NASA-TM-112447

Int. J. Biometeor. 1972, vol. 16, number 4, pp. 375-387

Maximal Oxygen Uptake, Sweating and Tolerance to Exercise in the Heat

by

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INTRODUCTION

The physiological mechanisms that facilitate acute acclimation to heat have not been fully elucidated, but the result is the establishment of a more efficient cardiovascular system to increase heat dissipation via increased sweating (Wyndham et al., 1968) that allows the acclimated man to function with a cooler internal environment and to extend his performance (Rowell et al., 1967). Men in good physical condition with high maximal oxygen uptakes generally acclimate to heat more rapidly and retain it longer than men in poorer condition (Bean and Eichna, 1943; Eichna et al., 1945). Also, upon first exposure trained men tolerate exercise in the heat better than untrained men (Greenleaf, 1964; Piwonka et al., 1965). Both resting in heat and physical training in a cool environment confer only partial acclimation when first exposed to work in the heat (Bean and Eichna, 1943; Strydom et al., 1966). These observations suggest separate additive stimuli of metabolic heat from exercise and environmental heat to increase sweating during the acclimation process. However, the necessity of utilizing physical exercise during acclimation has been questioned. Bradbury et al. (1964) have concluded exercise has no effect on the course of heat acclimation since increased sweating can be induced by merely heating resting subjects.

Preliminary evidence suggests there is a direct relationship between the maximal oxygen uptake and the capacity to maintain thermal regulation, particularly through the control of sweating (Astrand, 1960; Kozlowski and Saltin, 1964; Saltin and Hermansen, 1966). Since increased sweating is an important mechanism for the development of heat acclimation, and fit men have high sweat rates, it follows that upon initial exposure to exercise in the heat, men with high maximal oxygen uptakes should exhibit less strain than men with lower maximal oxygen uptakes. The purpose of this study was (a) to determine if men with higher maximal oxygen uptakes exhibit greater tolerance than men with lower oxygen uptakes during early exposure to exercise in the heat, and (b) to investigate further the mechanism of the relationship between sweating and maximal work capacity.

PROCEDURE AND METHODS

Seven healthy young men with maximal oxygen uptakes between 2.83 l/min [42 ml/(min.kg)] and 5.97 l/min [66 ml/(min.kg)] were employed as subjects (Table 1). After determination of their maximal oxygen uptakes, they were tested in pairs in an environmental chamber and underwent one 2-hr control exercise

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Received 10 August 1972

TABLE 1. Anthropometric data and cardio-respiratory values during maximal work and during the experimental tests

	Anthropometry			Maximal work values					Experimental values 24°C and 47°C		
Subject	Age	Wt	A_b	Work load	$\dot{V}_{O_2}$	$\dot{V}_{O_2}$	$\dot{V}_{E_{BTPS}}$	Heart rate	Work load	$\dot{V}_{O_2}$	$\frac{\dot{V}_{O_2}}{\dot{V}_{O_2} max} \times 100$
	yr	kg	m^2	watts	l/min	ml/(min.kg)	l/min	beats/min	watts	l/min	%
AMB	21	80.92	2.01	350	4.38	54.1	185.0	198	55	1.36	31
BUC	22	90.98	2.10	400	5.97	65.6	201.0	198	80	1.61	27
GIL	21	88.28	2.23	375	5.34	60.5	154.1	189	70	1.17	22
JEW	27	66.82	1.89	225	2.83	42.4	117.6	201	30	0.92	33
McC	26	93.06	2.18	250	3.93	42.2	168.8	204	45	1.16	30
SCH	23	79.14	2.05	350	5.08	64.2	198.6	183	70	1.22	24
SHA	24	66.66	1.85	300	4.23	63.5	140.4	177	55	1.16	27
X	23	80.84	2.04	320	4.54	56.1	166.5	193	58	1.23	28
±SE	1	4.11	0.05	25	0.39	3.8	11.7	4	6	0.08	1

test on a Monark bicycle ergometer at 24°C T_{db}. Each pair of subjects then underwent three 2-hr acclimation exposures at 47°C T_{db} with one day of rest between exposures (Table 2). During all tests the subjects exercised at a relative oxygen uptake ($\dot{V}_{O2}$ x $100/\dot{V}_{O2}$ max) of 28 ± 1% (Table 1). Workloads that gave approximately the same relative oxygen uptakes were employed instead of constant absolute workloads to provide comparable "internal stress" and similar elevation of core temperature for each subject. The environmental conditions provided constant "external stress" and comparable levels of skin temperature.

TABLE 2. Average environmental conditions during the experiment

	T_{db}	T_{wb}	rh	P_{H_2O}	T_g
	°C	°C	%	mm Hg	°C
Control test	24	16	44	10	21
Acclimation test no 1	48	32	34	27	47
Acclimation test no 2	48	33	38	31	47
Acclimation test no 3	47	33	41	32	47

In all tests turbulent air motion varied from 12 to 15 m/min.

Expired gas was collected in meteorological balloons and the O_2 and CO_2 concentrations were determined immediately with Beckman E2 and Beckman IR 215 analyzers. Analyzer calibrating gases were calibrated with the micro-Scholander technique (Scholander, 1947). Oxygen uptake was calculated with data from the nomogram of Dill and Fölling (1928). The reproducibility of duplicate $\dot{V}_{O2}$ measurements averaged ± 0.02 l/min. The 175 ml dead space in the modified Otis-McKerrow respiratory valve was included in the calculation of $V_{E_{BTPS}}$ from $V_{E_{ATPS}}$. Heart rate was determined from the continuous EKG record.

Rectal (T_{re}), auditory canal (T_{ac}) and skin temperatures were measured with YSI series 400 thermistors and recorded on a Digitek thermometer; system accuracy was ± 0.05°C. The rectal thermistor was inserted 17 cm and the six skin thermistors were fixed to spring clips attached to plastic rings that allowed free evaporation of sweat around each thermistor. The skin thermistors were located on the medio-lateral arm, medio-lateral forearm, upper abdomen, subscapular region, medio-anterior thigh and medio-lateral leg. Each skin thermistor reading was multiplied by the proportion of total surface area represented by that thermistor and the sum of the six products was the mean skin temperature ($\bar{T}_s$). Auditory canal temperature was measured 8 to 10 mm from the tympanic membrane (Greenleaf and Castle, 1972). Total body sweat rate was calculated from changes in body wt measured on a platform balance (± 5 kg) at half-hourly intervals taking into account voluntary tap water consumption (37°C) but not respiratory gas exchange.

The criteria for terminating a test (tolerance time) were either a T_{re} of 40°C, a maximal heart rate for one min, or the subject's request to stop. The main signs and symptoms of most subjects at the termination of work were those of classical heat exhaustion: fatigue, nausea, excessively high heart rates, syncope during the rest periods, dizziness, chills and shortness of breath.

RESULTS

MAXIMAL OXYGEN UPTAKE AND TOLERANCE

The results indicate essentially no demonstrable positive relationship between maximal oxygen uptake and tolerance to T_{db} 47°C while working at an average workload of 58 W and a relative oxygen uptake of 28% (Fig. 1). Subject BUC, with the highest maximal oxygen uptake of 65.6 ml/(min.kg), and subject JEW, with the second lowest maximal oxygen uptake of 42.4 ml/(min.kg), were exposed simultaneously and their tolerances for each of the three acclimation exposures were practically the same: subject BUC tolerance times were 55, 85 and 85 min; subject JEW times were 55, 75 and 85 min, respectively (Fig. 1, Table 3).

During the first acclimation exposure subject AMB was able to work for 120 min (100% tolerance), subject SHA completed 115 min and subject McC, who had the lowest maximal oxygen uptake [42.2 ml/(min.kg),] stopped at 85 min. Three other subjects (BUC, SCH, GIL) with high maximal oxygen uptakes had first exposure tolerances of 55 min or less.

During the second acclimation exposure, the tolerance of subject AMB decreased from 120 min on the first exposure, the tolerance of subject SHS dropped from 115 to 70 min and McC from 85 to 70 min. Conversely, those subjects with the lowest first exposure tolerances all had greater tolerance during the second exposure: GIL went from 50 to 55 min, SCH increased from 50 to 75 min and JEW from 55 min (he was stopped because his heart rate reached 200 beats/min) to 75 min. The average tolerance of 82 min was highest during the third acclimation exposure. It should be emphasized that the second exposure tolerances of subjects AMB, SHA and McC (55, 70 and 70 min, respectively), who had the greatest first exposure tolerances, were not appreciably different than the second exposure tolerances of subjects GIL, SCH and JEW (55, 75 and 75 min, respectively), who had the lowest first exposure tolerances. In all but two exposures termination was by voluntary withdrawal.

COMPARISON OF SUBJECTS WITH HIGH AND LOW MAXIMAL OXYGEN UPTAKES

A comparison of average tolerance time, ΔT_{re}, Δ heart rate and terminal heart rates between the two subjects with the highest maximal oxygen uptake (BUC and SCH, $\bar{X}$ area = 2.08 m^2) and the lowest maximal oxygen uptake (JEW and McC, $\bar{X}$ area = 2.04 m^2) is presented in Fig. 2. During the first acclimation exposures (A1), the low max V_{02} pair had greater tolerance, 58 min, compared with 44 min for the high max V_{02} pair; the values for the other three variables for the two pairs were essentially the same.

During the second acclimation exposure (A2), the high max V_{02} pair had a ΔT_{re} of 2.55°C compared with 1.98°C for the low group (Fig. 3). Terminal heart rates were 10 beats/min higher in the low pair.

During the third acclimation exposure (A3), while tolerance time, ΔT_{re} and terminal heart rates were essentially the same, the Δ heart rate for the low maximum pair was reduced 25 beats/min compared with the high maximum pair due to elevated resting heart rates in the former (Fig. 2, Table 3). From these data it is clear that, when working at the same relative load, the high capacity pair has no appreciable advantage in tolerance over the low capacity pair during early exposure to heat.

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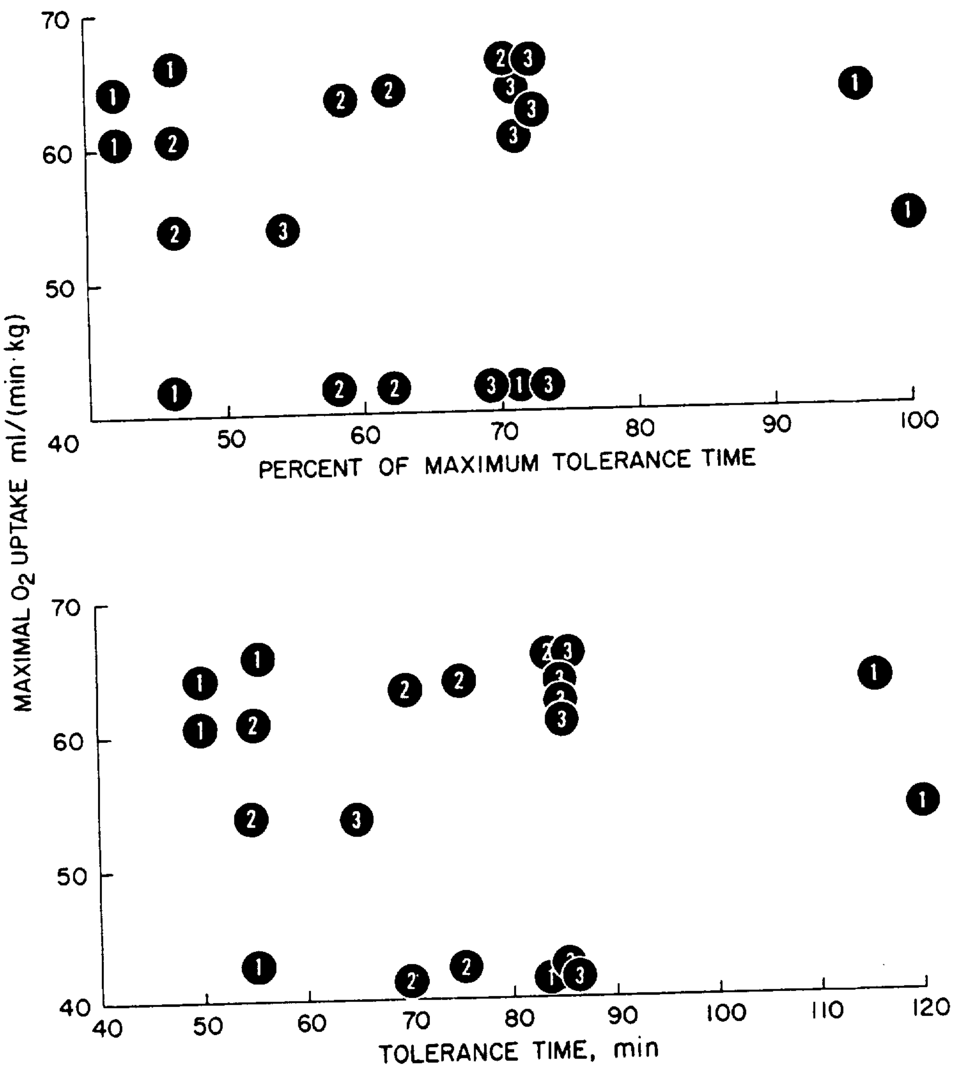

Fig. 1. Individual values for maximal oxygen uptake and tolerance time expressed as % of maximal for the first ①, second ② and third ③ heat exposures.

TABLE 3. Tolerance time, body temperature, heart rate and sweat rate during the control and acclimation exposures. Sweat rate was the average loss over the exposure. 0 = zero time value; t = terminal value.

Subject	Tolerance time	Tolerance time	T_{re_0}	T_{re_t}	ΔT_{re}	$\overline{T}_{s_0}$	$\overline{T}_{s_t}$	$\Delta\overline{T}_s$	Heart $rate_0$	Heart $rate_t$	ΔHeart rate	Heart $rate_t$	Sweat rate
	min	% max	°C	°C	°C	°C	°C	°C	beats/min	beats/min	beats/min	% max	$g/(hr.m^2)$
CONTROL													
AMB	120	100	37.40	37.81	0.41	31.88	31.66	-0.22	76	107	31	54	118
BUC	120	100	37.46	37.62	0.16	31.73	31.46	-0.27	70	113	43	57	228
GIL	120	100	36.70	37.75	1.05	29.84	32.07	2.23	64	125	61	66	101
JEW	120	100	37.43	37.49	0.06	32.46	32.71	0.25	88	109	21	54	17
McC	120	100	37.40	37.64	0.24	32.29	32.41	0.12	84	108	24	53	31
SCH	120	100	36.57	37.45	0.88	29.42	31.14	1.72	61	94	33	48	128
SHA	120	100	37.39	37.40	0.01	31.80	32.22	0.42	60	87	27	49	49
$\overline{X}$	120	100	37.19	37.59	0.40	31.35	31.95	0.61	72	106	34	54	96
±SE	0	0	0.15	0.06	0.15	0.46	0.21	0.37	4	5	5	2	27
ACCLIMATION NO 1													
AMB	120	100	37.41	40.03	2.62	37.64	39.83	2.19	82	172	90	87	585
BUC	55	46	37.19	39.13	1.94	37.62	39.58	1.96	73	170	97	86	996
GIL	50	42	37.62	39.03	1.41	38.73	39.60	0.87	86	154	68	81	-
JEW	55	46	37.13	38.91	1.73	38.82	39.78	0.96	99	184	85	92	374
McC	85	71	37.43	39.16	1.73	38.47	40.03	1.56	96	168	72	82	298
SCH	50	42	37.25	38.96	1.71	37.01	39.43	2.42	76	135	59	69	-
SHA	115	96	36.89	39.72	2.83	37.81	40.00	2.19	72	152	80	86	478
$\overline{X}$	76	63	37.28	39.28	2.00	38.01	39.75	1.74	83	162	79	83	546
±SE	12	10	0.05	0.16	0.20	0.25	0.08	0.23	4	6	5	3	122
ACCLIMATION NO 2													

SCH	50	42	37.25	38.96	1.71	37.01	39.43	2.42	76	135	59	69	-
SHA	115	96	36.89	39.72	2.83	37.81	40.00	2.19	72	152	80	86	478
$\overline{X}$	76	63	37.28	39.28	2.00	38.01	39.75	1.74	83	162	79	83	546
±SE	12	10	0.05	0.16	0.20	0.25	0.08	0.23	4	6	5	3	122

ACCLIMATION NO 2

AMB	55	46	37.12	38.91	1.79	37.43	39.06	1.63	88	168	80	85	743
BUC	85	71	37.16	39.77	2.61	37.09	39.92	2.83	75	169	94	85	666
GIL	55	46	37.46	38.60	1.14	37.81	39.32	1.51	88	162	74	86	411
JEW	75	62	37.06	39.47	2.41	39.33	39.90	0.57	96	194	98	97	333
McC	70	58	37.54	39.08	1.54	37.67	39.49	1.82	92	165	73	81	310
SCH	75	62	37.23	39.72	2.49	37.62	39.72	2.10	69	148	79	75	1517
SHA	70	58	37.22	39.42	2.20	39.21	39.89	0.68	68	140	72	79	667
$\overline{X}$	69	58	37.26	39.28	2.03	38.02	39.61	1.59	82	164	81	84	664
±SE	4	3	0.07	0.16	0.21	0.33	0.13	0.30	4	7	4	3	157

ACCLIMATION NO 3

AMB	65	54	37.07	39.03	1.96	37.80	39.02	1.22	90	165	75	83	784
BUC	85	71	37.07	39.28	2.21	38.15	39.47	1.32	65	164	99	83	822
GIL	85	71	37.50	39.13	1.63	36.23	38.99	2.76	80	164	84	87	480
JEW	85	71	36.89	39.08	2.19	38.87	38.92	0.05	103	170	67	85	532
McC	85	71	37.41	39.42	2.01	37.62	39.93	2.31	100	166	66	81	389
SCH	85	71	37.47	39.48	2.01	36.29	39.31	3.02	73	156	83	80	947
SHA	85	71	36.59	39.37	2.78	38.03	39.41	1.38	56	138	82	78	758
$\overline{X}$	82	69	37.14	39.26	2.11	37.57	39.29	1.72	81	160	79	82	673
±SE	3	2	0.13	0.07	0.13	0.98	0.13	0.39	7	4	4	1	78

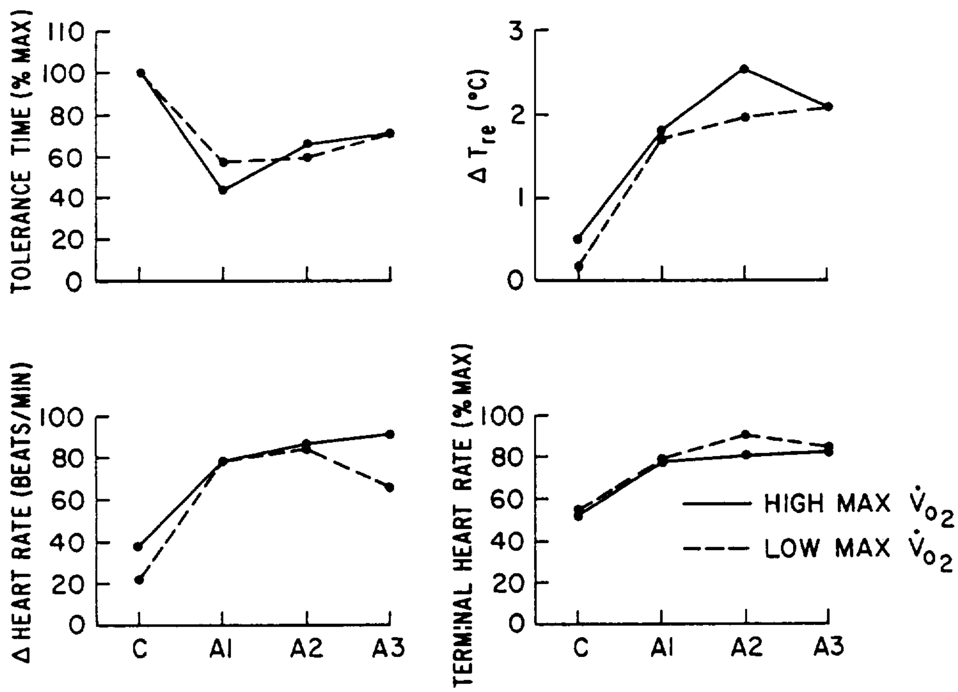

Fig. 2. Comparison of average tolerance time, Δheart rate, Δ rectal temperature and terminal heart rate (% of maximum) between the two subjects with the highest V_{02} (BUC and SCH) and the two subjects with the lowest max $\dot{V}_{02}$ (JEW and McC). C = control, A1 = acclimation no 1, etc.

MAXIMAL OXYGEN UPTAKE AND SWEAT RATES

In five of the seven subjects sweat rates progressively increased from the first through the third acclimation exposures (Fig. 3, Table 4). Of particular interest is the relationship between "maximal" sweat rates (those measured during the second half-hour period) and maximal oxygen uptake (Fig. 3). The solid line is the average of the C, A1, A2 and A3 sweat rates. The missing data during the first acclimation exposure in subjects SCH and GIL were due to the inability of these men to complete the second half-hour work period. During the 24°C control test, the average second period sweat rate in the two high max $\dot{V}_{02}$ subjects [178 g/(hr·m^2)] was much greater than the sweat rate in the two low maximum subjects [24 g/(hr·m^2)]. This difference was also present during the three acclimation exposures (Table 4). In general, during the three acclimation exposures, the maximal oxygen uptake, expressed as ml/(min·kg), was proportional to the sweat rate expressed as g/(hr·m^2).

GENERAL RESULTS

In the control experiment the average ΔT_{re} was + 0.40°C, $\Delta \overline{T}_s$ was + 0.61°C, Δheart rate was 34 beats/min and the terminal heart rate was 54% of the maximal heart rate (Table 3). The average sweat rate increased from 66 g/(hr·m^2) during the first half-hour work period to 110 g/(hr·m^2) during the fourth half-hour period.

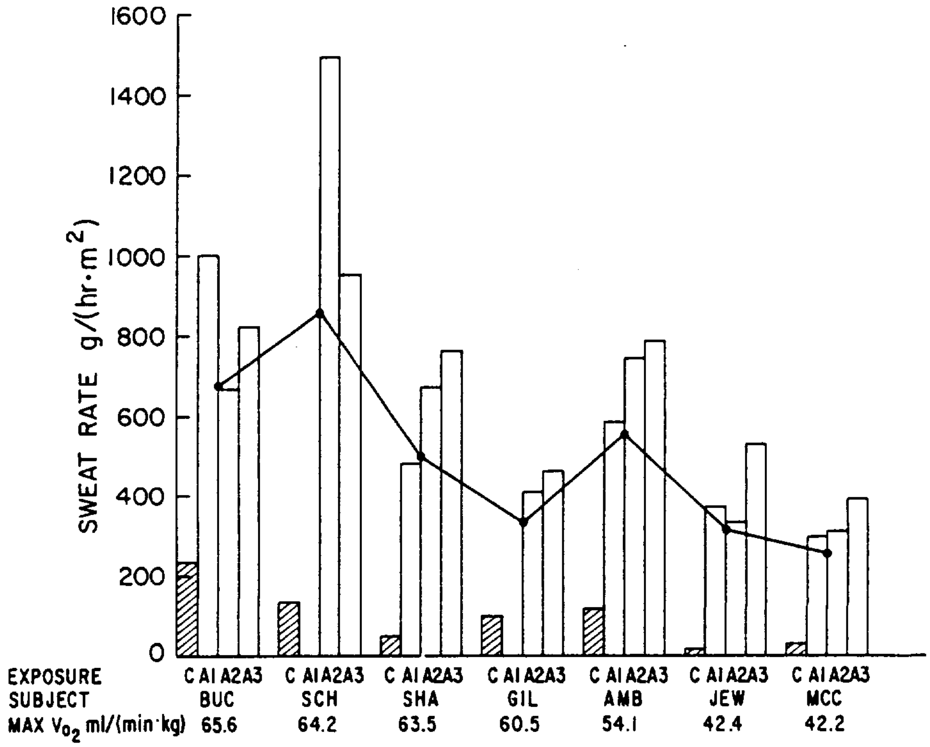

Fig. 3. Individual values during the second half hr of work for sweating during the control (C) and the acclimation (A1, A2, A3) exposures: the solid line connects the average of the four values. Missing data due to subjects inability to complete work task.

TABLE 4. Average body temperatures and sweat rates for the two subjects with high max $\dot{V}_{O2}$ and low max $\dot{V}_{O2}$ during the control and acclimation exposures (t = terminal values)

	T_{re_t}	ΔT_{re}	T_{s_t}	ΔT_s	Sweat rate
	C	C	C	C	g/(hr·m^2)
Control					
High max	37.54	0.52	31.30	0.72	178
Low max	37.56	0.15	32.56	0.18	24
Acclimation no 1					
High max	39.04	1.82	39.50	2.19	996
Low max	39.04	1.73	39.90	1.26	336
Acclimation no 2					
High max	39.74	2.55	39.82	2.46	1,092
Low max	39.28	1.98	39.70	1.20	322
Acclimation no 3					
High max	39.38	1.11	39.39	2.17	884
Low max	39.25	1.10	39.42	1.18	460

During the first acclimation exposure, the average tolerance time was 76 min, ΔT_{re} was +2.00°C, $\Delta \overline{T}_s$ was +1.75°C and Δheart rate was 79 beats/min.

A comparison of average data between the first and third acclimation exposures at the point of exhaustion shows that some measurements were remarkably constant: terminal T_{re} (39.28°C vs 39.26°C), $\Delta \overline{T}_s$ (+1.74°C), ΔT_{re} (2.0°C vs 2.1°C) terminal heart rate (162 vs 160 beats/min), Δheart rate (79 vs 79 beats/min), and terminal heart rate in percent of maximum (83% vs 82%). The more variable measurements were: tolerance time in percent of maximum increased from 63% to 69%, terminal T_s decreased from 39.75° to 39.29°C and first period sweat rates increased 20%, from 337 to 419 g/(hr·m^2). Some possible criteria for tolerance limits might be constructed from these data: rectal temperature of 39.3°C; heart rate of 160 beats/min (82% of maximum); and a change in heart rate of 80 beats/min.

DISCUSSION

Men with high maximal oxygen uptake are capable of performing heavier work for longer periods of time than lower capacity men. The greater metabolic heat produced by the high capacity men, resulting from the greater absolute work loads, must be dissipated or hyperprexia would occur. Therefore, men with high aerobic capacity must have high heat loss capability or they will not be able to work near their maximal levels.

The results of the present study indicate that near maximal sweat rates, induced by mild exercise in the heat, are proportional to the maximal oxygen uptake. Subjects with maximal oxygen uptakes of 64 ml/(min·kg) had maximal sweat rates of 884 to 1,092 g/(hr·m^2) while those with maximal oxygen uptakes of 42 ml/(min·kg) had maximal sweat rates of 336 to 460 g/(hr·m^2) (Table 4). The lower sweat rates in the lower capacity subjects were not due to lower tolerance times in the heat (Fig. 2, upper left). During the control exposure at T_{db} 25°C average sweat rate was 96 g/(hr·m^2) but the high capacity subjects (BUC, SCH, SHA) had sweat rates between 49 and 228 g/(hr·m^2) while the lower capacity men (JEW, McC) sweated between 17 and 31 g/(hr·m^2). Thus the exercise per se contributed less than 20 percent of the maximal sweat rates during exercise in the heat.

Saltin and Hermansen (1966) suggested there was a direct relationship between maximal oxygen uptake and the rate of sweating during moderate exercise at 24°C ambient temperature. Two men with widely different maximal oxygen uptakes and working at the same relative oxygen uptakes but different absolute work loads had the same equilibrium levels of rectal temperature. Since the higher capacity subject had greater heat production because of his greater work load than the lower capacity subject, the "excess" heat from the former had to be dissipated for the rectal temperatures to attain the same level. The "excess" heat was dissipated mainly through greater evaporative loss since the exercise sweat rate of the high capacity subject was about 60% greater than that of the lower capacity man. In the present study the subjects worked at essentially the same relative oxygen uptakes but dry-bulb temperature was elevated to elicit maximal sweating. There is a positive relationship between the rate of sweating and maximal oxygen uptake with either a moderately heavy load in a cool environment (Saltin and Hermansen, 1966), resting in a sauna bath (Kozlowski and Saltin, 1964) or with a mild work load in the heat (present study). These observations suggest that as long as there is a stimulus sufficient to initiate sweating, this relationship between sweating and maximal oxygen uptake is not specifically dependent upon work load, metabolic rate or ambient temperature.

To explain the greater exercise sweating with high maximal oxygen uptakes in men who have the same equilibrium levels of core and skin temperature as lower capacity men, Saltin and Hermansen (1966) suggest that any mechanism responding directly with the individual max $\dot{V}_{O2}$ or the absolute work load, for example mechanoreceptor function, may provide stimuli that results in increased sweating. Smiles and Robinson (1971) present evidence that the level of exercise sweating is controlled by an undefined stimulus proportional to oxygen uptake (metabolic rate) plus a neuromuscular stimulus proportional to the speed of muscular movement (walking). However, other evidence suggests mechanoreceptor function is probably not an important part of the mechanism (Ekblom, Greenleaf and Hermansen, 1971; Greenleaf et al., 1971; Nielsen, 1968).

In the present study the high correlation between maximal oxygen uptake and sweating during work in heat could not have been influenced by speed of movement since there was a constant rate of pedaling the ergometer. The greater sweating in our higher capacity subjects was not related in any consistent pattern to terminal T_{re}, ΔT_{re} or terminal $\overline{T}_s$. The high capacity subjects did exhibit a two-fold greater $\Delta \overline{T}_s$ during the control and heat exposures compared with the low capacity men (Table 4). Since terminal $\overline{T}_s$ were the same in the two groups, the difference in $\Delta \overline{T}_s$ was due to different resting skin temperatures (Table 3). The higher $\overline{T}_{s_o}$ in the low capacity group was probably due to their lower sweat rates in the rest period before exercise commenced (Kozlowski and Saltin, 1964). Thus, we are left with a still undefined mechanism for the observed relationship between maximal oxygen uptake and maximal sweating.

In normal, ambulatory people, exercise training of progressively increasing intensity can increase maximal oxygen utilization only 15 to 20 percent (Ekblom, 1969). Bed rest deconditioning reduces max $\dot{V}_{O2}$ up to 100 percent (Saltin et al., 1968). Maximal rates of sweating have not been measured in deconditioned subjects. It is possible that heredity sets the upper and perhaps also the lower limits of the oxygen uptake capacity from training and deconditioning. If the rate of sweating is coupled directly with the oxygen uptake capacity, then perhaps genetic factors influence the limits of sweating. It is also possible that both maximal oxygen uptake and maximal sweating are responding to a third common unknown variable or mechanism.

There was no appreciable difference between the responses of our high capacity and low capacity subjects to endurance, Δ heart rate, ΔT_{re} or terminal heart rate during the control and heat exposures (Fig. 2). But, there was a large difference in rates of sweating. These results modify observations from earlier studies that fit men exhibited more favorable responses to initial work in the heat than less fit men. One reason for this discrepancy is that in each of the earlier studies all subjects worked at the same absolute load during the acclimation exposures. Since the more fit men probably had higher maximal oxygen uptakes, they would have been working at lower relative loads, hence the attenuated physiological responses and greater performance. The similar endurance performances of our high and low capacity subjects appear to be the result of similar relative loads, in spite of wide variations in sweating. These results question the importance of the rate of sweating as a major determinant of performance during early heat exposure but affirm the close relationship between maximal oxygen uptake and the capacity to maintain thermal homeostasis.

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ABSTRACT. - The purpose of this experiment was to determine if tolerance to exercise in the heat is related to maximal oxygen uptake (max $\dot{V}_{02}$) and sweating. Seven men with max $\dot{V}_{02}$ between 42 and 66 ml/(min·kg) underwent one 2-hr exposure at 24°C T_a while working on a bicycle ergometer at $\overline{X}$ rel $\dot{V}_{02}$ of 28% ($\overline{X}$ $\dot{V}_{02}$ = 1.23 l/min). In the hot exposures the high capacity subjects had maximal sweat rates of 800 to 1,000 g/(hr·m^2) while the lower capacity men sweated 300 to 400 g/(hr·m^2). These differences in sweating were not related to neuromuscular stimuli, $\dot{V}_{02}$ (metabolic rate), T_{re}, ΔT_{re}, $\overline{T}_s$, $\Delta \overline{T}_s$ or tolerance time. Tolerance to exercise in the heat was not related to maximal $\dot{V}_{02}$ capacity when the subjects worked at the same relative load in spite of large differences in sweating. These results question the importance of the rate of sweating for predicting work performance in hot environments.

ZUSAMMENFASSUNG. - Das Ziel dieser Untersuchung war, zu prüfen, ob die Toleranz bei Arbeit in der Hitze in einer Beziehung steht zur maximalen O_2-Aufnahme und Schwitzen. Sieben Männer mit V_{02} zwischen 42 - 66 ml/(min·kg) wurden belastet während 2 Stunden bei T_a 24°C und 3 x 2 Stunden bei 47°C mit Arbeit auf dem Fahrrad-Ergometer bei im Mittel von 28% V_{02} = 1.23 l/min. Während der Hitzebelastung zeigten die leistungsfähigen Personen Schweissekretionsraten von 800 - 1000 g/(hr·m^2) und die wenig leistungsfähigen 300 - 400 g/(hr·m^2). Diese Unterschiede waren ohne Beziehung zu neuromuskulären Stimuli, Stoffwechselrate, T_{re}, ΔT_{re}, $\overline{T}_s$, $\Delta\overline{T}_s$ oder der Toleranzzeit. Ausdauer bei Arbeit in der Hitze war ohne Beziehung zur maximalen V_{02}-Kapazität, wenn die Personen bei der gleichen relativen Belastung arbeiteten tro grosser Unterschiede im Schwitzen. Die Ergebnisse stellen den Wert der Schweissekretionsrate zur Voraussage der Arbeitsleistung in der Hitze in Frage.

RESUME. - Dans cette étude, on a cherché à voir si la tolérance au travail sous contrainte de chaleur était en relation avec la possibilité maximum d'absorption de O_2 ($\dot{V}_{02}$) d'une part, de transpirer d'autre part. 7 hommes présentant des $\dot{V}_{02}$ compris entre 42 et 66 ml/(min . kg) ont pédalé sur un ergomètre pendant 2 heures par une T_a de 24°C et 3 x 2 heures par 47°C et cela par une $\dot{V}_{02}$ relative de 28% ($\overline{X}$ $\dot{V}_{02}$ = 1,25 l/min). Durant l'effort sous contrainte de chaleur, les plus actifs ont eu des sécrétions de sueur de 800 à 1.000 g h^{-1} m^{-2} et les moins actifs de 300 à 400 g/h . m^2. Ces différences étaient sans rapport avec les stimulus neuro-musculaires, le taux de métabolisme, T_{re}, ΔT_{re}, T_s et ΔT_s ou la durée de tolérance. L'endurance au travail sous contrainte de chaleur n'a pas été fonction de la capacité maximum de $\dot{V}_{02}$, lorsque les personnes travaillaient dans des conditions analogues, même si l'on a noté de grandes différences dans la transpiration. Ces résultats mettent en doute la représentativité du taux de sécrétion de sueur comme indicatif des possibilités de travailler en atmosphère chaude.