Understanding Aquatic Heart Rate Deductions

By June M. Chewning, MA

As a practiced aquatic fitness professional, you understand that heart rates are lower in the water than comparable exercise on land. You know that there are 6 factors that affect and lower the aquatic heart rate response at rest and when exercising: temperature, compression, gravity, partial pressure, the dive reflex, and reduced body mass. You understand that you are supposed to use an aquatic deduction for your clients when measuring their heart rate in the water. But how do you sort through all of the confusing research information and the math to determine a safe and effective target heart rate or target heart rate range for exercise in the water?

If you are confused about aquatic heart rates, you are not alone! As more special populations and advanced athletes enter the water to exercise, it is as important as ever to understand how to prescribe a safe intensity for aquatic exercise for your clients. If your client comes to you from cardiac rehabilitation and their physician prescribes a maximum heart rate they are not to exceed, how do you translate that to a safe maximum heart rate for exercise in the water?

As a fitness professional, it is important for you to understand how to set parameters, monitor, and interpret your clients' intensity. Understanding and properly applying intensity also plays a role in reducing your liability risk and increasing your success with clients. It is important for many reasons including:

- Intensity plays a major role in the safety and effectiveness of a workout.
- Proper manipulation of intensity plays a major role in progression and success in reaching personal fitness goals.
- Proper intensity allows you to help medically referred clients comply with their health care provider's recommendations for safe exercise.
- Proper application of intensity is critical when working with more fit clients.

There are two parts to finding the appropriate target heart rate or target heart rate range for your client.

- First, you must do the math and **determine the numbers** you need for your client. You may be trying to determine a heart rate range (minimum and maximum) for your client, or simply a minimum heart rate you want them to remain above, a maximum number you want them to stay below, or a target number that you want them to achieve and maintain.
- Second, you must understand how to **measure and interpret** the client's heart rate response in the water.

Determine the Numbers

This is the hard part for many fitness professionals. It requires a basic understanding of math and an understanding of the choices you have for the calculations. Determining the numbers to use to monitor intensity requires three parts, and you have to make decisions for all three parts.

- First, you have to decide which formula you will use to **estimate your client's maximal heart rate**. There are two formulas you can use.
- Second, you must determine which formula you will use to **calculate the target heart rate number**. There are three options.
- And third, you must determine which **aquatic deduction** you want to use. There are three options here as well, but only 2 are now recommended.

Part 1: Calculate an Estimated Maximal Heart Rate

To get a true maximal heart rate, you would need to put your client on a treadmill or bike with an EKG and run them until exhaustion. Since this is not an option for most of your clients, you can <u>estimate</u> their maximal heart rate by using one of two formulas.

- You can calculate your client's maximal heart rate (HRmax) by simply using the equation 220-age. If your client is 50 years old, you would take 220 – 50 = 170. This gives you a simple estimation of HRmax to use in the second part of the calculation. This equation has been used historically, but it can actually overestimate max HR for men and women younger than 40 and can underestimate if you are older than 40. It is acceptable to use when accuracy is not critical. (1)
- Recently a more accurate equation was presented by Gellish et al in 2007 and is recommended when accuracy is important; for example when working with a cardiac patient, a personal training client, or an athlete. (1) This equation is a little more complicated. The equation is HRmax = 206.9 – (0.67 x age). So for a 50 year old you would calculate as follows. (Remember the basic math rule: calculate what is in the parentheses first.)

$$
\begin{aligned}
HRmax &= 206.9 - (0.67 \times age) \\
HRmax &= 206.9 - (0.67 \times 50) \\
HRmax &= 206.9 - (33.5) \\
HRmax &= 173.4
\end{aligned}
$$

So you have the option of using the simple equation of 220-age (HRmax = 170) or the more complicated equation of 206.9 – (0.67 x age) (HRmax = 173.4). You would use either of these numbers in the second or next part of the calculation.

Part 2: Use a Formula to Calculate Target Heart Rate

On land, there are two formulas you can use to determine a target heart rate:

- **Standard Maximal HR Equation**
  HRmax (calculated above) x Desired Intensity % = Target Intensity <u>without</u> the aquatic deduction
  This equation is simple to use, does not require additional information from the client, and is great for group fitness. If you want a target heart rate range, you simply do the equation twice; once for the minimum number and once for the maximum number, changing the desired percentage number as needed. You can purchase target heart rate charts that use this equation and have the numbers calculated for each age and put into a table. ACSM recommends the following intensity ranges for various levels of conditioning; 57-67% for Poor, 64-74% for Poor-fair, 74-84% Fair-average, 80-91% Average-good, 84-94% for Good-excellent. (1)
- **Heart Rate Reserve (HRres) / Karvonen Equation**
  This equation is a little more complex, but takes into account the individual's resting heart rate and is believed to reflect energy expenditure a little more accurately than other methods. (1) (Remember the basic math rule: Calculate the ( ) parentheses first and then the [ ] parentheses)
  [(HRmax (calculated above) – HRrest) x Desired Intensity %] + HRrest = Target Intensity <u>without</u> the aquatic deduction
  For this equation, you need to know your client's Resting Heart Rate (HRrest). A true resting number can be determined by averaging a 30 or 60 second pulse taken for three mornings after waking but before rising. Because this can sometimes be difficult to get a client to do, a sitting heart rate (determined after 5-10 minutes sitting at rest) is often used. A sitting heart rate is often affected by stress, medication, caffeine, and/or environment. Whenever possible, get your client to find a true resting heart rate to use in the heart rate reserve equation. In addition, resting heart rate can be a valuable number to know and can add to knowledge of overall health status in a metabolic profile for your client. ACSM recommends the following intensity ranges for various levels of conditioning; 30-45% for Poor, 40-55% for Poor-fair, 55-70% Fair-average, 65-80% Average-good, 70-85% for Good-excellent. (1)

You can use these two formulas to determine a target <u>heart rate</u> or <u>heart rate range</u> for aquatic exercise as well. For a target heart rate, you perform the calculation one time resulting in a target number. For a target heart rate range, you perform the calculation two times: once to determine the low end, and once to determine the high end of the range. **After you have the target heart rate/range using one of these two equations, you must then apply an aquatic HR deduction as indicated in Part 3**.

Part 3: Aquatic Deduction

In the past, a deduction of 17 BPM was typically used as an acceptable heart rate deduction for water exercise. Since using a straight BPM deduction can skew the numbers at the upper and especially the lower end of the target heart rate range, a percentage deduction is now more commonly recommended. A heart rate deduction of 13% was recommended by McArdle and colleagues in 1971 and is still widely accepted as a valid deduction.(3) Although this number is still generically used, research indicates that aquatic heart rates may be individual and may be even lower than this percentage for deep water exercise.

Option 1:
To calculate an aquatic HR using the accepted 13% deduction:
If the calculated HR was 130: 130 x .87 = 113 (aquatic target heart rate with 13% deduction)
[Math pointer: 100% (1.0) - 13% (.13) = 87% (.87). So you multiply the target heart rate by .87 to have the 13% deduction.]

Option 2:
Recently, research in Brazil investigated the concept of an individualized aquatic heart rate deduction. To read more about on how this concept was developed, go to the AEA Website and look in the "Research" section for the "Monitoring Your Aquatic Heart Rate: Increasing Accuracy with the Kruel Aquatic Adaptation" article. (4)
To use the new Kruel Aquatic Individual HR Deduction, you must first find your client's individualized heart rate deduction. Please see the protocol for performing this simple assessment.

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.

After you have used this protocol to find your client's individual aquatic deduction, then simply plug the number into the Heart rate Reserve/ Karvonen Equation as indicated. **So you would combine step 2 and 3 with this one equation that calculates the target heart rate including the individual heart rate deduction in the HRres/ Karvonen Equation.**

[(HRmax – RHR – Aquatic Deduction) x Desired Intensity Percentage] + RHR = Target Intensity with the aquatic deduction.
(Sample math is provided in the box below)

Measure and Interpret the Heart Rate

Now that you have found your numbers, the math is over and you can put down your calculator and put your client in the water. Once your client is in the water, you simply measure their heart rate, compare it to the numbers you calculated, and try to keep them at the intensity you want. Many aquatic professionals get confused and think that the heart rate they measure in the water needs to have an additional deduction taken. Or they get confused as to exactly when the deduction occurs.
Here are the simple "Rules of Thumb" to remember:

- The Aquatic HR Deduction is done in your math equations prior to putting your client in the water. You have to determine the heart rate range, target heart rate, or maximum/ minimum heart rate WITH the aquatic deduction before you put them in the water.
- Once they are in the water, the heart rate palpitated or shown on the heart rate monitor already reflects their aquatic heart rate. They are in the water and the water is doing its thing and suppressing their heart rate. At this point, all you have to do is make sure the number(s) you get for their HR in the water are matching the target numbers you so carefully calculated.

Heart Rate Monitor

If you are using a heart rate monitor, remember that the monitor shows you the person's hear rate at any given moment in time. The number on the monitor reflects what the person's heart rate is at that moment in time.

Pulse: Palpitation at the Wrist or Neck

If you are taking a pulse or palpitating your client's heart rate at the wrist or neck, you need to measure for 6 to 10 seconds. You are measuring the HR over time as opposed to any moment in time. It takes practice palpitating a heart rate to become accurate. If you have a high risk client in the water, you may want to consider using a heart rate monitor and palpitating for accuracy. This is also a good way to check yourself as you practice to become more proficient at palpitation. Just remember that the heart rate you palpitate and what shows on the monitor may not be exact, but should be within a few beats.

There are many variables that affect a person's heart rate during exercise including medication, stress, caffeine, chronic conditions, and environment. Although monitoring intensity using heart rate is not the most accurate way, it is the best way we have at this point in time for most clients in a non-medical setting. Many fitness professionals will combine heart rate with Rate of Perceived Exertion (RPE) to more closely monitor intensity. If you have a client referred from a health care provider, follow recommendations carefully.

Other ways to monitor exercise intensity are not as practical as using heart rate in most fitness settings. These include:

- Using a percentage of Peak VO_2 or VO_2 Reserve. Typically an exercise test is performed and then activities are prescribed using tables and calculations to determine speed (horizontal component) and elevation (vertical component) for various physical activities.
- Metabolic Equivalents (METS). Typically an exercise test is performed and then activities are prescribed within a MET range determined from tables of activities with researched and predetermined MET levels.
- Subjective Measures. Subjective measures include Rate of Perceived Exertion (RPE), OMNI scales, and the Talk Test which is considered less accurate.

Regardless of your role as a fitness professional, accurate knowledge and the ability to implement appropriate exercise intensity during group fitness or personal training is nothing short of essential. It is a skill that you want to learn and practice to raise your professionalism, provide more effective exercise for your client, and to maintain your client's safety.

Use this summary outline and table and sample calculations to help guide you to practice and become more proficient at calculation of target heart rates/ ranges for your clients.

Calculating a Target Heart Rate/Range

Determine the Numbers

Step 1: Calculate an Estimated Maximal Hear Rate (HRmax)

a. Use the simple formula: 220 – age **OR**
b. The more complicated formula: 206.9 – (0.67 x age)

Step 2: Use a Formula to Calculate Target Heart Rate

a. Use the standard maximal HR Equation **OR**
b. The Heart Rate Reserve/ Karvonen Equation

Step 3: Aquatic Deduction

a. Use the standard 13% deduction **OR**
b. Combine steps 2 and 3 and use the new Kruel Aquatic Heart Rate Equation

Measure and Interpret the Heart Rate

Monitor heart rate to maintain the desired intensity.

a. Palpitate the heart rate at the radial or carotid artery for 6 seconds **OR**
b. Use a quality heart rate monitor that can be used in water

Determine the Numbers	
Step 1: Calculate Maximal Heart Rate You can use the simple equation <u>or</u> the more complicated equation.	**Simple Equation:** **HRmax = 220 - age** For a 50 year old person: 220 - 50 = 170. **More Complicated/Accurate Equation:** For a 50 year old person: **HRmax = 206.9 – (0.67 x age)** HRmax = 206.9 – (0.67 x 50) HRmax = 206.9 – (33.5) HRmax = 173.4
Step 2: Use a Formula to Calculate Target Heart Rate You can use the Standard Maximal HR Equation <u>or</u> the Heart Rate Reserve/	**Standard Maximal HR:** **HRmax (calculated above) x Desired Intensity % = Target Intensity <u>without</u> the aquatic deduction**

<table>
<tr><td>Karvonen’s Equation. Remember that the ACSM recommended percentages are quite different between the Maximal HR equation and the HRres equation. Use the appropriate recommended percentages for the equation you choose.</td><td>HRmax x % Desired Intensity = Target Intensity
(Fair-average conditioning level- 80% intensity.)
173 x 80% (.80) = 138.4

Heart Rate Reserve/ Karvonen’s:
[(HRmax (calculated above) – HRrest) x Desired Intensity %] + HRrest = Target Intensity <u>without</u> the aquatic deduction
[(HRmax – HRrest) x Desired Intensity %] + HRrest = Target Intensity
(Resting heart rate = 65 BPM. Fair-average conditioning level- 60% intensity.)
[(173 – 65) x 60% (.60)] + 65
[108 x .60] + 65
64.8 + 65 = 129.8</td></tr>
<tr><td>Step 3: Aquatic Deduction
You can use the accepted 13% deduction or combine steps 2 and 3 and use the Kruel Aquatic Individual HR Deduction.

Note: You can see that this person’s individual aquatic deduction was well below the 17 BPM or the 13% typically used. So this person will exercise at a higher aquatic target rate at 60% intensity than what was calculated with the standard 13%.)</td><td>13% Deduction:
From the heart Rate Reserve equation above, the target HR is 129.8.
Target HR x .87 (13% deduction) = Aquatic Target HR
129.8 x .87 = 113 Aqautic Target HR

Kruel Aquatic Individual HR Deduction
[(HRmax – RHR – Aquatic Deduction) x Desired Intensity Percentage] + RHR = Target Intensity with the aquatic deduction.
(Resting heart rate = 65 BPM. Fair-average conditioning level- 60% intensity. Individual aquatic deduction is 12 BPM)
[(173 - 65 – 12) x .60] + 65
[96 x .60] + 65
57.6 + 65 = 123</td></tr>
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b. Use a quality heart rate monitor that can be used in water</td></tr>
</table>

1. American College of Sports Medicine (2010) ACSM’s Guidelines for Exercise Testing and Prescription. Lippincott, Williams, and Wilkins.

2. Gelish RL, Goslin BR, Olson RE, McDonald A, Russi GD, Moudgil VK. (2007) Longitudinal modeling of the relationship between age and maximal heart rate. Med Sci Sport Exer. 39(5):822-9.
3. McArdle W., Glasner R. and Magel J. (1971). Metabolic and cardio-respiratory responses during free swimming and treadmill walking. Journal of Applied Physiology. 33 (5) 733-738.
4. Chewning J, Krist P, and Figueiredo P. (2009). Monitoring Your Aquatic Heart Rate: Increasing Accuracy with the Kruel Aquatic Adaptation. Downloaded March 2010. http://www.aeawave.com/PublicPages/Research/ResearchResources.aspx