Brief History of the Evolution of Resistance Training in the Aquatic Environment

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The complete version of this article is available in the 2010 International Aquatic Therapy Symposium Research Proceedings. The Proceedings will be available in September 2010 from ATRI.

In watching research funnel through the Aquatic Exercise Association Research Committee, it was particularly interesting in the mid 1990's to see research emerge on comparison studies for rehabilitation on land as opposed to in the water. Although rehabilitation in the water could still benefit from additional research, there is evidence that rehabilitation in the water did transfer to similar improved function on land.

One study in particular caught the committee's attention: "Comparison of the effects of exercise in water and on land on the rehabilitation of patients with intra-articular anterior cruciate ligament reconstruction." (1994 Tovin et al) This study concluded that: "Although exercise in water may not be as effective as exercise on land for regaining maximum muscle performance, rehabilitation in water may minimize the amount of joint effusion and lead to greater self-reports of functional improvement in subjects with intra-articular ACL reconstructions." When looking more closely at the methods of the study, it is apparent that the training modes used for land and water were not very comparable. Step exercises were used both on land and in the water. Step muscle physiology is very different in the water compared to land due to the reduction of body mass associated with the water's buoyancy, and the water's resistance.

In addition, the land resistance was progressively overloaded systematically with pulleys and stack weights. In the water, the resistance was self-paced with a Hydrotone drag resistance exercise boot. The question arose as to how to measure and quantify workload in the aquatic environment for resistance training.

The aquatic industry thought process for resistance training went through 2 stages. The first stage recommendations were reasonably vague.
These basically included:

- Training in the water primarily builds muscular endurance.
- Water creates resistance in all planes of motion and in all directions.
- You can't really build strength effectively in the water.

After research advanced, the second set of guidelines became a little more specific and included biomechanic concepts. These basically included:
In the water, the following factors must be considered and controlled when resistance training:

- The length of the limb.
- Equipment factors: surface (drag) area, level of buoyancy, amount of weight, or tension of the rubberized equipment.

- The velocity or speed of movement.
- Controlling range of motion is important in progressive overload.

Using these basic concepts, you can progressively overload in aquatic resistance training in three ways:

- More repetitions (increase speed) through full range of motion within the same period of time.
- More repetitions through full range of motion at the same rate of speed; this option will take a longer period of time.
- Systematically increase the frontal surface area, buoyancy, or resistance depending on the type of equipment being used.

Even though these guidelines were less vague, there was very little scientific evidence available to make them more concrete. The Aquatic Exercise Association listed investigating resistance training in the water as a primary research need for the aquatic industry.

In the past decade, there are 2 primary research groups who have looked at resistance training in the aquatic environment. The first is a research group from Finland, led by Tapani Pöyhönen. This group's research focuses on knee flexion and extension, EMG activity, drag forces, drag coefficients, progressive resistance overload, and knee rehabilitation exercises.

Initial studies by this group investigated EMG responses, force output, and drag coefficients. There were two training studies conducted. The aquatic training protocols used in the 2 training studies were developed based on previous research conducted by the group. Workload progressed by manipulating all variables including:

- Sets: 2-4
- Repetitions per set: 12-30
- Duration using a designated period of time (30 to 45 seconds)
- Resistance: different sized drag boots
- Perceived exertion on the 6-20 scale was measured and they were encouraged to work at maximal effort.

Recommendations included the use of a timing device (duration and repetitions), systematically varying the load of the equipment, and use of perceived exertion. By carefully controlling these variables, the researchers were able to create progressive overload training protocols that produced significant physiological improvement. (For protocols, see Pöyhönen et al 2002 and 2010)

The second research group is from Spain, and the primary researcher is Juan C. Colado. This group investigated aquatic resistance training as a viable alternative for general and athletic populations. They believe that resistance training in the water is not widely used because there were no methods for controlling and monitoring intensity. They conducted 7 research investigations and then formulated a method for creating progressive overload for resistance training in the water.

Electromyography, controlled cadence, progressively sized drag equipment, and water currents were used to compare land and water resistance training exercises using fit young men, postmenopausal women, and the general population as subjects. EMG measurements for this group were primarily focused on the pectoralis and posterior deltoid muscles testing glenohumeral adduction and abduction movement in the transverse plane. They also investigated EMG in trunk muscles finding that activation of the erector spinae lumborum was significantly higher in the aquatic medium. Good form and technique as well as adequate strength in the stabilizing trunk musculature is recommended before performing aquatic resistance training exercises with high resistance/intensity.

In a summary paper (Colado and Triplet 2009) recommendations and guidelines are given to maximize success in an aquatic resistance training program through proper monitoring of volume and intensity.

Objective Recommendations/ Guidelines for program design with devices that increase drag force (DIDF) (adapted from Colado/Triplett 2009)

- The same program design recommendations used for land resistance training should also be used for the aquatic environment to determine load, volume and progression.

1. You must have combined control of:
   - Cadence / movement pace
   - Size of the equipment (surface area)
   - Length of the extremity (lever arm)
   - Hydrodynamic position of the moving segment and device used
   - Perception of effort at a predetermined number of reps using the OMNI Resistance Exercise Scale (OMNI-RES)
2. Monitor pace with beats per minute or a device like a metronome.
   - The resistance provided by the water is always the same.
   - Use the same form and technique through full ROM.
   - When you increase the pace, resistance increases quadraticly.
3. When necessary, increase DIDF to the amount necessary to keep a prescribed pace of movement and reach the desired number of reps and level of effort.
4. Increase the pace of movement with same size DIDF.

Recommended Steps to Determine Intensity of Aquatic Resistance Exercises: (Colado/Triplett 2009)

1. Determine desired rep range based on client goals and training history.
2. Determine desired level of exertion
   - Use the OMNI-RES Scale (This is a scale that was developed for resistance training which is similar to the Borg Scale.)
   - You can also use the OMNI scale to vary intensity
3. Choose the appropriate DIDF
   - Based on the client’s reps and exertion level

- This may involve a trial and error process just as for land RT
- The cadence should be the maximal possible allowing the exerciser to complete targeted reps at the targeted OMNI-RES level
- Cadences are commonly between 44 and 64 beats per minute

The future looks much clearer for resistance training in the aquatic environment. With the help of vital research, recommendations and guidelines for exercise in the water continue to progress. As health-fitness professionals continue to put research into practice, more people will come to the water and experience success in rehabilitation, general fitness, and athletic training.

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