WBGT degC	DRY degC	WET degC	RH %	Amb. Vap. Press. kPa
10	13	9	60	0.9
20	24	18	50	1.7
24	30	22	50	2.1
28	38	24	30	2.0
29	30	28	86	3.7

Five or 6 subjects were used in each experiment aged 21–43 years and unacclimatised to the heat. The SEMI and IMP suits were worn with underpants, cotton aork dress, boots and S10 respirators. Heart rate (HR) was monitored from a 3-lead ECG (Siemens Telecust). Aural temperature (TDB) was monitored continuously to 0.05°C by means of insulated thermistors and recorded every 2.5 minutes (SQ1200 Grant Instruments) together with mean skin temperature (TSK) from skin thermistors at 4 sites[1]. Sweat production (SP) and evaporation (SE) rates were calculated from changes in body weight corrected for fluid intake (water, ad. lib. via the drinking tube of the respirator).

Subjects were seated whilst baseline measurements were taken and then commenced stepping, up to a height of 22.5 cm at a rate of 12 complete steps/min. (approximately 310 J/sec)[2]. Subjects continued until their TDB reached 38.5°C when they were allowed to rest until TDB fell to 38.0°C. This cycle was repeated to a maximum of 3 hours work/rest. Subjects who did not achieve a rise to 38.5°C worked continuously for 3 hours unless they requested a rest for which 15 minutes was permitted.

RESULTS

Univariate analysis of variance (ANOVA) has been performed to assess for differences between the 2 suits based on a hear additive model including the main effects for 'suit', WBGT index' and the interaction between these 2 factors. At the WBGT 10°C level TSK was significantly (P<0.05) lower in the IMP but all 6 subjects completed 3 hours of work in both suits at this temperature. Of the remaining 4 WBGT levels, maximum times were achieved only in the SEMI suit: 3 subjects at WBGT 20°C and 1 at WBGT 24°C. Subjects wearing the SEMI worked for longer (P<0.05) at WBGTs 24°C and 28°C. At WBGT 29°C the differential between work times for IMP and SEMI was small. At WBGT 20'C 2 subjects showed no difference between IMP and SEMI (180 minutes) whilst 3 others achieved at least 40% extra work in SEMI compared to IMP. The times to the first stop (column 1) and total work time (column 2, max 180 mins) are given below.

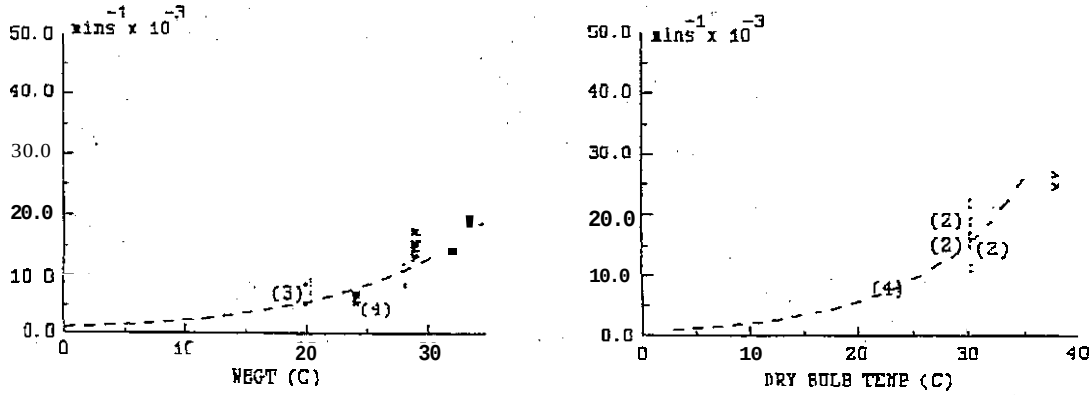
WBGT deg	No.Subs (max)	IMP (mins) Min		IMP (mins) Median		IMP (mins) Max		SEMI (mins) Min		SEMI (mins) Median		SEMI (mins) Max	
20	6	35	110	85	123	104	147	50	114	180	180	180	180
24	5	40	52	59	60	99	118	79	149	143	165	180	180
28	6	20	20	31	31	41	41	63	76	81	113	128	155
29	5	40	40	53	53	65	65	41	57	61	65	77	77

(P<0.01) slower compared to SEMI at WBGTs 20°C, 24°C and 28°C but not at WBGT 29°C. At WBGT 28°C all subjects demonstrated a slow continuous rise in TDB when at rest, more rapidly so after cessation of work. In addition, HR increased more rapidly (P<0.05) in IMP at WBGTs 20°C, 24°C and 28°C. At the end of the first work period the TSK was higher (P<0.01) with IMP at all WBGT levels examined. SP was greater (P<0.01) in the IMP suit but only at WBGT 28°C whilst rates of SE were lower (P<0.01) for IMP compared to SEMI at all WBGT levels.

CONCLUSIONS

From the above series of experiments it is clear that for a WBGT of 10°C the IMP suit presented no additional physiological burden compared to the SEMI. At the higher WBGTs the reduced rate of SE increased the body temperature by reducing evaporative heat losses and the t h e d gradient for conduction through higher TSK temperatures. This also necessitated an increase in HR to increase cardiac output to the cutaneous vessels'. The overall effect of these mechanisms is to reduce. the work output of the subject wearing the IMP suit through heat

Inverse of Work Time against WBGT Temperature for the two Suit Assemblies



SEMI Suit IMP Suit

exhaustion It can be seen that work time in the IMP snit is limited by the dry bulb temperature. The results here would indicate that using a work/rest schedule in the IMP suit, work times of 2 hours and 1 hour are possible over a 3 hour period at dry bulb temperatures below 24°C and 30°C respectively. It is estimated that the 'safe' dry bulb temperature limit below which work is unlikely to be limited by the demands of thermoregulation is approximately 20°C. This compares to the 22.2°C reported elsewhere for men wearing NBC beneath impermeable waterproofs[4].

The steady increase in TDB at WBGT 28°C in the IMP suit suggests that the body cannot attain thermal equilbrium under these circumstances. As the major determinant of thermal load in the IMP suit is the dry bulb then the results for WBGT 24°C and WBGT 29°C should be similar. However, an close examination it was apparent that many of the measures indicated a more severe thermal stress at the higher WBGT level, perhaps due to reduced respiratory heat loss in the higher ambient vapour pressure. The results from the 29°C environment also show that the gradient for SE, although reduced, still allowed a substantial degree of evaporative cooling.

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