THE RELATIONSHIP BETWEEN PULSE COUNT AND ENERGY EXPENDITURE AT SUB MAXIMAL WORK UNDER DIFFERENT AMBIENT TEMPERATURES

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Studies were carried out on six soldiers to evaluate the energy expenditure at submaximal work under three environmental temperatures of 22° C, 30° C and 37° C. The subjects were given a standard graded exercise of varying work loads from 200 to 600 kgm/min on a bicycle ergometer. Pulse count, pulmonary ventilation, oxygen consumption, carbon dioxide elimination and breathing frequency were measured during rest and at each work load. Results indicated that oxygen consumption was not influenced by environment, whereas, pulse count was significantly influenced by environment, being highest for subjects at 37° C ($P<0.01$). The findings of the present study assess the likely effect of variation in environmental temperatures between 22° C and 30° C, 22° C and 37° C and 30° C and 37° C on the physiological responses to the submaximal type of exercise.

The effects of different environmental temperatures on various physiological responses to physical activity have been studied by Brouha[1] *et al.* The results showed that the heart rate was the physiological variable that most faithfully reflected the total strain influenced by the simultaneous actions of work and heat. The oxygen consumption was related principally to the intensity of work and was influenced little by the degree of environmental stress, thus confirming the results obtained by Edholm[2] *et al.* Therefore, in hot environment the oxygen consumption may give a wrong indication of the total stress on the subject. Williams *et al.* and Sengupta[4] *et al.* have observed that there is a decrease in aerobic oxygen supply during work in heat. Conversely, Consolazio[5] *et al.* have observed that as the environmental temperature increases there is an increase in metabolic rate of subjects performing a fixed task, and this increase is due to heat load imposed on the body and not due to acclimatization or training effect. Although considerable work has been done on environmental temperatures and energy expenditures, it appears that no attempt has yet been made to relate the pulse count with the energy expenditure under different environmental temperatures; hence this study was undertaken.

EXPERIMENTAL PROCEDURE

The study was conducted on six healthy clinically normal soldiers. Their mean age, weight and height together with the standard deviation were 24.0±2.4 yr, 60.2±3.8 kg and 170.9±4.4 cm respectively. They were exposed to rest (sitting relaxed on a chair) for thirty minutes in a temperature controlled room at 22°C, 30°C and 37°C (22.10°C with 70% RH, 30.16°C with 68% RH and 37.05°C with 56% RH). Their resting heart rate (H_R), oxygen consumption (V_{O_2}), pulmonary ventilation (V_E), carbon dioxide elimination (V_{CO_2}) and breathing frequency (f_R) were recorded. Thereafter, they were given graded submaximal work loads varying from 200 to 600 kgm/min on a bicycle ergometer (Model 844, Quinton. USA) at a pedal frequency of 60 rev/min. After attainment of steady state on each work load, V_{O_2}, V_{CO_2} V_E and f_R were again noted.

Oxygen consumption was determined from the collections of expired air over a 2 minutes period i.e. from 6th to 8th minutes by Kofranyi-Michaelis meter. Simultaneously, the heart rates were counted over the apex region by a stethoscope during the last 30 sec of each minute. The expired air was analysed in duplicate for oxygen and carbon dioxide content by Scholander Microgas analyser. The energy expenditure was calculated by using Weir's[6] formula.

RESULTS

The values of the mean changes (±SD) of the heart rate, energy expenditure, pulmonary ventilation, carbon dioxide elimination and breathing frequency during rest and graded submaximal work at three environmental temperatures are summarised in Tables 1 and 2. The mean H_R values for the work load of 500 and 600 kgm/min were significantly ($P<0.05$) increased at 22°C *vs* 30°C and 22°C *vs* 37°C. But H_R was highly significant ($P<0.01$) only at 600 kgm/min in 30°C *vs* 37° C. The energy expenditur

TABLE 1

MEAN VALUES (±SD) AND STATISTICAL ANALYSIS IN HEART RATE AND ENERGY EXPENDITURE DURING GRADED SUBMAXIMAL WORK UNDER THREE ENVIRONMENTAL TEMPERATURES

	Heart rate (Beats/min)			Energy expenditure (kcal/min)			Significance					
	22°C	30°C	37°C	22°C	30°C	37°C	22°C vs 30°C		22°C vs 37°C		30°C vs 37°C	
							H_R /min	E. exp (kcal/min)	H_R /min	E. exp. (kcal/min)	H_R /min	E.exp. (kcal/min)
Rest (sitting)	70.6 ±6.9	72.8 ±4.9	74.6 ±3.9	1.15 ±0.13	1.17 ±0.12	1.21 ±0.14	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
200 kgm/min	95.0 ±6.6	97.8 ±9.3	100.0 ±7.4	2.87 ±0.22	3.11 ±0.18	3.26 ±0.09	N.S.	N.S.	N.S.	P<0.01	N.S.	N.S.
300 kgm/min	102.3 ±5.7	110.0 ±6.4	117.3 ±9.4	4.78 ±0.29	4.94 ±0.11	5.00 ±0.15	N.S.	N.S.	P<0.01	N.S.	N.S.	N.S
400 kgm/min	123.6 ±5.4	130.3 ±9.1	142.0 ±13.4	7.23 ±0.17	7.39 ±0.49	7.39 ±0.35	N.S.	N.S.	P<0.05	N.S.	N.S.	N.S.
500 kgm/min	127.3 ±8.0	141.0 ±12.1	149.6 ±13.0	7.33 ±0.29	7.55 ±0.45	7.69 ±0.41	P<0.05	N.S.	P<0.01	N.S.	N.S.	N.S.
600 kgm/min	145.5 ±4.2	152.1 ±5.2	167.6 ±10.4	9.84 ±1.35	9.98 ±0.76	10.09 ±0.89	P<0.05	N.S.	P<0.01	N.S.	P<0.01	N.S

TABLE 2

MEAN VALUES (±SD) IN PULMONARY VENTILATION, CARBON DIOXIDE ELIMINATION AND BREATHING FREQUENCY DURING GRADED SUBMAXIMAL WORK AT THREE ENVIRONMENTAL TEMPERATURES

	Pulmonary ventilation L/min (BTPS)			C_{O_2} elimination L/min (STPD)			Breathing frequency f_R /min		
	22°C	30°C	37°C	22°C	30°C	37°C	22°C	30°C	37°C
Rest (sitting)	7.86 ±1.84	9.59 ±1.05	10.53 ±1.38	0.178 ±0.025	0.189 ±0.024	0.202 ±0.021	16 ±3	17 ±2	17 ±4
200 kgm/min	17.67 ±1.61	17.99 ±2.40	19.84 ±0.86	0.464 ±0.046	0.508 ±0.047	0.559 ±0.016	22 ±3	22 ±3	25 ±3
300 kgm/min	26.57 ±2.59	28.24 ±1.31	29.08 ±2.17	0.795 ±0.043	0.857 ±0.035	0.869 ±0.074	25 ±3	27 ±1	26 ±3
400 kgm/min	35.69 ±4.19	38.80 ±2.44	39.86 ±3.92	1.239 ±0.065	1.243 ±0.070	1.318 ±0.132	26 ±4	28 ±2	29 ±5
500 kgm/min	36.67 ±4.55	40.11 ±4.06	42.99 ±4.89	1.264 ±0.079	1.339 ±0.155	1.346 ±0.160	26 ±4	31 ±3	31 ±6
600 kgm/min	49.15 ±6.82	51.89 ±7.37	57.28 ±8.68	1.728 ±0.277	1.793 ±0.132	1.789 ±0.261	34 ±5	34 ±3	34 ±3

lues varied slightly with rise in environmental mperatures. Similarly V_E, V_{CO_2}, and f_R at rest and five different work loads varied slightly for the ree different environments but the differences ere not statistically significant. The values for the art rate plotted against the different graded ork at three ambient temperatures are shown Fig. 1.

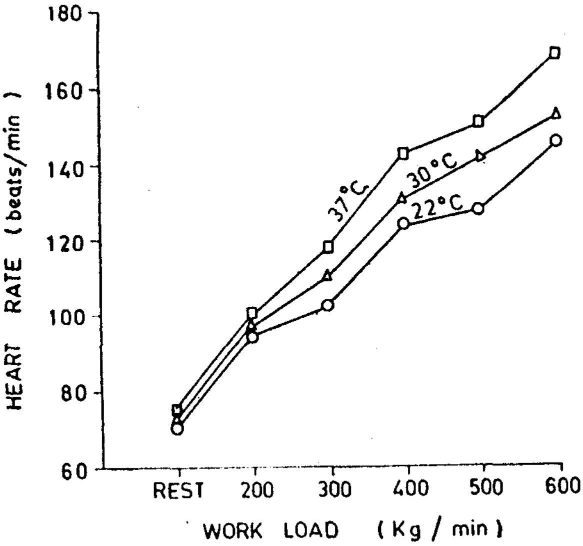

Fig. 1—Changes in heart rate against graded work at three ambient temperatures.

DISCUSSION

It is of great interest to know the physical erformance of army personnel for various acti- ties in different environmental temperatures. hey maintained their physical status through alanced diet and routine physical exercise. he physical performance depends on the rdiovascular system, which has a vital role supplying oxygen to the working muscles. It is well known that the V_{O_2} is a measure of energy penditure and that at ambient temperature the H_R during steady state bears a linear relationship with he V_{O_2} for an individual[7]. This linear relationship between H_R and V_{O_2} at submaximal exercise per- its to use the heart rate to estimate the intensity of exercise. However, this relationship does not hold in ase of higher temperatures as the thermal balance cannot be maintained.

Changes in thermal environment did not affect energy expenditure for a fixed work load. Also at diffe- nt ambient temperatures the f_R showed very little variation at the fixed activity. On the average, H_R at rest nd in exercise increased with rise in ambient temperature[8]. This is clear from Fig. 1. The little differences bserved in V_E and V_{CO_2} are not statistically significant. These results are inconsistent with those of onsolazio[5] *et al.*

The H_R is elevated and may increase progressively throughout the exposure in the hot environment, but he magnitude of energy expenditure is not of the same order. The results of Brouha[9] *et al.* confirmed and mphasised the validity of H_R as an indicator of physiological strain of a fixed work in a hot environment contrast to energy expenditure. The data of the present study indicate that the H_R of a fixed task ncreases significantly with temperature, and that this increase is not due to the intensity of work load which as same at all the three temperatures. The mechanism of enhancement of the H_R response in a hot and umid environment was not due to the intensity of work but rather due to vasodilation in the circulation hich, inturn, helps in the dissipation of heat. Our data are in conformity with those reported by Robinson[10]

Thus, it can be concluded that during submaximal exercise in different environments, the metabolic ost of an individual remains unchanged but the pulse rate is affected by the environmental conditions uring even submaximal effort.

It should be emphasised that further research be carried out to work out a nomogram of pulse count ith energy expenditure of various activities of the soldiers under different ambient temperatures and at ltitudes. The nomogram developed may help the army authorities to determine work load of a particular ask, thus enabling them to take appropriate steps to increase or decrease the duration and intensity of hysical activity commensurate with climatic changes.

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