The ‘P’ Phenomenon

"James Crook of Long Acre, had dropsy, jaundice, palsy, rheumatism, and an inveterate pain in his back. In three immersions, the swelling of his legs sunk, so did the pain of his back, as did the jaundice, blowing from his nose a great quantity of bilious yellow matter. From the rigidity and the pressure of the fluid we may account for his pissing more than he drank."

A. Sutherland, 1764

Why Does It Happen?
Go diving, swimming, or step into the bath, and you have to "go." This increased urine output has been called the "P Phenomenon" (PP), but it's also called immersion diuresis. It's usually explained by immersion, usually in water, which shifts blood from your legs to your thorax. Volume detectors in your heart notice the increase and, to normalize volume, signal your body to move some fluid out. But fluid shift from your legs doesn't explain it all. A study comparing double amputees with non-amputees found that leg volumes only partly contribute. You can tell this by standing on your head, or lying on your back with your feet up. Blood shifts from your legs without diuresis. So what else is going on?

Mechanical Factors
Position. More diuresis occurs when you are immersed in water to the neck than if you're immersed only to the hip. A misconception is that since pressure increases with depth, greater water pressure on your legs than on your upper body will squeeze blood upward. But diuresis occurs when you are horizontal in the water, and during microgravity in space flight, two conditions with no difference between the pressures on your head and feet. Diuresis also occurs when you're upside-down underwater, where the pressure difference, (hydrostatic gradient) is reversed.

Blood is not squeezed into your feet. So what else is involved?
Gravity. When you lie down on land, blood pressure in your arms and legs is about equal. When you stand, leg blood pressure rises because of the weight of blood in the vessels above. You get some pooling in your legs because of gravity, and because your veins (more than arteries) expand to hold more blood. Less blood flows back to your heart. When you immerse in water, effects on your blood volume are mostly counteracted by buoyancy. This blood pressure equalization (not squeezing from water pressure) increases thorax blood volume and diuresis. In space the pull of gravity is weak, and like buoyancy underwater, counteracts downward blood pressure. In space, blood does not pool in your legs. Astronauts and mission control scientists use a technical term for the headward fluid volume shift during space flight. They call it the "Fat-Face-Chicken-Legs-Effect."

Negative Pressure. When you are in water up to your neck, air pressure at your mouth is lower than water pressure on your chest. It takes some effort to inhale, like drinking through a straw. Breathing in against this lower pressure is called negative pressure breathing. Many effects occur. One is a small amount of blood drawn into the chest, and a slight, if any, diuresis. Underwater, scuba regulators deliver air at close to the same pressure as surrounding water, no matter if you are head-up or head-down. But variations occur, creating constantly changing slight positive and negative pressure breathing, driving inconsequential blood volume shifts in either direction.

Chemical Factors
Blood centralization with immersion stimulates your body to release interesting chemicals that produce and regulate diuresis, excretion of sodium (called natriuresis) and potassium (termed kaliuresis). One of your main chemicals for controlling fluid output is the hormone vasopressin. One action of vasopressin is

to concentrate and decrease how much you 'P.' Vasopressin's common name is antidiuretic hormone (ADH). ADH is important in daily life so you don't dry out. Immersion suppresses ADH. Output increases, at least temporarily. Another familiar influence suppresses ADH with similar effect: ingestion of strong alcohol. A more important chemical in The P Phenomenon is ANF.

When immersion centralizes your blood volume, the upper chambers of your heart (atria) distend from extra blood. To reduce extra volume, atrial cells secrete a substance to increase diuresis, suppress thirst, increase natriuresis and release a counterbalancing set of chemicals. Because it is secreted in the atria, and is a major factor in natriuresis, it's called atrial natriuretic factor, or ANF. ANF is a particular type of protein molecule known as a peptide, and is also called atrial natriuretic peptide (ANP).

Environmental Factors

Diuresis is higher during the day than night, a helpful thing to let you get a night's sleep, immersed or otherwise. Salt water, denser than fresh water, slightly increases buoyancy and the diuretic effect of fluid shifting. These are minor factors. With cold immersion, the blood vessels in your limbs constrict to reduce heat loss. Blood centralizes and you feel the need in a big way. Not as much diuresis occurs in hot water, such as a hot bath, but still occurs until you get warm enough and your blood vessels shifts blood away from your core to dump heat. Cold is such a big factor that you feel the effect stepping into a cool shower with no immersion at all.

Personal Factors

Exercise reduces diuresis by a complex series of reactions. More and faster diuresis occurs in older subjects (ages 62-74) compared to younger ones (ages 21-28) in experiments of age and immersion, even with the same central blood shift. Fear, apprehension and emotional stress add to neural signals to the kidney, increasing output.

Factors Unknown

Although diuresis does not change with depth, it increases in dry hyperbaric chambers during deep saturation studies. We don't know exactly why, but it may be increased gas pressure and density, and reduced water loss through the skin. Your body uses the alternate route to remove water.

P Phenomenon Myth

It is not true that putting a sleeping person's hand in water (of any temperature) will cause the P Phenomenon during sleep.

Summary

Immersion is not a single condition, so diuresis has many contributors. Combinations of mechanical, neural, environmental and chemical influences control fluid volume in intricate feedback loops. On the other hand, sometimes it's just, "When you gotta go, you gotta go."