

lation and by operation of the sweat glands (physical regulation). The reactions involved in cold and in hot environments are on the whole radically different in nature. The mechanisms of adjustment involved are extremely complex and, while they are receiving considerable study, a complete understanding of their operation is still lacking.

Some of the phenomena of body temperature control are shown graphically in Fig. 2. The dotted curves, from a study at the John B. Pierce Laboratory of Hygiene⁸, are for subjects lightly clothed in a semi-reclining position and give the relation between the dry-bulb temperature of the environment (with about 45 per cent relative humidity) and the metabolic rate (heat production), the rate of heat dissipation by radiation and convection combined, and the latent heat loss due

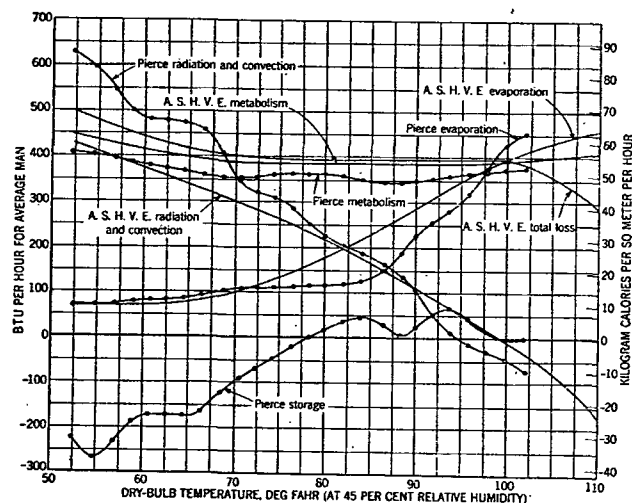


FIG. 2. RELATION BETWEEN METABOLISM, STORAGE, EVAPORATION, RADIATION PLUS CONVECTION, AND OPERATIVE TEMPERATURE FOR THE CLOTHED SUBJECT

to evaporation from the skin and the respiratory tract. The smooth line curves from the work of the A.S.H.V.E. Research Laboratory⁹ give the same relationships for healthy, male subjects (18 to 24 years of age), seated at rest and dressed in customary winter indoor clothing. The Pierce Laboratory data for the semi-reclining subjects also include the rate of heat storage (either positive or negative) due to a rise or fall in body temperature. For the normally clothed subjects, a curve gives the total heat loss (that is, the sum of the radiation, convection and evaporative losses). Here, storage is given by the difference between the metabolism and total heat loss.

The small difference between the metabolic rates for the two groups of subjects may be accounted for by difference in activity. Heat exchange between the body and the environment by radiation and convection is greater for the lightly clothed subject, both for cool conditions where there is excessive heat loss, and for very warm conditions where there is transfer of heat from the atmosphere to the body. The two curves for

evaporative loss serve to show how physiological control uses evaporation of perspiration to maintain equilibrium at high temperatures. Below 75 F for the normally clothed subject, and below 85 F for the lightly clothed subject, evaporation loss is minimal and constant. Above these temperatures control is obtained by the availability of perspiration for evaporation. The difference in the curves above 75 F is probably largely determined by the difference in clothing and activity. In temperatures well above 95 F radiation and convection change from positive to negative. Even the greatly increased evaporative heat loss ceases to take care of heat production plus radiation and convection gains. Heat storage results with a consequent rise in body temperature and metabolic rate. This may be accounted for by increased chemical reaction with rise in temperature, and indicates the point where a breakdown in thermal equilibrium begins. Survival time is limited when the accelerated metabolic rate raises body temperature to 105 F.

TABLE 2. PHYSIOLOGICAL RESPONSES TO HEAT OF MEN AT REST AND AT WORK^a

EFFECTIVE TEMP	ACTUAL CHIEF TEMP (Fahr Deg)	MEN AT REST			MEN AT WORK 90,000 FT-LB OF WORK PER HOUR			
		Rise in Rectal Temp (Fahr Deg per Hr)	Increase in Pulse Rate (Beats per Min per Hr)	Approximate Loss in Body Weight by Perspiration (Lb per Hr)	Total Work Accomplished (Ft-Lb)	Rise in Body Temp (Fahr Deg per Hr)	Increase in Pulse Rate (Beats per Min per Hr)	Approximate Loss in Body Wt by Perspiration (Lb per Hr)
60	-----	-----	-----	-----	225,000	0.0	6	0.5
70	-----	0.0	0	0.2	225,000	0.1	7	0.6
80	96.1	0.0	0	0.3	209,000	0.3	11	0.8
85	96.6	0.1	1	0.4	190,000	0.6	17	1.1
90	97.0	0.3	4	0.5	153,000	1.2	31	1.5
95	97.6	0.9	15	0.9	102,000	2.3	61	2.0
100	99.6	2.2	40	1.7	67,000	4.0 ^b	103 ^b	2.7 ^b
105	104.7	4.0	83	2.7	49,000	6.0 ^b	158 ^b	3.5 ^b
110	-----	5.9 ^b	137 ^b	4.0 ^b	37,000	8.5 ^b	237 ^b	4.4 ^b

^aData by A.S.H.V.E. Research Laboratory.

^bComputed value from exposures lasting less than one hour.

HIGH TEMPERATURE HAZARDS

Studies at the A.S.H.V.E. Research Laboratory¹⁰ and elsewhere during the past two decades have made available much information dealing with the physiological effects of hot atmospheres on workers and means of alleviating the distress and hazards associated therewith. Table 2 gives some of the physiological responses of men at rest and at work to hot environments. Frequent and continued exposure of workers to hot environments results in physiological derangement affecting the leucocyte count of the blood, and other factors dealing with man's mechanism of defense against infection¹⁰.

Wherever *S* (Equation 1) becomes strongly positive and body temperature rises progressively men will continue to work until body temperature reaches 101 to 103 F. When these body temperatures are exceeded men work with declining efficiency and are liable to heat exhaustion, heat cramps, or heat stroke.

Heat exhaustion is a circulatory failure in which the venous return to the heart is reduced so that fainting results¹¹. Early symptoms of heat