Muscles' properties in cold and hot water immersion, contrast water therapy. Body and core temperature changes during immersion

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A NATIONAL HOLIDAY

- **JULY 6th: Lithuanian STATEHOOD DAY**
  Events dedicated to the 6th of July, the day of the Coronation of the Lithuanian King Mindaugas (in 1253).

- Commemoration of
  THE MILLENNIUM OF LITHUANIA. The first reference to the name of Lithuania in written sources comes to us in 1009 as described in the annals of Quedlinburg, Germany (Annales Quedlinburgenses).

WATER THE GREAT HEALER !

- Water therapy has been used for centuries to heal the sick.

- Hydro- and hydrothermal therapy are traditional methods of treatment that have been used for the treatment of disease and injury by many cultures.

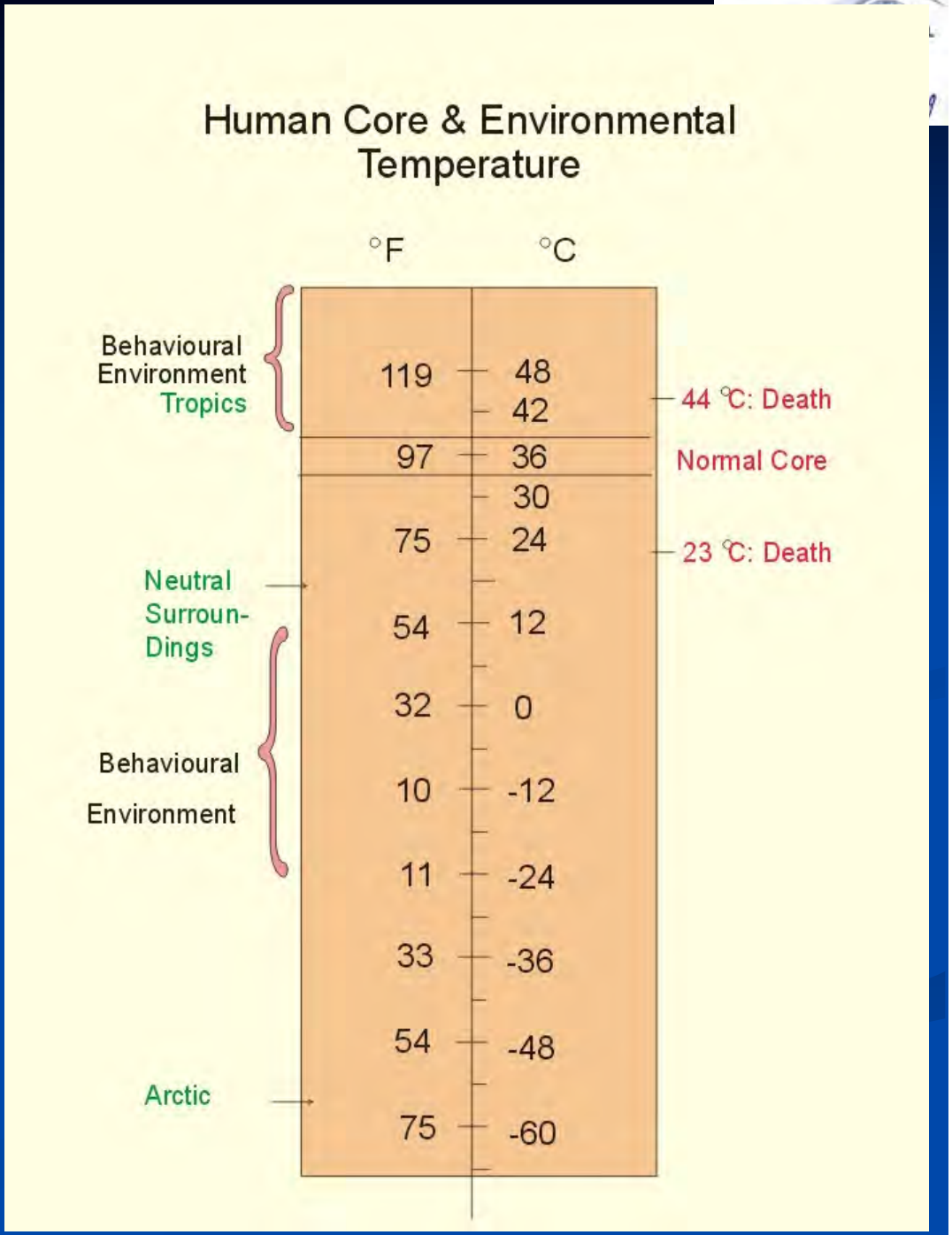
CONTENT OF THE LECTURE

- Body temperature
- Core / shell temperature.
- Thermal sensation

- Recovery (after / before):
  - Cold water immersion
  - Hot water immersion
  - Contrast water therapy

Body temperature

- is a measure of the body's ability to generate and get rid of heat.



BODY TEMPERATURE

- Ear,
- Oral,
- Rectal,
- Armpit.

A rectal or ear temperature is 0.3 to 0.6 °C higher than an oral temperature.

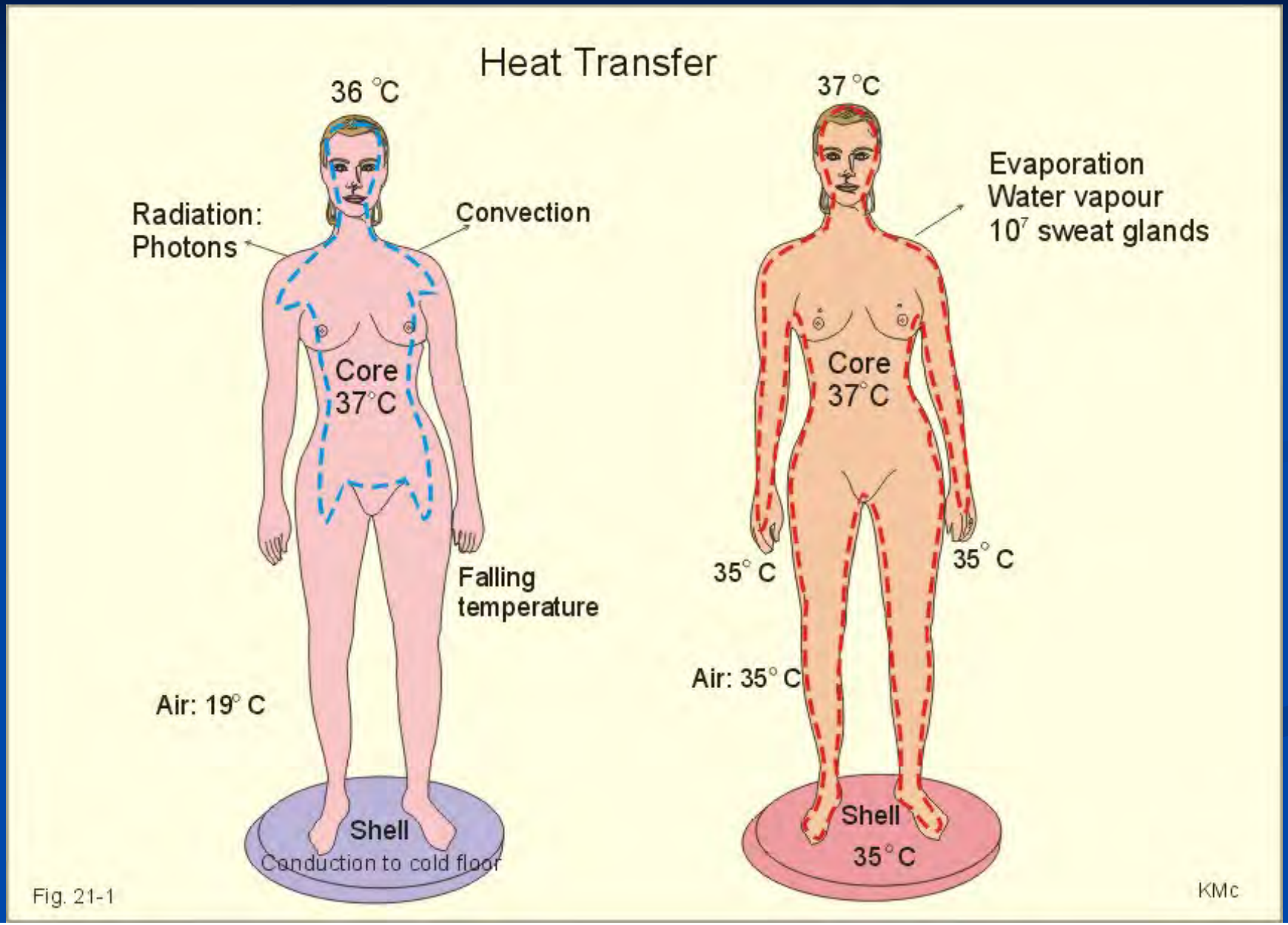
A temperature taken in the armpit is 0.3 to 0.6 °C lower than an oral temperature.

CORE & SHELL

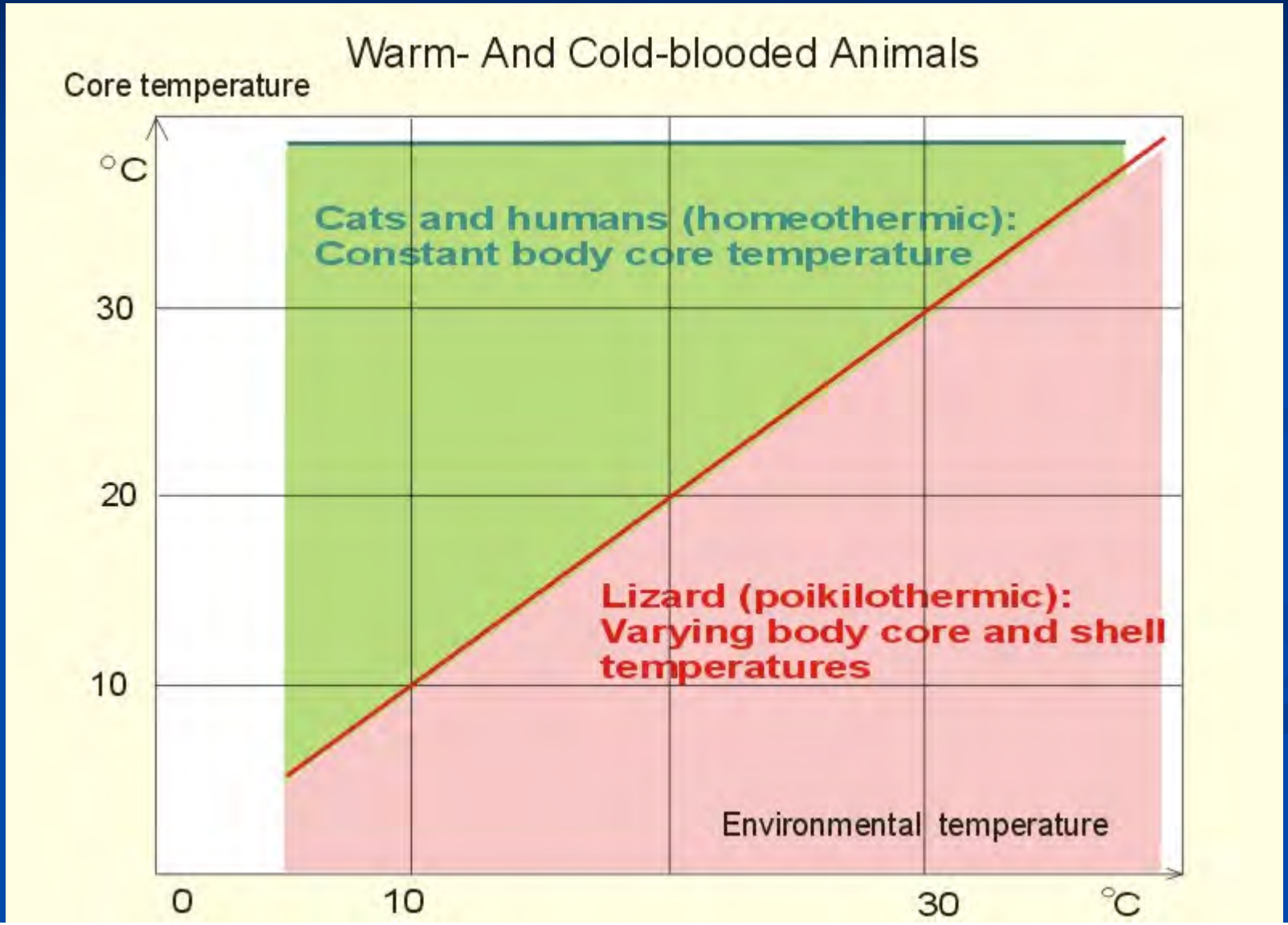
Body core consists of the deeper parts of the body and the proximal extremity portions of warm-blooded animals including man.

Body shell refers to those outer parts of the body (skin and subcutaneous tissue) that change temperature at cold exposure.

THE *CORE* TEMPERATURE



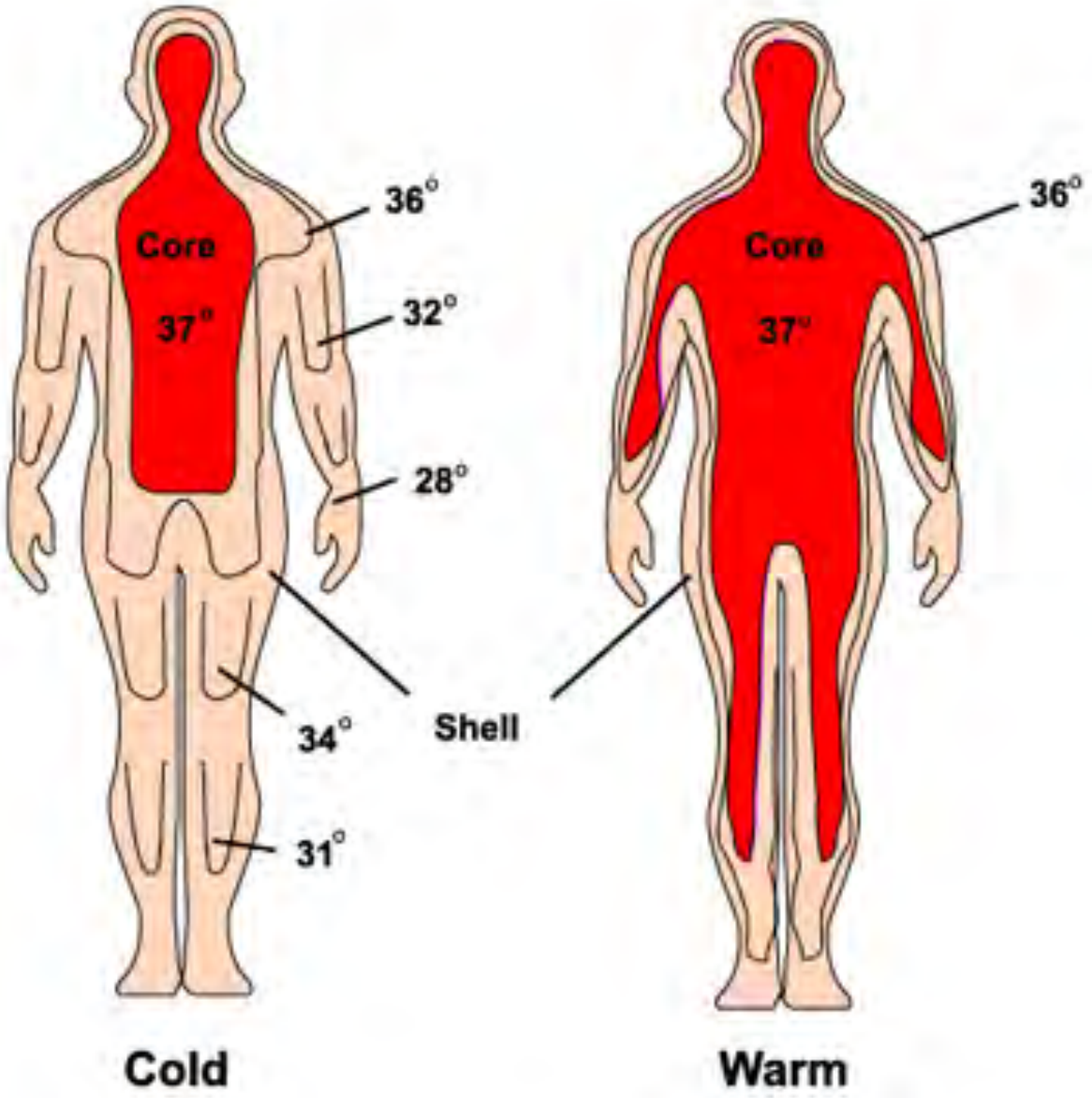
The body core temperature and the environmental body temperature for a warm-blooded animal (cat) and a cold-blooded animal (lizard)



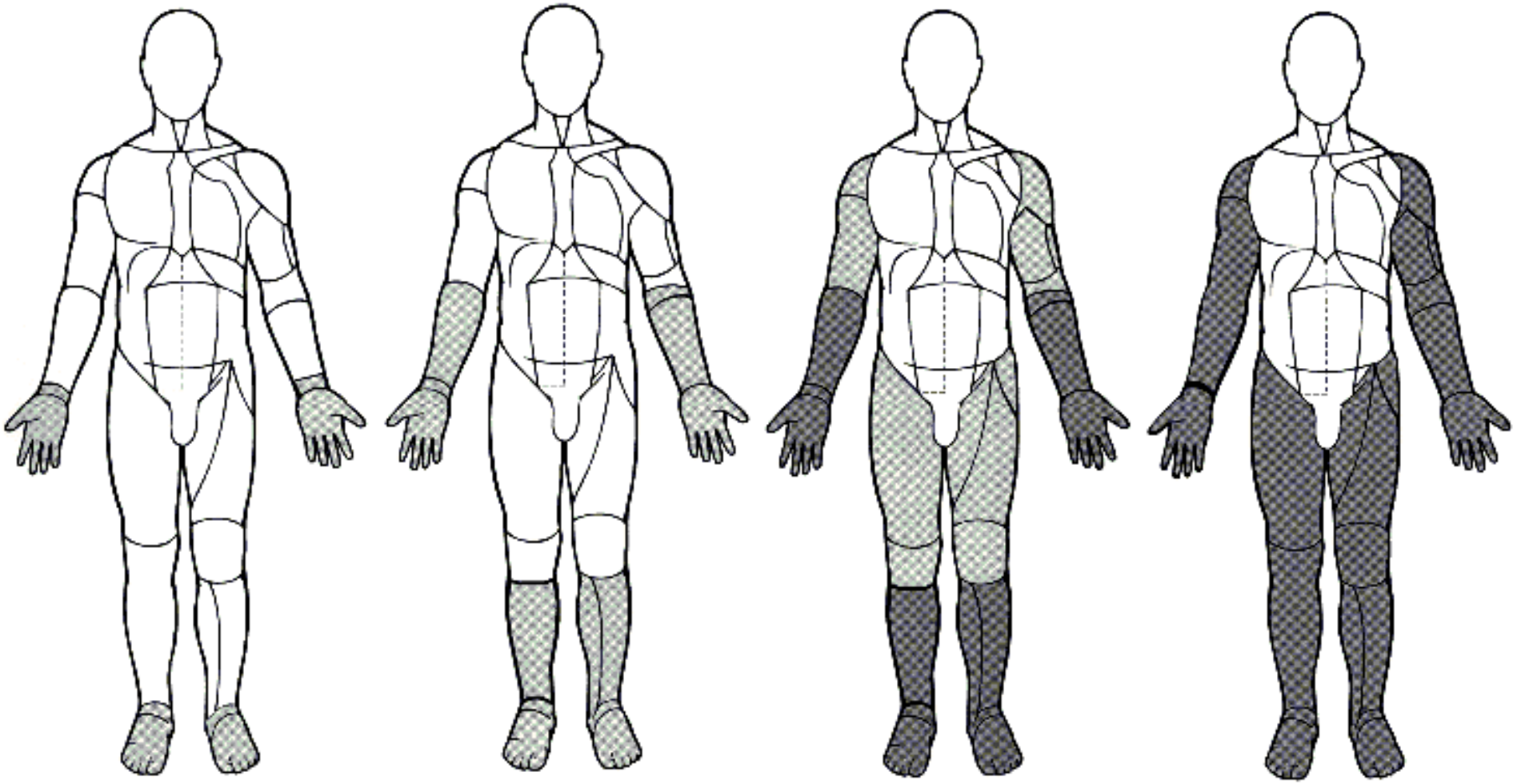
THE *SHELL* TEMPERATURE

- The shell temperature is several degrees lower than the temperature in the central core.
- The shell temperature and the size of the shell vary with the environmental temperature and the thermal state of the person.
- The shell temperature of the skin and distal extremities is difficult to evaluate. The best estimate is measurement of the infrared heat radiation flux with a radiometer.

Relative Size of Insulating Shell



The growing of “shell” area of lowered skin temperature in naked body at decreasing ambient temperatures from left to right

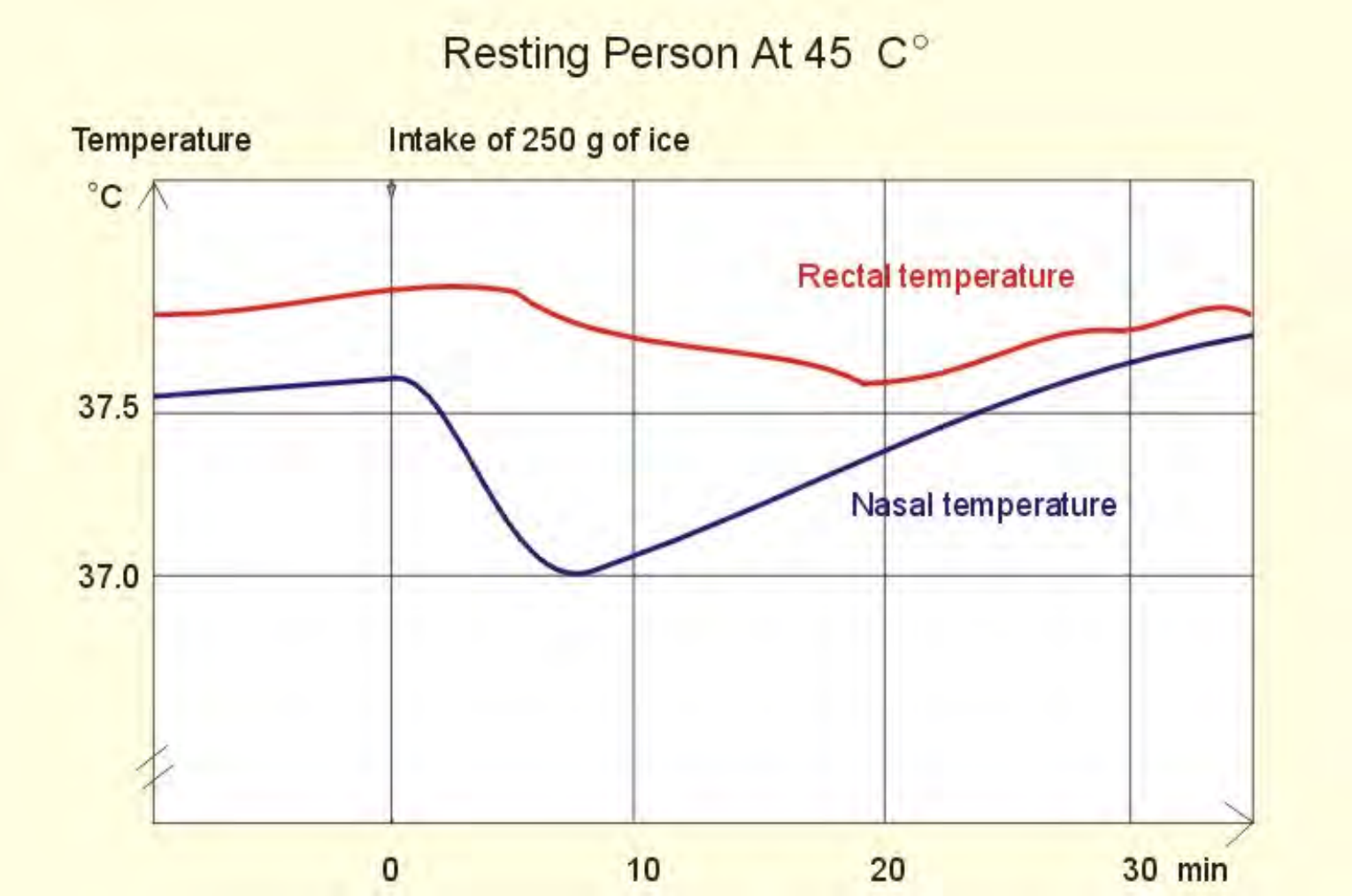


(Modified from figures by Jessen 1984, Ilmarinen 1987 and Lloyd 1994)

THE *RECTAL* TEMPERATURE

- A high core temperature is found to be constant in the rectum about 10-15 cm from the anus.
- The rectal temperature falls when the feet are cold, because cold blood passes the rectum in the veins from the legs.
- The rectal temperature rises during heavy work involving the legs.

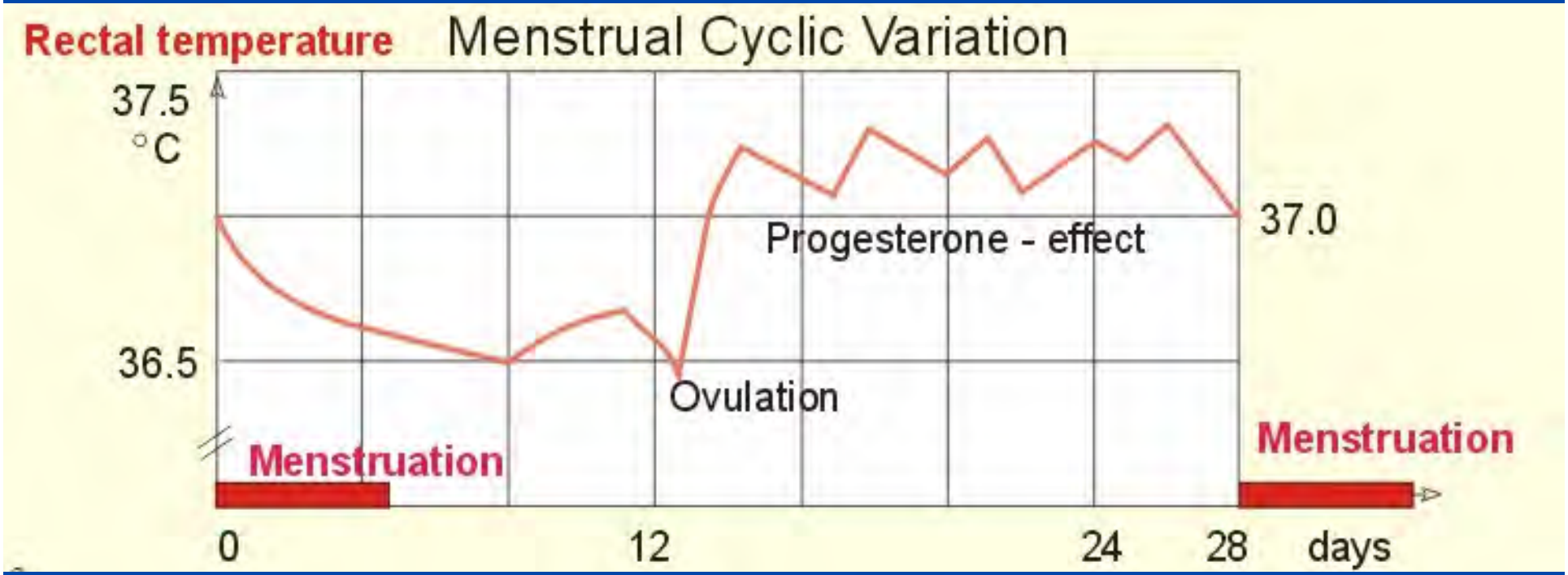
RECTAL & NASAL TEMPERATURES



CHANGES IN CORE TEMPERATURE DURING THE DAY

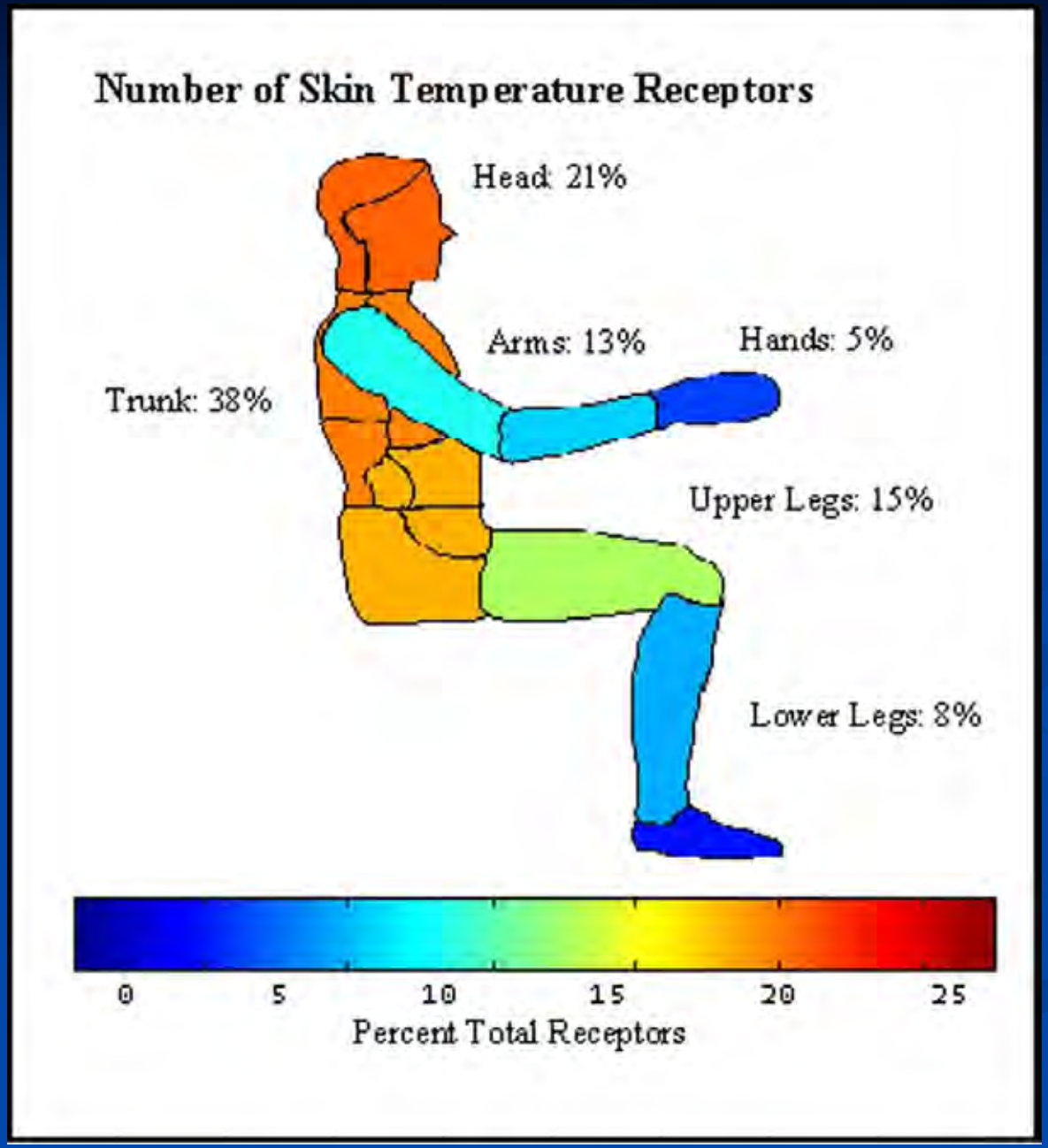
RECTAL TEPMERATURE IN WOMEN

may be higher or lower when a woman is ovulating or having her menstrual period.

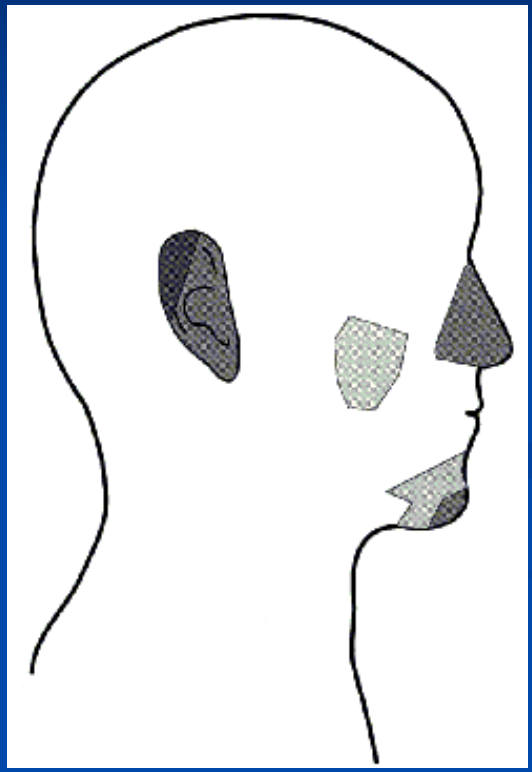


THERMAL SENSATION

- **thermoreceptor** - a sensory receptor that responds to heat and cold.
- HEAT receptors: fingertips, nose, elbows.
- COLD receptors: upper lip, nose, chin, chest, fingers.
- Fingertips are most sensitive to rate of heat conduction.


Number of Skin Temperature Receptors
Head: 21%
Arms: 13%
Hands: 5%
Trunk: 38%
Upper Legs: 15%
Lower Legs: 8%
0
5
10
15
20
25
Percent Total Receptors

The coldest areas of the uncovered head at 0°C ambient temperature

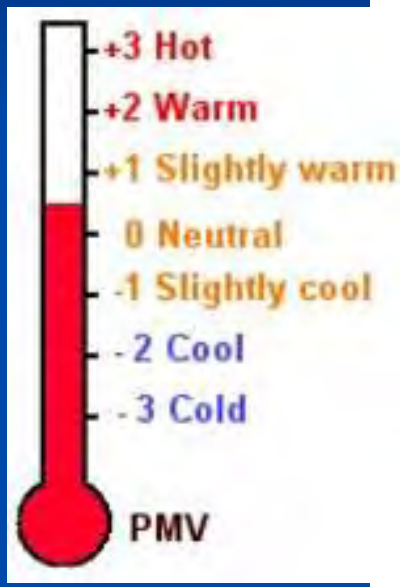


(Modified from Edwards & Burton 1960 and Steegman 1979.)

THERMAL SENSATION SCALES

1 - unbearably cold	–	1 – cold
2 - extremely cold		
3 - very cold		2 – cool
4 - cold		
5 - cool		3 – slightly cool
6 - slightly cool		
7 - neutral		4 – neutral
8 - slightly warm		
9 - warm		5 – slightly warm
10 - hot		
11 - very hot		6 – warm
12 - extremely hot		
13 - unbearably hot	+	7 - hot

The ASHRAE scale



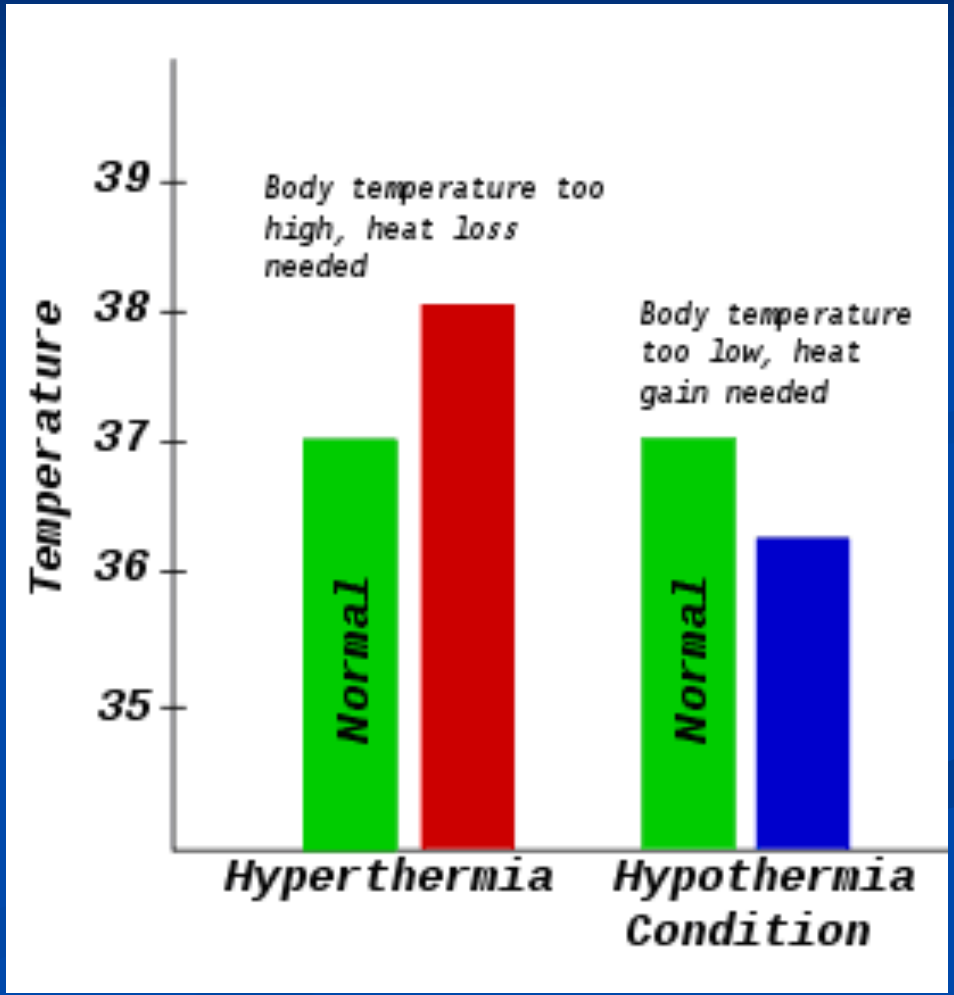
+3	Hot
+2	Warm
+1	Slightly Warm
0	Neutral
-1	Slightly Cool
-2	Cool
-3	Cold

HYPERTHERMIA / HYPOTHERMIA

Hypothermia is a fall in core temperature to values below 35°C. Hypothermic subjects lose consciousness, when the core temperature falls below 32°C.

In extreme hyperthermia the core temperature may rise to more than 41°C (heat stroke).

Irreversible protein denaturation occurs above 44°C with brain oedema and destroyed thermoneurons in the hypothalamus.

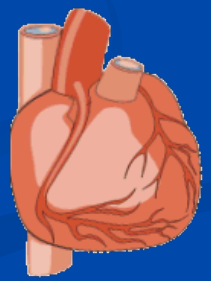


WATER / AIR

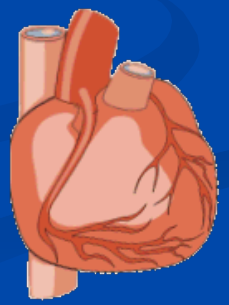
- Enhanced conduction of warmth.
- Loss of warmth grater than in the air:
  - Increased loss of warmth during exercise,
  - Loss of warmth depends on subcutaneous t.
- Protective mechanisms against excessive loss of warmth:
  - Peripheral vasoconstriction,
  - Reduced blood circulation (increases loss of warmth ~ 2-3x)

WATER TEMPERATURE: *WARM*

- Loss of body warmth into the water is reduced (no exchange of warmth between body and water)
  - Significant increase in heart rate.



  - Cardiovascular diseases!!!



WATER TEMPERATURE: *COLD*

- Freezing → trembling/shaking of the muscles:
  - Oxygen consumption is significantly increased at 25°C.
  - +Adiposity: additional loss / consumption of energy.
  - - children: very thin subcutaneous.

WATER TEMPERATURE

- Too cold/ too warm – additional load on the cardiovascular system.
- Recommendations of temperature:
  - Children - 30°C.
  - Adults depending on the load:
    - 28-30°C aqua jogging
    - >30°C aqua gymnastics
    - >34°C gait training
    - <28 – high performance

COLD WATER IMMERSION

Body experiences a variety of physiological responses affected by:

- the temperature of the water,
- the amount of time person is exposed to the water.

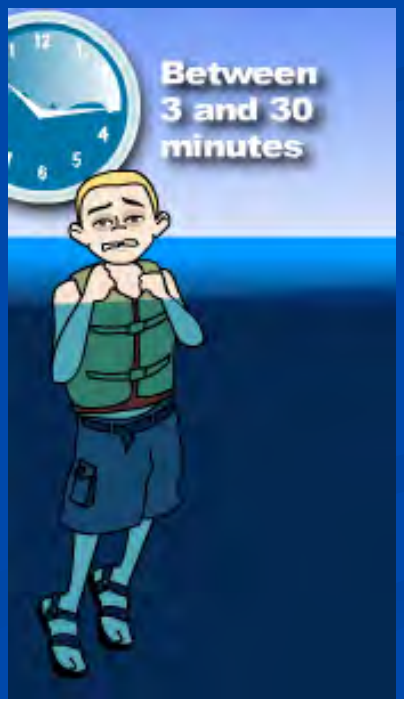
COLD WATER SHOCK

- "gasp reflex"
  - Hyperventilation
  - Muscle spasm

- Changes in heart rate and blood pressure

IN COLD WATER

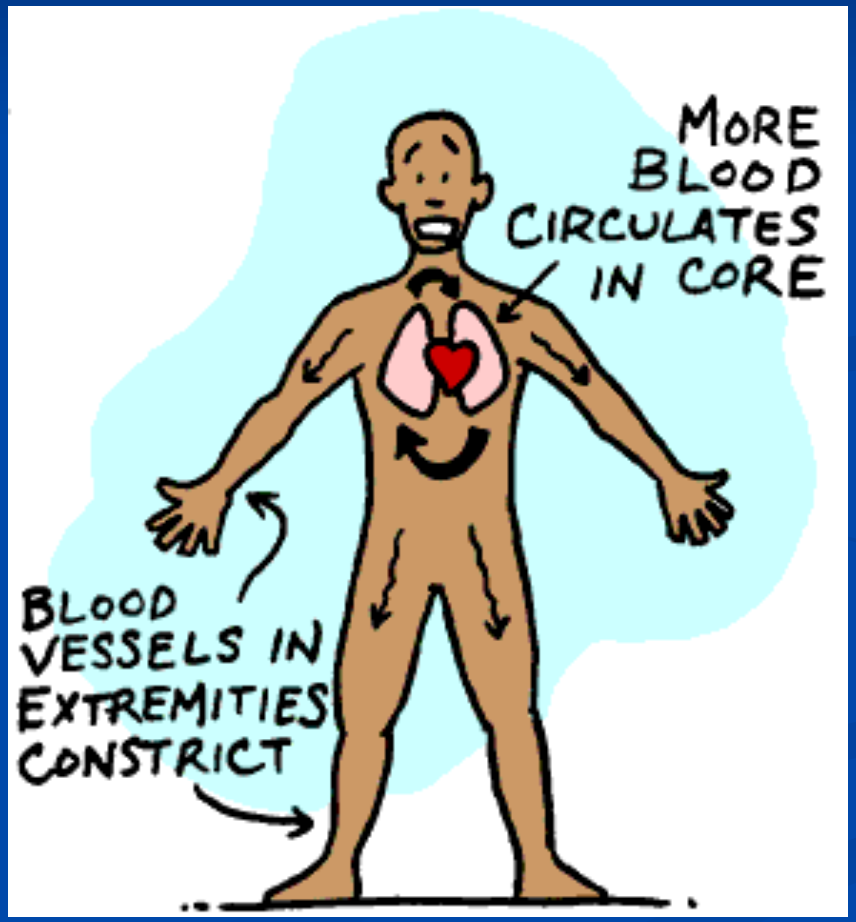
- The loss of basic motor skills after only a few minutes in the water,
- Hands quickly begin to loose strength and sensation.



Cryotherapy / Cold Water Therapy

Helps to reduce pain and swelling and facilitates rehabilitation.

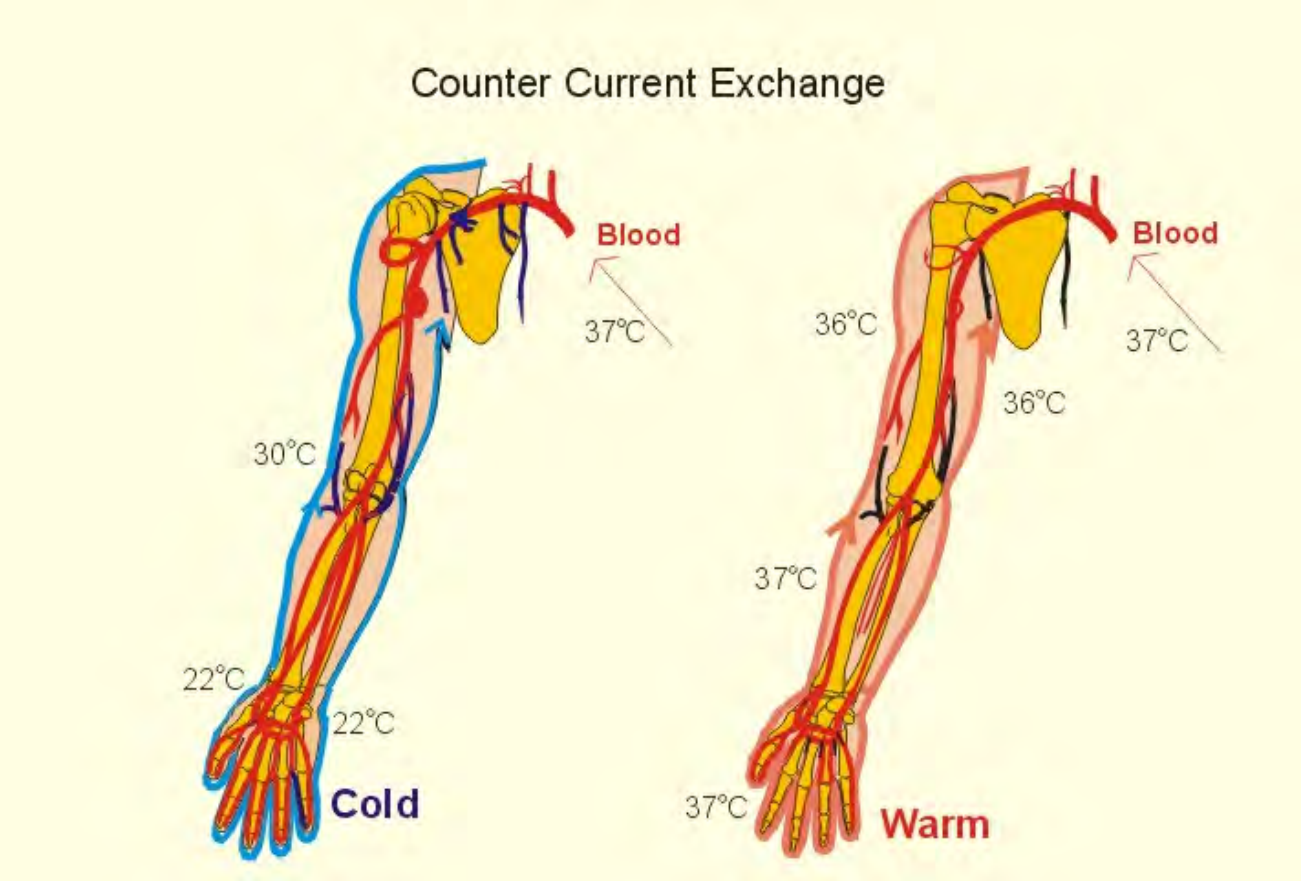
BODY-RESPONSES TO COLD



BODY-RESPONSES TO COLD / WARM

Counter-current exchange in a human arm conserving heat energy in a cold climate.

Superficial venous cooling blood vessels eliminate heat energy in a warm climate.



BODY-RESPONSES TO COLD

- **SHIVERING** - is a *reflex myogenic response* to cold with *asynchronous* or balanced muscle contractions elicited from the hypothalamus via cutaneous receptors.

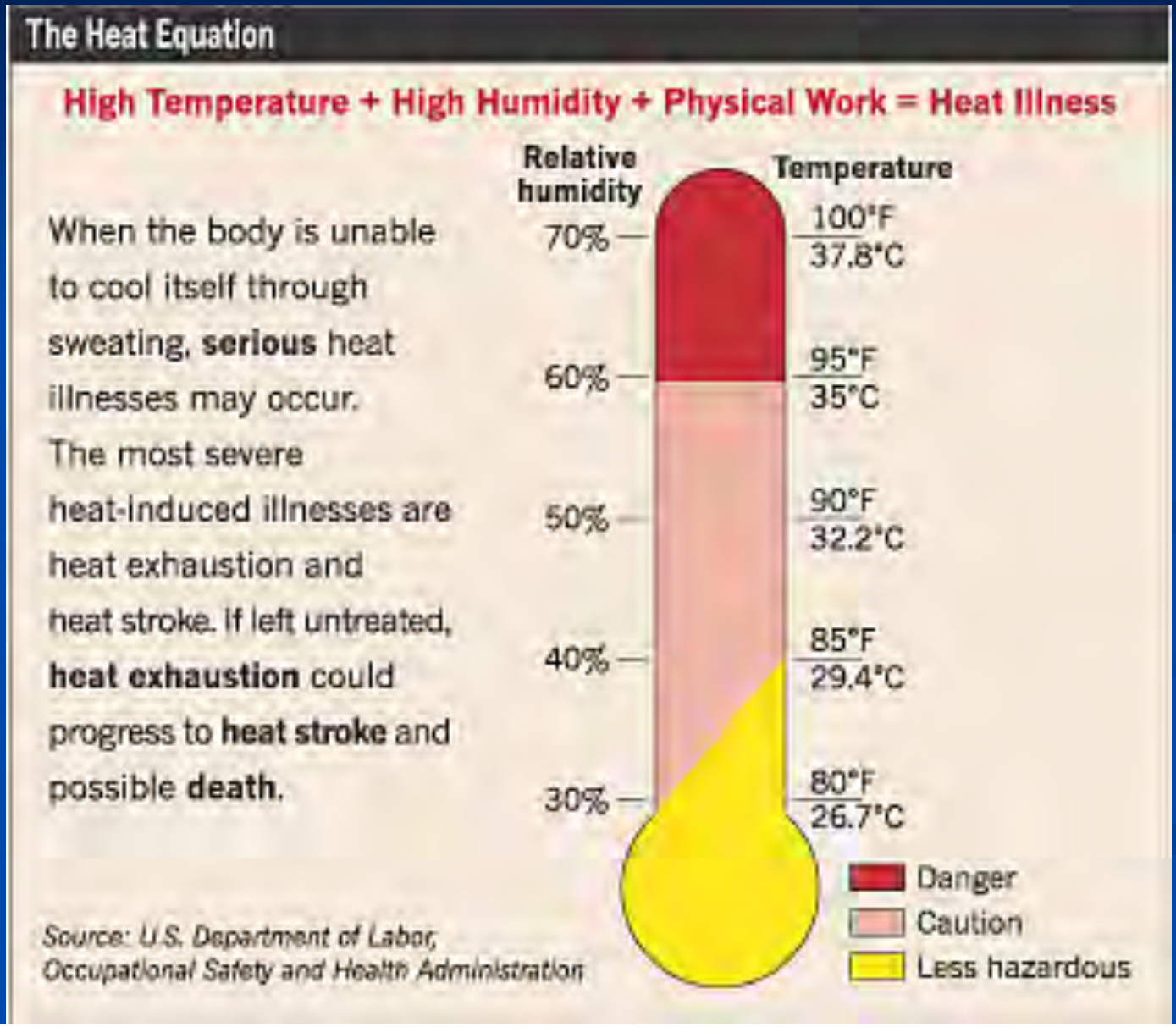
- *External work,* such as running, is helpful in maintaining body temperature when feeling cold.

- Cold increases the motivation for *warm-up exercises.*

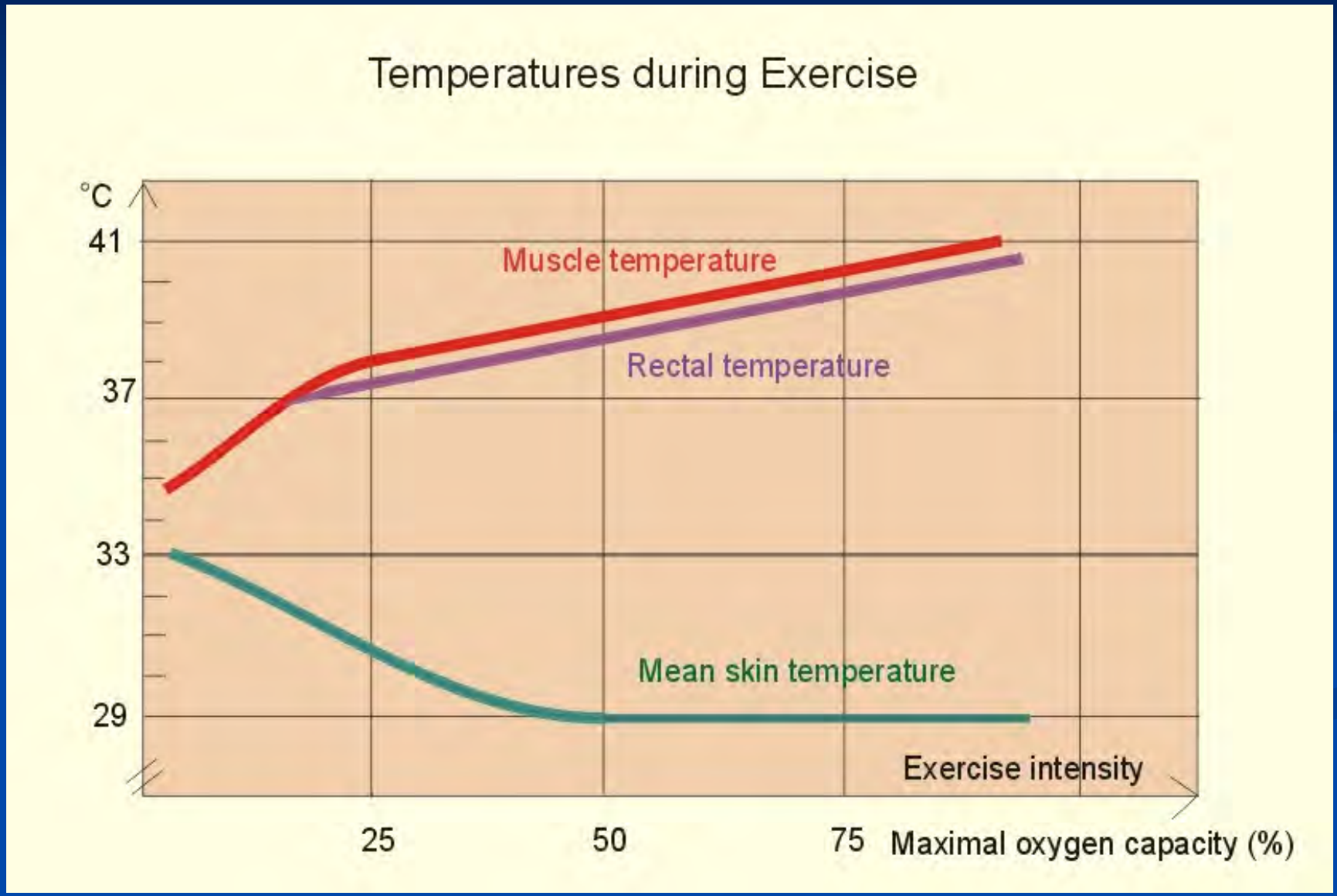
EXERCISE IN HOT AND COLD ENVIRONMENTS

- The role of exercise in hot and cold water is different.
- In water warmer than 24°C, body temperature rises as it does in the air.
- In colder water body accelerates cooling, because more heat is sent to the skin due to increased peripheral blood flow, → in cold water heat loss will be accelerated.
- Children are more at risk with the very youngest cooling fastest, and boys cooling faster than girls because both groups are usually thinner than adults.

HEAT + WORK


The Heat Equation
High Temperature + High Humidity + Physical Work = Heat Illness
When the body is unable to cool itself through sweating, **serious** heat illnesses may occur. The most severe heat-induced illnesses are heat exhaustion and heat stroke. If left untreated, **heat exhaustion** could progress to **heat stroke** and possible **death**.
Relative humidity
Temperature
70%
60%
50%
40%
30%
100°F 37.8°C
95°F 35°C
90°F 32.2°C
85°F 29.4°C
80°F 26.7°C
Danger
Caution
Less hazardous
Source: U.S. Department of Labor, Occupational Safety and Health Administration

MUSCULAR AND RECTAL TEMPERATURES DURING STEADY STATE EXERCISE



THERMOREGULATORY AND PERCEPTUAL RESPONSE TO SWIMMING WITH A CAP

Matsunami, M., &Taimura, A. (2001). *Medicine and Science in Sports and Exercise, 33(5),* Supplement abstract 751.

- The caps increased cranial temperature greater than the body.
- The use of caps in warm water could increase the level of stress on the swimmer.

Not using a cap could improve tolerance for swimming in warm environments.

Conclusion. Do not wear swim caps when training in warm water (30°C).

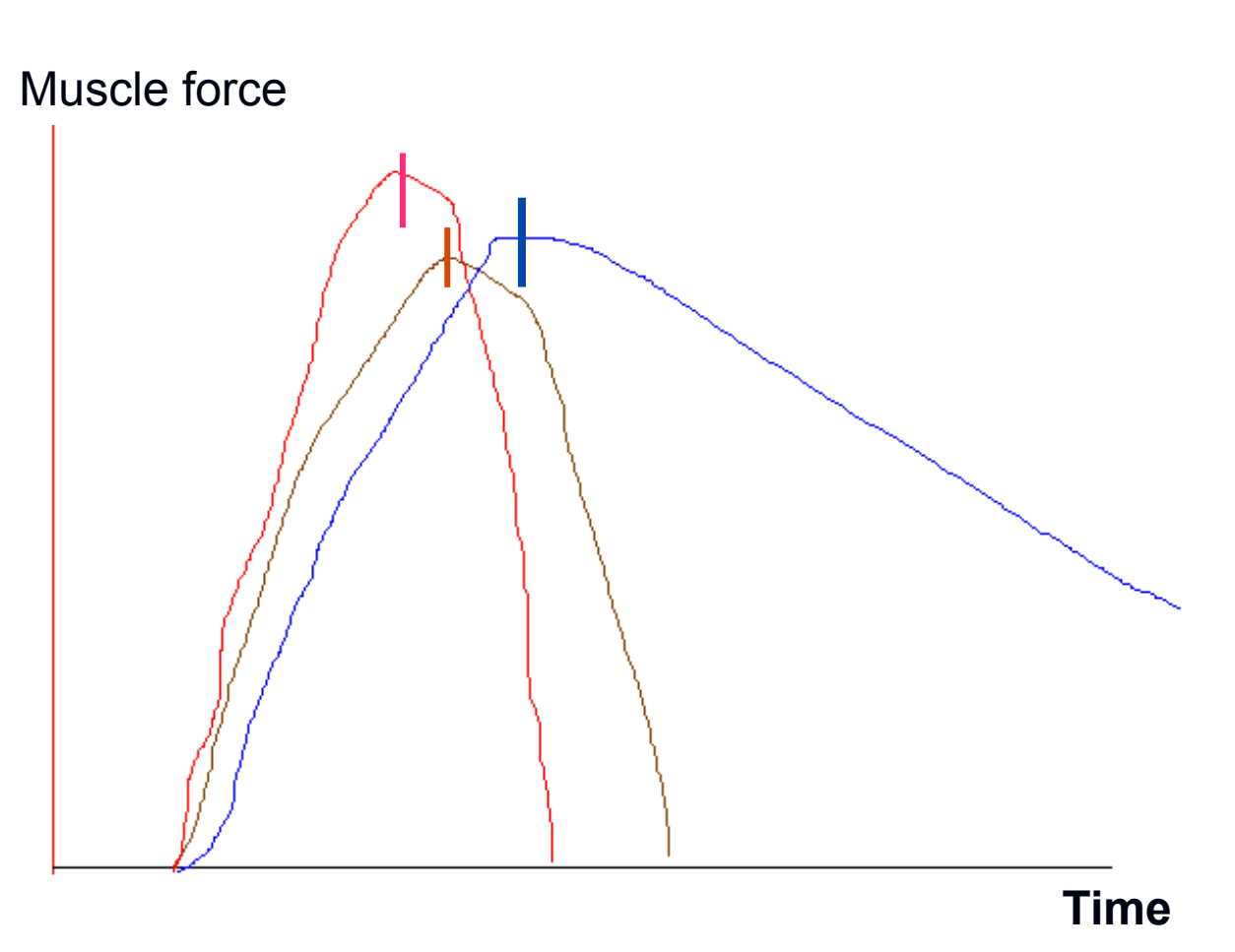
THERMAL RESPONSES IN SWIMMING IS AFFECTED BY THE MATERIAL OF SWIM CAPS

Matsunami, M., Taimura, A., & Sugawara, M. (2003). *Medicine and Science in Sports and Exercise, 35(5)*, Supplement abstract 148.

- The waterproof cap obstructed heat dissipation and caused greater measures of head skin temperature and thermal sensation.

Conclusion. Waterproof head caps appear to be "*hotter*" than mesh caps. This might have an effect of compromising a swimmer's response to an extended training program.

MUSCLE CONTRACTION / RELAXATION TIME, AND FORCE



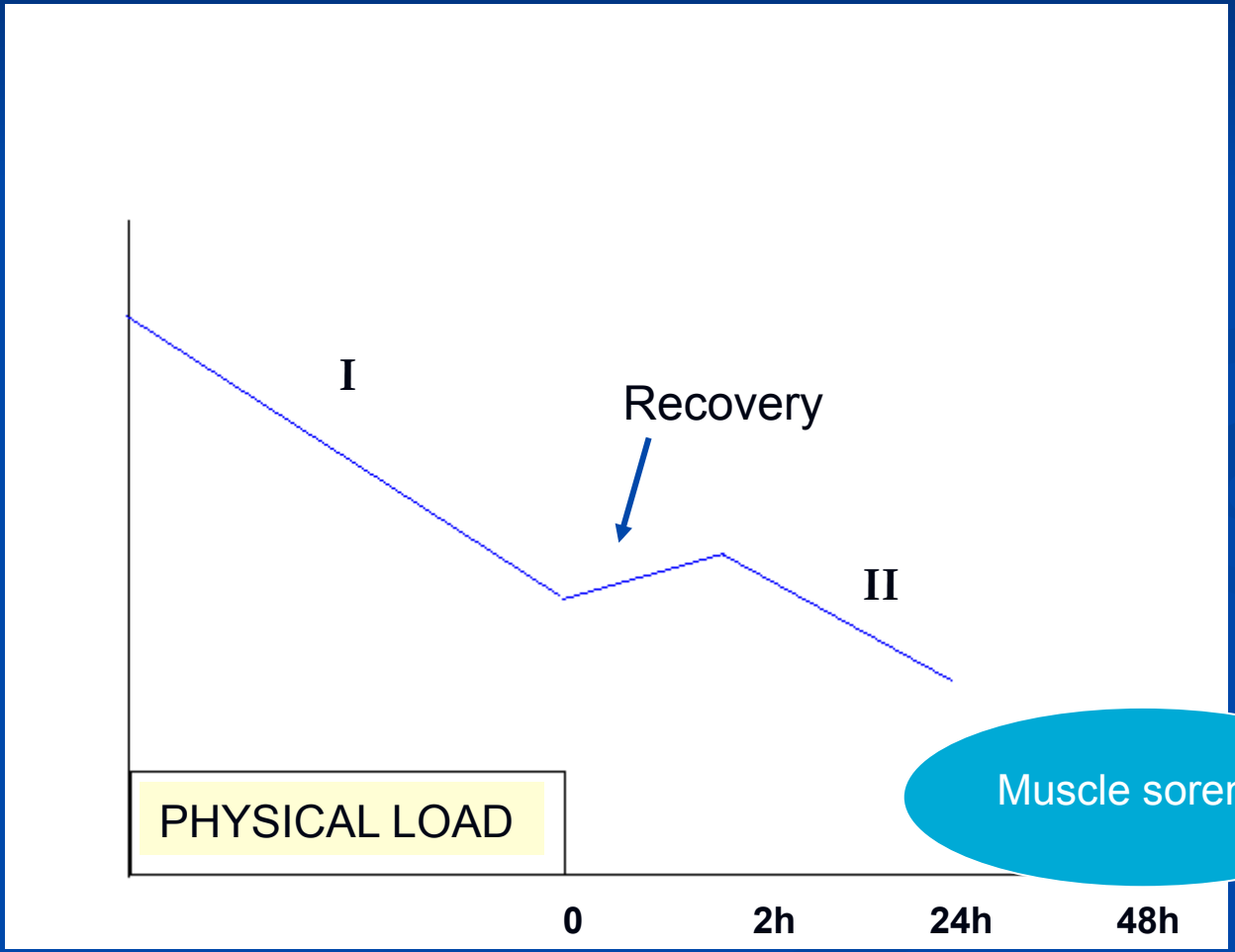
DOMS

- Delayed
- Onset
- Muscle
- Soreness

- Exercise induced muscle damage:
  - eccentric exercise,
  - Unknown, ….
  - intensive

DROP JUMPS

DELAYED ONSET MUSCLE SORENESS



PRE-COOLING REDUCES THERMOREGULATORY STRAIN AND SKIN BLOOD FLOW DURING EXERCISE

Cable, N. T., & Weston, M. (1999). *Medicine and Science in Sports and Exercise, 31(5),* Supplement abstract 1515.

- This study examined the thermoregulatory response of skin blood flow during exercise with and without pre-cooling.

- Conclusion. Pre-cooling reduces blood flow to the skin making more blood available for muscular work.

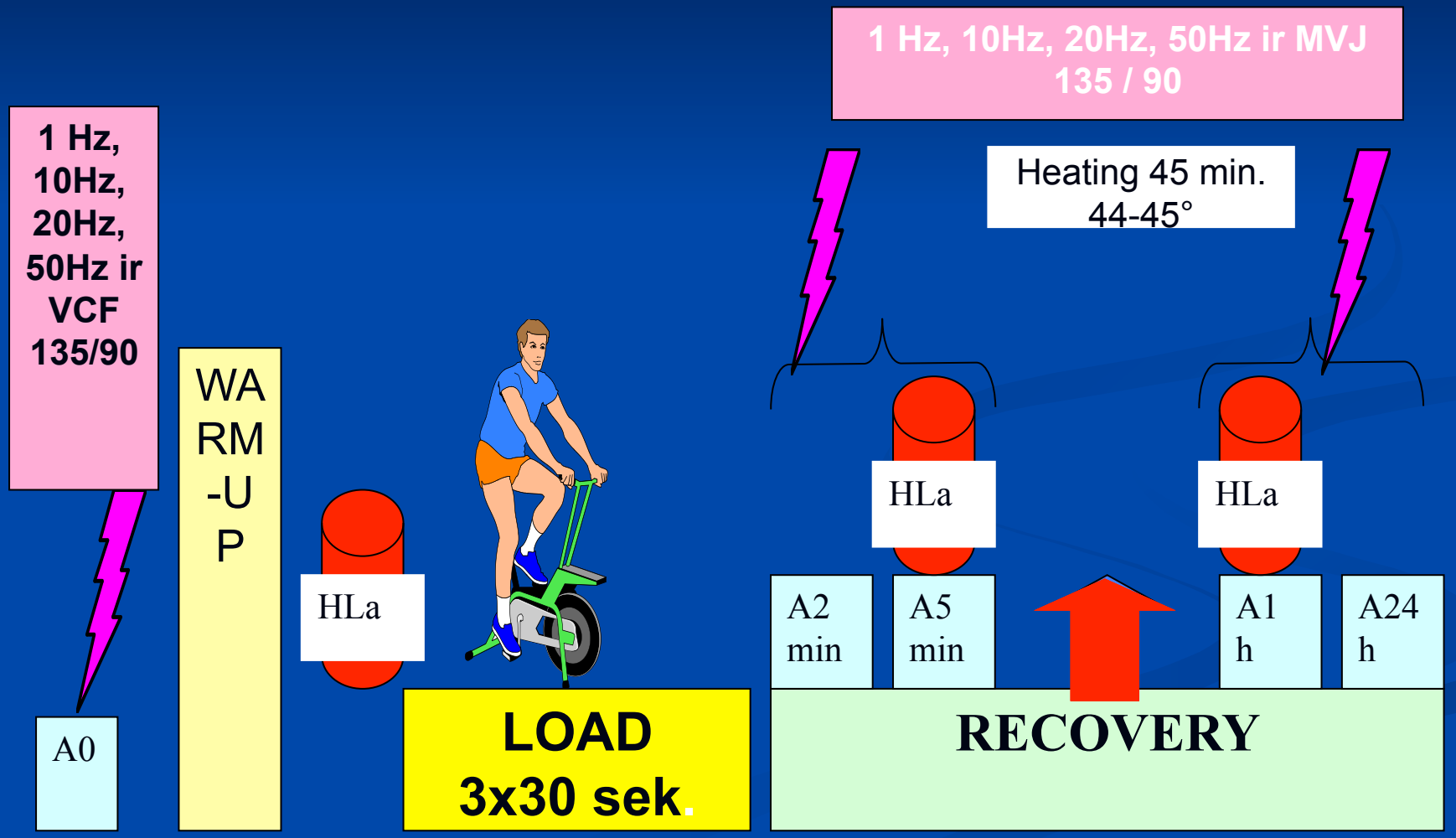
INFLUENCE OF TEMPERATURE ON THE RECOVERY OF MUSCLE FUNCTION AFTER PERFORMING MAXIMAL INTENSITY EXERCISE

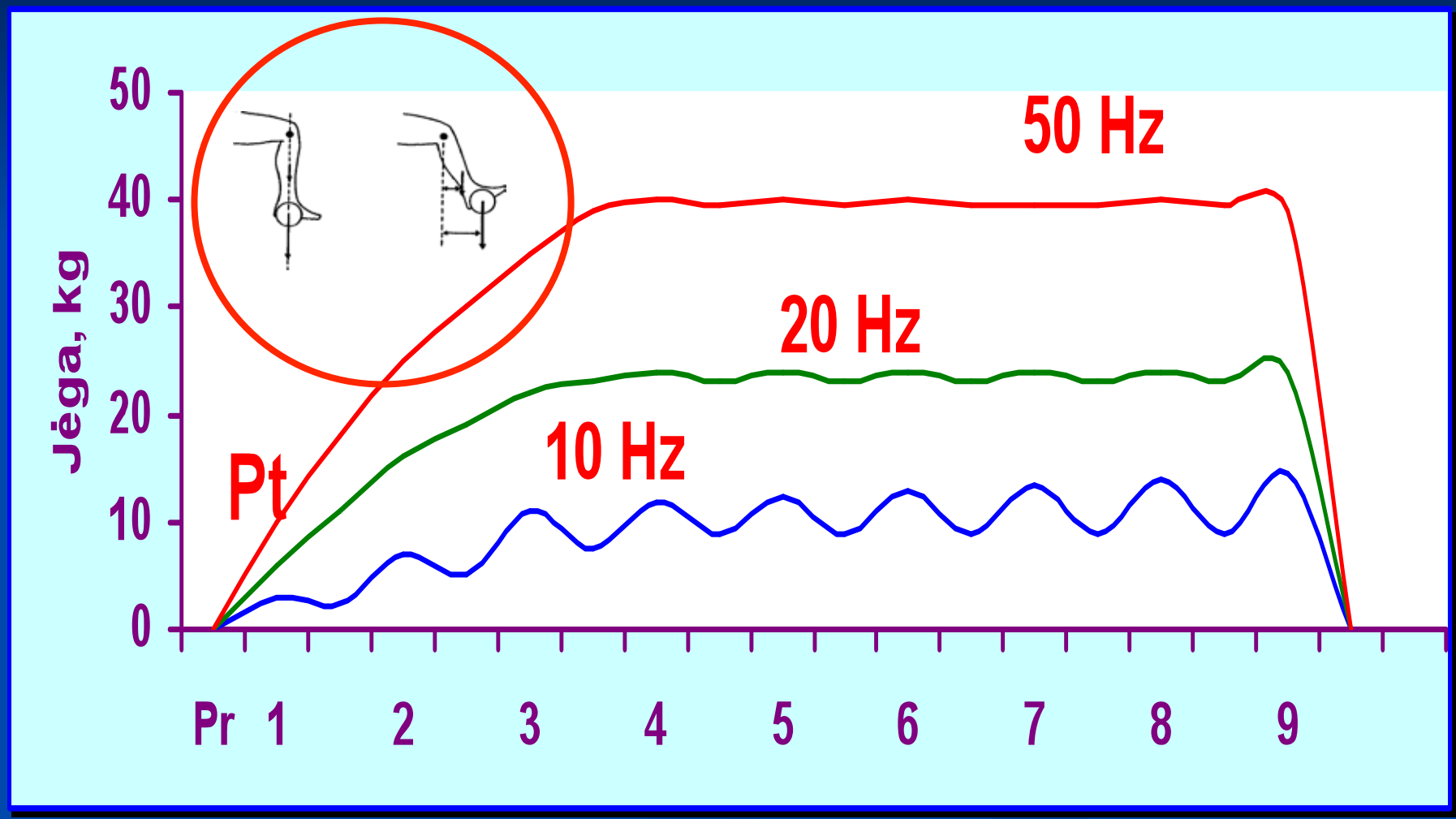
Skurvydas A, Dudoniene V, Bartasevicius L.Medicina (Kaunas). 2002;38(6):641-6.

The purpose of this study was to establish the influence of temperature on quadriceps femoris muscle force, contraction and relaxation time, low frequency fatigue and muscle recovery after performing high-intensity exercise.

Conclusions: muscle heating does not influence the recovery properties of muscle contraction and relaxation during 24 hours after performing high-intensity exercise.

Effect of heating on recovery of muscle function after max intensity exercises





LFF=P20/P50

LEG IMMERSION IN WARM WATER, STRETCH-SHORTENING EXERCISE, AND EXERCISE-INDUCED MUSCLE DAMAGE

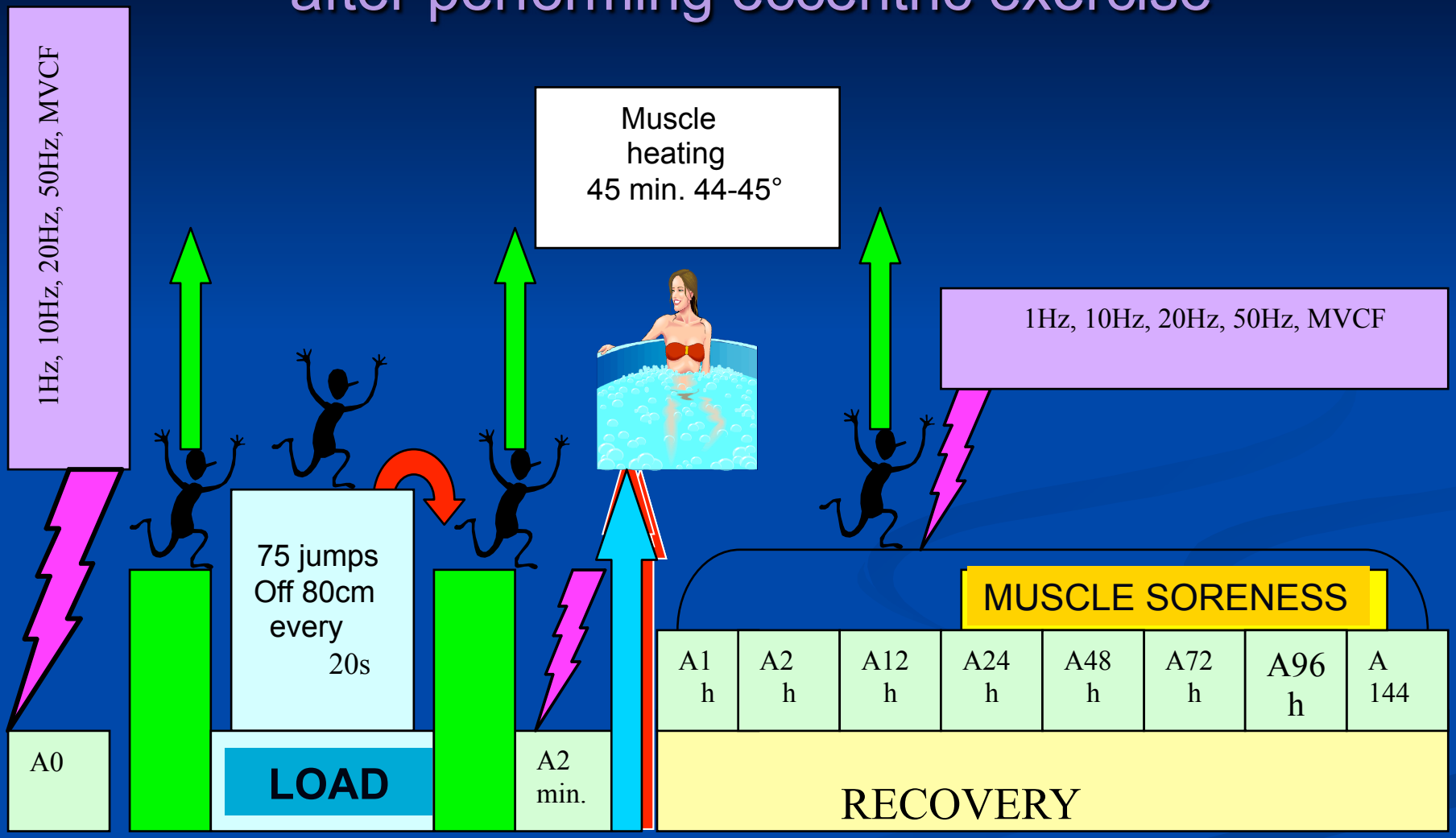
Skurvydas A, Kamandulis S, Stanislovaitis A, Streckis V, Mamkus G, Drazdauskas A. J Athl Train. 2008 Oct-Dec;43(6):592-9.

OBJECTIVE: To determine the effect of leg immersion in warm water before stretch-shortening exercise on the time course of indirect markers (CK) of exercise-induced muscle damage.

CONCLUSIONS: Leg immersion in warm water before stretch-shortening exercise reduced most of the indirect markers of exercise-induced muscle damage.

However, the clinical application of muscle pre-warming may be limited, because decreasing muscle damage did not necessarily lead to improved voluntary performance.

Effect of heating on recovery of muscle function after performing eccentric exercise



HEATING didn't help to recover.

Core T increased up to 39.5°C – central fatigue

CONCLUSION

HEATING after physical load is not effective means to eliminate long lasting fatigue due to metabolic and non-metabolic factors.

IMPACT OF COLD WATER IMMERSION ON 5KM RACING PERFORMANCE

Bosak A., Bishop P., Green J., Hawver G. (2008). America's Sports University, The Sport Journal.

Ice water immersion

Passive recovery

Conclusion. Cold water immersion does not sufficiently enhance recovery .

What works for one person may not work for another person.

EFFECT OF HYDROTHERAPY ON RECOVERY FROM FATIGUE

Vaile J, Halson S, Gill N, Dawson B. Int J Sports Med. 2008 Jul;29(7):539-44. Australia

The study investigated the effects of three hydrotherapy interventions on next day performance recovery following strenuous training.

- 14-min recovery intervention:
  - cold water immersion (CWI),
  - hot water immersion (HWI),
  - contrast water therapy (CWT),
  - passive recovery (PAS).

Conclusion. CWI and CWT appear to improve recovery from high-intensity cycling when compared to HWI and PAS, with athletes better able to maintain performance across a five-day period.

COOLING MAKES RECOVERY OF MUSCLE FASTER AFTER ECCENTRIC-CONCENTRIC THAN CONCENTRIC EXERCISE

Sipaviciene S, Skurvydas A, Ramanauskiene I, Senikeine Z, Dumciene A. Medicina (Kaunas). 2008;44(3):225-31.

The aim of the study was to establish the influence of muscle cooling on muscle recovery after concentric and eccentric-concentric exercise.

The results show that cooling applied to muscles after concentric and eccentric-concentric exercise affected the indicators of muscle damage--the activity of creatine kinase was decreased and muscle strength recovered faster.

Conclusion. The cooling effect is greater when it is applied after eccentric-concentric exercise.

ATTENUATION OF MUSCLE DAMAGE BY PRECONDITIONING WITH MUSCLE HYPERTHERMIA 1-DAY PRIOR TO ECCENTIC EXERCISE

Nosaka K, Muthalib M, Lavender A, Laursen PB. Eur J Appl Physiol. 2007 Jan;99 (2):183-92.

This study investigated the hypothesis that muscle damage would be attenuated in muscles subjected to passive hyperthermia 1 day prior to exercise.

Conclusion: passive hyperthermia treatment 1 day prior to eccentric exercise-induced muscle damage has a prophylactic effect, but the effect is not as strong as the repeated bout effect.

COLD WATER IMMERSION FOLLOWING INTENSE INTERVAL RUNNING IMPROVES SUBSEQUENT RUNNING PERFORMANCE

Fowles, J. R., Boutilier, G., & Murphy, R. J. (2003). *Medicine and Science in Sports and Exercise, 35(5)*, Supplement abstract 183.

This study evaluated the effects of cold-water immersion (in 8°C water) after intense interval training on performance. Vertical jump, heart rate, ratings of perceived exertion, performance in the intense interval run, and soreness were evaluated.

Implication. Cold-water immersion following intense exercise may reduce the effects of fatigue and improve subsequent submaximal performance but not maximal performance.

WHAT COULD HELP TO RECOVER ?

COOLING just after eccentric, unknown, unusual, unaccustomed and intensive exercise.

But… how long, how often ????

Implication. Heating before load increases muscles' plasticity, protects against damage, especially if patient is not unaccustomed.

Cooling immediately following intense efforts decreases injury.

CONCLUSIONS

1. The therapeutic use of cold is the most commonly used modality in the acute management of musculoskeletal injuries.
2. Applying cold to an injured site:
   - decreases pain sensation,
   - improves the metabolic rate of tissue,
   - allows uninjured tissue to survive a post-injury period of ischemia.

Thank You for Your attention