

Cardiovascular effects of heat exposure

Causes of Heat-related mortality



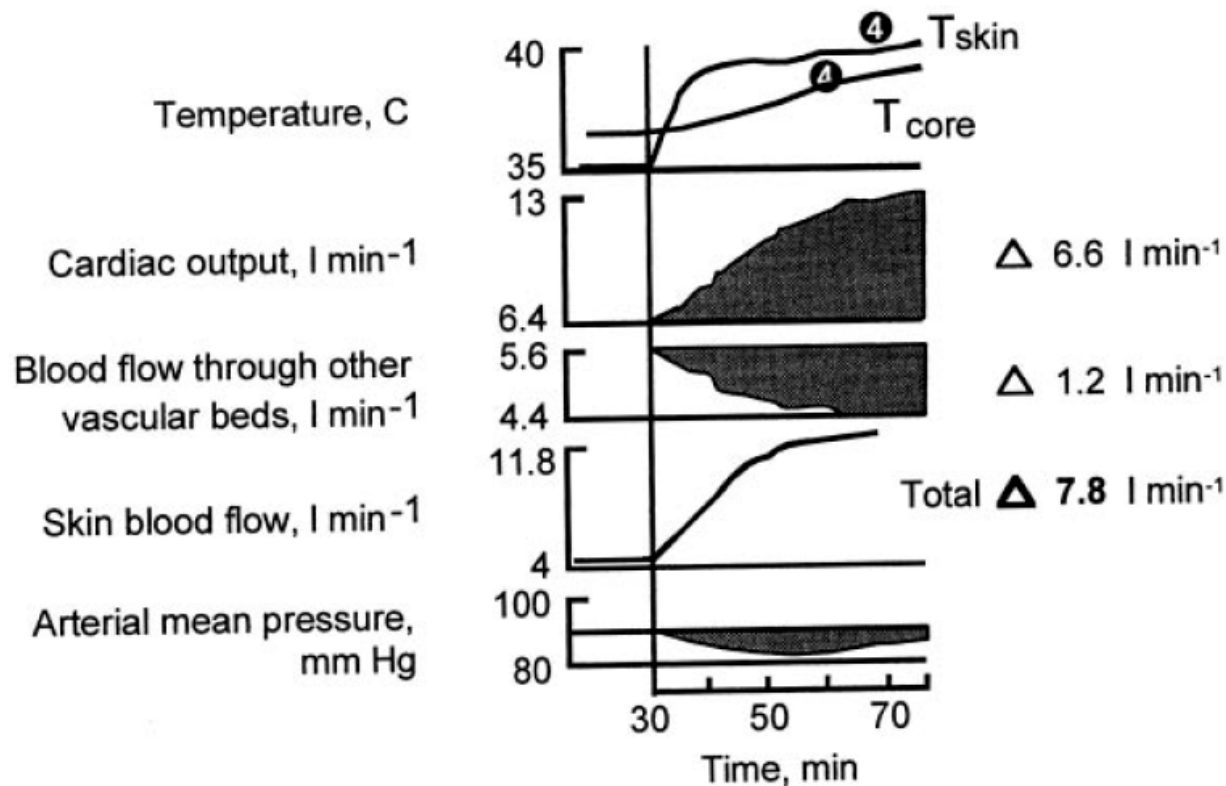


Figure 1. Cardiovascular adjustment in supine resting volunteers heated to the limits of thermal tolerance. From reference 4.

Rowell LB. Cardiovascular aspects of human thermoregulation. *Circ Res* 1983; 52: 367–79.

TABLE I Changes in Blood Cells, Platelets, and Viscosity during Heat Stress

	Before Experiment	Change during First Hour	Change during Six Hours
Red blood cell count ($\times 10^{12}$ /liter blood)	4.50 \pm 0.11	+0.09 \pm 0.03*	+0.40 \pm 0.06***
Mean red blood cell volume (μm^3)	88.7 \pm 1.0	-0.4 \pm 0.2*	0.0 \pm 0.3
Packed cell volume (percent)	0.400 \pm 0.012	+0.006 \pm 0.002*	+0.036 \pm 0.005***
Platelet count ($\times 10^9$ /liter blood)	268 \pm 17	+38 \pm 9**	+56 \pm 13**
Platelet volume (fl)	9.0 \pm 0.3	-0.4 \pm 0.1**	-0.3 \pm 0.2
Neutrophil count ($\times 10^9$ /liter blood)	3.85 \pm 0.23	+0.28 \pm 0.17	+3.72 \pm 1.19*
Viscosity			
Blood			
At shear rate of 230 per second (mPas)	3.8 \pm 0.1	+0.2 \pm 0.1*	+0.8 \pm 0.1***
At shear rate of 23 per second (mPas)	5.9 \pm 0.3	+0.6 \pm 0.2	+1.6 \pm 0.2***
Plasma			
At shear rate of 230 per second (mPas)	1.3 \pm 0.0	+0.1 \pm 0.0*	+0.2 \pm 0.0**
At shear rate of 23 per second (mPas)	2.1 \pm 0.3	+0.3 \pm 0.2	+0.1 \pm 0.1

Values are means \pm SE of eight experiments except for viscosity measurements (seven subjects). Difference from initial value: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Table II Changes in Serum Cholesterol Values (mmol/liter) during Heat Stress

	Before Experiment	Change during First Hour	Change during Six Hours
Total cholesterol	4.15 \pm 0.22	+0.18 \pm 0.08	+0.59 \pm 0.14**
High-density lipoprotein	1.23 \pm 0.47	+0.04 \pm 0.02	+0.12 \pm 0.04*
Low-density lipoprotein	2.47 \pm 0.23	+0.25 \pm 0.10*	+0.54 \pm 0.15*
Very-low-density lipoprotein	0.24 \pm 0.04	-0.05 \pm 0.02	+0.07 \pm 0.03*

Values are means \pm SE of eight experiments.

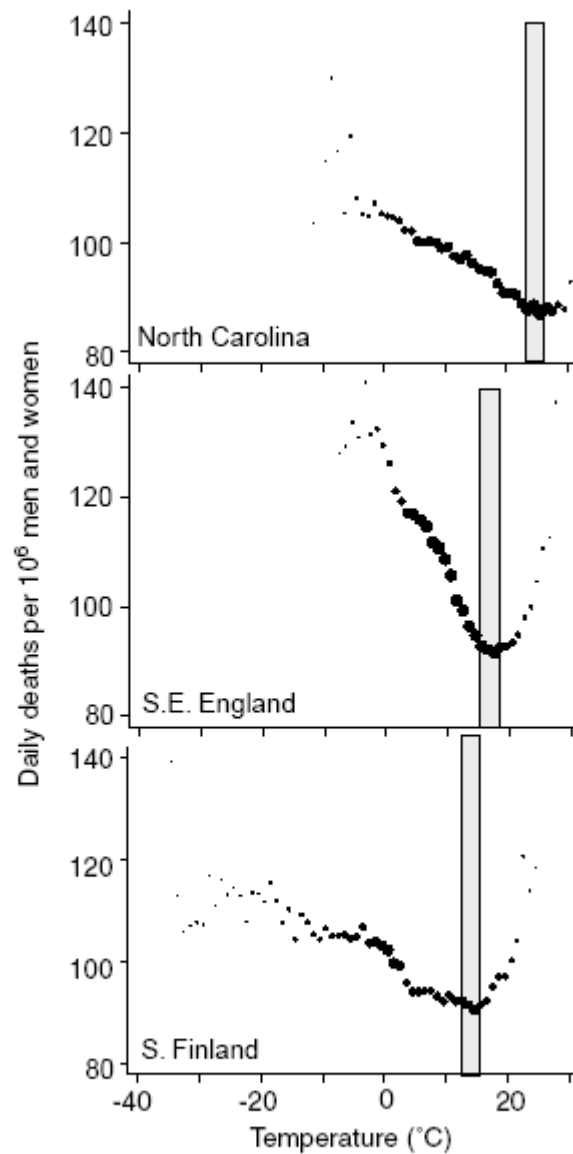
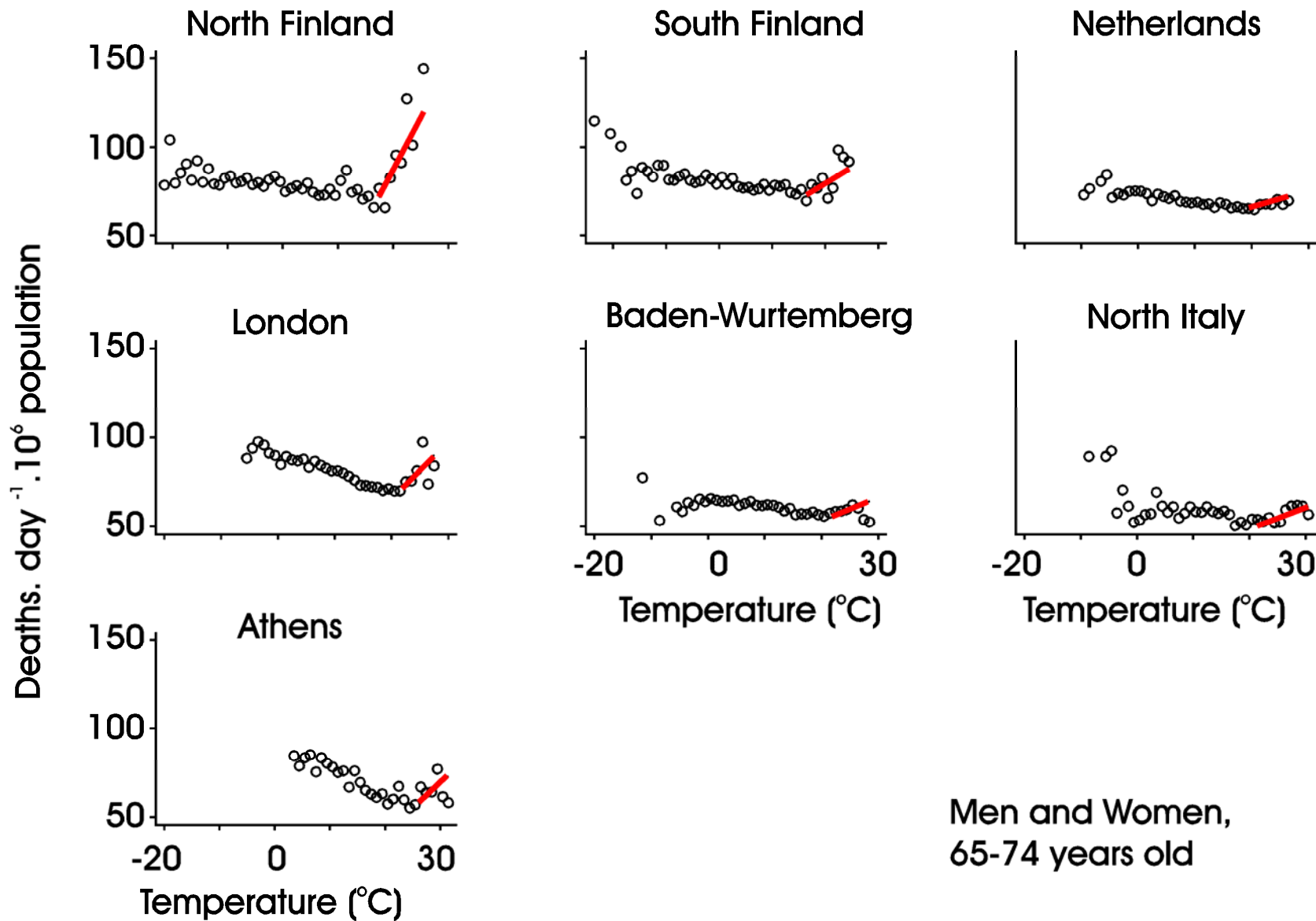


Fig. 1. Mortality at different mean daily temperatures. Pooled data for each region at age 55+, 1971–1997. The areas of circles are proportional to the number of days at each temperature.



Men and Women,
65-74 years old

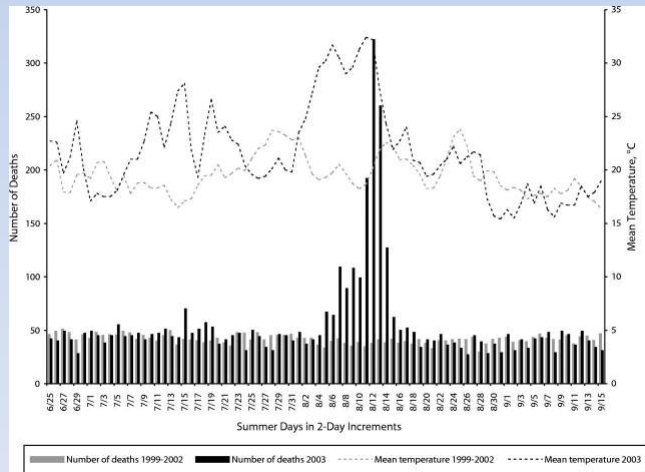
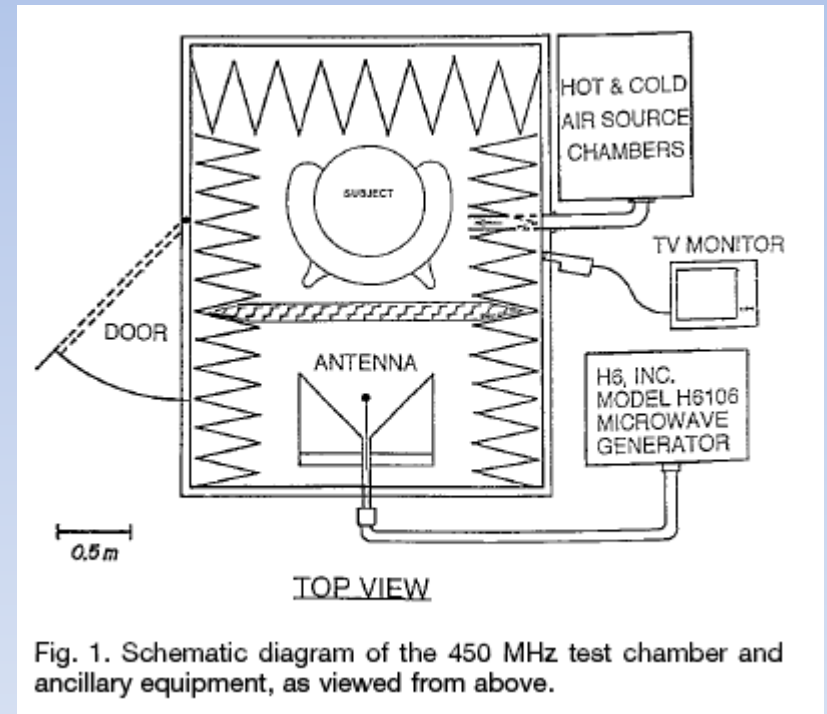


Table 1. Cardiovascular system

Reference	Population	Reported effect
<i>Heart rate (HR) and blood pressure</i>		
Gadzicka et al. (1997)	Radio-station workers	↓ Day/night HR variability
Bortkiewicz et al. (1997)	Radio-station workers	Abnormal electrocardiogram
Szmigielski et al. (1998)	RFE workers	↓ Amplitude of diurnal HR and blood pressure rhythms
Mann et al. (1998a)	Subjects during sleep	No cardiovascular effects
Braune et al. (2002)	Normal subjects	No cardiovascular effects
Bortkiewicz et al. (2003)	Mobile-phone users	“Neurovegetative regulation disorders”
Huber et al. (2003)	Normal population	Slight ↓ HR before sleep
Celik and Hascalik (2004)	Pregnant women	No changes in fetal HR
Wilén et al. (2004)	RFE plastic sealer operators	↓ HR
Tahvanainen et al. (2004)	Normal subjects	No cardiovascular effects
Müller et al. (2004b)	Normal subjects	No cardiovascular effects
Kantz et al. (2005)	Normal subjects	No cardiovascular effects
Wilén et al. (2006)	Mobile-phone users who reported symptoms	No cardiovascular effects during RFE exposure
Vangelova et al. (2006)	Broadcast- and TV-station operators	↑ Blood pressure and cholesterol
Atlasz et al. (2006)	Healthy subjects	No changes in HR
<i>Local blood flow changes</i>		
Khudnitskii et al. (1999)	Normal subjects	“Cardiovascular changes”
Paredi et al. (2001)	Normal subjects	Local vasodilator response
Monfrecola et al. (2003)	Normal subject	↑ Ear cutaneous blood flow
Huber et al. (2002)	Normal subjects	↑ Cerebral blood flow
Haarala et al. (2003)	Normal subjects	↓ Cerebral blood flow (but due to auditory signal, not RFE exposure)
Huber et al. (2005)	Normal subjects	Cerebral blood flow
Aalto et al. (2006)	Normal subjects	Both – and – in cerebral blood flow

Human exposures to RF

- Two groups of volunteers exposed to 2450 MHz CW and PW (65 μ s pulse width).
- Post acclimitisation to 24, 28 or 30C irradiated for 45 min at (0, 27, 35 mW/cm²)



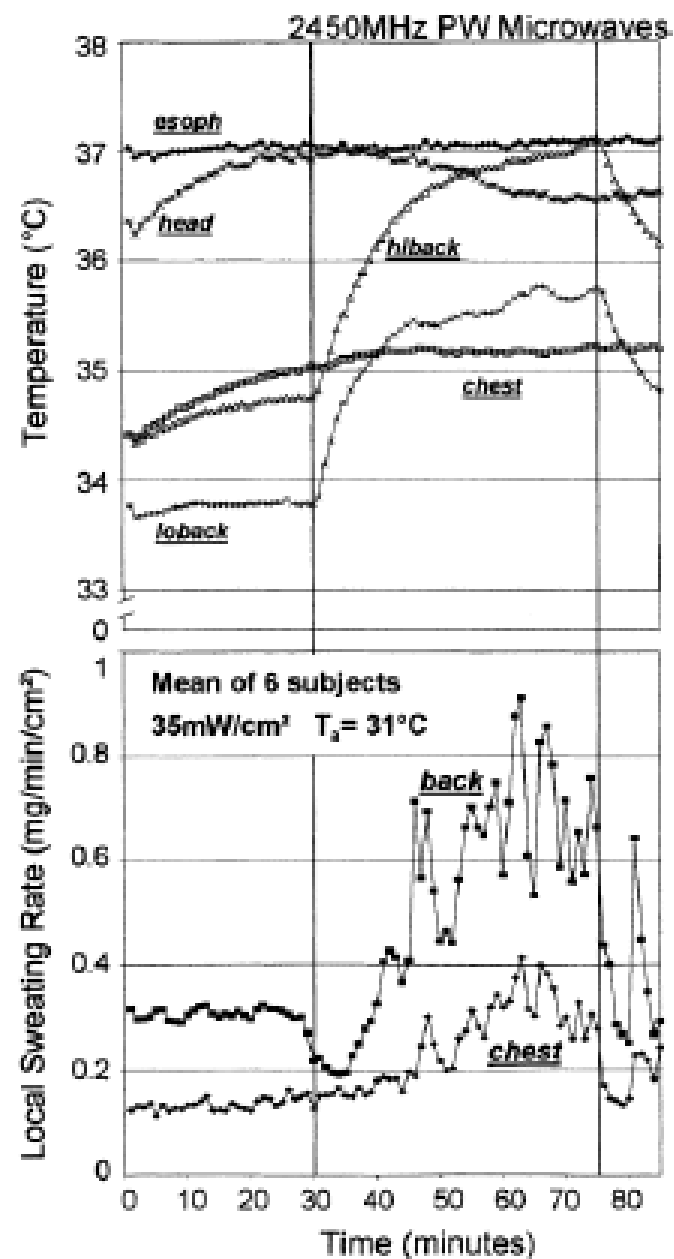
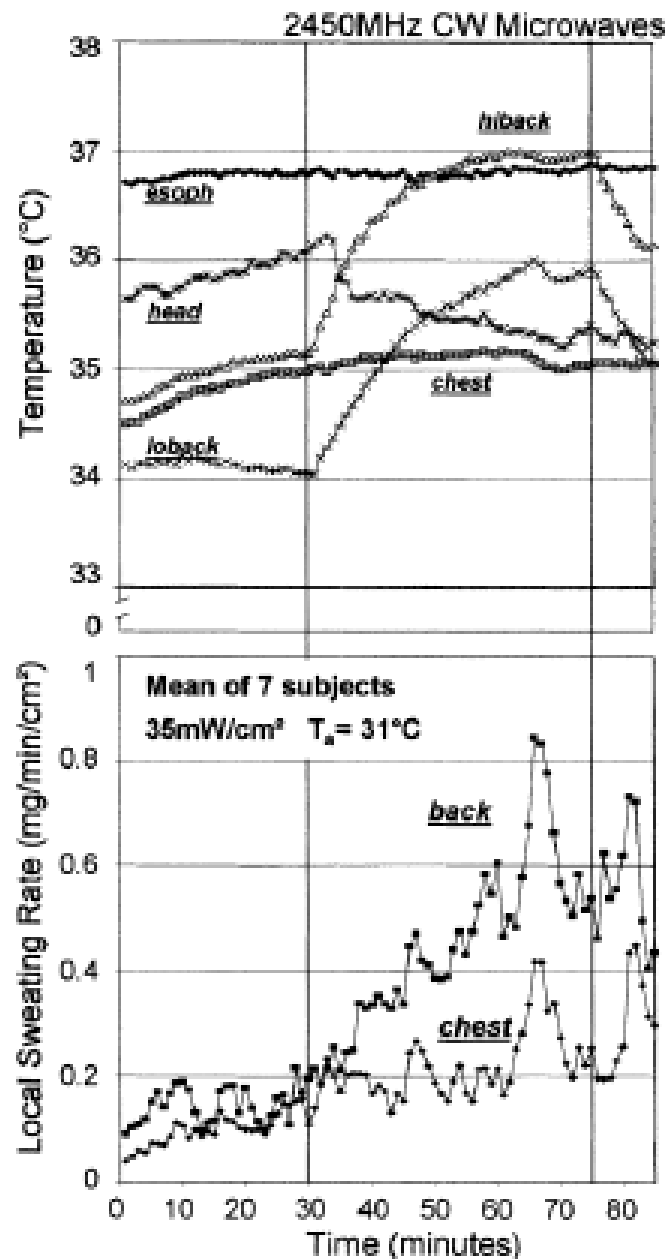


Fig. 3. Meandata for two groups of subjects exposed to 2450 MHz RF energy at $T_a = 31^\circ\text{C}$. Left: CW; right: PW (65 μs pulse width, 10^4 pps). Upper: esophageal and four local skin temperatures; lower: local sweating rate from back and chest skin.

The American conference of Governmental Industrial Hygienists (1992) states that workers should not be permitted to work when deep body temperature exceeds 38C

Adopted by NIOSH – US National Institute for Occupation Safety and Health.

Also recommended by ISO (International Standards Organisation).

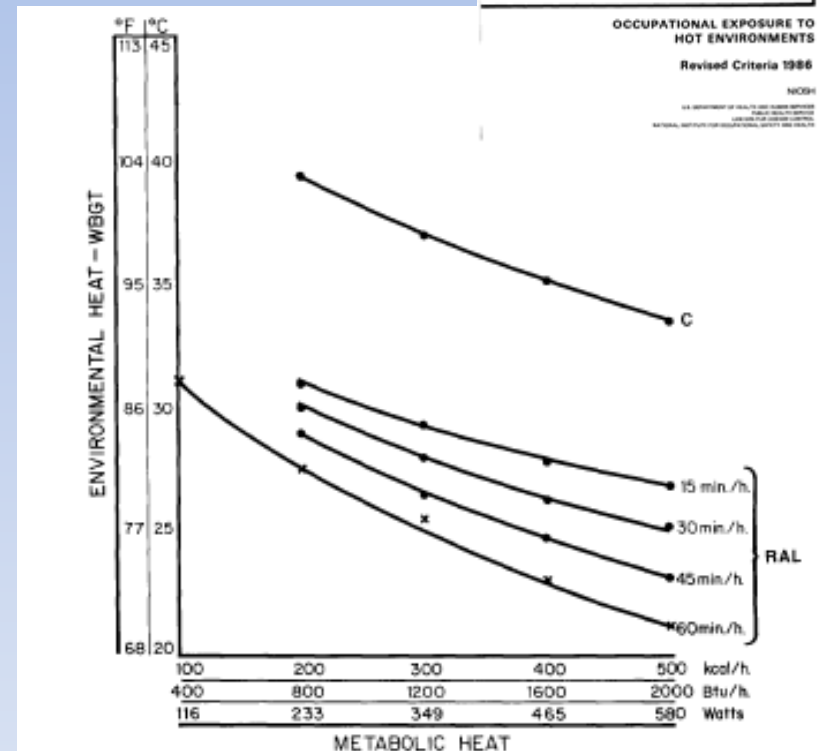
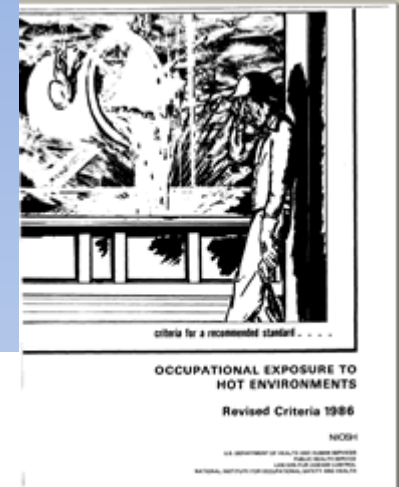


Figure 1. Recommended Heat-Stress Alert Limits Heat-Unacclimatized Workers

C = Ceiling Limit
 RAL = Recommended Alert Limit
 *For "standard worker" of 70 kg (154 lbs) body weight and 1.8 m² (19.4 ft²) body surface.
 Based on References 2,3,4,5,6,7,8.