Summary of the principles of Whole Body Cryotherapy (WBC) and CTN's Vortex technology

How we react to changes in temperature?

We have a built-in sensory system for perceiving temperature
Being a warm-blooded (or homeothermic) animal, we humans have a built in sensory process — called **thermoreception** — by which we detect different levels of temperatures in the environment and in the body. This process helps us to maintain considerable inner physiological stability (e.g., body temperature and metabolism) under changing environmental conditions.

Different sensors perceive different temperatures
We perceive *external* temperature via **thermoreceptors** in our skin, which, in response to temperature stimuli, fires a specific neural pathway that carries a representation of thermosensory activity to the cerebral cortex in our forebrain. These receptors come in different types, some being **warm spots** and other being **cold spots**. These are, as you guessed, specific places in the our skin that are selectively sensitive to warm or cool stimuli.

We can sense a reasonably wide range of temperatures: roughly 5 – 45 °C
The cold spots in our skin fire when temperatures go below the neutral skin temperature (~34 °C [93 °F]). The warm spots have increased activity at temperatures warmer than neutral skin temperature. The sensitivity of these receptors extends across a continuum of thresholds and response maxima. The static activity of many cold receptors reaches a maximum at temperatures around 20–30 °C (68–86 °F). Some receptors have lower thresholds (i.e., less than 30 °C [86 °F]) and maximal activity at colder temperatures (i.e., less than 20 °C [68 °F]). Warm receptors are continuously active at constant temperatures above neutral skin temperature and have response maxima around 41–46 °C (106–115 °F), although, in many cases, warm receptors are inactive at temperatures above 45 °C (113 °F).

When the temperature is over 45 °C, and less than 5 °C (these values change slightly depending on the source), pain receptors called thermal nociceptors fire signals. These signals are what we experience as pain.

Temperature receptors
The sensory system involved in perceiving the changes in skin temperature begins with free nerve endings found in the dermal and epidermal layers of skin that can be functionally classified as cold and warm thermoreceptors. Warm and cold receptors respond similarly to radiant and conducted thermal energy and are involved in the perception of innocuous (harmless) temperatures. The molecular mechanisms underlying temperature sensation have been extensively studied over the past decade with the result that several temperature-sensitive ion channels of the transient receptor potential (TRP) family have been identified as candidate temperature sensors. These thermos TRP channels are expressed in sensory nerve endings and are active at specific temperatures ranging from noxious cold to burning heat (Dhaka et al., 2006). In addition to responding to changes in temperature, these thermos TRPs are involved in chemesthesis, and so mediate the pungent qualities of stimuli such as capsaicin, the "hot" ingredient in chili peppers and menthol, the "cooling" compound from mint.

Thermoreceptors in the glabrous skin on the palm of the hand are mainly used to assist in identifying objects in contact with the hand, whereas thermoreceptors in hairy skin are particularly important in thermoregulation. Cold receptors respond to decreases in skin temperature over a range of 5-43 °C, and discharge most vigorously at skin temperatures around 25 °C.

In addition to sensing the temperature of objects in contact with the skin, afferent signals arising from cold thermoreceptors have been shown to play a role in the perception of wetness. It appears that thermal cues are used in conjunction with tactile inputs to perceive the wetness experienced when the skin is in contact with a wet surface (Filingeri et al., 2014). These interactions between thermal and tactile inputs presumably account for the illusion of skin wetness that can occur when the skin is exposed to cold-dry stimuli which result in cooling rates similar to those that occur during evaporation of water from the skin surface.

The number and density of thermoreceptors in the skin has been measured by placing small warm and cold stimulators on the skin and recording the sites at which a person detects a change in temperature. The locations at which a thermal stimulus is detected are known as warm and cold spots and are assumed to mark the receptive fields of underlying thermoreceptors. Warm and cold spots are only a few millimeters in diameter, and are distributed independently. There are more cold spots than warm spots, and the density of spots varies across the body. For example, on the forearm it is estimated that there are approximately 7 cold spots and 0.24 warm spots per 100 mm^2. In addition to differences in the distribution of cold and warm thermoreceptors across the skin surface, the two types of receptor differ with respect to the conduction velocities of the afferent fibers that convey information from the receptor to the central nervous system. Cold afferent fibers are myelinated and so are much faster than unmyelinated warm afferent fibers with conduction velocities of 10-20 m/s as compared to 1-2 m/s for warm fibers. As would be expected from these differences in conduction velocities, the time to respond to a cold stimulus is significantly shorter than that for a warm stimulus.

The skin also contains thermally sensitive receptors leading to pain sensation known as thermal nociceptors that respond to noxious or harmful temperatures. Nociceptors that are responsive to temperature signal to the central nervous system that tissue damage is imminent and that the affected body part should be withdrawn immediately from the thermal source (e.g. a finger on a hot plate). These receptors are active when the temperature of the skin falls below 15-18 °C or rises above 45 °C. When they are activated, the sensation is one of pain. Although the thresholds for activating heat and cold-sensitive nociceptors are usually described as being greater than 45 °C and less than 15°C, in some individuals mild cooling (25-31 °C) and warming (34-40 °C) of the skin can evoke sensations of burning and stinging as well as innocuous sensations of cold and warmth (Green, 2002). Changes in skin temperature also affect the responses of mechanoreceptors in the skin that signal mechanical deformation, such as pressure or vibration, which is why the hands often seem clumsy when they are cold. However, it is generally accepted that mechanoreceptors do not have sufficient encoding capacity to account for thermal sensations.

The Vortex™ principle

The thermometer measures temperature, wind chill measures heat loss from a body warmer than the air. Moving (rotating) gas inside the Vortex™ cryo cabin makes more unheated air available to conduct heat away from the skin's surface, but with a body at air temperature no heat is being conducted away from the thermometer.

Inert devices like thermometers aren't endothermic like we are, so the effects of moving cold air don't apply to such measuring devices. This is why an algorithm needs to be used to factor in the actual heat extraction level for the person inside the cryo cabin.

WBC is not based on our conscious level of pain or discomfort. The efficiency of the treatment is dependent on the exposure to extreme cold temperatures at cellular level. The larger number of cells exposed to low temperatures the better. More receptors exposed means more "SOS" signals to our brain, signalling our body to produce the maximum output of life supporting enzymes and hormones. Thermal shock type of conscious sensations of pain or other discomfort have no impact on the treatment results. E.g. if a person is submerged into +4 degrees Celsius water, the feeling of pain & thermal shock are imminent, however this does not result in similar therapeutic effect as WBC, partly because the length of exposure is usually very short. Our cold receptors are deeper in our skin than out heat receptors and they stop registering temperatures few degrees before sub zero levels are reached. After reaching +4C cold receptors stop registering temperature and our pain receptors take over. In the case of WBC pain does equal gain.

The Vortex system has been designed to provide optimal therapeutic effect with minimal discomfort. It has been proven in several clinical studies that cryotherapy works efficiently under temperatures of -110 degrees Celcius. The ideal (= efficient yet safe) treatment temperature inside a Cryo cabin equipped with Vortex technology is between -110 and –130 degrees Celcius (-166 to -202F). Going lower than that does not enhance the treatment results, and can cause frost bites to people with weaker blood circulation. Cold air can be compared to hot steam. The more pinpointed and concentrared the delivery of the cold or hot energy is, the more painful it feels on our skin.

Summary and conclusion

The more even the distribution of super cooled gas mixture is, the less discomfort we experience. However, the receptors exposed to life threatening temperature levels will signal the brain via our central nervous system, that all available life support is needed. This is the essence of successful WBC session, not the level of discomfort in our conscious mind.

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