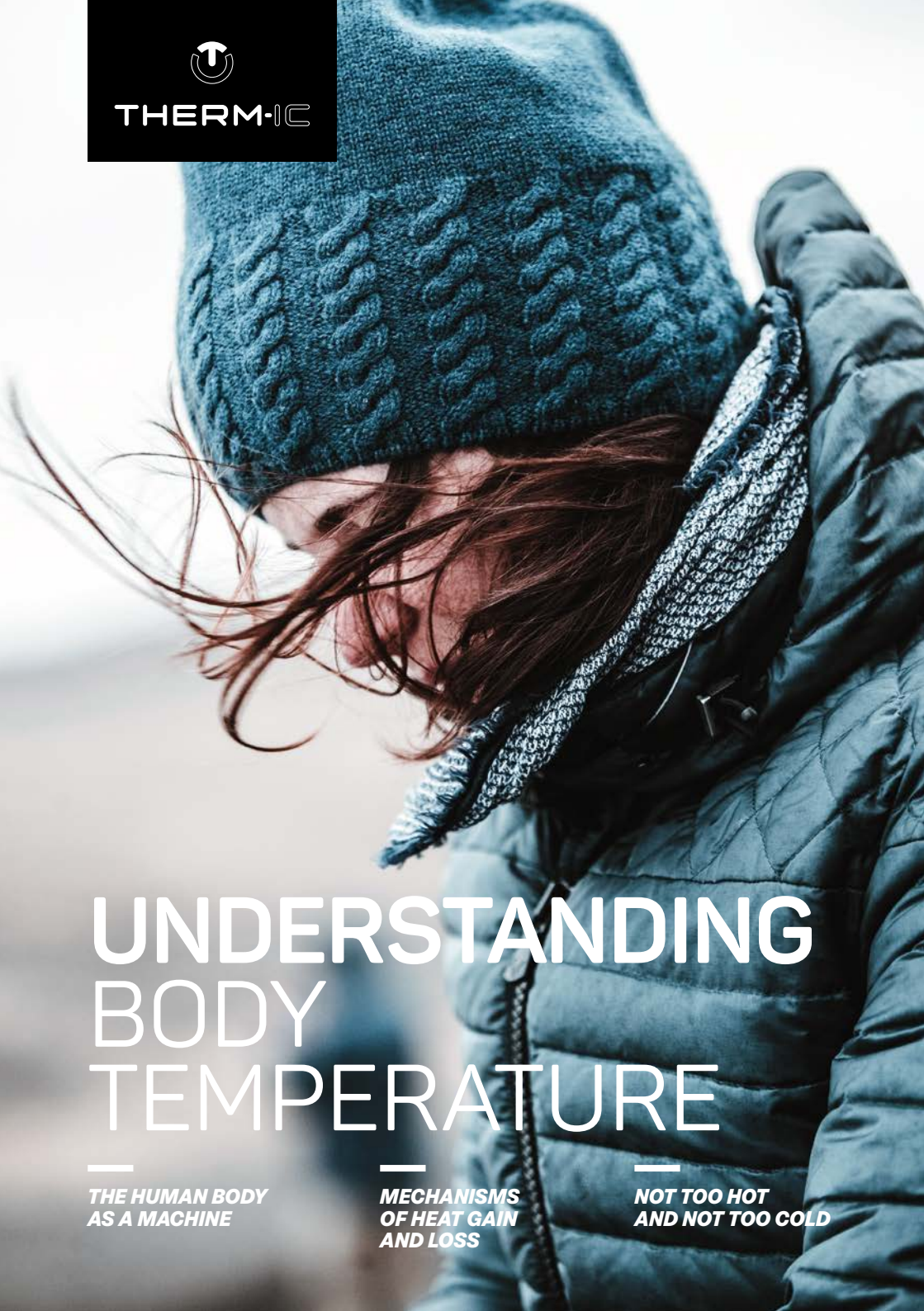


THERM-IC

UNDERSTANDING BODY TEMPERATURE

THE HUMAN BODY AS A MACHINE

MECHANISMS OF HEAT GAIN AND LOSS

NOT TOO HOT AND NOT TOO COLD

Humans: warm-blooded beings that know how to keep their cool

Humans are superhuman. They are gifted with exceptional resilience. The human body is equipped with the ability to survive in all kinds of conditions. From the cold of the Siberian steppes to the sweltering heat of the Arabian desert, and from the humidity of the Amazonian rainforest to the Himalayan mountain ranges, humans are able to adapt.

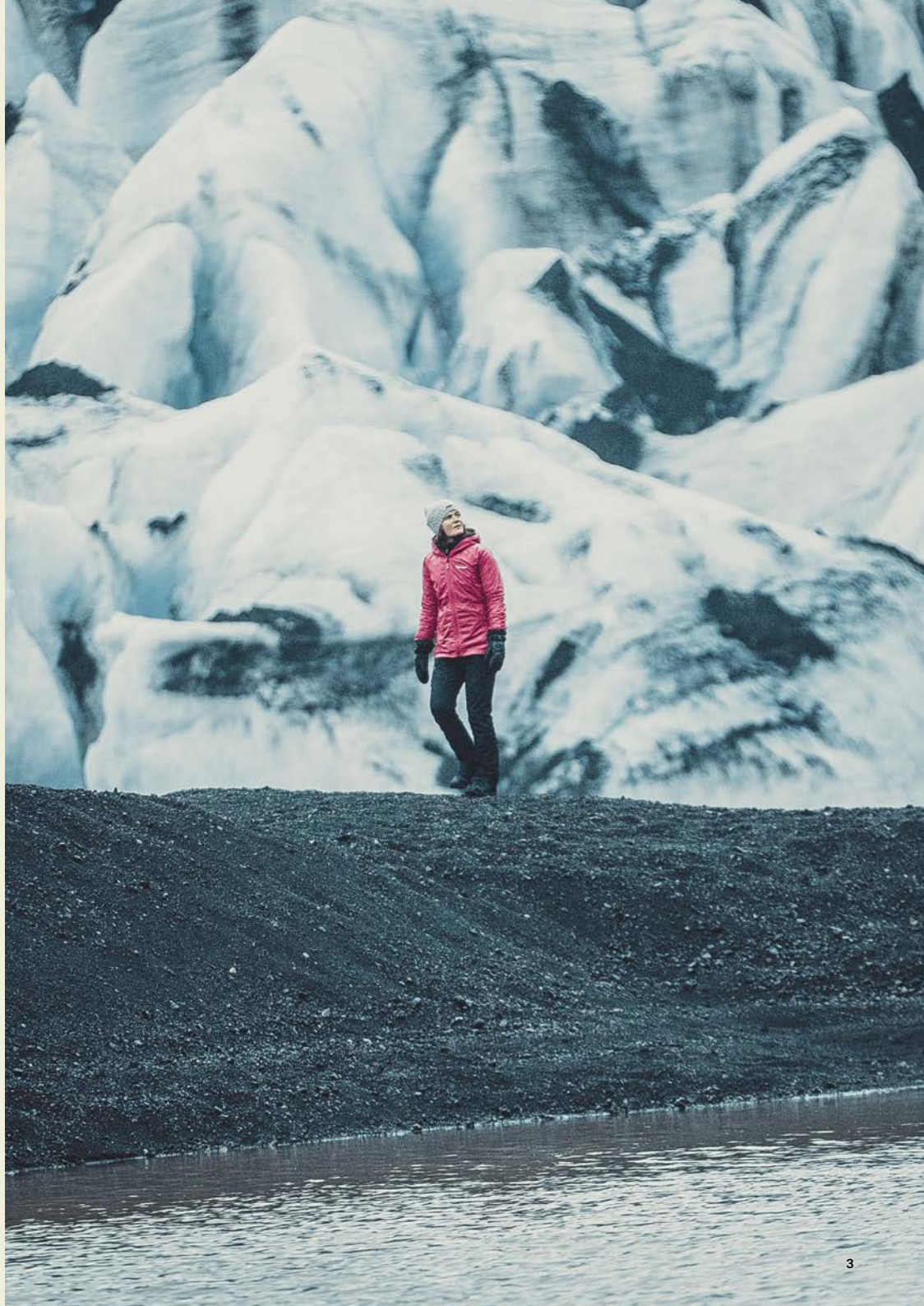
They do so through natural mechanisms that allow them to acclimatise and regulate themselves in response to their environment. This is how body temperature is controlled. No matter what their environment, human beings seek to keep their body at a constant temperature. Humans are therefore **"warm-blooded"** beings, said to be **homeotherms:** whatever the external conditions, they keep their internal temperature around an average target value of **37 °C**.

Why? Because 37 °C is the optimal working temperature for metabolism and muscles. In other words, our cells and muscles are most effective at 37 °C.

More precisely, body temperature fluctuates between **36.1 °C, in the middle of the night**, when our metabolism is least active, and **37.8 °C in the late afternoon, when it is at the peak of its activity.**

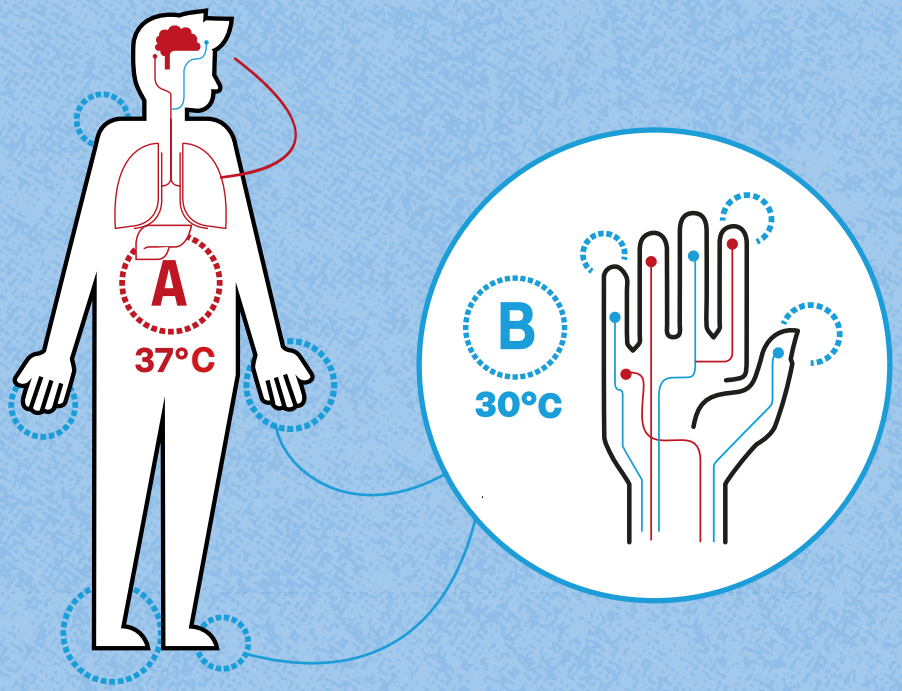
In contrast to humans as homeotherms, some species, such as lizards, are called **poikilotherms.** This means that their internal temperature is the same as the ambient air temperature.

36,1° / 37° / 37,8°



Two rooms with two different ambiances

While the average human body temperature is 37°C, it is **not exactly the same throughout the body.** The human body is actually made up of two different regions. Two rooms with two different feels. Two areas, two atmospheres:



A

The central region, called the “core” or “trunk”

which includes all the vital organs essential to our survival (the respiratory and digestive systems and the brain), and whose temperature is **maintained around 37 °C.**

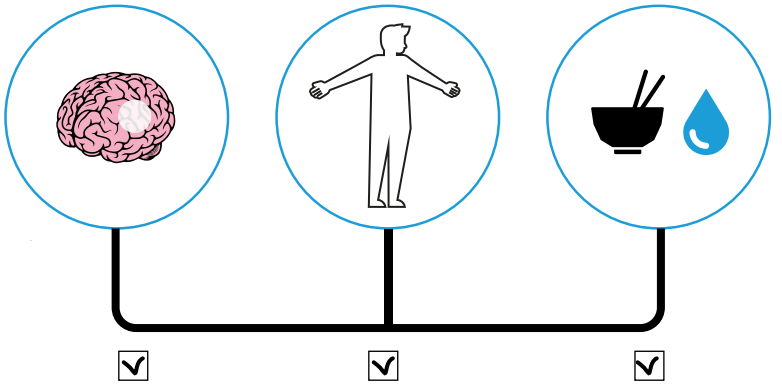
B

The peripheral shell

which includes all of the “extremities.” These organs are incredibly useful but not essential to life (hands, feet, etc.), and can slightly fluctuate in temperature without causing significant harm to the body.

The human body as a machine

The body is an incredible machine. The way it **regulates its own temperature** can be likened to a shiny sports car, which requires:



A driver: the hypothalamus.

Situated in the brain, this plays a crucial role as a **control centre** responsible for continually analysing information from central **thermoreceptors,** sensing blood temperature, and from peripheral thermoreceptors in the skin.

When it receives this information, it compares it to a set value and then **activates regulating mechanisms**.

An engine.

The “central core” or trunk of the body, whose **sole objective** is to maintain its constant, optimal cruising speed of **37 °C**.

Fuel.

Because, to work efficiently, our thermoregulation system needs **food** and energy for metabolic reactions: **oxygen** to maintain cell activity, and **water**, which is essential for blood flow.

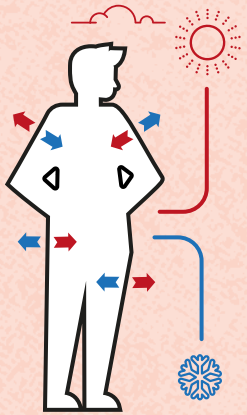
Mechanisms of heat gain and loss

Maintaining a constant temperature requires the body to constantly seek a balance. A tightrope walk on the thin wire of 37 degrees Celsius.

1

Radiation

Radiation is the exchange of heat in the form of infrared rays between the human body and elements around it with a different temperature.



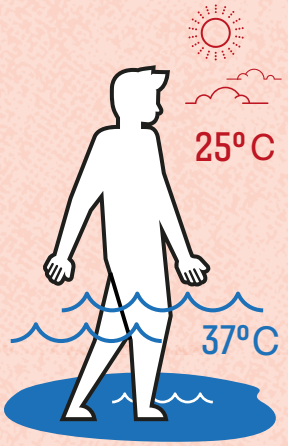
» It is through **RADIATION** that the body heats itself by absorbing rays of sunshine. It is also through RADIATION that it loses heat by radiating it out in turn in cold conditions.

» RADIATION accounts for most of the heat exchange carried out by the human body. In fact, despite being scarcely noticeable, radiation constitutes **the main source of heat loss for human beings** (between 40 and 60%).

2

Convection

Convection is defined as the exchange of heat between the body and the ambient air or water in which it moves.
Both air and water have an isothermic point.
The isothermic point is the temperature below which the human body, in that particular environment, loses heat.



» The isothermic point of air is **25°C**
> when the ambient air temperature is below 25°C, the human body loses heat.

» The isothermic point of water is **37 °C**
> when the ambient water temperature is below 37°C, the human body loses heat.

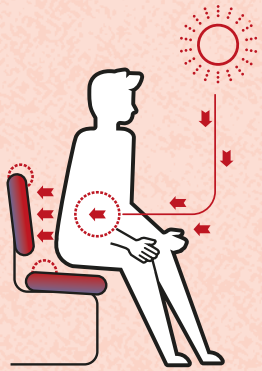
Heat loss through convection thus increases if the surrounding air or water is in motion. Wind therefore contributes to cooling. This is called the "wind chill factor," and explains why the much talked-about "apparent temperatures" in winter are often below those shown on the thermometer.

3

Conduction

CONDUCTION is the exchange of heat between two bodies in contact, without one moving away from the other.

» You can see an example of this in action when a seat stays warm after you have sat on it for a while.



4

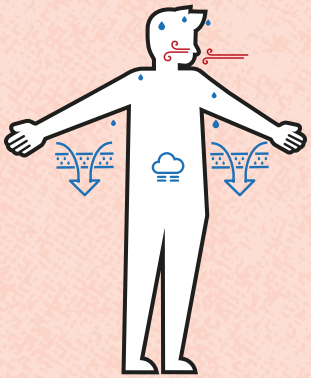
Evaporation

Evaporation is the loss of heat linked to secretion of water by the body.

This EVAPORATION can be:
» Passive, via **RESPIRATION** > the air we breath out is laden with moisture.

» Active, via **PERSPIRATION** > when the body creates a layer of water on the skin in order to cool down.

Evaporation represents around **25% of heat loss at rest** but can reach up to **80% during exertion**, mainly through sweating, in the context of physical activity.



In summary

» In order to maintain its comfort, our body seeks a balance of temperature. It achieves this when the heat it generates balances out the heat it loses through external cooling. Balanced body temperature is the product of these 4 heat transfers, which we may not even notice taking place: they happen naturally, but help our body to adapt to all kinds of conditions.

NOT TOO HOT...

How your body protects itself from the danger of “overheating”:

Cold is often seen as the only climate factor that can really harm humans in the context of mountain sports or professional activities. This is a **total misconception**, because **high temperatures, which are wrongly seen as uncomfortable rather than dangerous,** can become a real threat to health. A threat that the body is able to contain, up to a certain point, due to its ability to self-regulate.

A

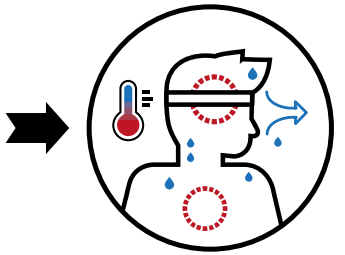
A dispersal of heat through thermolysis

i.e. the set of processes used by the body to expel excess internal heat towards its external environment.

» 01/ As we saw before, **radiation, convection and conduction all play a role in heat dispersal**, but they often turn out to be insufficient in the context of exertion during sport.

» 02/ Evaporation of heat after sweating then becomes the main method by which the body regulates itself.

Sweating produces **a thin film of water on the surface of the skin.** This very thin layer of liquid cools us down, first by **reducing the temperature of the skin**, and then by producing **a loss of thermal energy** of 600 kcal/h to enable this sweat to evaporate.



B

The circulation also adjusts

The circulation also adjusts to promote heat dispersal, as seen in **vasodilation of the blood vessels**, which expand in diameter. This increases blood flow and rapidly expels excess heat in the central core towards the peripheral shell.

How your body reacts to the danger of hypothermia

When our core temperature falls below 37°C, our body **gets cold** and responds with two immediate reflexes: generating heat, and retaining heat.

A

Generating heat

Via two main mechanisms:

» 01/ THERMOGENESIS
Generation of heat linked to metabolic activity in the body.

Shivering is a sign of thermogenesis in the skin: it consists of **repeated involuntary muscle contractions leading to production of heat by the subcutaneous tissues.**
Some experts call it *"a natural response to cold"* that can serve as a *"poor man's thermometer."*

» 02/ ABSORPTION OF HEAT FROM AN EXTERNAL SOURCE

Sources of heat can be: **ambient air**, if warmer than 25°C (convection), or **rays of sunshine** (the phenomenon of radiation, see pages 6 & 7).

B

Heat retention

The generation of heat is accompanied by retention of the heat that is already in the body. This retention is seen in **vasoconstriction of the peripheral blood vessels** in order to limit exchange with the external environment.

The vessels located near the skin **shrink in diameter in order to isolate the peripheral shell from the central core** and direct blood flow primarily towards the deep veins.

At this time, the body prioritises protecting organs from the cold in order of importance. **The trunk and vital organs are favoured to the detriment of the hands and feet, which are "sacrificed".** This is primarily seen in a sudden drop in skin temperature.

HIGH RISK ACTIVITIES

It is unusual for feelings of cold or warmth to become immediately unbearable. This is why we may not seem particularly bothered by them at first. However, such carelessness can tip the body into extreme and even sometimes irreversible situations: **hypothermia** or **hyperthermia**. These are extreme dangers to which people can be exposed even in fairly ordinary conditions, simply through lack of experience or negligence - not just when climbing Everest. **Caution** is therefore the key.

A

Hyperthermia

⚠ >40°

From 38 °C, the body is subject to nausea, vomiting, dizziness and major muscle weakness. But **the situation really becomes critical when the individual stops sweating.**

⏩ Hyperthermia corresponds to an elevation of the core temperature to around 40 °C. It equates to what is often called "heatstroke", a state characterised by the inability of the body to regulate its own temperature.

There are numerous clinical signs, which worsen as the temperature increases.

⏩ Hyperthermia **above 40 °C** leads to liver and kidney failure, severe neurological problems, hyperventilation, hypotension and tachycardia.

CASE EXAMPLE

*Some individuals, who have **Raynaud's syndrome**, are predisposed to problems with their body temperature. This chronic condition manifests itself in **problems with circulation in the extremities** (hands and feet, etc.) and **hypersensitivity to the cold**. For people with this syndrome, having white hands and numb feet is a daily reality in winter. It can however be managed with appropriate specialised gear.*

B

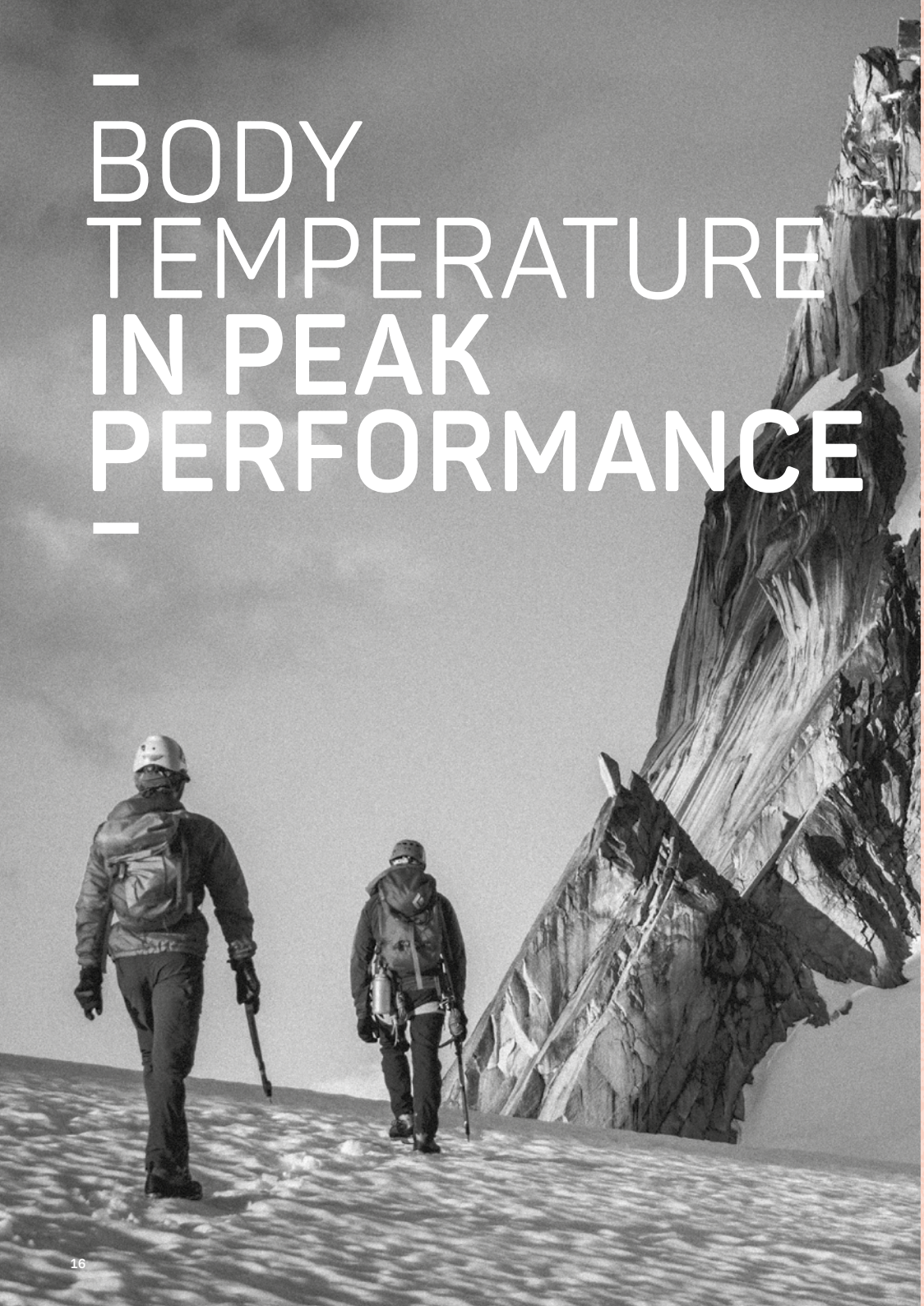
Hypothermia

⚠ ❄ <35°

⏩ **Hypothermia is defined as the critical situation where the temperature of the central core falls below 35 °C, with potentially fatal consequences unless action is rapidly taken.**

⏩ Hypothermia is preceded by several successive stages of thermoregulatory response at different thresholds:

At 36.8 °C	At 36 °C	At 35.5 °C	At 35 °C
Vasoconstriction to limit heat loss is triggered.	**The production of heat** via thermogenesis becomes highly active.	Onset of **shivering**.	**The body shivers** at its maximum intensity but **the mind remains clear**.
Between 35 and 32 °C	**Between 32 and 28 °C**	**Between 28 and 25 °C**	**Below 25 °C**
MODERATE HYPOTHERMIA	SEVERE HYPOTHERMIA	EXTREME HYPOTHERMIA	STATE OF APPARENT DEATH, DUE TO CARDIAC ARREST
Shivering becomes constant, normal functions decline and the desire for survival decreases, but **the individual remains conscious**.	**Shivering stops** and is replaced by muscle rigidity. **The individual becomes very confused.**	**Severely life-threatening.** Muscle rigidity reaches its peak while heart rhythm and respiration become very weak.	



BODY TEMPERATURE IN PEAK PERFORMANCE

Pascal Zellner is a doctor. A doctor of mathematics, physics and medicine, but above all of the mountains. A pro on the peaks and an authority on altitude, this emergency doctor is the guardian angel of daring (sometimes too daring) climbers. Driven by his passion for mountains and a desire to advance science, he created and now chairs IFREMMONT, the Institut de Formation et de Recherche de la Médecine de Montagne (Institute for Alpine Medicine Training and Research), which is based in Chamonix.

WHAT ROLE DOES MANAGEMENT OF BODY TEMPERATURE PLAY IN THE MOUNTAINS?

Thermoregulation plays an essential, fundamental role. Proper management of body temperature is a major factor in the success of an ascent, which often takes place over several hours. The body thermometer is the barometer for an individual's fitness, level of fatigue and remaining reserves. For optimal management, it is crucial to pay attention to your body, and to know it inside out. Because a problem with body temperature can be resolved much more quickly than an issue with hydration or food intake, but if not managed can put you in a dangerous situation very suddenly.

"THERMOREGULATION HAS A MAJOR IMPACT ON SPORTS PERFORMANCE"

OTHER THAN IN RELATION TO RISK MANAGEMENT, DOES PROPER CONTROL OF BODY TEMPERATURE HAVE AN IMPACT ON SPORTS PERFORMANCE AT ALTITUDE?

Absolutely! Thermoregulation is not simply an issue of survival. It also plays a key role for those involved in sport with a desire to perform. The bodies of elite athletes have a quite simply extraordinary ability to adapt to conditions.

HOW DOES THERMOREGULATION CONDITION OPTIMAL SPORTS PERFORMANCE?

There are two reasons for this. Firstly, sports performance is linked to muscle performance, and it is at 38 °C that the muscles are most efficient, when they can focus on pure function. Secondly, muscle performance itself depends on cell performance. And all metabolic mechanisms, including generation of the energy needed by the muscles, work best when the core of the body where these interactions take place is at 37 °C.

WHAT IS THE IMPACT OF ALTITUDE ON HUMAN BODY TEMPERATURE CONTROL?

The higher up it goes, the more the human body comes up against a dual challenge. Firstly, the level of oxygen decreases, reducing performance and impairing heat generation. Secondly, it is estimated that external temperature falls by an average of 1°C for every 100 metres of ascent during an expedition. This is the double difficulty of altitude: the ambient temperature decreases, and heat generation decreases. ●

Thermo-stats

1978

The year that saw the introduction of the first cryotherapy chamber, a tank injected with nitrogen-rich air at temperatures as low as -164°C.

4 *g/L*

Loss of mineral salts due to sweating during physical activity.

32°C

Minimal core body temperature; temperatures below this are life-threatening.

200 kcal/day

The daily production of heat linked to respiration alone.

93%

Of the body's thermal sensors are used to measure cold.

3

layers of appropriate clothing that you should put on before venturing into the mountains.

1500/1700 kcal/day

Standard daily production of heat for a woman / a man.

2L

of water lost in 1 h during relatively strenuous physical exercise.

⚠ 40.5°

Critical body temperature where hyperthermia becomes a deadly risk.

60%

of heat loss from the human body occurs through radiation.

75%

loss of power and endurance in the muscles when their temperature drops.

1.7 L

of sweat lost, without doing any particular physical activity, in hot conditions.

10

micro-contractions in the muscles per second when you shiver.

500 *mL/hour*

minimum intake of fluid during a session of sport.

True or false

“The speed with which blood circulates is the same throughout the body”

▶ FALSE...

At rest, when it leaves the heart, blood flows at a speed of 400 mm/s (millimetres per second) in the arteries, compared to 0.5 mm/s in the blood vessels in the fingers, which are much narrower. This is why the extremities are less resistant to cold.

“The body cools down much quicker in water”

▶ TRUE...

The isothermic point of water is 37 °C, compared to 25 °C in air. The isothermic point is the temperature at which our body loses heat through conduction to its surroundings. That’s why water at a temperature of 22 °C makes you feel much colder than air at 22 °C, which is generally rather pleasant.

“High altitude begins at 4000 metres; below that you’re at intermediate altitude!”

▶ FALSE...

High altitude begins at 2000 m! This is where the early signs of hypoxia begin, the body’s cells become less efficient, and regulation of our body temperature is also therefore impaired.

“Hot drinks are a better source of hydration”

▶ TRUE, BUT...

The image of the Tuareg people sipping boiling hot tea amid the searing 50 °C ambient heat of the Sahara desert is no myth. Hot drinks do in fact promote vasodilatation along with heat loss through evaporation. However, drinks that are “too” hot can be counterproductive, because sweating “too” much necessarily leads to dehydration.

“You should wipe sweat away when you perspire”

▶ FALSE...

Sweating allows the body to cool down by creating a thin film of water on the surface of the skin. Wiping this off is therefore like pulling the rug from under the body’s feet in an attempt to disperse heat.

“You only get goose bumps when the body is cold”

▶ FALSE...

Goose bumps can be caused by cold, but also by strong emotion and even heatstroke. This pimpling of the skin is a natural response of the body to certain kinds of imbalance, not to be confused with shivering, which occurs when the body gets cold, to contract the muscles and warm it up.

“Our ability to regulate our own body temperature changes over the course of our lives”

▶ TRUE...

Management of body temperature changes with age: in newborns it is highly erratic because their central nervous system is still very immature, while the elderly, who have much weaker blood flow, succumb more easily to variations in temperature.

“When someone has hypothermia, they need to be warmed up to 37°C as quickly as possible”

▶ FALSE...

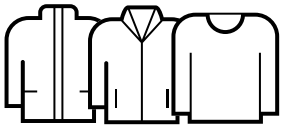
The worst possible response would be to try and reverse this drop in temperature suddenly. They must be warmed up very gradually, otherwise there is a risk of cold blood rising from the extremities to the heart and triggering a cardiac arrest.

TIPS

PROTECTING YOURSELF FROM THE COLD

You can't be judged by your clothes - except when it's really cold, your clothes become the key to avoiding hypothermia.

"The rule of 3"

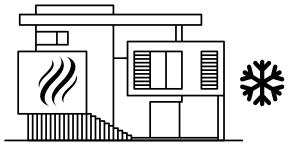


In the mountains, the rule of 3 becomes a golden rule for clothing. You should wear at least 3 layers of clothing, but these should be chosen carefully.
The first layer, in contact with the skin, should be breathable in order to wick away sweat and thus reduce moisture. **The second layer** should trap in warm air, in order to create a temperate middle section. **The third and final waterproof layer** should protect the body from the elements such as water and wind.

The extremities: the weak link

The hands, feet and head are most exposed to the cold. They should therefore be protected with specialist high-quality clothing (gloves, socks and hats). Glove liners work well, but **heating products** can be even more useful and effective in helping the body to **regulate its temperature**.

Gradual change is the key



The human body **hates sudden changes** - that's why it's not a good idea to turn your flat into a sauna during the winter, or turn your car into an oven before a day's skiing. The bigger and **more sudden the drop in temperature**, the harder it is for our body to implement the right measures.

TIPS

PROTECTING YOURSELF FROM HEAT

Although seldom seen as a threat, hyperthermia is just as dangerous as hypothermia.

Pay attention to your thermostat

The best advice is to remain alert to **the signs from your body**. The body cleverly provides very clear signals that you need to be able to decipher. For example, staying well hydrated may seem obvious, but is still important to remember.

However, the most important thing is to ensure that you keep sweating.
Why? Because if you have stopped sweating, it means that your body no longer has enough water **to disperse heat through sweat**. That's when heatstroke becomes a looming, imminent threat! The only solution is to stop, hydrate properly and spray yourself with water.

Drink plenty - but not too hot, and not too cold

Drinking more than usual in very hot weather, particularly when playing sport, may seem obvious, and even a survival instinct. However, there are many misconceptions in relation to this. The only rules to follow are **balance and moderation**:

» By all means take in extra electrolytes, but do **not drink overly salty drinks**, as a clump of salt could stick to the oesophagus and create an ulcer.

» Avoid **overly cold** drinks too, as **the refreshment they produce is only a temporary feeling** caused by disruption of thermoreceptors.

» And finally, avoid overly hot drinks... you're not a Tuareg.

Cover up in the sun

Heat often comes with another adversary that is particularly damaging to the human body: radiation from the sun. Rays of sunshine greatly accelerate the risk of "heatstroke." Protect your head to avoid sunstroke, and if the UV index is very high, cover as much of your body with clothing (ideally white, as it reflects the light) as you can. This will prevent you from being directly exposed to these rays, which accelerate evaporation of the crucial thin film of water generated by sweat that is designed to cool down the surface of your skin.

TIP

Making a material difference

The body has a natural ability to regulate itself. However, like any self-respecting hero, it needs a faithful lieutenant to support it on its daily travels. This loyal and devoted ally is clothing.
There are many different types of clothing fibre, both synthetic and natural, each with its specific features, advantages and disadvantages.

Synthetic fibres

- Polyester
- Polyamide (or Nylon)
- Elastane
- Acrylic
- Microfibre

\+

Synthetic fibres are ideal for:

- Insulation, particularly thermal insulation.
- Lightness.
- Softness.
- Wicking away sweat.
- Quick drying.
- Resistance to wear and tear.
- Not shrinking in the wash.
- Their very low cost.

\-

The downsides of synthetic fibres are:

- Their tendency to retain odours.
- Their environmental cost.

Natural fibres

- Sheep's Wool
- Alpaca Wool
- Mohair Wool
- Merino Wool
- Cashmere
- Cotton Silk / Linen

\+

The advantages of natural fibres are:

- Their soft and silky feel.
- Their insulation ability.
- Their stretchiness.
- They disperse odours.
- The prestige of a raw material.
- Their environmentally-friendly aspect.

\-

The undeniable disadvantages of natural fibres are:

- Their cost, which is higher than that of synthetic fibres.
- They have low breathability and thus are ineffective at wicking away sweat.
- They are delicate (in terms of playing sport and washing).

It is now possible to combine the two types of fibre in one item of clothing in order to draw on the advantages of both and thus create the ideal covering.

Equip yourself against the cold!

MODERATE COLD

Insulated mittens with flaps + integrated custom warmers
Insulating materials and natural warmth thanks to an ergonomic custom warmer.
Versatil light Gloves

Pocket warmers
Ideal for all outdoor activities, it goes into your jacket pocket and diffuses a gentle warmth.
Pocket Warmers

Lined insulated socks
An inner layer of silk and Primaloft to keep out the cold, combined with a merino wool outer layer for warmth and comfort.
Ski double insulation

Insulated insoles
Keep out the cold and keep comfortable at the same time, with good support thanks to their 3D shape.
Insulation 3D

INTENSE COLD

Heated mittens
Look after your extremities with these heated mittens offering up to 10 hours of heat, with a choice of three heat settings.
You can't be judged by your clothes - except when it's really cold, your clothes become the key to avoiding hypothermia.
Ultra heat Mittens

Heated jacket
Fight the cold thanks to the 6 heated zones inside the jacket. Control the heat level remotely by using bluetooth on your telephone.
Heated Vest

Heated socks
Socks fitted with invisible heat elements, with bluetooth batteries to regulate the heat remotely.
Powersocks Set Heat Uni + S-Pack 1400B

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