WARM WEATHER FLIGHT TRIAL OF A PORTABLE PERSONAL CONDITIONING SYSTEM FOR USE IN HELICOPTERS

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INTRODUCTION

Military helicopters with poor environmental control systems can generate high levels of thermal stress when operating in warm or hot climates. This may be exacerbated if crew members are required to wear insulative clothing such as chemical defence ensembles and may alter performance, decrease operational effectiveness and hazard flight safety. This paper describes a flight trial designed to assess the effectiveness of a portable personal conditioning system in an operational setting.

METHOD

The trial took place in Cyprus during August 1993 when average outside T_{wbgt} exceeded 27°C. Six subjects each flew 4 sorties wearing chemical defence ensembles in a Gazelle helicopter, 2 wearing the conditioning system (Exotemp CD2, Pembroke, Ontario), and 2 as controls. Sorties consisted of a preflight planning phase, activity at the aircraft prior to flight and a flight profile containing a number of operational activities. The conditioning system consisted of a long-sleeved, Nomex vest worn next to the skin with a number of tubes sewn to its inner surace around which was circulated cold water. This cold water was produced by melting ice contained within a 2 litre bottle, each bottle providing 60 minutes of cooling. When the cooling vest was worn, conditioning commenced as soon as instrumentation and dressing had been completed. Paired control and test flights were flown at the same time of day. Ground and cockpit environmental measures were wet and dry bulb, and miniature black globe temperatures, and ground wind speed and direction. Thermal strain was assessed by measuring rectal and skin temperatures, heart rate and sweat loss. Subjective thermal comfort was assessed using a 9 point rating scale ranging from -4 (unbearably cold), through 0 (comfortable) to 4 (unbearably hot). Subjective fatigue was measured with a 5 point scale ranging from 0 (not tired) to 4 (exhausted). The safety pilots assessed flying performance in terms of lookout, performance of checks, observance of limits, and control accuracy and smoothness at a number of predetermined points during the sortie. On completion of each sortie, subjects participated in a structured interview to record general thermal comfort and fatigue and to assess attitudes to the conditioning system. So that accurate comparisons could be made between the sorties and to reduce the problems associated with autocorrelation, various points throughout the sortie were identified at which comparisons could be made and the means of 5 readings (2.5 minutes) around the selected points were analyzed. Analysis of variance using an unbalanced design was performed on the data; the factors considered were subject, point in the sortie, condition (control or test sortie), safety (assessing) pilot, time of day (morning or afternoon sorties), and trial experience (first or second pair of sorties).

RESULTS

Analysis of the environmental conditions showed no difference between control and conditioned sorties. Mean T_{wbgt} varied throughout each flight (Figure 1) from 17°C during the dressing and instrumentation phase to over 28°C during activity on the ground pre- and post-flight. Thermal strain was significantly reduced by the use of the conditioning system. Rectal temperature was influenced by point in the sortie, by wearing the cooling vest, and by the interaction of these 2 main effects. For subjects wearing the conditioning vest, rectal temperature stayed close to initial values whereas for control subjects, the temperature rose steadily to just below 38°C (Figure 2). Rectal temperatures were slightly higher in the afternoon. Mean skin temperature showed similar effects with skin temperatures being higher without the vest (approximately 36°C compared with 32°C) from the start of the preflight ground phase. Heart rate was also affected by stage of the sortie and by condition and by the interaction of these 2 main effects. In general, when the vest was worn heart rate was between 80 and 100 beats per minute whereas in the control condition it varied from 103 to 122 beats per minute. Sweat rate was significantly affected by conditioning; body weight in control subjects decreased by a mean of 1.75kg whilst for subjects wearing the vest the weight loss was 0.60kg.

Thermal comfort rating was affected by condition and by stage of the sortie; subjects reported greater thermal comfort in the LCV condition than in the control condition (means were 0.44 and 1.63 respectively) and were significantly less comfortable at the end of the sortie. The mean rating of fatigue was lower in the LCV condition than in the control condition but this difference was not significant (means were 0.39 and 0.82 respectively). ANOVA indicated a significant effect of stage of sortie on ratings of subjective fatigue but further analysis using the Newman-Keuls range test did not confirm the existence of sortie stage differences in fatigue. Analysis of the safety pilots' ratings of subjects' lookout indicated a significant effect of condition. However, analysis also yielded evidence of an interaction effect of condition and safety pilot, suggesting a difference between the raters in their evaluation of performance in the two conditions. Analysis of this interaction effect using Dunn's Test indicated that one safety pilot gave higher ratings of performance when the LCV was worn whereas there was no significant difference between the conditions in the ratings awarded by the second safety pilot. Analysis of the ratings of control accuracy yielded a similar pattern of results; there was a significant effect of condition and a significant interaction between condition and safety pilot. Again, Dunn's Test indicated that one safety pilot perceived performance to be better when the LCV was worn but there was no difference between the conditions in the ratings made by the second pilot. There was a significant effect of condition on the safety pilots' ratings of control smoothness. Although ANOVA did not yield evidence of an interaction between condition and safety pilot, this was tested explicitly using Dunn's test, which indicated that one rater had again awarded significantly higher ratings when the LCV was in use whereas the second pilot did not perceive a difference in control smoothness between the two conditions. There was no evidence of differences between conditions in the number of checks omitted or of limits exceeded.

FIGURE 1
Environmental Temperature (WBGT)

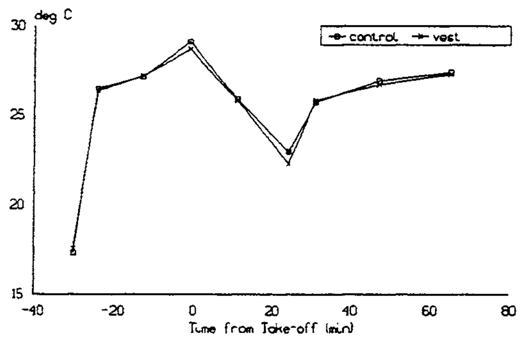
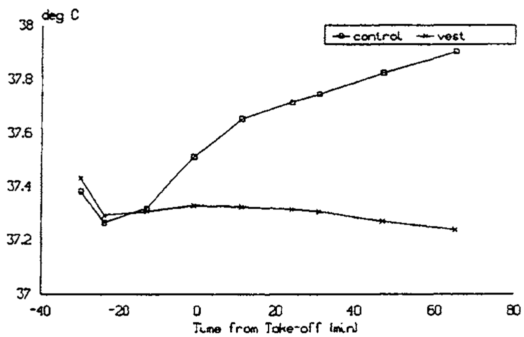


FIGURE 2
Rectal Temperature



Analysis of comments collected during interview indicated that subjects experienced less thermal discomfort when the conditioning system was in operation. In general, subjects were more comfortable both before and during flight when the LCV was worn. The increase in thermal discomfort associated with the physically demanding phases of the exercise was reported to be less when conditioning was used. Sweating was reported to be less severe during the conditioned sorties although all subjects complained that their hands sweated heavily and were uncomfortable regardless of the use of conditioning. Fatigue was less when the LCV was worn. After each flight, subjects were asked how long they would wish to wait if required to repeat the sortie. Following the non-conditioned sorties, subjects reported that a rest period of two or more hours would be desirable whereas when the LCV had been worn, several subjects indicated that they could repeat the sortie immediately.

CONCLUSIONS

Personal conditioning reduced thermal strain and improved thermal comfort for helicopter aircrew flying in a warm climate whilst wearing chemical defence clothing. It was not possible to demonstrate conclusively that flight performance varied significantly between the control and the test sorties although this may be due to the limitations of the performance assessment techniques used.