the heart (Swain *et al.,* 1994).

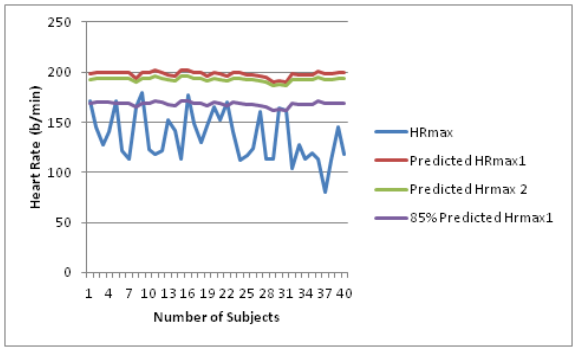

Fig. 1. Graphical presentation of measured HRmax compared to predicted HRmax.

HRmax is supposed to predict what the heart rate should be as the heart rate is found to correlate strongly with age irrespective of gender and physical activity status(Tanaka *et al.,* 2001). The results in this study revealed a great difference, statistically, between HRmax and Predicted HRmax. It is found to be much higher than what is really measured, which will raise concern in using predicted values to prescribe limit of heart rate for exercise. Even the 85% of the Predicted HRmax, is supposed to bring it down to a relatively safe level is still higher (significantly) than the measured values. The prediction error was found to be as high as 62 b/min and 32 b/min when reduced to 85% (Table 1). HRmax measurement is likely to be accurate to within ±2 b/min, if the subject truly attains maximal exertion. In some studies values as high as 11 b/min was accepted as safe deviation (Robert and Roberto, 2002); the result here is far above that range. But when we tried 70% Predicted HRmax1 we got a desirable result. The means was not statistically different from measured HRmax and the prediction error is within acceptable range. For Black Africans who have high prevalence of essential hypertension (Lindhorst *et al.,* 2007), and thus cardiovascular diseases, there is need to consider these variations.

All the subjects used were around the same age bracket, so comparison with age will not give good statistical picture, but when the data is arranged from the lowest HRmax to the highest, we noticed that the higher the HRmax, the closer it is to the predicted values (Fig. 2). This paints even a more gruesome picture, as the older patients that these formulae are applied to are unlikely to be among those with high HRmax. They have lower HRmax and needed more protection, but are being exposed to higher HRmax above what they should bear.

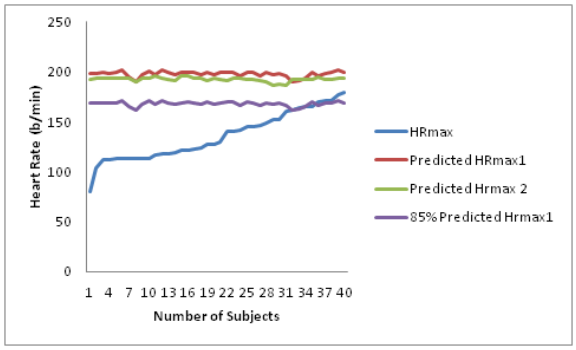

Fig. 2. Graphical presentation of measured HRmax compared to predicted HRmax arranging the data from lowest to the highest HRmax.

This, however, is not a surprise finding. Researchers found that there are three different HR response patterns in cycle ergometer exercise and running (Hofmann *et al.,* 1997) where, in about 16% of the young healthy male and female subjects, this response was not regular. Secondly in older subjects (Pokan *et al.*, 1998a) and thirdly most cardiac patients (Pokan *et al.,* 1998b) show a higher degree of nonregular HR performance curve (Hofmann *et al.*, 2001)

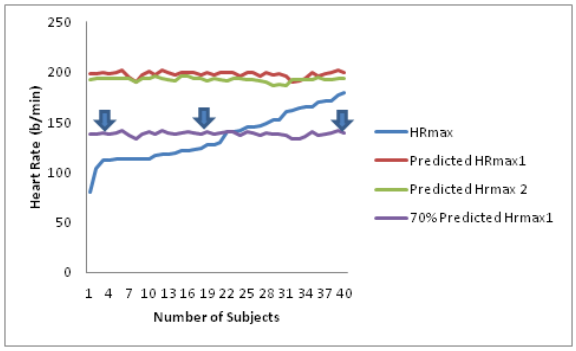

Fig. 3. When 70% Predicted HRmax (down arrows), it moves closer to the means of measured HRmax.

Limitations

This is a pilot study and thus the number of subjects is very few, we cannot categorically state that this is the average HRmax findings in Nigeria. It is also restricted to subjects less than 30 years so we cannot generalise it to the whole population.

Conclusion and Recommendations

There is need to be extremely cautious in using 220 – age and 208 – 0.7 x age as a formula in prescribing HRmax in elderly subjects. If it must be used, it should be lower than 85% of Predicted HRmax. This is a pilot study using a small population, there is need to expand this study and see what the bigger picture will look like, especially among wider age groups in black Africans.

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