The Properties of Water and Their Effect on Aquatic Therapy

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The use of water as a treatment form dates back to ancient times with the Greeks and Romans. Even Hippocrates advocated hydrotherapy. Today water is used by therapists in the form of a traditional whirlpool treatment or as an exercise medium. Almost any exercise can be adapted to water by taking into account the force principles that apply to water: density, buoyancy, moment of force, hydrostatic pressure, viscosity, and cohesion.

Current hydrotherapy began in the form of submersion of the injured extremity in either cold or warm baths. Then agitation was added in the form of whirlpool treatments. Because of the therapeutic benefits of hydrotherapy, the practice has grown rapidly in the last 2 decades and is manifested as aquatic exercise therapy.

Early aquatic therapy programs were based on the traditional swimming strokes. But physical therapists soon realized that the properties of water allow people to do things in water that they cannot do on land. So traditional exercise themes were adapted to the pool environment.

Now water exercise is employed by therapists to treat a broad range of pathologies. Following injury, elite athletes benefit greatly from exercise in water because it allows them to maintain their conditioning by minimizing muscle atrophy (Levin, 1991). At the other end of the spectrum, persons who are extremely arthritic or debilitated can take advantage of the buoyancy and warmth of water to diminish the degenerative effects of disease or injury, maintain range of motion, and improve flexibility and overall condition (Levin, 1991).

Physiological Adaptations

The effects of exercise and the warmth of water, ideally 80 to 92 °F, work together to produce a range of physiological effects. The benefits (see Table 1) vary depending on intensity and duration of exercise (Haralson, 1985).

Psychological changes may be the result of the physical effects listed in Table 1, or perhaps the feeling of hope that comes from being able to do things one could not do before, even if only in the water (Routi et al., 1994).

Pertinent Properties of Water

There are six properties of water that must be understood in order to develop a water program that will yield the specific effects a therapist is looking for (Collender, 1995):

1. Relative density
2. Buoyancy
3. Hydrostatic pressure
4. Viscosity
5. Cohesion
6. Moment of force

<table>
<thead>
<tr>
<th>Effects</th>
<th>Benefits</th>
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<tbody>
<tr>
<td>Increased circulation to the muscles</td>
<td>Decreased pain</td>
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<tr>
<td>Increased heart rate</td>
<td>Decreased joint effusion</td>
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<tr>
<td>Increased respiratory rate</td>
<td>Improved range of motion &amp; flexibility</td>
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<tr>
<td>Increased general muscle metabolism</td>
<td>Increased strength &amp; coordination</td>
</tr>
<tr>
<td>Decreased blood pressure</td>
<td>Improved ease of ambulation</td>
</tr>
<tr>
<td>Decreased sensitivity of sensory nerve endings</td>
<td>Improved mood</td>
</tr>
<tr>
<td>General muscle relaxation</td>
<td>Increased feeling of well-being</td>
</tr>
</tbody>
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Table 1
Effects and Benefits of Hydrotherapy
**Relative Density**

The relative density (i.e., specific gravity) of a substance affects its ability to float. The specific gravity of water is 1.0. Anything with a specific gravity less than 1.0 will float. The specific gravity of the human body averages about 0.974; this depends of course on the proportion of fat to bone and lean body mass and on the amount of air in the lungs.

The higher the % body fat and the more air that can be retained in the lungs, the easier it is to float. Most people will be able to float, or nearly float, and this principle also holds true for individual limbs (Haralson, 1985).

**Buoyancy**

Buoyancy is perhaps the most important property to understand, for it has the ability to either assist or resist motion in the water. Archimede’s principle states that when a body is partially or fully submerged in water, it experiences an upward push equal to the weight of the fluid it displaced within an area. This force is the opposite of gravity and contributes to the weightlessness a person experiences in water.

When a patient is submerged to chin level, it is estimated that only 1/10 of his or her body weight is actually supported by the joints; the rest is supported by the water's buoyancy. Harrison et al. (1992), with the help of a loading platform designed from a Salter bathroom scale, measured the actual force of patients walking in the water.

The effect of buoyancy is augmented by the moment of force or, more specifically, the turning effect of buoyancy on a joint. This effect increases as the limb moves toward the surface and increases the lever arm length. In practical terms, this means the ability of the buoyancy to assist movement toward the surface of the water is affected by the position of the limb in the water (Collender, 1995). The more horizontal the limb, the greater the buoyancy. Adding floats can also increase buoyancy.

**Hydrostatic Pressure**

Hydrostatic pressure is horizontal pressure that is exerted on the entire body when it is immersed in water. The amount of pressure is proportional to the depth of submersion, that is, how deep the affected area is below the surface. This has the effect of decreasing the amount of blood pooling in the extremities (McCulloch & Boyd, 1992) and is also thought to provide some static support for unstable joints (Speer et al., 1993).

**Viscosity and Cohesion**

Viscosity is the amount of friction acting on a moving part in water. Cohesion is the tendency of water molecules to stick to each other. When motion occurs slowly in water, there is very little friction and little resistance from cohesion. The faster the motion, however, the greater the forces of friction and cohesion. It is this principle that make water exercise isokinetic in nature (Haralson, 1985).

**Moment of Force**

The moment of force on a body in water is defined by multiplying