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Considering Water Temperature: A Proposed Model

You can probably picture the beginning of our Masters swim team practice most early mornings: teammates gathered on the deck doing a variety of stretches, waiting for our coach to indicate what the warm up is going to be, often gazing at the water with some trepidation. Many mornings, especially during the frigid Ohio winter months (outside air temperatures ranging from 0° to -29° C, or 32° to -20° F), this scene can remind me of the porridge episode in the Goldilocks and the Three Bears children's fable. There is occasionally someone who suggests the water temperature is "too warm." One or more typically complain that the water is "too cold!" And, then someone may chime in that it is "just right!" Ironically, I do not believe the water temperature in BGSU's Cooper Pool where we train (50 meters × 25 yards) ever varies by more than one degree Fahrenheit! It remains fairly constant between 81° and 82° F (i.e., 27.2–27.8° C) with a similarly steady air temperature of 75–76° F (~24° C). And, even more paradoxically, the "too warm," "too cold," and "just right" interpretations are all of the same water temperature!

A number of years ago at another pool at another university where we offered a Saturday physical activity program for children that included both land and water activities, parents and children complained that the water was just too cold (even though it was probably about the same 81° F as the BGSU pool). Many of the thinner, younger children actually would have blue lips and be shivering after only 15-20 minutes of instruction in the pool, so it wasn't just their imagination. Because the pool was a multi-use facility for the university, we really did not have the capability of increasing the water temperature. I discovered a simple and easy to make adjustment that seemed to work: About two hours before the children came to the pool, we raised the *air* temperature about 5 or more degrees. Because air is so much less dense than water, the temperature indeed was elevated within this period as was the relative humidity. And, surprisingly, the children stopped shivering and feeling cold. Parents thanked us for raising the water temperature, which, of course, we had not done (and realistically we couldn't have accomplished since it would have taken well over 24 hours to raise the water temperature in a pool that large even a single degree with a decided energy cost). Of course, the lifeguards didn't appreciate sitting in this humidity for several hours, but they were the only ones who seemed to mind.

This "experiment" is a variation on what happens naturally during the summer months in many temperate climates such as here in Ohio: Water temperatures in lakes, streams, and outdoor pools that we would absolutely have shunned as completely frigid during colder weather we find to be refreshing and even enjoyable. What is the difference? I am pretty sure it is the increased air temperature and summer humidity that allow us to perceive the water to be comfortable and even enjoyable when it is 10° F or colder than our indoor pool.

I had learned an interesting practical lesson from my experiment with raising the air temperature: Both the perception and experience of water temperature is strongly affected by more than just the absolute water temperature. Air temperature and the concomitant humidity appear to be major factors in how warm or cool the water feels and affects individuals. Of course, a person's body composition and the types of physical activity in which the person is engaging both play major roles in the experience of the water temperature. In fact, if we consider Karl Newell's "constraints model" (Newell, 1986), although it was mainly intended for explaining and understanding movement coordination and control, we may have a potential model for considering how a variety of factors influence the perception and experience of water temperature. Newell (1986) proposed that movement coordination and control is impacted by three factors: the individual, the task, and the environment, whose relationships mutually constrain each other. It seems to me that our experience with water temperatures can similarly be described as being affected by individual, task, and environmental factors interacting (Figure 1).

Here's how I think that this "water temperature experience" constraints model might work. There are a number of *individual characteristics* that alter how we perceive water temperature: our body composition (i.e., how much superficial adipose tissue we have in relation to our lean body mass, expressed directly as percent body fat or indirectly as body mass index, or BMI), our absolute body size, and the

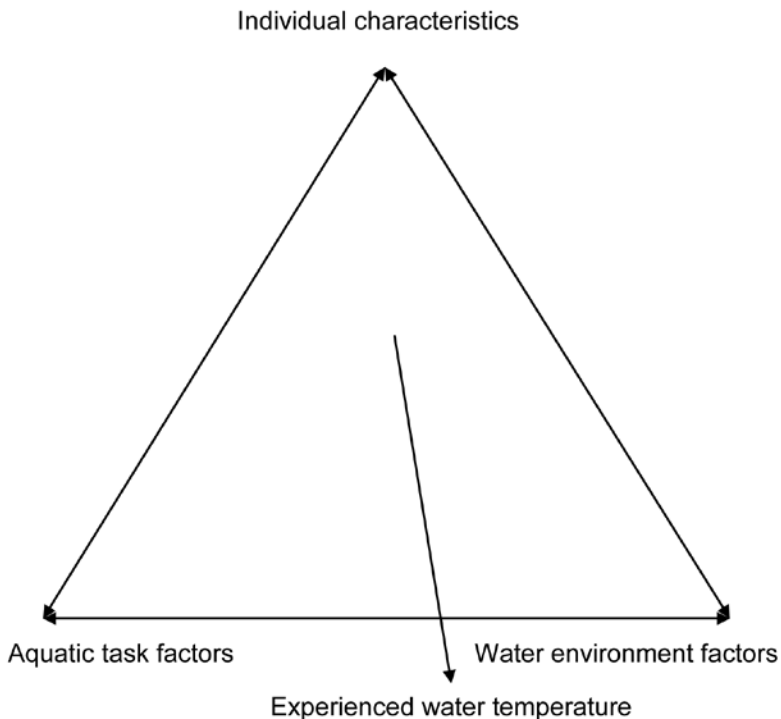


Figure 1 — A proposed "water temperature experience" constraints model.
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ratio of body mass to skin area. This final individual quality, the ratio of body mass and skin area, is an important factor particularly related to the safe range of water temperatures for infants and young children. Because infants and young children have a relatively large surface area to their body mass, they can become either hypothermic or hyperthermic much more easily than older children, adolescents, and adults. The implication is that for young children's swim lessons, absolute water temperature as well as the relationship to air temperature and humidity needs to be monitored closely so that it is neither too cold nor too warm.

Most obviously, the *water environment factors* that influence our perception and experience of the water include the absolute water temperature, the absolute air temperature, the relative humidity, the ratio of the air to water temperature, and the length of time during which we are exposed to the water. As I have already illustrated, by simply changing the ratio between air and water temperature, the perception and reality of the water temperature can be altered dramatically.

Finally, we should consider that the types of *aquatic tasks* or activities in which people are engaging comprise an important set of factors. If swimmers are actively training in the water such as while competitive or fitness swimming, they are expending energy and thereby generating body heat that make cooler water temperatures feel more comfortable. In contrast, if someone is simply standing in or moving slowly in the water such as occurs during many swim lessons, they will likely find water temperatures much colder feeling. Also, the body orientation (vertical vs. horizontal) and the amount of the body submerged or exposed to the air are other potential aquatic task factors influencing how we experience water temperature.

My point in proposing this potential model is that at least these three sets of factors and characteristics influence how we experience and perceive the water. Also, these factors act as "constraints," or in mutual relationships with each other. For example, a competitive or fitness swimmer who is very lean may still feel particularly cool in the water despite swimming vigorously. One of my Masters teammates, who suffers from asthma and who is quite thin, is particularly sensitive to very minor shifts in water and air temperature. When the water feels cold to her, it is much more likely that she will need her asthma medication or even need to get out of the water. On the other hand, a person with a higher BMI may be able to tolerate cooler water despite not moving very rapidly in the water. Similarly, young children, despite being very active playing games in the water, may become hypothermic because of their relatively large skin surface area in relationship to their body mass as well as having a lower BMI. The impact of their skin surface area may be accentuated if they are playing in shallower water where their trunk is alternately submerged and then exposed to the air and the cooling effect of water evaporating from their skin.

If one peruses the various national aquatic programs (e.g., American Red Cross, YMCA of the USA), different water temperatures are often recommended for different age groups and aquatic activities. The water temperatures for swim programs involving infants, young children, and those with differing abilities is usually recommended to be warmer than for more typical children and adults. As I have already noted, water for competitive and fitness lap swimming or water polo is typically allowed to be cooler (e.g., 78° F or 25.5° C) than that suggested for instructional swimming lessons.

In the past, I think recommended water temperatures, both minimums and maximums (such as in spas or hot tubs), have been made on the basis of trial and

error or practical experience. As with other areas of aquatics, I am a strong supporter of employing evidenced-based research to help us make decisions and recommendations. I am proposing that one way to begin to gather more scientifically-sound evidence for recommendations such as water and air temperatures is through the use of a theoretical model such as the “water temperature experience” constraints model that I have adapted from Newell’s movement constraints model. I believe it can be used to design important empirical studies to determine how individual, task, and environmental factors impact our experience and perceptions of water temperatures.

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Reference

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