HEART RATE, CORE TEMPERATURE AND STROKE VOLUME AS INDICATORS OF VOLITIONAL FATIGUE DURING EXERCISE IN THE HEAT

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INTRODUCTION

During exercise testing, research subjects are frequently encouraged to continue their effort until volitional fatigue has been reached. Typically, a core temperature of > 39.0°C and/or a heart rate > 180 bpm are used as end-of-test criteria (1,2,3). This study investigated the similarity of these "traditional" end- points, in addition to stroke volume, as markers of volitional fatigue during exercise in the heat.

METHODS

Eight, heat acclimated males walked approximately 20-min at 4.8 km/hr and 3% grade every hour (with 40-min seated rest) in 44°C, 49% relative humidity (RH); 51°C, 33%RH; and 57°C, 24%RH ambient air temperatures for six hours or until volitional fatigue. To provide a comparison environment, the above workload and heat exposures were repeated with and without wearing a passive ice vest. Rectal temperature (Tre), heart rate (HR), cardiac output (CO) and stroke volume (SV) were measured midway through the treadmill walk each hour. CO was determined using a carbon dioxide rebreathing technique and stroke volume was calculated as CO divided by HR. A repeated measures ANOVA was used to determine statistical significance between the five volitional tests across all vest and temperature conditions. Volitional fatigue was not reached in the 44°C vest condition (i.e. the subjects completed the six hour test), therefore, it was not included in the statistical analysis.

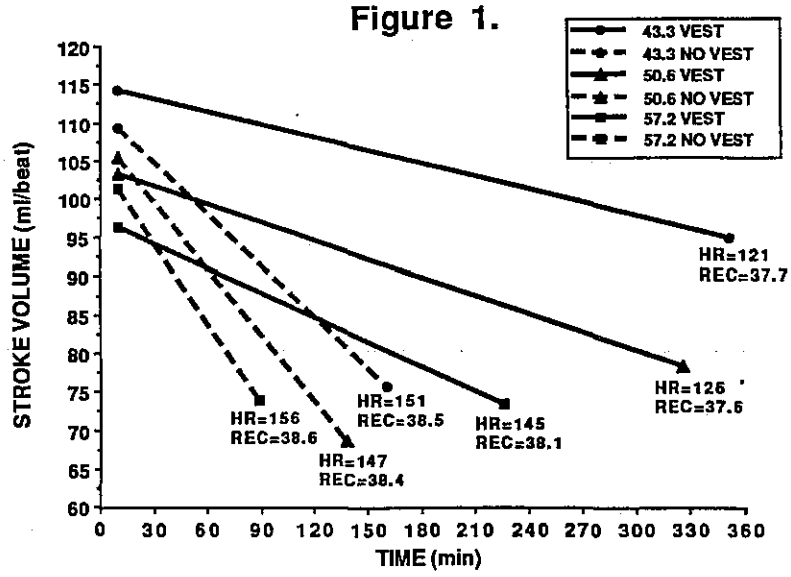
RESULTS & DISCUSSION

End exercise Tre, HR and SV for the five walks that resulted in volitional fatigue, are shown in Table 1. As can be seen, there was great variability in the ending Tre (37.6 - 38.6°C) and HR (126 - 156 bpm) for the five conditions. End-point Tre and HR values were significantly different ($p<.05$) across all temperature and vest conditions. A post hoc analysis determined that the 51°C vest Tre and HR were the only values different from the other temperature and vest conditions. Ending SV, however, was not significantly different for the five conditions. Figure 1 displays the decrease between first and last SV for all six conditions and includes HR and Tre data. The graph demonstrates that regardless of test duration, temperature or vest condition, when SV fell to approximately 75 ml/beat, end-of-test volitional fatigue was reached in both vest and non-vest conditions despite Tre and HR values well less than 39° and 180 bpm respectively. Interestingly, in the 44°C vest condition, which did not result in volitional fatigue (i.e. the subjects lasted all six hours), SV only fell to 95 ml/beat while Tre, HR and CO were 121 bpm, 37.7°C, and 11.4 l/min respectively.

Table 1.

*=p<.05	44°C No Vest	51°C Vest	51°C No Vest	58°C Vest	58°C No Vest
Tre (°C) *	38.5	37.6	38.4	38.1	38.6
HR (bpm) *	151	126	147	145	156
SV (ml/beat)	75.7	78.4	68.7	73.5	73.9
CO (l/min)	11.4	9.7	9.9	10.6	11.3

Figure 1.



CONCLUSION

If the effort put forth by the subjects in this study were evaluated based on Tre and HR values only, their performance would likely be considered a less than maximal exertion. In fact, in similar experiments, subjects with the Tre and HR values observed during this investigation would most likely be encouraged to continue the experiment. It was concluded that, in the current study, end-point or terminal stroke volume provided a better indication of volitional fatigue than either ending Tre or HR values.

REFERENCES

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