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Age Predicted Heart Rate Max Equations in College-Aged Students

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AGE PREDICTED HEART RATE MAX EQUATIONS IN COLLEGE-AGED STUDENTS
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Introduction:

There have been many different opinions on how to calculate a predicted maximum heart rate in human beings. Currently, most people are told to use the equation 220-age to get their predicted max. But a recent study introduced a new equation that claims to be more accurate in determining a predicted heart rate max. This equation is 206.9-(.67. x age) (Gellish, et al., 2007). Age is said to be the primary factor influencing heart rate max, but it is commonly acknowledged that the equations are not accurate enough for the true heart rate max of an individual. It is crucial to get an accurate prediction for max heart rate for many reasons. One reason is for means of exercise prescription. Many clinicians use heart rate to tell how fit an individual is and how healthy they are. They can prescribe exercise based on heart rate and other medical conditions to help clients get better through exercise. Instead of running a client through a graded exercise test each time there is a problem, it would be much more effective to find an accurate equation to predict a max heart rate value and prescribe exercise using that value. The purpose of this experiment is to see which equation tends to predict the most accurate max heart after.

Literature Review:

Maximal heart rate is one of the most commonly used values in clinical medicine and physiology. Maximal heart rate and heart rate reserve are used for disease prevention, prescribing exercise intensities for healthy individuals, and rehabilitative settings (Tanaka et al., 2001). There is physiological evidence that with increasing age, the maximal pulse rate will decline. Because of this, many people have used the heart rate equations with age to predict max heart rate. The 220-age equation has proven to be quite inconsistent with estimates having standard deviation between 10bpm-12bpm (Gellish, et al., 2007). Furthermore, in 1971, when Fox, Naughton and Haskell came up with this 220-age equation, they did not fit the formula to an applicable population. Fox's subjects were all male and all under the age of 55, and the study was formulated for a rough estimate of how much heart rate declines over age. Other heart rate equations have since been formulated to make more accurate predictions to a true heart rate max. Meta-analytic and various heart rate responses across different populations have been explored to try and come up with the best equation possible (Tanaka et al., 2001). Many researchers think that age is not the only contributing factor that affects heart rate. Engels, Zhu, and Moffatt (1998), tested the effects of age, gender aerobic fitness and body mass index (BMI) as heart rate max determinants. He found that age made up about 43% of total variance of heart rate and 220-age under-estimated by about 6 bpm on average. Gender, aerobic fitness and BMI did not have any effect on predicting the max heart rate.

Most researchers use a maximal graded exercise test to get a subject to their max heart rate to evaluate each equation. In order for a VO2 max to be considered valid, the participant must have an RER of greater than 1.15. RER is the respiratory exchange ratio, or the amount of oxygen consumed over how much carbon dioxide is let off. The next criterion that must be met is the rate of perceived exertion (RPE). RPE is the intensity at which the patient himself thinks they are working. It is a ranking from 6-20; six meaning they feel great and 20 meaning they cannot perform the activity any longer. The researcher is told to ask the patient after each minute how they feel on this scale. In order for it to be considered a true VO2 max test, the subject must reach an RPE of at least 18. Another criterion for it to be a true VO2 max test is the subject has to reach a VO2 plateau. Lastly, the subject's heart rate must be within six beats per minute within the predicted heart rate max, or reach a plateau (Kaminsky 2005). If the subject meets three out of the four above criteria to be considered a true physiological max test.

All of our subjects decided to perform a maximal treadmill test. Before the test can begin, subjects predicted max heart needs to be calculated, in order to decide if they met the criteria. In order to find predicted heart rate max, you must do 220 minus the subject's age. The test can last between 10-12 minutes for a fit person. They are set on a speed based on heart rate and throughout the test the incline, or grade, is the only thing that increases after each two minute stage. This is the criteria for the Modified Costill Treadmill test (Fairburn 1994).

There is also a maximal test for VO2 and that uses the cycle ergometer. This type of test is mostly advanced cyclist would choose to perform a cycle ergometer test, rather than a treadmill, to get the most accurate results of VO2. Furthermore, cycle ergometer is used for the elderly or people with previous injuries or health implications. (Anderson & Warren 1995). Many older people have arthritis or health implications that do not allow them to work till full exhaustion. Due to injuries and health risks, researchers established a sub maximal test for the subjects that are not able to perform a maximal test. Sub-maximal testing is done on a cycle ergometer, which is a stationary bike. During a max test on a bike, researchers measure heart rate in each stage on the bike as the workload increases. Workload is measured in kilograms and increases .5 kg each stage as the speed remains constant. The test is conducted the same as the Bruce treadmill test using the same criteria of RER, RPE, heart rate and oxygen consumption, just performed on a bike rather than a treadmill. A sub-maximal test is carried out a little differently than the max test. According to Latin et al. (1993), once the subject goes through two three minute stages with their heart rate above 110 beats per min, the test is over. The research team would then measure the heart rate and workload at the end of each stage and plug it in to an equation to predict the true VO2 max. The subject will normally work to about 85% of actually

VO2 max. Many people find this test much easier, and if the subject has many risk factors, and is elder, this test is more effective and secure.

Some of the VO2 studies that have already been conducted support the theory that an average young untrained male will have a VO2 max of 3.5 liters/min and/or 45 ml/kg/min. There are two separate numbers because the first one is just absolute VO2 and the second number is relative and uses the person's body weight. The numbers indicate the maximum amount of oxygen consumed in the test. The average young untrained female will have a VO2 max of 2.0 L/min and/or 38 ml/kg/min (Malek et al., 2004). These numbers can improve with training and decrease with age. In very physically fit world-class athletes, the VO2 max can range from 70 ml/kg/min to 85 ml/kg/min (Malek et al., 2009). This same study established reasons as to why VO2 maxes vary. The main reasons are age, gender, fitness and training, altitude and ventilator muscles.

Before VO2, heart rate has been used for many means of predicting a person's fitness. In the exercise world, heart rate is the main component to an exercise session and serves as a baseline for work rate. Many exercise specialists tell patients to work within 70-85% of age-predicted heart rate max. It is the easiest and most effective way to measure exercise intensity without having to strap on something to measure one's oxygen consumption. In the past, everyone predicted max heart rate as 220 minus their age. But in a more recent study, people have suggested that to be not as accurate as current equations being developed.

This study is based off two previous studies. The first was a study done by Gellish, Goslin, Olsen, McDonald, Russi and Moudgil in 2007. This research team claimed they found a new heart rate equation that was much more accurate and applicable that the 220-age that is widely known today. Their equation is 206.9-(.67 x age). Although the study showed that the equation was in fact more accurate, the criteria in which they based their study on was flawed. Most of the subjects that were evaluated were predominantly non-hispanic, white males who were above the age of 35 that exhibited an above-average physical condition. Furthermore, many of the subjects did not reach a full maximal test. The subjects stopped before all the criteria was met for a "true" VO2 max test such as RER, RPE, heart rate and oxygen consumption. Because of this, many researchers question the validity of the experiment. This is what this study is trying to investigate. Gaspari in 2009 found 38 previous VO2 max tests that were performed recently that matched up with the criteria. They then used the max heart rate of each of those subject's test to look at both equations, 220- age and 206.9-(.67 X age), to see which was most accurate. What they found was that out of 38 subjects was that Gellish's equation over-predicts whereas the 220-age equation under predicts. The purpose of this study is to compare Gellish's and Gaspari's research, on heart rate, and apply it to college age students. We will be discovering whether Gellish's equation is more accurate than 220-age by putting 8 college aged students through a VO2 maximal test.

Methods:

We acquired 8 subjects between the ages of 20-40 and conducted a VO2 max test by either cycle ergometer or treadmill. Each subject had to be healthy and have no myocardial diseases and limited risk factors. During pre testing, we took their heart rate, weight and height. Each subject was given instructions prior to beginning any maximal test. We then let the subject pick whether they wanted to do a treadmill VO2 max test or a cycle one. Once a test was chosen we put a heart rate monitor around them and made sure it worked properly. If a treadmill is selected, we started them off by having them perform a warm up run without any incline to set a baseline by getting the subject to about 80-85% of heart rate max. The subjects reached the 85% heart rate max and that speed was set. The subject was monitored at the end of every minute where their blood pressure, RER, RPE and heart rate is recorded. After each two minute interval, we increased the incline by 2% grade, as the speed stays the same, to get the subject closer to their maximal oxygen consumption. The subject will run as long as they can withstand. The test is designed to only last 10-12 minutes. If the subject picks the cycle ergometer test they will go through the same criteria just increase resistance every two minutes instead of grade. We gathered all 8 subjects heart rate max, we then compared each max heart rate to the equations to see which heart rate equation was the most accurate.

Results:

Descriptive characteristics for the sample of all of our subjects are displayed in table 3 on the attached sheet. The sample represented very fit individuals with an average VO2 max of 50.6 ml/kg/min. According to the ACSM (2009), for their age, they are in the 85th percentile for maximal aerobic power. Average age of subjects was 21 years old. The 220-age equations under predicted the true max heart rate value by 1.8 bpm and Gellish's equation under predicted by 7.8 bpm. Figure one displays the results of this. 5 out of the 8 subjects reached a true physiological max. Of this population that reached a physiological max, the 220-age equation differed from the actual by 4 bpm and Gellish's equation differed by 10 bpm. This is expressed in figure 2.

DESCRIPTIVE CHARACTERISTICS FOR ALL SUBJECTS (PERCIEVED MAX)

Characteristics	Subjects	Mean
Age	8	21.13

pounds	8	154.0875
VO2 max (ml/kg/min)	8	50.58
HR max	8	200.75
Difference 220-age	8	-1.8750
Difference Gellish equation	8	-7.8750

DESCRIPTIVE CHARACTERISTICS FOR SUBJECTS THAT REACHED PHYSIOLOGICAL MAX:

Characteristics	Subjects	Mean
age	5	20.8
pounds	5	140.82
VO2 max (ml/kg/min)	5	52.3
HRmax	5	203.2
Difference 220-age	5	-4
Difference Gellish equation	5	-10

Paired t-test statistics for the prediction model that included all of our subjects indicated the difference between 220-age value versus the actual value is .525. The difference between Gellish's equation value and the actual value is .026 ($P < .05$). This is statistically different therefore Gellish's equation is significantly different than the actual true heart rate max found. Paired t-statistics for the prediction model that included only the subjects that reached a true physiological max indicated the difference between 220-age value versus the actual value is .387. The difference between Gellish's equation value and the actual value is .072. Neither equation predicted a value that was significantly different than the actual value for subjects that reached a true physiological max.

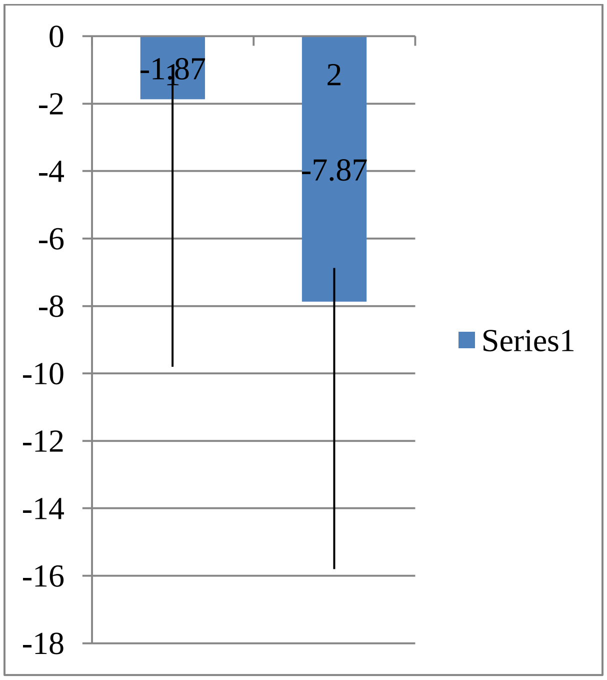

Figure 1:Bar1=220-age;Bar 2= Gellish Equation

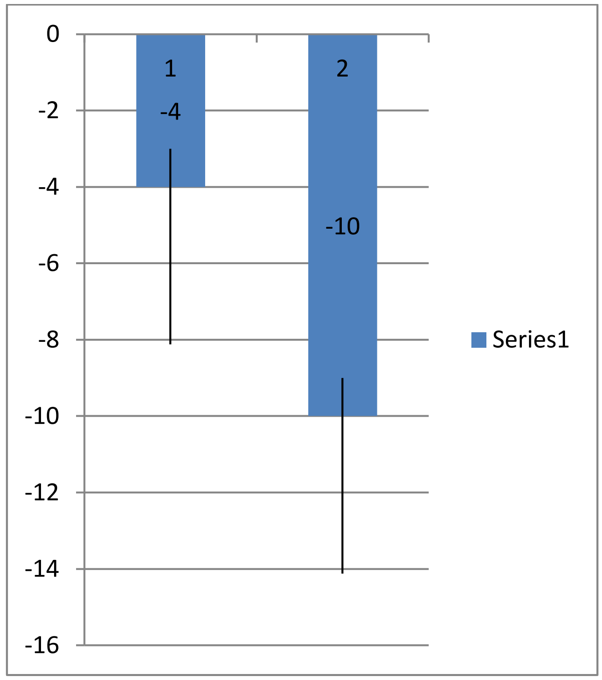

Figure 1: 220-age;Bar 2= Gellish Equation

Discussion:

My subjects were a group of very fit individuals. Their mean VO2 max was around 50 ml/kg/min, which is high for their age, compared to an average of 35 ml/kg/min. According to the ACSM, there VO2 max values, according to their age, puts them in the 85th percentile which groups them in excellent shape. Their average age was 21 years old. Furthermore, this study found that Gellish's equation under predicts the true heart rate max value by about 8 bpm, and the 220-age equation only under predicts by 2 bpm. According to the paired-t statistics, Gellish's equation develops a significantly different value than the true max value of all 8 subjects that participated in study. When looking at just the subjects that reach a true physiological max, both equations do not produce a significantly different value than the true max heart rate.

Gellish's study is refuted based on my results. For college- aged students, that are fit, Gellish's equation predicts a value that is significantly more inaccurate than the 220-age equation. Even when compared to the subjects that reached a true physiological max, Gellish's study is still refuted. His equation was not any more accurate than the 220-age equation based on my research whether the subjects went to a true max or not. My study more correlates with Gaspari's study in the fact that Gellish's study is not a valid in saying that his equation is more accurate than 220-age. Gaspari did find that 220-age over predicted whereas Gellish's equation under predicted. In college-aged students, both equations tended to under predict for all 8 subjects. Therefore my study came to the conclusion that younger subjects should use the 220-age prediction equations because it is more accurate overall than 206.9-(.67 x age).

Determining an accurate max heart rate is very beneficial for many reasons. The first is to determine a safe heart rate to work-zone when prescribing exercise for medicine. Many new studies have shown that by exercising one can reduce their number of risk factors and certain illnesses and diseases. A risk factor is anything that could be detrimental to a person's health or well being. Risk factors include; smoking, sedentary from not exercising, high blood pressure (over 140-90), family history of cardiac disease, diabetes, high cholesterol and body mass index above normal (Dustin 2011). If these subjects have more than two risk factors or a chronic illness, a doctor should be present during the study in case of any type of emergency. Once the subject is cleared, they then can begin the Bruce protocol, on the treadmill, to find a VO2 max. If doctors had an accurate maximum heart rate value to utilize they could better prescribe protocols to clients to limit diseases and illnesses that can be treatable through safe exercise.

In addition to above, to find an accurate heart rate predictive equation can be the difference between life and death, for patients with cardiac disease. Once a patient with a cardiac disease is admitted into the hospital, before beginning any physical activity, a baseline assessment should be conducted by healthcare provider (American Association of Cardiovascular and Pulmonary Rehabilitation, 2004).Once the patient is released they are told they are able to work out at an intensity of about 40-80% heart rate reserve. In order to find this, they need an accurate predicted heart rate max. Furthermore, many cardiac patients are on certain medication that does affect heart rate. So it is even more crucial to have the most accurate prediction equation with cardiac patients because there are so many other factors that can change max heart rate as it is (Leon et al., 2005). Not only do the cardiac patients need the most accurate measurement possible, so do patients with hypertension, type 1 diabetes, overweight, high cholesterol and people with disabilities. When performing a maximal test on these populations, it is very crucial to monitor heart rate closely in case of an emergency. Most of these patients would perform a sub-maximal test to limit the risk of a medical emergency (Center for Disease Control and Prevention, 2001). A sub-maximal test is based solely on max heart rate prediction equations so one must know the right equation to use.

Also, while conducting the VO2 max test, it took longer than the normal 10-12 minutes for people to reach their maximal oxygen consumption. This possibly has to do with the under-predicting of max heart rate from the beginning of the test. We used the 220-age equation to predict heart rate max before we began the test for each subject. During the warm up, we determined the speed at which the subject should run at throughout the test by making them run at a speed that gets their heart rate to about 85% of their max heart rate. Because this equation was under predicted, the running speed was a bit too slow for some fit individuals and the test lasted longer than 15 minutes. If we have a more accurate heart rate equation, we can more effectively run the test and be more time efficient to get a more precise number for oxygen consumption.

Another study (Gibbons, Balady, Beasley 1997) noticed that there are clinical implications having differences in heart rate max. Premature endings of maximal exercise tests are one implication. Another reason is the physical activity intervention programs; an aerobic exercise plan that does not attain requirements for a true max will result in a heart rate below its intended target. Thirdly, in fitness and health settings, many maximal aerobic capacity tests are done through sub-maximal tests (YMCA protocol) and rely heavily on the prediction of max heart rate. To have an accurate maximal heart rate would ensure better predictions on a submaximal level (Tanaka et al 2001).

The results, in this study, are consistent with the findings of many other published heart rate max prediction studies (Gellish et at. 2007). Furthermore, many cross-sectional studies have shown that body weight and height show no significant effects on maximal heart rate. Heart rate is independent from body mass index (BMI). Our research found that the more fit the individual was, the more likely they pushed themselves to a true physiological max. This can be seen in the difference between tables 1 and 2 under VO2 max. The 5 subjects that pushed themselves to a true physiological max, had a higher mean max VO2 than those that did not. Furthermore, it altered how well the equations predict their true heart rate max value. Dehn et al. in 1973 concluded that people with higher levels of physical fitness might just push themselves that extra bit because they are more comfortable in putting forth strenuous effort.

Some further research should be done to find a more accurate heart rate equation that does not over predict or under predict. Furthermore, there should be tests done to see if there should be two different equations for older and younger adults considering age is found to be the only factor that affects heart rate. Also I would like to see if there are any other different ways to measure VO2 max based on their specific sport like the skiing study (Klusiewicz et al., 2011). The closer the person can get to attaining their VO2 max, the better we value we will get for their max heart rate. If we have more options besides just running on a treadmill and biking, like a ski ergometer or swimming test, the subjects would last longer and give us more of an accurate measurement.

The purpose of this research was to evaluate the accuracy of 220-age prediction equations and 206.9-(.67 X age) prediction equation in college- aged students that are fit individuals. The results indicated that Gellish's equation was statistically inaccurate across the whole population. However, those subjects that reached a true physiological max, neither equation was any more accurate than the other based on the stats. Therefore, 220-age is a sufficient enough equation to be used for college aged students and should not be replaced by Gellish's equation. Furthermore, Gaspari argued that 220-age over predicted and Gellish's equation under predicted. But for college students, both equations under predicted the true heart rate max.

This study had some limitations. One limitation was time. If I had more time our research would have more subjects and be able to get better statistics across a larger population. It was also hard to get people to reach a true physiological max to get an accurate heart rate max value. Furthermore it was difficult to gather college students that wanted to do a VO2 max test because the test is physically demanding and many students do not have enough time in their weekly schedule to prepare themselves for the test. In the future, I would like to gather more college students and see if I get the same results as this research just gathered. I also would like to see if there is a difference between males and females and heart rate prediction. Also, if how fit a person is changes which equations would be more accurate based on heart rate.

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