

Monitoring Your Aquatic Heart Rate: Increasing Accuracy with the Kruel Aquatic Adaptation

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During the past eight years, the aquatic fitness industry has seen a shift in exercise formats as well as participant population. There is a worldwide trend toward more fit and athletic aquatic participants in addition to a general surge in aquatic personal training, indicating the need for a more individualized and precise measurement of intensity in aquatic exercise.

In the 2010 Guidelines for Exercise Testing and Prescription, the American College of Sports Medicine recommends the use of the heart rate reserve (HRR) formula for calculating and monitoring intensity for cardiorespiratory exercise. "HRR and VO₂R reflect the rate of energy expenditure during the physical activity more accurately than the other exercise intensity prescription methods. For this reason, these are the preferred methods for prescribing exercise intensity whenever possible." (ACSM 2010, page 156) It is further recommended that perceived exertion be used in combination with heart rate (HR) measurement to monitor intensity. This is particularly valuable in the aquatic setting due to the heart rate bradycardia affect experienced with water immersion. In the 2010 ACSM Guidelines, Karvonen's formula (HRR) is still considered most accurate, along with a revision to the maximal HR (220 – age) formula. "The practitioner must decide if ease of use or accuracy is more important when deciding which age-predicted maximal heart rate equation to use." (ACSM 2010, page 155)

Fitness professionals interested in determining heart rates have utilized the standard maximal heart rate (HR_{MAX}) equation, **220 – Age**, for many years. The resulting number was multiplied by the target heart rate percentage to determine the number of beats per minute a person should reach while exercising. Applying the standard peak heart rate equation (% HR_{MAX}), charts with ranges for different age groups have been developed. These charts are used at many fitness facilities because they are easy to use, quick reference points and work well in the group exercise setting where ease of use is more important than individualized accuracy needed with personal training. An intensity range of 57-74% is recommended for deconditioned individuals, and a range of 74-94% is recommended for conditioned individuals with the peak HR formula. (ACSM 2010)

The Karvonen method became popular as a closer approximation for an individual's heart rate and has been used for calculating heart rate range (typically 30-45% for deconditioned individuals and 55-85% for conditioned individuals) for traditional exercise out of the water. (ACSM 2010) The Karvonen method expands on the peak heart rate formula by taking resting heart rate (RHR) into consideration. Resting heart rate is subtracted from the age deduction and the result is multiplied by the desired intensity level; resting heart rate is then added to the resulting number.

Standard Age-Predicted Maximal HR Formula:

$$220 - \text{Age} = \text{Age-Predicted Maximal HR}$$

Gellish, et al. 2007 Revised Age-Predicted Maximal HR Formula: (ACSM 2010)

$$206.9 - (.67 \times \text{Age}) = \text{Age-Predicted Maximal HR}$$

The Karvonen Formula can be used with any maximum heart rate equation. Below are land-based exercise examples with the traditional age-predicted equation and the Gellish equation.

Karvonen Formula with Traditional Age-Predicted Maximal HR:

$$(220 - \text{age} - \text{RHR}) \times \text{Percentage} + \text{RHR} = \text{Desired Intensity}$$

Karvonen Formula with Gellish Formula for Age-Predicted Maximal HR:

$$[206.9 - (.67 \times \text{Age}) - \text{RHR}] \times \text{Percentage} + \text{RHR} = \text{Desired Intensity}$$

The aquatic fitness community has long been aware that water affects an individual's heart rate; a person's heart rate lowers in the water. For years, the aquatic fitness community has been working to determine the best deduction to use when calculating a target heart rate for water exercise versus land exercise. McArdle and colleagues (1971) suggested a deduction of 13% taken at the end of Karvonen's or the peak heart rate equation. In the early days of the Aquatic Exercise Association, a 17 beat per minute deduction (Sova 1991) was recommended and subtracted at the end of the Karvonen's method or the peak heart rate equation. Use of a standard deduction can over or under estimate both maximum heart rate and calculated percentages of maximum for a given individual due to a number of factors, including fitness level.

Recent research in Brazil and in the United States indicates that the use of a standard percent or a standard number of beats per minute may not be as accurate to use as a deduction in determining one's individual aquatic heart rate calculation. Dr. Luiz Fernando Martins Krueel's research group in Brazil conducted several studies comparing physiological responses for land and water that included hundreds of people (Krueel, 1994; Coertjens et al., 2000; Krueel et al., 2002; Alberton et al., 2003). Many of these studies compared heart rates taken at two positions out of the water and at two depths in the water. They concluded that two heart rate measurements are needed to determine an individual's **aquatic deduction**.

Protocol for Determining Aquatic Heart Rate Deduction

Individual has a one-minute heart rate taken after standing out of the pool for three minutes and a one-minute heart rate taken after standing in the water for three minutes at armpit depth. *(Remember that environmental conditions, medication, caffeine and excessive movement when entering the pool can affect heart rate response. Care should be taken to minimize these factors.)* The **Aquatic Heart Rate Deduction** is determined by subtracting the heart rate standing in the water from the heart rate standing out of the water.

The following examples show how to implement the Krueel Aquatic Heart Rate Deduction with various formulas.

- Krueel Aquatic HR Deduction: Peak HR Formula

By applying the Krueel Aquatic HR Deduction to the traditional peak heart rate equation ($\% HR_{MAX}$), the target aquatic heart rate for a specific percent exertion is calculated:

$(220 - \text{Age} - \text{Aquatic Deduction}) \times \text{Desired Intensity Percentage}$

A range within 74-94% is typically prescribed for conditioned individuals.

Using the standard peak heart rate formula, a 50-year-old woman who wants to exercise in the water at 82% of her maximum heart rate and who has found her aquatic deduction to be 8, would calculate in the following manner.

$$(220 - 50 (\text{Age}) - 8 (\text{Aquatic Deduction})) \times .82 (\text{Intensity}) = 133$$

- Krueel Aquatic HR Deduction: Karvonen Formula

Depending on the client or situation, you might prefer to include resting heart rate when making the calculations. Applying the Krueel Aquatic HR Deduction to the HR Reserve formula or the Karvonen Formula, the target aquatic heart rate for an individual is calculated:

$[(220 - \text{Age} - \text{RHR} - \text{Aquatic Deduction}) \times \text{Desired Intensity Percentage}] + \text{RHR}$

A range within 55-85% is typically prescribed for conditioned individuals.

Using the Karvonen method, a 50-year-old woman with a resting heart rate of 70, who wants to exercise in the water at 65% of her heart rate reserve and who has found her aquatic deduction to be 8, would calculate in the following manner.

$$[(220 - 50 (\text{Age}) - 70 (\text{Resting Heart Rate}) - 8 (\text{Aquatic Deduction})) \times .65 (\text{Intensity})] + 70 (\text{RHR}) = 130$$

- Krueel Aquatic HR Deduction: Gellish Formula for Age-Predicted HR

Using the Gellish formula for the individual's maximum HR, the calculations above for the 50-year-old woman with a resting heart rate of 70 and an aquatic deduction of 8 would be:

$$\text{Peak HR Formula} = [206.9 - (0.67 \times 50) - 8] \times 0.82 = 136$$

$$\text{Karvonen Formula} = [206.9 - (0.67 \times 50) - 70 - 8] \times 0.65 + 70 = 132$$

A small study conducted by instructors and trainers for the Aquatic Exercise Association in 2008 used Krueel's protocol and examined whether there were any systematic differences by age group or gender for the aquatic deduction. No age or gender differences were found in the sample of 71 people of varied ages.

If you are working with a client where you need to carefully monitor and manipulate intensity, using Krueel's individualized aquatic heart rate deduction can help guide your programming. As the aquatic fitness industry continues to evolve, more accurate information brings us better guidelines based on research.

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