HEALING WATERS

If you think the water just makes people feel good, you don't know the half of it. Here's a physiological explanation of the surprising and amazing ways the simple act of being in the water promotes well-being. | by Bruce Becker

It doesn't take long to notice that people in pools are having fun. Nor does it take long to see happy faces in a group of aquatic exercisers, or a smile replace the facial stress lines of someone sinking into a hot tub. The feeling of relaxation after a vigorous pool workout is wonderful, and unlike most other exercise experiences.

As a scientist, I've been impressed with the consistency and universality of these observations. When I began to work with Olympic athletes who were used to vigorous exercise routines, they often commented on the difference in their post-exercise comfort from an aquatic exercise session vs. their normal exercise routine. But there's too much scientist in me not to wonder why these findings occur with such frequency and regularity. As I researched the medical literature, I couldn't find much to explain such common events. But when I began to dig into the basic science literature, I did find information that provided some potential explanation.

The physiology of immersion has been studied extensively since we prepared to put man into space in the late 1960s because the closest proxy to weightlessness on the planet is to be found when immersed in water. To study the physiological changes that would occur in space, it became important to study those changes occurring during immersion. The physiological alterations were profound and led to further research of specific body systems. Still, most of this research was not translated into medical applications, but rather, was located in highly scientific physiology journals.

Even today, there's relatively little research on the clinical applications of aquatic activity or exercise to be found in medical journals. This crossover from basic science into clinical

PHOTO BY HENRY OLIVAS

application is called translational research and it is only beginning to emerge for aquatics. But as more people turn to the water for therapy and healing, that body of evidence is growing daily.

If the industry can capitalize on these findings, understand and promote them effectively, aquatics could become the next big health craze, with the promise of helping everything from high blood pressure to heart failure. Given that the American Heart Association says 72 million Americans suffer from high blood pressure and more than 79 million have cardiovascular disease, that could be a powerful incentive.

The nation, in turn, could save huge amounts in health expenses if the public were educated about the value of aquatic activity, if the political powers directed public expenditures toward pool construction to improve public access and the medical establishment understood the potential value of aquatic activity across a wide range of clinical problems. But it must start with us. It must start with understanding why water is so healing.

Finding balance

To understand why aquatics is so good for your health, you must first understand some basic physiology. Our bodies are constantly trying to seek a physiological balance point called homeostasis. This state preserves optimum function despite changes in position, activity, stress, aging or disease. The effort to find homeostasis is what propels most of the functional adaptations that occur during immersion in water, with some changes being immediate and others only after a period of time. Like many adaptations, a cascade of other physiological changes occur, some sequentially and some concurrently.

Here's how it works: Because water compresses the body, it pushes blood into the deep vessels during immersion. As the bather steps into deeper water, blood is pushed upward, first into the large capacity vessels of the pelvis and abdomen. Then as depth increases yet further, blood is pushed above the diaphragm into the chest. With neck-depth immersion, nearly three-quarters of a quart of blood is displaced, with two-thirds of it going into large pulmonary vessels and one-third into the heart.

The heart responds to this extra volume of blood by increasing the amount propelled with each beat, which is called stroke volume. At rest during neck-depth immersion, stroke volume normally increases approximately 30 percent. The total volume of blood propelled by the heart during a minute is called cardiac output, and this also increases nearly 30 percent. That's approximately the same increase that occurs during light exercise, so even at rest during neck-depth immersion, the heart is performing just as it would during exercise on land.

At the same time, the body senses that more blood is being pushed into circulation, so to adjust, the arterial blood vessels relax without causing an increase in blood pressure. Thus, healthy individuals will lower their blood pressure during immersion, and usually so will individuals with elevated blood pressure (hypertension.) The magnitude of this drop is related to the temperature of the water.

Usually, there's an initial brief increase in blood pressure upon entering cold water, and also extremely warm water. Maybe that's why in the past, it was often stated that individuals with hypertension should avoid hot tubs. Many physical therapy texts also say that patients with elevated blood pressure should not undergo aquatic therapy. In actual fact, immersion may benefit such patients.

7 BENEFITS OF IMMERSION

- Usually lowers blood pressure
- Reduces stress hormones
- Strengthens the muscles of respiration
- Enhances cardiovascular efficiency
- Improves kidney function
- Increases muscle blood circulation
- Offloads joints, and probably increases circulation to them

Heart and health

Patients with congestive heart failure are another clinical population that has been counseled to avoid aquatic exercise or even immersion. But several recent Japanese and Israeli studies have found that for people with mild to moderate heart failure, aquatics may be a very useful and therapeutic environment. That's because immersion offers a unique combination of benefits: It decreases circulatory resistance and improves heart contraction efficiency.

One of these studies compared the effects of aquatic exercise with rest in a group of patients with moderate congestive heart failure. It was found that the aquatic exercise group of patients significantly improved in muscle function, walking distance, aerobic fitness and exercise capacity. They also experienced nearly 40 percent improvement in their quality of life.

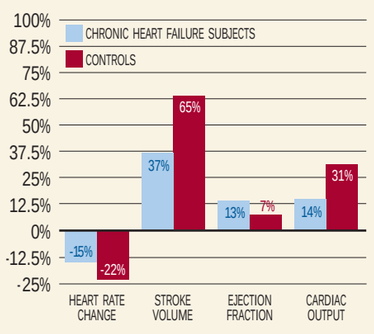
One reason may be that during immersion, the increased blood volume is pushed into deeper tissues. Muscle circulation then improves and there's a consequent increase in oxygen delivery, which is useful for muscle healing or recovering from exercise. A study done on astronauts in training showed that the blood flow into their calves was increased by nearly 250 percent at rest during neck-depth immersion.

At the same time, the kidneys see an increase in blood volume. Sensors within the heart and elsewhere interpret the increase in blood volume as a potential overload, so the body sends signals to the endocrine system to reduce this blood volume. As a result, the kidneys begin their role in regulating blood volume through excreting sodium and potassium, and along with those ions, water. As all aquatics professionals have experienced firsthand, this process produces an increase in urine volume and the kidneys also become slightly more efficient. In ancient Greek and Roman times, when medications were very limited,

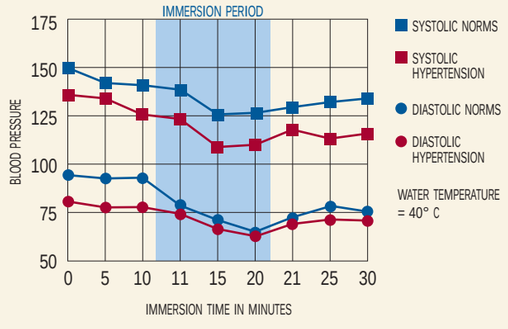
WARM WATER AND IMMERSION

Warm-water immersion has numerous beneficial effects. In chronic heart failure patients, it decreases circulatory resistance and improves the heart contraction efficiency. In hypertensive patients, it lowers blood pressure.

Effects on Congestive Chronic Heart Failure Patients



Hypertension and Hot Tubs



PHYSIOLOGY AND IMMERSION

This diagram shows what's happening in the body before a person enters the water, and what happens afterward. The changes are significant, especially those involving blood flow and the heart. The deeper a person is immersed, the more the health benefits increase. At neck level, even the brain is affected because more blood is forced upward from the lower extremities.

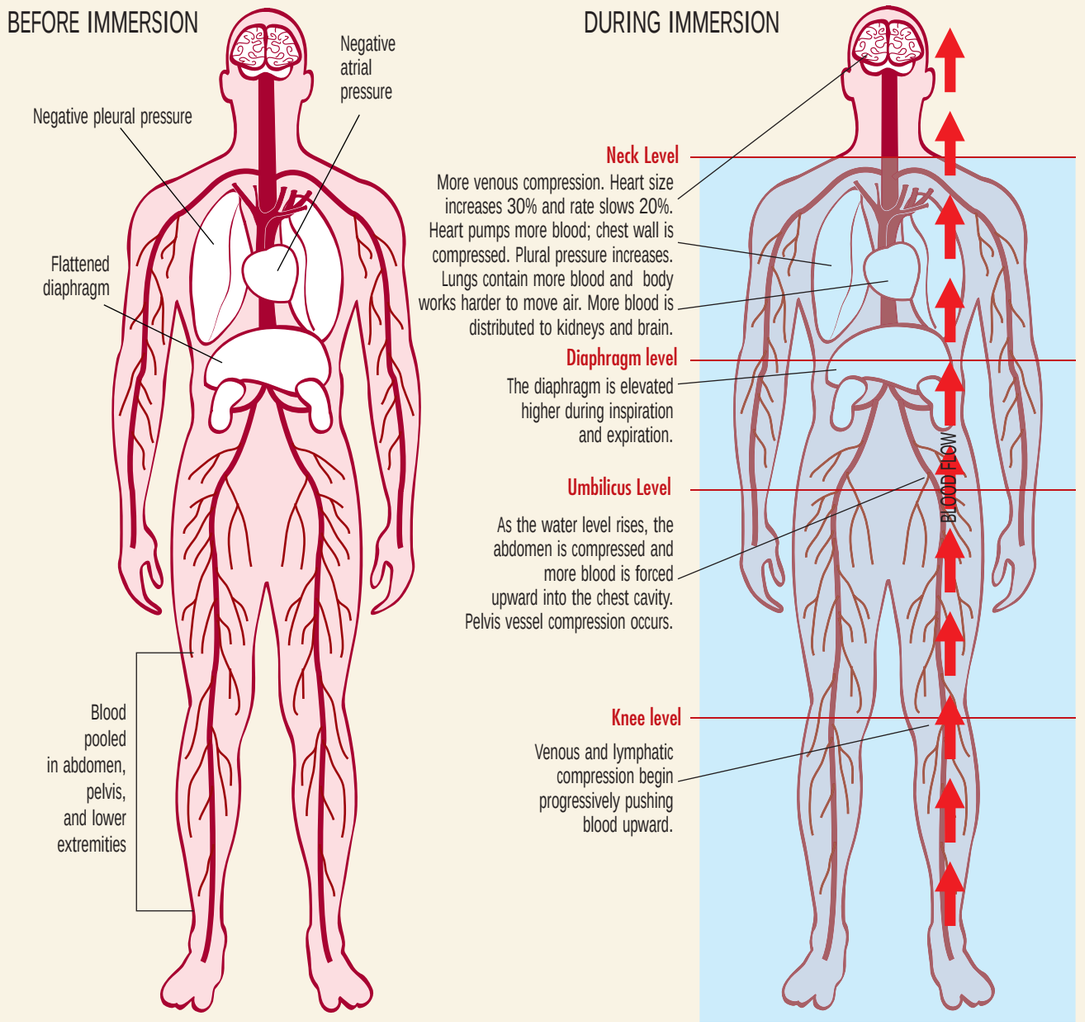


ILLUSTRATION BY TIM BOBKO

immersion was actually used as a way to treat individuals with kidney disease.

Stress is another ailment that immersion can help alleviate. Some of the same hormones that the body uses to regulate arterial function and tone are a component part of our body's response to stress. These hormones are called catacholamines. During immersion, the body sends out a signal to alter the balance of these catacholamines in a manner that is similar to the balance found during relaxation or meditation.

Not all of the effects of this alteration are known, but probably these changes are important in modifying the heart rhythm in a manner to mimic a relaxed state, and also in creating some of the feeling of relaxation that occurs following aquatic activity.

Exercise and endurance

The connection between exercise and stress reduction has been well-established, and the work the body must do in water may be one reason. During immersion, compression of the chest wall combined with the increased blood volume makes it more work to breathe — approximately 60 percent more with water up to the neck. This, in turn, can lead not only to lower stress, but also better performance during land workouts.

In my experience working with Olympic-level athletes, a frequent comment was how much the aquatic workouts had added to their overall feeling of fitness. I believe what they were noticing is that strengthening the muscles of respiration had significantly improved their respiratory efficiency, so during a land-based workout they didn't feel so "winded."

If the workload increase is 60 percent during inactive immersion, there is almost certainly a much greater workload increase during immersed exercise. Blood and water are viscous substances, and the force required to move against viscosity is related to velocity in a complex equation. Essentially, as the frequency of respiration increases, so does the work of displacing blood from the chest cavity to allow air in. The chest wall must then expand against the compression of surrounding water. As a consequence, deep-water exercise potentially could be a very useful method of strengthening the muscles of respiration, which could be helpful in athletes, as well as in the rehabilitation of people with respiratory weakness or other lung diseases.

We decided to test that possibility in a study completed last year at Washington State University. We worked with two groups of WSU students, 50 in each group. One group did land-based aerobics for a 50-minute period, three times per week for a semester. The other group did aquatic aerobics 50 minutes per session three times per week. We measured aerobic conditioning, percent age of body fat, and a number of measures of respiratory efficiency and strength. All of the students increased in their aerobic fitness, all decreased their body fat percentages, and all improved in some of the respiratory measures. But only the aquatic students showed improvement in their respiratory endurance measures.

We plan to repeat this study with more focus on higher-fit student athletes to see if the same effect is noted. There is a potentially major benefit of improving respiratory endurance because as the muscles of respiration fatigue, the body begins to shunt blood from the lower extremities up to the chest muscles to support respiratory effort.

Obviously, in an athlete who is reliant upon the legs, robbing these muscles of blood flow to supply the muscles of respiration causes a decrease in athletic performance. A basketball player who is getting respiratory fatigue will "hang on his shorts," which can be seen often at the end of a basketball game. This action aids the accessory muscles of respiration. But if at the same time, the leg muscles are being starved of blood, the player is going to feel like his or her legs are "dead."

Studies have shown that exercise activities to improve endurance of the muscles of respiration actually do improve athletic performance, but deep-water exercise would be an easier and potentially more efficient means of producing such an effect, while allowing the athlete to decrease stress forces upon the spine and lower extremities simultaneously.

Rehab and weight loss

This latter effect occurs because of the offloading effects of buoyancy. At waist-level immersion depth, the hips, knees, ankles and feet have a 50 percent reduction in loading due to buoyancy; at mid-chest depth, there's a 75 percent offloading.

As a consequence, this effect may be used to excellent clinical benefit in facilitating recovery from training, or rehabilitating from a lower extremity or spine injury.

The combination of joint offloading, with the improvement in deep-tissue circulation makes the aquatic environment very useful in rehabilitation. In fact, even before these effects were known, deep-water exercise was used to improve racehorse performance without exposing the animals to the trauma of the racetrack. Owners found they could nearly triple the expected race career of a horse if they used aquatic training for a significant part of the workout regimen. In working with Olympic distance runners through the Nike development program, we tried to have about one-third of the training done in water, which seemed to reduce injuries as well as improve performance.

The value of aquatic exercise in patients with osteoporosis has been controversial. The aquatic environment would be ideal for this group because of the frequent co-existence of joint disease and the decreased risk of fractures from falling during land-based exercise. Many such patients have a fear of falling that limits their tolerance of a land-based walking program, an activity that has been shown to build bone mineralization and reduce osteoporosis. Most studies of aquatic exercise have not shown a useful benefit upon bone mineralization, however. Studies comparing regular aquatic exercisers with regular land-based exercisers have shown better bone mineralization in the land-based groups at nearly all ages from adolescence through senior groups.

This does not mean that aquatic exercise lacks a place in this group of individuals. In my practice, I will typically start such a patient in an aquatic exercise regimen, which has been well shown to boost lower extremity strength and endurance, as well as improve balance. The combination of increased strength and balance skills is usually sufficient to enable that individual to embark upon a walking program safely and begin the bone-building process.

Another controversial point is how aquatic exercise works for obese individuals. Because of the offloading produced by buoyancy, the aquatic environment seems ideal, especially in persons with decreased lower extremity strength. It has been shown that aquatic exercise is less efficient in decreasing body fat percentages than land-based programs.

Even at Olympic levels of training, these athletes have a higher percentage of body fat than their track athlete peers, as can be seen readily. The swimmers have sculpted beautiful bodies with higher percentages of body fat, whereas the track athletes have greyhound-slim bodies with very, very low percentages.

Despite this concern, the value of exercise in obese individuals is absolutely essential, and aquatics may be a tremendously useful method of initiating a program *and* losing weight over time. While it may not be as efficient from an absolute standpoint, it is still effective and likely to be better sustained because of the lower risk of joint injury in aquatics for this group.

HURDLES TO ESTABLISHING AQUATIC HEALTH

- Too little information in the media about aquatic health benefits.
- Insufficient science is completed and published in medical journals.
- Health care arena is unaware of clinical science that does exist regarding aquatic health benefits.
- Health care reimbursement is not currently directed toward prevention of illness or disability.

BLOOD FLOW AND IMMERSION

During immersion, more oxygen-rich blood is pushed into the deep muscle tissues — up to 250 percent more. The heart also grows in size, improving cardiac output and overall heart health.

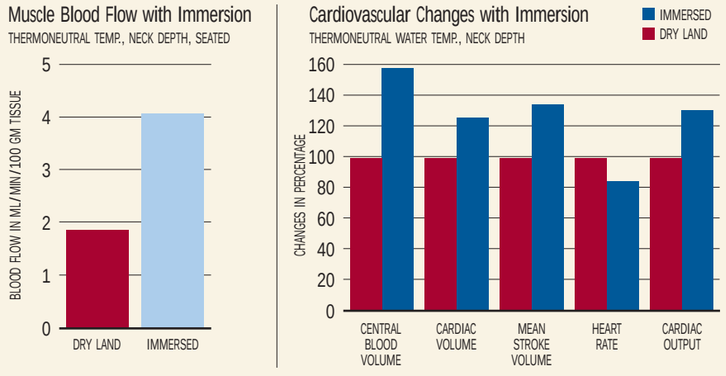


PHOTO BY HENRY OLIVAS

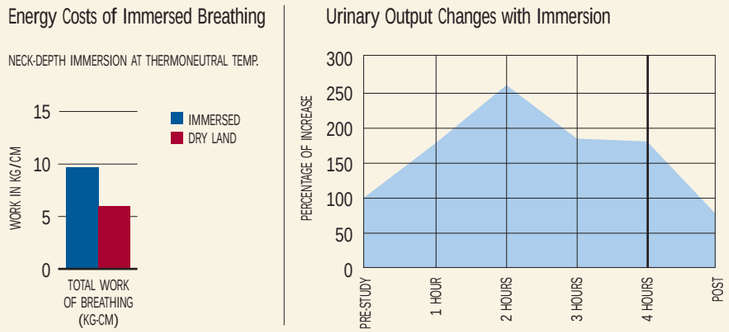
STRESS RELIEF During immersion, the body sends out a signal to alter the balance of a certain type of hormone, which creates a balance similar to relaxation or meditation.

BENEFITS OF AQUATIC VS. LAND EXERCISE

- Buoyancy gives the disabled or overweight more freedom.
- Multidimensional movement is easy.
- The viscosity of water adds graded resistance.
- Immersion is usually pleasurable.
- Relaxation is nearly automatic.
- Water has its own healing properties.

BODY FUNCTIONS AND IMMERSION

Compressed chest wall during immersion means more energy — 30 percent more — is expended to breathe. Meanwhile, increased blood flow and other changes cause urinary output to spike.



Many of these individuals can participate successfully for years in a group format, and I've seen people whose lives were totally changed because of such a program.

On the whole, the response of the human body to the aquatic environment is profound. Perhaps it is because all of us spent the initial formative months of our lives immersed in a warm-water pool of amniotic fluid that we can so readily sink into a pool with relief. Such an environment would provide protection and the optimum conditions for growth during this critical period.

But the combined effects of all the properties of water, from buoyancy through hydrostatic pressure to its thermal conductive properties make the aquatic environment tremendously useful and effective for health recovery and maintenance, and recreation.

At Washington State University, we are striving to create a body of clinically directed translational research so that such an understanding might emerge within the public, as well as the medical profession. We're also trying to create a broader understanding of the immense value of aquatics for high-level athletic training because the public seems to relate to the effectiveness of this kind of effort as well.

It is my hope and belief that in the future, we will see a wetter, happier and healthier world. ■

WAYS TO BROADEN SUPPORT FOR AQUATIC HEALTH

- Broad public awareness campaigns
- Education within the medical community
- More active community involvement
- Legislative advocacy
- Promotion and dissemination of clinical research in consumer and medical media

PHOTO BY RIN-RIN YU

FEEL THE HEAT **Among other benefits, hot-water immersion has been shown to reduce blood pressure and lower stress levels.**