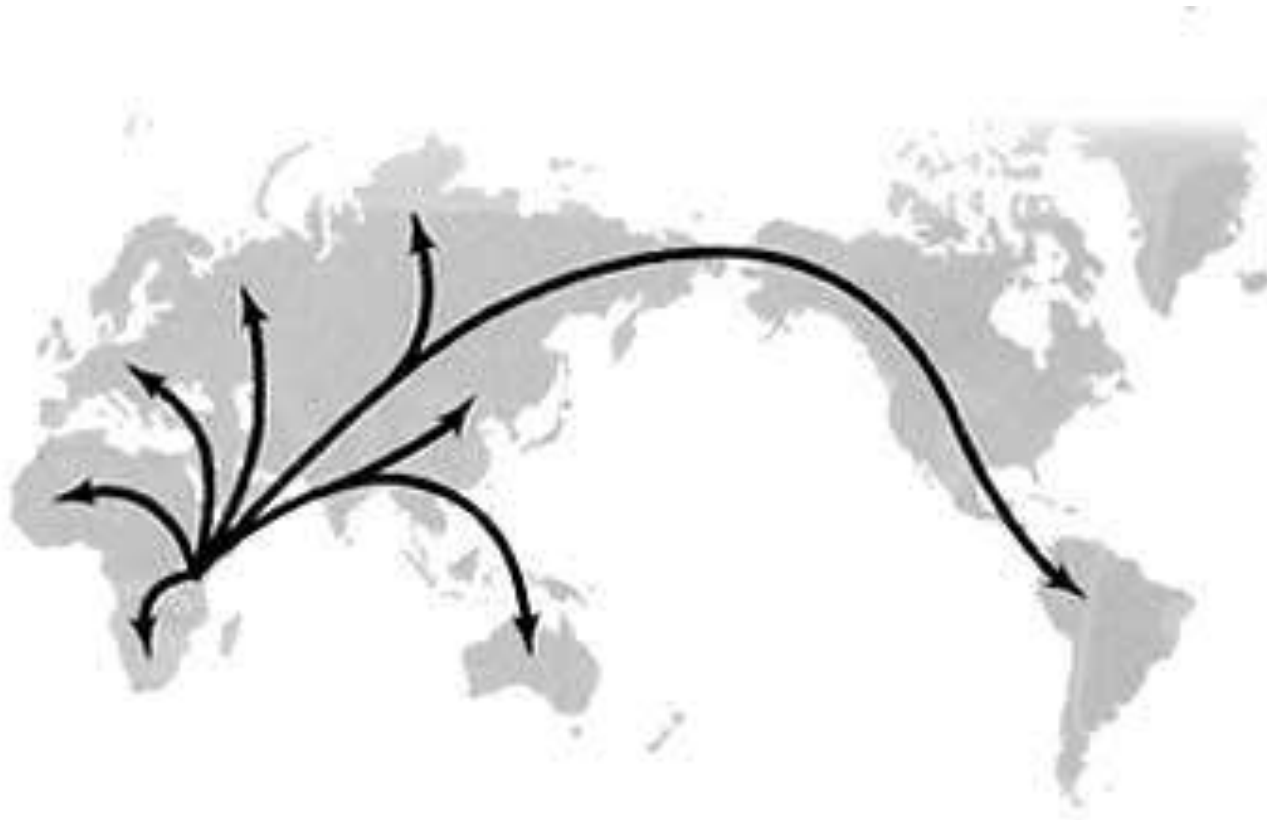




# Bevriezing

Anne Brants,  
SEH-arts KNMG & Expedition Doctor





Forster, Peter & Matsumura, Shuichi. Did Early Humans Go North or South? *Science* 2005; 308 (5724): 965-966

Studies regarding the effect of repeated cold water immersion on metabolism, thermal insulation and peripheral blood flow (cold induced vasodilation (CIVD)).

Authors	Year	#subjects	#immersion days	duration (min)	water temp. (°C)	exercise	metabolism change	insulation change	CIVD
Young et al.	1986	7M	25	90	18	none	Initial 20% drop (10 min) during cold air exposure	increased Tre-Tsk gradient	
Bittel	1987	9M	32-40	60-180	10-15	none	no change	increased Tre-Tsk	

Studies regarding the effect of mild cold exposure on metabolism and thermal insulation.

Authors	Year	#subjects	#days	duration (h)	air temp. (°C)	BAT	metabolism	CIVD	
Budd et al.	1991							ve	
Jansky et al.	1991								
Golden&Tipton	1991								
O'Brien et al.	2001	Davis	10M	31	8	13.5	NA	no change in EE; decrease in shivering	
Stocks et al.	2001	Lans, van der et al.	9F8M	10	6	14-15	increase	increase NST ( $\Delta$ NST: 75%)	deci de
Zeyl et al.	2001	Yoneshiro et al	51M	42	2	19	increase	increase NST ( $\Delta$ NST: 150%-estimated from bar graph)	
Wakabayashi et al.	2001	Chen et al./Lee et al.	10F14M	42	12 (overnight)	19	increase	increase in EE; no change in NST	
Tipton et al.	2001	Blondin et al.*	6	28 (5d/wk)	2	10*	increase	shivering intensity did not change; increase BAT oxidative capacity	
Brazaitis et al.	2001	Hanssen et al.	8	10	6	14-15	increase	increase NST	

Hein A.M. Daanen and Wouter D. Van Marken Lichtenbelt. Human whole body cold adaptation Temperature (Austin). 2016 Jan-Mar; 3(1): 104-118.

“Repeated exposure to severe cold does not lead to beneficial physiological adaptations”

- Temperatuur daalt sneller
- Vermindering van warmteproductie
- Vermindering sensibiliteit voor kou

Hein A.M. Daanen and Wouter D. Van Marken Lichtenbelt. Human whole body cold adaptation Temperature (Austin). 2016 Jan-Mar; 3(1): 104–118.

- Klimaat
- Kleding
- Metabolisme
- Individuele Factoren

#### Box 1 | Predisposing factors

General: Unusually cold weather, prolonged exposure to cold, inadequate clothing, inadequate use of appropriate clothing, homelessness, smoking, dehydration, old age, ethnic origin, high altitude

Systemic disease: Peripheral vascular disease, diabetes, Raynaud's disease, sepsis, previous cold injury

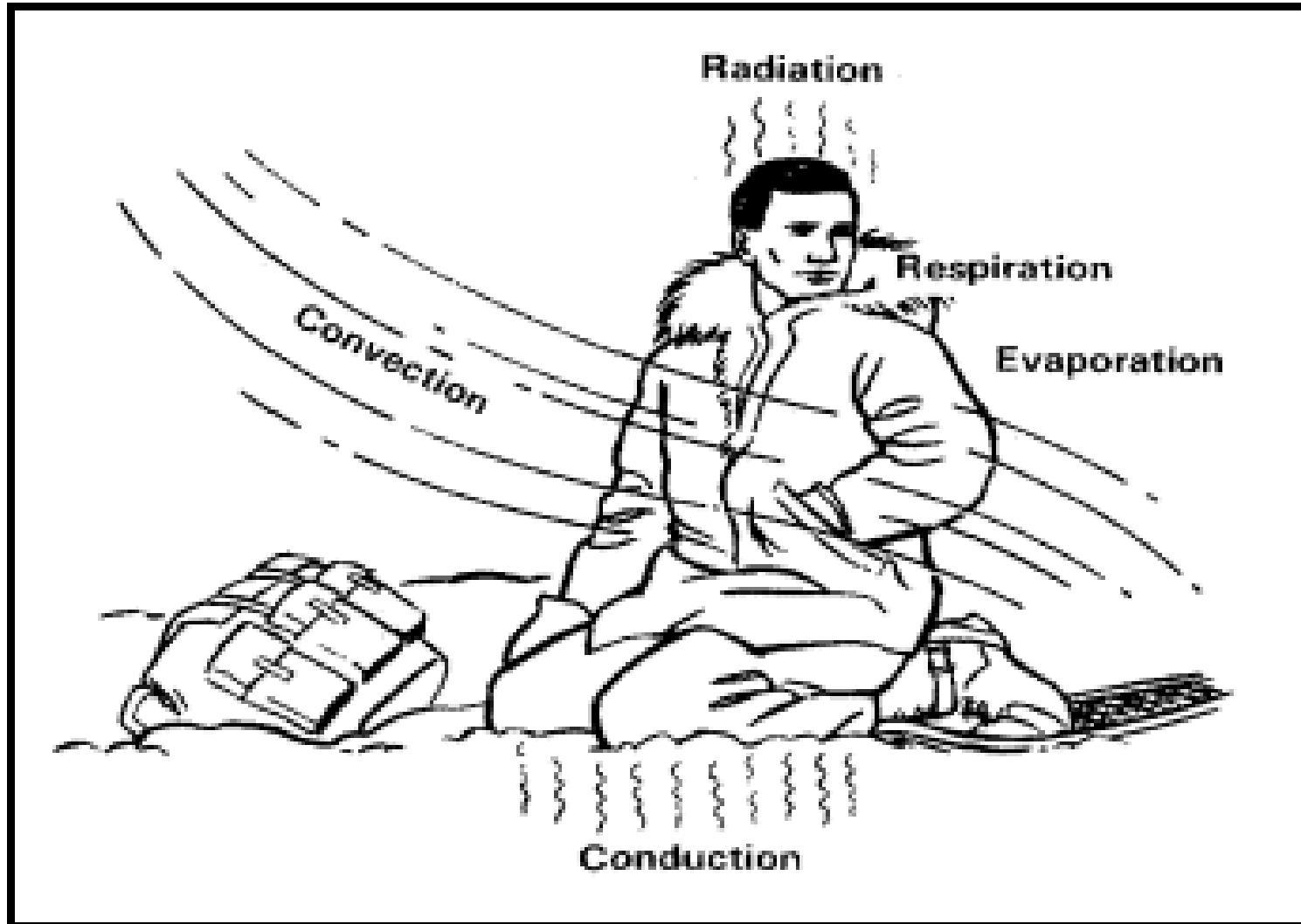
Psychiatric illness

Drugs:  $\beta$  blockers, sedatives, and neuroleptics

Trauma: Any immobilising injury, but especially head and spinal injuries and proximal limb trauma that compromises the distal circulation

Intoxication: Alcohol and illicit drug use

BMJ topic: Managing frostbite, 2010





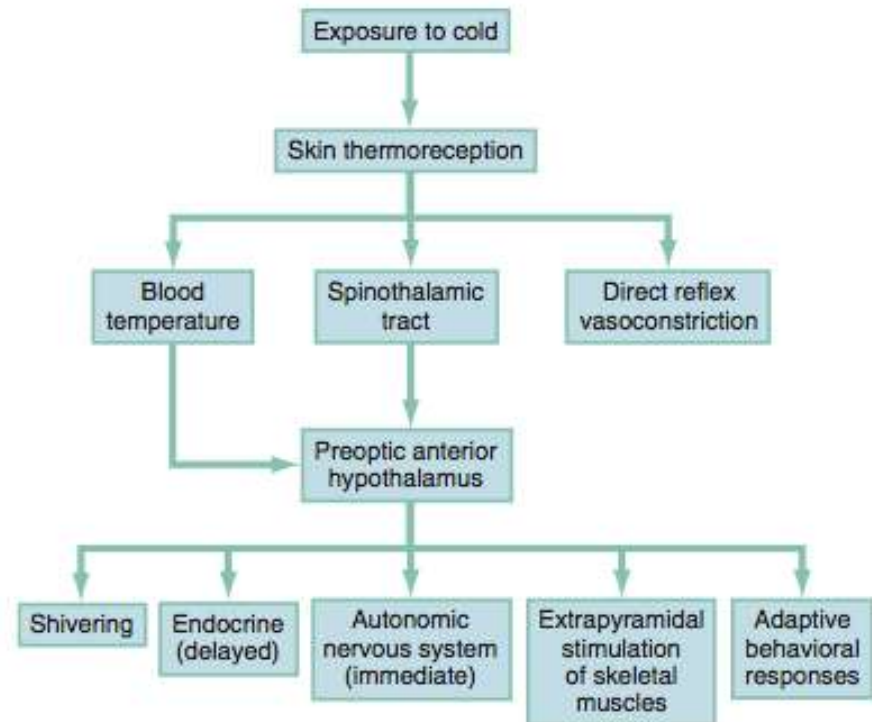
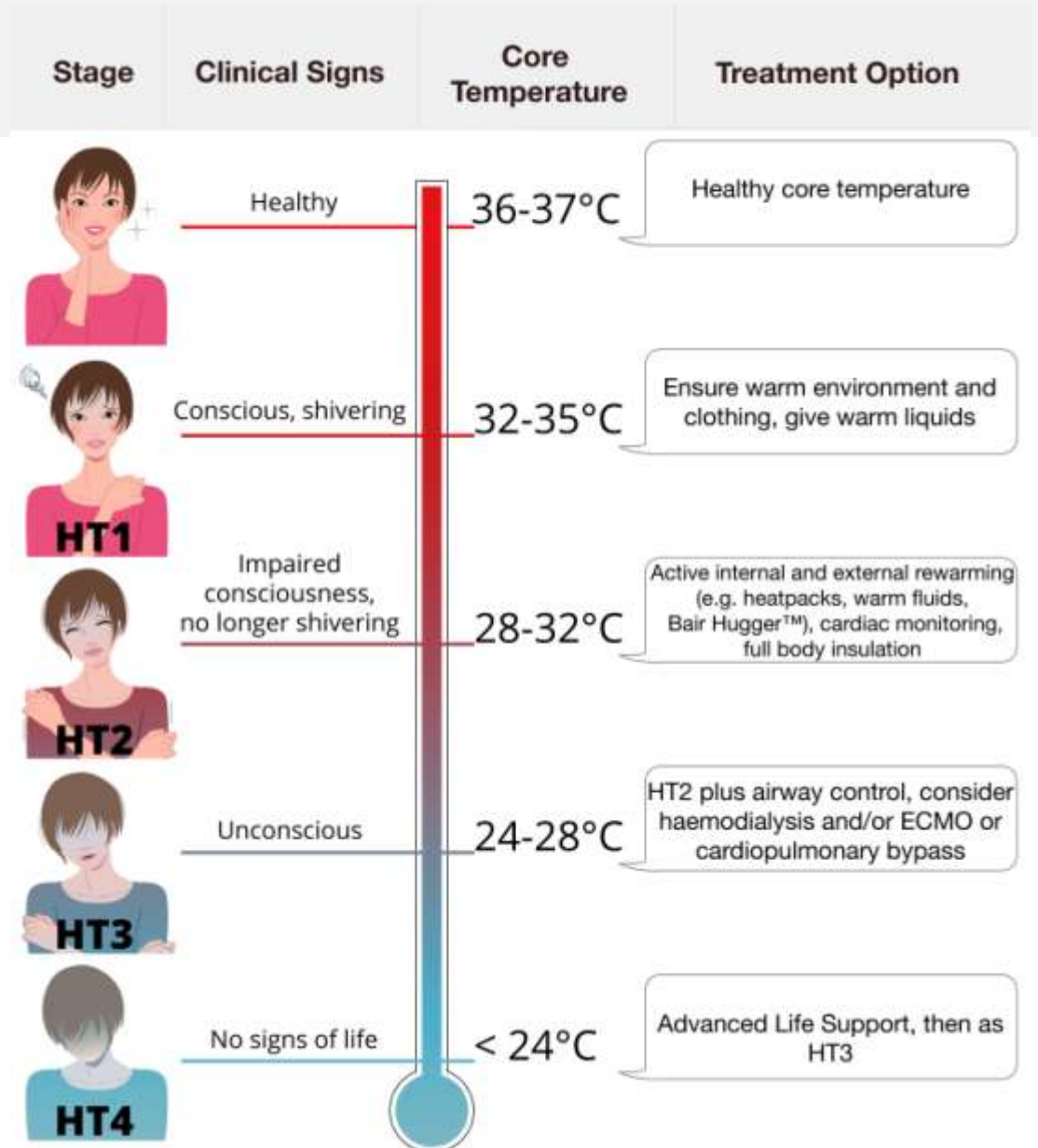


Figure 138-1. Physiology of cold exposure.





“Voorkomen is beter dan genezen”

- Temperatuur
- Windchill
- Water
- Hoogte
- Voedingstoestand
- Hydratie
- Tijd van exposure



# NWS Windchill Chart



		Temperature (°F)																	
		40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
Wind (mph)	Calmm	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
	5	36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57	-63
	10	34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66	-72
	15	32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71	-77
	20	30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74	-81
	25	29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78	-84
	30	28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80	-87
	35	28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82	-89
	40	27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84	-91
	45	26	19	12	5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79	-86	-93
	50	26	19	12	4	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81	-88	-95
55	25	18	11	4	-3	-11	-18	-25	-32	-39	-46	-54	-61	-68	-75	-82	-89	-97	
60	25	17	10	3	-4	-11	-19	-26	-33	-40	-48	-55	-62	-69	-76	-84	-91	-98	

Frostbite Times



30 minutes



10 minutes



5 minutes

$$\text{Wind Chill (°F)} = 35.74 + 0.6215T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})$$

Where, T= Air Temperature (°F) V= Wind Speed (mph)

Effective 11/01/01

Weefsel schade als gevolg van blootstelling  
aan temperatuur beneden eigen vriespunt  
( $-0.55^{\circ}\text{C}$ )

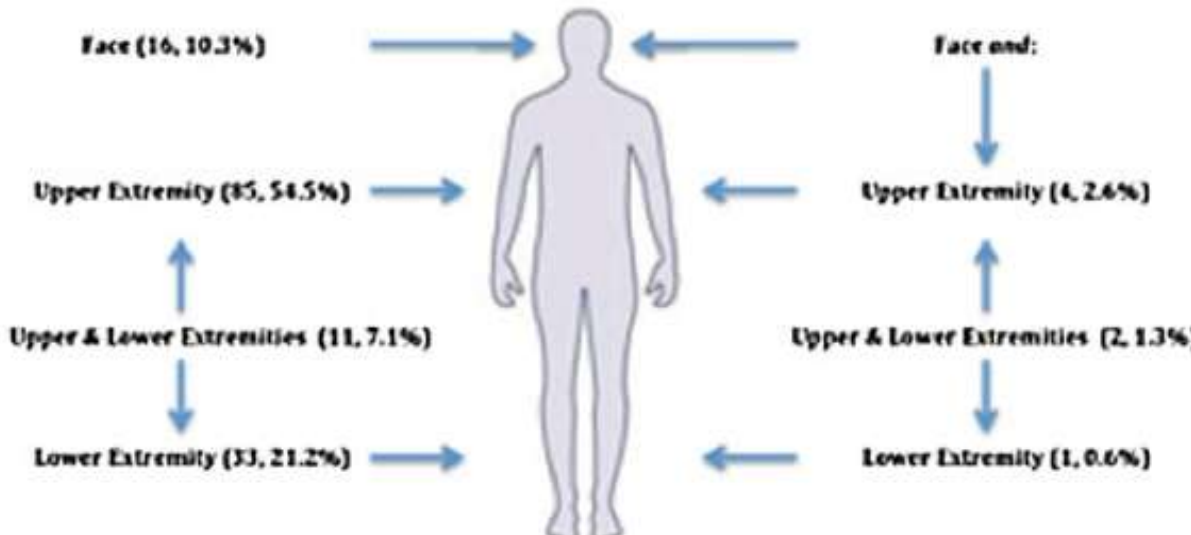


Larrey DJ: Memoirs of Military Surgery, Vol 2. Baltimore, Joseph Cushing, 1814.

## Mountaineering Medical Events and Trauma on Denali, 1992–2011

Scott E. McIntosh,<sup>1</sup> Aaron Campbell,<sup>2</sup> David Weber,<sup>3,4</sup> Jennifer Dow,<sup>5</sup>  
Elizabeth Joy,<sup>6</sup> and Colin K. Grissom<sup>7</sup>

<i>Diagnosis or chief complaint</i>	<i>Frequency</i>	<i>Percent</i>
Frostbite	171	18.1
AMS	127	13.4
HAPE	20	2.1
HACE	1	0.1
Upper respiratory		
Bronchitis		
Asthma		
Dehydration		
Ankle injury		
Fatigue		
Gastroenteritis		
Laceration		
Pneumonia		

The diagram shows a human silhouette with arrows pointing to various body parts and associated injury statistics:

- Face (16, 10.3%)**: Arrow pointing to the face.
- Upper Extremity (85, 54.5%)**: Arrow pointing to the upper extremities.
- Upper & Lower Extremities (11, 7.1%)**: Double-headed arrow between the upper and lower extremities.
- Lower Extremity (33, 21.2%)**: Arrow pointing to the lower extremities.
- Face and:** Arrow pointing down from the face.
- Upper Extremity (4, 2.6%)**: Arrow pointing to the upper extremities.
- Upper & Lower Extremities (2, 1.3%)**: Double-headed arrow between the upper and lower extremities.
- Lower Extremity (1, 0.6%)**: Arrow pointing to the lower extremities.

- At risk: vingers, tenen, neus wangen, oren en mannelijk geslachtsdeel
- Co-morbiditeit: hypothermie, trauma, intoxicatie



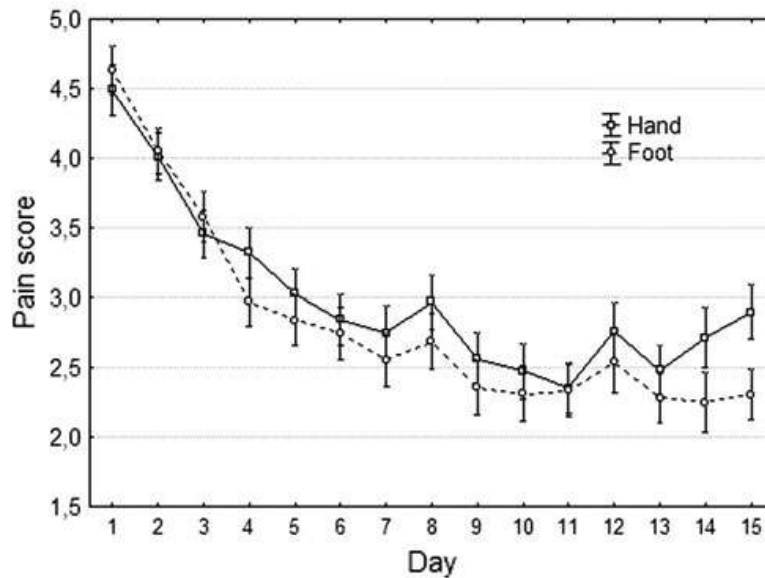
Eur J Appl Physiol (2012) 112:2595–2601  
DOI 10.1007/s00421-011-2233-4

ORIGINAL ARTICLE

## Trainability of cold induced vasodilatation in fingers and toes

Hein A. M. Daanen · Jens Koedam ·  
Stephen S. Cheung

“Koudere vingers en minder pijn”



Nelms and Soper, 1961

- Directe schade door bevriezing en vorming van ijskristallen (extra-cellulair / intra-cellulair)
- Late schade door inflammatie en coagulatie gedurende dooi fase, leidend tot ischemie (micro)circulatie
- Refreeze
- Trauma



- Oppervlakkig
  - 1e graads: bleek, doofheid, oedeem.
  - 2e graads: blaren met helder vocht, omliggend oedeem en erytheem ontstaan <24hr
- Diep
  - 3de graads: bloedblaren, na enkele weken zwarte demarcatie necrotisch weefsel
  - 4de graads: Weefsel volledig aangedaan incl spier en bot, mumificatie in 4-10 dagen

### Box 1 Factors that increase risk for frostbite

#### Behavioural

- ▶ Inadequate clothing and shelter
- ▶ Alcohol and other drug use
- ▶ Psychiatric illness
- ▶ Smoking

#### Physiological

- ▶ Genetic susceptibility
- ▶ Dehydration and hypovolaemia
- ▶ High altitude, hypoxia and hypothermia
- ▶ Diabetes, atherosclerosis, vasculitis
- ▶ Arthritis
- ▶ Raynaud's phenomenon
- ▶ Vasoconstrictive drugs
- ▶ Cryoglobulinopathies
- ▶ Sweating or hyperhydrosis ( ↑ heat loss)
- ▶ Previous frostbite

#### Mechanical

- ▶ Tightly constrictive clothing (too many socks)
- ▶ Contact with heat conductive materials
- ▶ Rings on fingers
- ▶ Immobility (military situations)



Imray C, Grieve A, Dhillon S; Caudwell Xtreme Everest Research Group. Cold damage to the extremities: frostbite and non-freezing cold injuries. *Postgrad Med J.* 2009;85(1007):481-8.

- Opwarmen in water (geen refreeze)
- Pijnstilling (NSAID / opiaat)
- Wondverzorging
  - Blaren
  - Aloe Vera?
- Rehydratie
- Tetanus tox
- Trombolyse / Iloprost <24 uur
- Geen vroege chirurgie!

## In de praktijk:

- Elfstedentocht 2018
  - Behandel hypothermie / dehydratie
  - Bescherm bevroren ledemaat
  - Ga naar trombolysen centrum <24u
  - Pijnstilling/opwarmen/trombolysen/tetanus
  - Get help van frostbite expert



- Mens past zich maar matig aan aan de kou
- Warmtebalans afhankelijk van klimaat, kleding, metabolisme en individuele factoren
- Voorkomen is veel beter dan genezen
- Voorkom refreeze
- “Freeze in winter, amputate in summer”