The Accuracy of the Traditional Predicted Maximal Heart Rate and Related Equations

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Abstract

Background: Most aerobic exercise programs are based on a percentage of an individual's maximal heart or heart rate reserve, of which maximal heart rate is a component. Maximal heart rate is the highest heart rate achieved by an individual while working at their maximal intensity, usually to fatigue. Maximal heart rate is related to an individual's age but is not completely dependent upon it. But there are risks that come with exercising maximally and some people do not want to put forth the effort; hence, prediction equations were created. Numerous equations for the prediction of maximal heart rate have been created, some for general population and some for specific special populations.

Purpose: The aim of this study was to test the accuracy of the traditional maximal heart rate equation and other predictive equations when compared to the actual measurement of maximal heart rate during an exercise test.

Methods: Subjects ran a graded exercise test in an attempt to achieve maximal heart rate. The Bruce protocol, which increases in speed and elevation every three minutes, was the chosen assessment. Heart rate was recorded with an electrocardiography machine, Quinton Q-Stress, by use of topical skin electrodes. The subjects were also connected to a metabolic cart, Sensor-Medics, with a mouthpiece which will analyze respiration rate and gas composition of each breath. Prior to testing, height, weight, and body fat percentage estimation were taken by the researcher using a 3-site skinfold technique. The equations tested in this study were Traditional (220-age), Tanaka (208-age*0.7), Londeree (206.3-age*0.771), ACSM (206.9-age*0.67), Lester trained (205-age*0.41), Lester untrained (198-age*0.41). SPSS was used to analyze the data.

Results: 21 subjects were tested but 3 subjects' data had to be excluded due to failure to meet acceptance criteria. 18 subjects' data [M(14), age=23.2±3.0 years, height=180.4±9.2 cm, weight =77.1±10.6 kg, BMI=23.7±2.6, BF=12.0±4.7%; F(4), age=22.0±1.4 years, height=172.7±9.3 cm, weight=73.4±5.4 kg, BMI=24.7±2.5, BF=24.4±3.4%] was used in the analysis. SPSS was used to analyze correlations between measured maximal heart rate and each of the other predictive heart rates. Analysis produced the following values: Traditional (r^2=0.037), Tanaka (r^2=0.042), Londeree (r^2= 0.042), ACSM (r^2=0.041), Lester trained (r^2=0.043), Lester Untrained (r^2=0.043). A paired samples t-test was also used: Traditional (p=0.337), Tanaka (p=0.088), Londeree (p= 0.010), ACSM (p=0.060), Lester trained (p=0.199), Lester Untrained (p=0.235).

Discussion: The results of the correlations found that none of the equations accurately predicted an individual's maximal heart rate, whether male, female, trained, or untrained. However, t-test analysis found significant difference (p<0.05) between Londeree and Measured Max values. Further statistical analysis found that all predictive equations used were highly correlated (r>±0.90) with one another. With this information, it is suggested that although maximal heart rate prediction equations cannot accurately estimate maximal heart rate, any of the tested equations would suffice, with the exception of Londeree, the traditional equation being the simplest. With a small sample size, limited age band, and short timeframe this research was severely restricted.

Purpose

The aim of this study was to test the accuracy of the traditional maximal heart rate equation and other predictive equations when compared to the actual measurement of maximal heart rate during an exercise test.

Introduction

- Maximal heart rate is used when creating aerobic exercise programs
- Maximal heart rate is related to age, but not dependent upon it
- Achieving maximal heart rate is hard work and carries inherent risk
- Due to the difficulty of achieving maximal heart rate, prediction equations were created to estimate this value
- Numerous equations for the prediction of maximal heart rate have been created, some for the general population and some for specific special populations

Methods

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Participants

- 21 subjects (15 male, 6 female)
- Subjects were instructed to avoid caffeine intake
- 3-site skinfold was taken from each subject

Figure 6: Skinfold calipers

Experiment

- Subjects were connected with a 12-lead electrocardiography (ECG)
  - Right Arm (RA): right deltoid fossa, mid-clavicular line
  - Left Arm (LA): left deltoid fossa, mid-clavicular line
  - Right Leg (RL): right of umbilicus, mid-clavicular line
  - Left Leg (LL): Left of umbilicus, mid-clavicular line
  - V1: Right of the sternum, fourth intercostals space
  - V2: Left of the sternum, fourth intercostals space
  - V3: Midway between V2 and V4
  - V4: Fifth intercostals space, mid-clavicular line
  - V5: Anterior axillary line in-line with V4
  - V6: Mid-axillary line in-line with V5

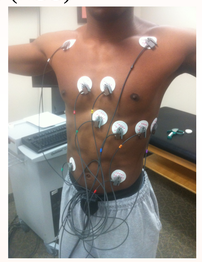

Figure 1: Electrode placement

- Resting heart rate was taken with the subject supine for five minutes
- Subjects were outfitted with a mouthpiece and headgear, which was connected to the SensorMedics metabolic cart to measure RQ (>1.15)
- The Bruce treadmill protocol was used for the maximal exercise test
  Increases speed and elevation every three minutes until subject terminates
- The predictive equations used in this study were:
  Traditional (220-age)
  Tanaka (208-age*0.7)
  Londeree (206.3-age*0.771)
  ACSM (206.9-age*0.67)
  Lester Trained (205-age*0.41)
  Lester Untrained (198-age*0.41)

Figure 2: Modified electrode placement

Figure 3: Bruce protocol

Figure 4: Electrodes and headgear

Figure 5: Skinfold measurement

Results

- 3 subjects' data had to be excluded to failure to meet acceptance criteria
- 18 subjects' data was used in the analysis
  Male(14), age=23.2±3.0 years, height=180.4±9.2 cm, weight =77.1±10.6 kg, BMI=23.7±2.6, BF=12.0±4.7%
  Female(4), age=22.0±1.4 years, height=172.7±9.3 cm, weight=73.4±5.4 kg, BMI=24.7±2.5, BF=24.4±3.4%
- SPSS analyzed correlations between measured values and each predicted equation (Table 1)
- SPSS performed paired samples t-tests between measured values and each predicted equation (Table 1)

Table 1: SPSS Statistical Analysis of Correlations and t-tests between Measured and Each Predicted Value

Predictive Equation	Correlation (r^2)	t-test (p)
Traditional (220-age)	0.037	0.337
Tanaka (208-age*0.7)	0.042	0.088
Londeree (206.3-age*0.771)	0.042	0.010*
ACSM (206.9-age*0.67)	0.041	0.060
Lester trained (205-age*0.41)	0.043	0.199
Lester untrained (198-age*0.41)	0.043	0.235

***= Significance (p<0.05)**

Conclusions

- Correlations found that none of the equations accurately predicted an individual's maximal heart rate, whether male, female, trained, or untrained.
- T-test analysis found significant difference (p<0.05) between Londeree and Measured Max values.
- Further statistical analysis found that all predictive equations used were highly correlated (r>±0.90) with one another.
- Maximal heart rate prediction equations cannot accurately estimate maximal heart rate, but any equation, with the exception of Londeree, will work.
- With a small sample size, limited age band, and short timeframe this research was severely restricted.
- ACSM values approached statistical significance; a larger and broader sample size could produce a more conclusive p-value.