# Feeling Cold

## Gender Differences to the Experience of Cold Stress

Gangapurna Tal – Glacial lake at base of Gangapurna Glacier, Nepal, 2012.

**This is an educational aide memoir and does not represent any medical advice. For that you need to see a qualified medical practitioner, ideally familiar with trekking and climbing, and managing cold weather.**

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## Document Control

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A conversation high on the side of Ama Dablam, Nepal, in 2014 got us thinking about the very real differences in perceptions of temperature between men and women. With the overnight 'still' temperatures plummeting to -30C it was a not unreasonable topic of conversation, and was sparked by our female colleagues who observed it was easier for men to find cold weather gear than men. And that this was a problem, given women felt the cold more than men. This difference was held out as real science by two of our female colleagues, one of whom was a doctor. Some of our female trekking colleagues will tell us they feel the cold more than their male counterparts. Is it imagination or is there real science in this? And if there is, does it really matter?

It matters in a number of areas. No trip planner should assume everyone will respond to extreme temperatures the same way as everyone else, whether that is male or female. And, as we discover below, there is indeed real science behind perception differences based on gender. That means a colleague's claim that they have had a more cold experience than you cannot be dismissed as simply "just in their head."

There has been little study done on gender differences in response to extreme ranges of temperatures, hot or cold. However there are extensive studies on male responses, many carried out by the military. For example, the US Navy has numerous studies on survival rates in various water temperatures. Given the preponderance of military research, the traditional gender bias towards males, is understandable. Those more recent comparative studies which have been carried out on both genders appear to suffer from very small sampling. In general, as one study noted, there is a "relatively poor understanding of female thermoregulation." But we work with what we can get our hands on.

**How Does Our Body respond to the Cold?**

There are two main responses, both of which you know. But one can be subtle, the other not. The first, and immediate response is the subtle response, and it's the action the body takes to limit the exposure of warm blood to cold air or water. In simple terms your body pulls back blood from the surface where it is coldest. The second response is active and not so subtle. It's metabolic, and aims to generate heat. In other words, shivering.

Constriction of Blood Vessels

Before we talk about blood vessel construction, remember that arteries are a high pressure system which carry oxygenated blood from the heart, while veins carry deoxygenated blood back to the heart. Veins are about carrying blood away from the skin and surface tissue.

In the first response the body moves blood back from the surface into the core. It does that by constricting the body's blood vessels. In what is called 'thermoneutrality" heat fluxes are controlled and temperature is regulated via skin vascular tone. Thermoneutrality exists when only cutaneous (skin) responses are recruited to regulate body temperature. In air, the ambient temperature for thermoneutrality is 23C-26C, while in water it is 34C-36C.[1] When the ambient temperature drops below these

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numbers the body automatically responds with vasoconstriction (increases cutaneous vasomotor tone). It also responds with a more dynamic activity - thermogenesis (metabolic energy transformation), which manifests itself most obviously by shivering. These two responses are the primary body responses to cold.

On exposure to cold air or water the immediate and generalised reduction in skin temperature leads to venoconstriction (constriction of veins) and vasoconstriction (constriction of blood vessels in general). Venoconstriction happens more quickly because cutaneous veins are more sensitive to temperature shifts. Increased tone in these vessels reduces the volume of blood at the surface, an action aided by various hormones. The constriction and other changes in the sub cutaneous veins displaces blood into deeper veins, moving from the periphery to the core, producing a rise in arterial pressure, a rise in heart output and stroke volume and a consequent reduction in cardiac frequency.

> *In sum "cold induced vasoconstriction is maximal even in in moderate air temperatures and reduces heat loss <u>instantaneously</u> by increasing tissue insulation, reducing conductive heat transfer and minimising exposure of warm blood to the cold environment."*

But there are some fascinating and complex mechanisms at play beyond the constriction we have just looked at. The extremities of the body, especially hands, feet and ears (or those things that seem to feel the cold first) contain "specialised networks of arteriovenous anastomoses (links) that supply blood to the venous plexus (a collection of veins in the body core. There are a few of them.) directly from small arteries. These anastomoses play an important role in temperature regulation since their synchronous closing is linked to heat balance. During thermoneutral exposures anastomoses <u>constrict up to three times a minute</u>, causing rapid blood velocity fluctuation in these arteries. They remain closed during cold stress but open during heating…”

Or in more simple terms, those cold bits you are always trying to cover up actually have pathways which help shift, or even pump blood away from them and point it into the centre of the body (venous plexus).

Shivering

The second principle reaction to the cold is metabolic – generating heat through shivering. Or, through "shivering thermogenesis". Shivering, which is an involuntary reaction, can increase metabolism 5 – 7 times above that which you experience at rest. In fact shivering is so powerful the contracting forces of the muscles can be 15-20% greater than the hardest voluntary work a muscle is asked to do.

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Metabolism is increased under acute cold stress by triggering adrenalin, specifically stimulating lipid (fat) and carbohydrate metabolisms.

**Water Versus Air**

While we are talking about how the body reacts to the cold its worth considering the different responses of the body to air versus water. Exposure to air is a very different experience to exposure to water. Water strips heat away from the body more comprehensively than air might, in particular because it accesses body areas which a huddled person might protect from cold air.

An experiment involving cold water immersion suggests there is no difference in response to cold temperature between the genders. The experiment was driven by the prediction models of survival time for cold exposure which are in use as a decision aid in search-and-rescue operations. Such predictions are largely based on the physiological factors that affect the rate of heat production within the body and physical factors that affect heat loss from the body. These models were subsequently calibrated against data involving male responses to cold.[2] This particular experiment was looking at the metabolic response to cold (in this case being immersed for 90 minutes up to the neck in water which was 18 degrees) and also the temperature response. There were different responses between men and women in areas such as blood concentrations of free fatty acids. But there were no significant gender differences in metabolic heat production. Nor was there any difference between fat used to produce heat. Men and women responded very similarly to being exposed to these conditions.

**Gender Differences**

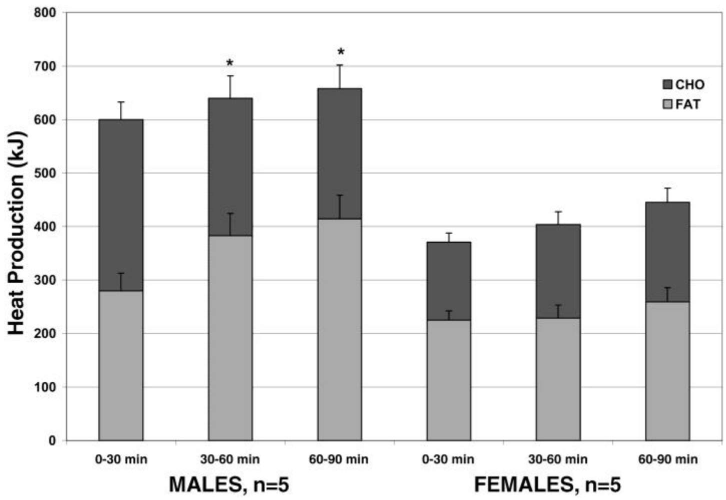
That last point nicely sums up the fact that the male and female physiological responses to cold temperatures are the same. That being the case, what if anything is the science behind the different perceptions of cold?

Gender Differences in Metabolic Burn

In the first instance, a matter of interest is the measurements which show gender difference in heat production due to the metabolic 'burn' of carbohydrate and fat. The difference between men and women is significant. Over time men burn fat at in

[2] Comparison of thermoregulatory responses between men and women immersed in cold water.
P. Tikuisis, I. Jacobs, D. Moroz, A. L. Vallerand, L. Martineau
Journal of Applied Physiology Published 1 October 2000 Vol. 89 no. 4, 1403-1411

increased rate while the fat burn rate of women is reasonably constant. You can see these differences captured in the chart below. Different burn rates may underpin the sensation by men that they don't feel as cold, even when sharing the same environment as women, as we observed on Ama Dablam. The researchers behind this data note these are absolute results and that when variations in body fat, weight and so on are taken into account there is no difference between the genders. But we all know that we never ever walk or climb with a standardised group. Ever. So the absolute results are actually of interest to us.




*Heat production due to carbohydrate (CHO) and fat metabolism of men and women who completed 90 min of immersion with similar intensities of shivering compared with their O2 consumption*



This was a physiological experiment, objectively assessing the response of the body to these conditions. What's of interest to us is what each of the male and female subjects said they felt about the temperature, a much more subjective problem to assess. Unfortunately the researchers didn't record of any of this feedback.

Gender Differences in Body Mass

Body mass has an impact on cooling rates, and in particular the ratio of body surface area to mass. This ratio is "…larger for smaller mammals, thereby facilitating heat loss as does a greater relative linearity. Consequently adolescents cool more rapidly, as do women with an adiposity equivalent to that of mean [a nice way of saying 'fatter than average'] and also tall lean people. Women also tend to have a relatively smaller muscle mass, a major contributor to resting insulation." [3] That latter observation is almost thrown away but is a significant factor in the differences between male and female perceptions of cold.

During cool air exposure women have lower skin temperature than men,[4] a difference maintained during exercise. In addition women tend to be more aware of skin cooling, particularly during the luteal phase (ovulation) and prefer a higher skin temperature.[5] Women also maintain a lower skin blood flow, even during resting heat stress. As a result women have show a greater resistance to cutaneous heat loss, and their skin environment temperature gradient is small in the cold.

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[3] Human Physciological Response to Cold Exposure, Authors: Stocks, Jodie M.; Taylor, Nigel A.S.; Tipton, Michael J.; Greenleaf, John E. Aviation, Space, and Environmental Medicine, Volume 75, Number 5, May 2004, pp. 444-457

[4] Comparative thermoregulatory responses of resting men and women, Journal of applied physiology: respiratory, environmental and exercise physiology 45(6):908-15 · January 1979

[5] Changes in the cool threshold associated with phases of the menstrual cycle Journal of applied physiology 21(3):1031-9 · June 1966

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Menstrual Cycle as a Temperature Regulator

Complicating any gender comparison is the fact that the menstrual cycle impacts body temperature and the regulating of temperature. The menstrual rhythm interacts with body temperature, thermos regulation and non thermos regulatory systems. The cycle can also lead to 0.7C fluctuations of core temperature over a 24hour period which in turn impacts vasomotor (actions which dictate blood vessel diameter) control. Further, interactions between the menstrual cycle and other regulatory hormones modify body fluid and electrolyte regulation, thermal comfort and [heat production] thresholds while estrogen is shown to impact thermos-sensitivity neurons in the brain. These are all factors difficult to control in experiments so there is little 'measurement' and only the sort of general observation we note here in this paper. In short, female regulation of heat is poorly understood.[6]

## Conclusion

So what does all this mean? Apart from (hopefully) having a slightly more informed understanding about our physiological response to cold, the science we have been able to unearth goes some way towards telling us there is indeed a gender based difference to how we feel the cold. That there are good physiological reasons behind why one person can be rugged up and still feel cold, while their walking partner is in shorts and T-shirt and feeling like they are overheating. But how does knowing what we already know impact our trekking and climbing activities? Here are a couple of thoughts.

Planning. You are in a hut getting ready to hit the snow and ice. Half your team is ready to go, but their cold weather gear is in their day pack, and one is in shorts, but wearing thermal vest and t-shirt. The other half of the group are still struggling into their gear. It's simple really – make sure your planning accommodates those who really do need to get those extra layers on. And mind the pace. Rushing out the door quickly because the lightly clad team members are more than ready and chaffing at the bit only runs the risk of those still getting dressed missing a vital piece of equipment. Take your time and make sure every team member is properly and safely and comfortably rigged before you depart.

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[6] Human Physciological Response to Cold Exposure, Authors: Stocks, Jodie M.; Taylor, Nigel A.S.; Tipton, Michael J.; Greenleaf, John E. Aviation, Space, and Environmental Medicine, Volume 75, Number 5, May 2004, pp. 444-457

But there is another perspective to planning. If you are one who feels the cold and know the extra layers need to be carefully applied, then allow extra time to get ready. That’s especially the case if you are on an expedition which has a ‘hard start’ time. For example, those early morning starts aimed to cover as much ground on hard snow before it turns to mush. You don’t really want to be holding up the group as you wrangle that extra glove layer or hunt for your chemical hand warmers.

Overall, it’s about being considerate of your fellow trekkers. Knowing there are different tolerance thresh-holds for temperature means we all need to be looking out for each other as we prepare gear and rig for a trek.  People can get lost in even a small group, so also pay attention to each other and look out for symptoms of extreme duress (hot or cold) even if you are not feeling stressed yourself. That’s not science. That’s just being considerate.

Gear planning.  You may want to pay particular attention to the preparations for cold weather of your female colleagues. A female mountaineering colleague has pointed out the obvious – just because you are a female does not mean you have to buy gear labelled for women. She noted the following in a conversation about gloves, “I wouldn't buy women's specific, they tend to skimp on the down stuffing due to the size of the glove.”  But she also said she was always on the hunt for warm gear. Does that mean men’s equipment is suitable? Possibly. There can be a down side (pun intended) to that as well. As another female climbing colleague noted, “buying men’s gloves is a problem as they are bigger and don’t fit my hands properly. I might be able to get another layer in there but the large gloves are clumsy and it’s hard to handle anything”.

However it’s these conversations, and trial and error that means the gear planning and experimentation can lead to those who feel the cold eventually rigging well for the weather.

Finally, this understanding helps ensure no one is ever guilty of dismissing the cry of 'I'm cold' as simply 'being in your head'. Well, it is. But it's also every other part of the body and it's a real perception which needs accommodating, not dismissing, ignoring or belittling.