National Academy of Sports Medicine

Comparing Heart Rate Formulas

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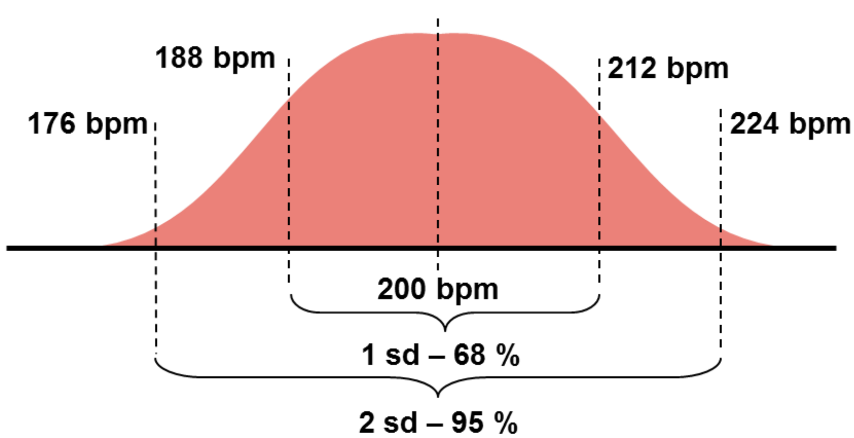
Introduction

The age-predicted formula for maximal heart rate (i.e., 220 – Age) developed by Fox and Haskell continues to be used as a basis for prescribing exercise programs and as a criterion for achieving maximal exertion (1,2). Despite widespread use as an integral part of our cardio culture for the past 40 years, the validity of the age-predicted formula has been investigated and demonstrated to show significant error, with a standard deviation of approximately 10-12 beats (3-5). This implies that — as illustrated in Figure 1 and using 12 beats as our example — the true MHR for one standard deviation of a population (~ 68% of the group), would really fall 12 beats on either side of the calculated number. For two standard deviations (95% of a population), the error doubles to 24 beats as illustrated.

The formula introduces a significant error in over- and under-training intensities for individuals. Furthermore, this equation was never established with a population sample that included a sufficient number of younger and older adults (1,2). Consequently, the 220 – Age formula does not validate MHR across the entire adult age range in healthy humans, especially when an individual is past 40 years of age, where the formula underestimates true MHR (4,5). The formula may also overestimate MHR in younger adults (6). For example, a 60-year-old individual may easily exceed a calculated MHR of 160 beats per minute (bpm) whereas a 20-year-old person may never reach a MHR of 200 bpm.

Figure 1 Standard Deviation of the Fox and Haskell MHR Equation



Another consideration with percentage MHR formulas is that they fail to accommodate for any discrepancies in resting heart rate (RHR). For example, to reach 150 bpm, an individual with a RHR of 60 bpm will need to train harder than an individual with a RHR of 80 bpm. Furthermore, not all individuals show a consistent one-beat drop in MHR with age. Although age explains about 80% of the individual variance in MHR, conditioning levels and other factors also exert an influence (5). While a decline in MHR does appear with aging due to reduced sensitivity in the heart's sinoatrial (SA) node, the truth is that MHR can remain somewhat constant for 20 years in conditioned individuals (4,5).

In 2010, ACSM recognized that more accurate mathematical formulas for MHR exist, and recommended using these formulas to replace the Fox and Haskell 220 – Age calculation (4-7). Tanaka and colleagues demonstrated that MHR decline did not differ between men and women, but did note differences between sedentary, active, and trained individuals. Thus, they created different MHR formulas, each with smaller standard deviations than the 220 – Age formula (5):

- Sedentary individuals should be measured using 211 – 0.8 x age.
- Active individuals are best measured using 207 – 0.7 x age.
- Endurance-trained individuals are best measured using 206 – 0.7 x age.

Since applying multiple MHR formulas can create the potential for confusion, their final regression equation for calculating MHR when all the subjects were combined was 208 – 0.7 x age, which demonstrates a standard deviation of approximately 7.4 beats per minute (5).

ACSM recognizes the Gellish et al formula as the most accurate, as it has the smallest standard deviation of approximately 6.6 beats per minute (6,7). Because this formula requires a more complex calculation (206.9 – 0.67 x age), practitioners should decide whether ease of use or accuracy is more important.

Here is a comparison of MHR estimates for a 20-year-old individual, calculated using the various formulas:

- Fox and Haskell: (220 – age) = 220 – 20 = 200 bpm

- Tanaka, et al: (208 – 0.7 x age) = 208 – (0.7 x 20) = 194 bpm
- Gellish, et al: (206.9 – 0.67 x age) = 206.9 – (0.67 x 20) = 193.5 bpm

Do The Math

Using the three mathematical formulas provided below, calculate Mark and Mindy's target heart rates (THR) at 70% MHR if Mark is 22 years old and Mindy is 57 years old.

- Fox and Haskell Formula: 220 – Age
- Tanaka, et al Formula: 208 – (0.7 x Age)
- Gellish, et al Formula: 206.9 – (0.67 x Age)

Answers:

F&H: MHR = 198 bpm, THR = 139 bpm (Mark); MHR = 163 bpm, THR = 114 bpm (Mindy)

T: MHR = 193 bpm, THR = 135 bpm (Mark); MHR = 168 bpm, THR = 118 bpm (Mindy)

G: MHR = 192 bpm, THR = 135 bpm (Mark); MHR = 169 bpm, THR = 118 bpm (Mindy)

Summary

Given this information, health and fitness professionals now have many options for estimating a client's maximal heart rate. Certain mathematical equations have shown to be more reliable (less standard deviation) from others. In light of this new research, health and fitness professional now have more tools to help them design cardiorespiratory programs. The MHR mathematical formula a health and fitness professional choses should be based on the professional's (1) comfort level performing arithmetic (2) accuracy of MHR equation (3) and time constraints. Since all MHR formulas have some degree error, continual adjustments to a client's cardiorespiratory program may be necessary Therefore, health and fitness professionals should continually monitor their client's adaptations and progress for all exercise, including cardiorespiratory programming and make adjustments accordingly.

References

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