RELIABILITY OF AEROBIC PERFORMANCE IN A CHEMICAL DEFENSE ENSEMBLE (CDE) IN A HOT (49°C), DRY (20% RH) CLIMATE FOR YOUNG, FIT MALES

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INTRODUCTION

The reliability of aerobic performance in thermoneutral climates in the lab or field has, generally, been reported to be quite satisfactory (1, pg. 269) with reliability coefficients ranging from r = .80 to .95 for subjects with heterogeneous levels of fitness. Moreover, these types of performances have been shown to be excellent estimates of maximal aerobic fitness (VO_{2max}). Maximal, paced runs of 12 to 15 min or 1 (1.6 km) to 3 miles (4.8 km) in distance have commonly been employed to evaluate large groups of subjects with widely variable fitness levels. However, it is not clear what the effect of a hot, *dry* climate is on the reliability of aerobic performance, especially when military operations require the use of chemical defense ensembles (CDEs). It appears that investigators have assumed that the usual excellent reliability of aerobic performance is not disturbed in the face of adverse climates nor will the wearing of vapor-tight clothing, including mask and gloves, as no studies could be located that investigated such effects. Given that there are individual differences in heat acclimatization and heat tolerance (1, pg. 225), it seems likely that both hot climates and working in CDEs will have variable effects on stability of aerobic performance and thus attenuate the usual strong relationship found among various measures of aerobic work performance and physiological aerobic measures such as VO_{2max} and the ventilatory threshold (VO_{2vt}).

Accordingly, it is the purpose of this paper to determine the reliability of marching time to exhaustion in a hot (49°C), *dry* (20% relative humidity [RH]) climate while wearing a CDE (MOPP4 condition) and a M17A2 mask; this measure has been named the criterion task (CT). A second purpose was to determine the relationship the aerobic performance made in the *dry* heat with aerobic measures made in thermoneutral climates, i.e., VO_{2max}, VO_{2vt} and 4.8 km run.

MATERIALS AND METHODS

After reviewing the experimental procedures, 20 fit, young males gave their consent to serve as subjects. Their mean physical characteristics were as follows: age = 28.8 (3.1) years, height = 177 (6.0) cm, weight = 76.2 (5.8) kg and relative body fat (via hydrostatic method) = 13.1 (2.3) %.

VO_{2max} was measured following a familiarization and warm-up of 10 min with a 5-min rest prior to the start of the test. The treadmill speed commenced at

9.7 km·h^{-1} (6.0 mph) and increased 0.8 kph (0.5 mph) each min to a speed of 16.1 km·h^{-1} (10 mph). After 1 min at the latter speed, the grade was raised 1.0% each min to exhaustion. The subjects breathed through a Rudolph valve (2700) into a corrugated tube (2.8 cm, id) that led to a 5-L mixing chamber. The exhaled air was sampled for FEO_2 and $FECO_2$ while the V_E was measured as it passed through a Rayfield dry gas meter. The percent of O_2 and CO_2 in the exhaled gas was determined by Applied Electrochemistry analyzers. All measures were monitored by a microcomputer and recorded for later analysis. Two of three criteria had to be attained in order to ascertain VO_{2max} and were as follows: plateau of VO_2; an RER >1.10; and 90% of age predicted maximal heart rate (HR_{max}).

VO_{2vt} was determined by use of gas transport (V_E l/min, BTPS) and gas exchange measures (V_E/VO_2 and VCO_2) and taken as the average VO_2 for the min that the ventilatory threshold was detected.

The 4.8-km run was conducted on a standard 400-m polyurethane track. Each subject was instructed to run the fastest, even pace possible, as each was given lap times and ran solo. During these runs, the dry bulb temperature ranged fi-om 20 to 24°C with an RH between 30 and 45%. The wind was still or light.

The treadmill walks to exhaustion, the CT, were done while wearing a CDE in a MOPP4 condition and a M17A2 breathing mask but walking in athletic shoes rather than boots. The latter was done in order to avoid blisters and other foot problems. The chamber temperature was constant at 49°C and an RH of 20%. The subjects were prehydrated and entered the chamber 15 minutesn prior to the commencement of exercise. They were encourage to take fluid every 5 minutes as an attempt to maintain a hydrated state. The exercise was terminated for any of the following reasons: when the subject's rectal temperature reached 39°C, or the HR max (as determined by the GXT) was maintained for 5 minutes or if any indications dictated it, including the subject's desire to stop. At this point, the subject was withdrawn from the chamber, stripped, and cooled with ice packs. A minimum of two days was interposed between the two walks to exhaustion.

RESULTS AND DISCUSSION

Table 1 summarizes the findings for all of the aerobic measures including d e CTs that were done in the heat while the remaining aerobic parameters were accomplished in thermoneutral conditions.

The average VO_{2max} was 52.7 ml·kg^{-1}·min^{-1}, STPD or about 20% greater than 45 ml·kg^{-1}·min^{-1}, a value frequently cited for normally active young males and reflects the fitness of the subjects as a result of their moderate aerobic training. The VO_{2vt}, which averaged 36.4 ml·kg^{-1}·min^{-1} or 69% of their VO_{2max}, also was indicative of moderately trained individuals.

Also found in Table 1 are the descriptive statistics for the 4.8 km run. The mean score of 21.2 min also indicates an above average level of fitness (1, pg. 102).

The data points for Figure 1 illustrate the reliability of marching performance wearing CDE in a hot, desertlike climate, simulating conditions when troops might be under biological or chemical attack in the summer Arabian

Table 1. The descriptive statistics for the aerobic measurements and criterion task far 20 male subjects.

Variables	Units	Mean	Std. Dev.	Minimum	Maximum
VO_2max	$l \cdot min^{-1}$	3.945	0.465	3.097	4.554
VO_2max	$ml \cdot kg \cdot min^{-1}$	52.7	8.2	33.8	5.4
VO_2vt	$ml \cdot kg \cdot min^{-1}$	36.4	3.6	19.7	4.2
4.8 km run	min	21.2	4.4	14.2	1.9
CT1	min	51.5	11.3	35	1
CT2	min	52.2	12.5	33	88
Ctmean	min	51.8	11.9	33	88

desert. The test-retest correlation coefficientis r = .71 with a Sx.y = 11.2 rnin and a regression equation for the prediction of CT2 (Y), Y' = 0.971*X* + 2.121 min.

The mean scores for CT1 and CT2 were 51.5 and 52.2 min, respectively (see Table 1). The performance was quite variable with coefficients of variation of 22 and 24% for CT1 and CT2, respectively. As indicated in Table 2 below, and depicted in Figure 1, the test-retest reliability was poor (r = .71) with a large standard error of estimate of 11.2 rnin or a 95% CI equal to –19 min. Table 2 provides a ***summary*** of the relationships among the aerobic measurements. The measurements made in a thermoneutral climate yielded typical moderate to strong relationships. However, the relationships between the CTs (made in 49°C heat) produced small, insignificant coefficients that generate common variances of less than 17%. The poor reliability of the CT in the heat represented only a mod-

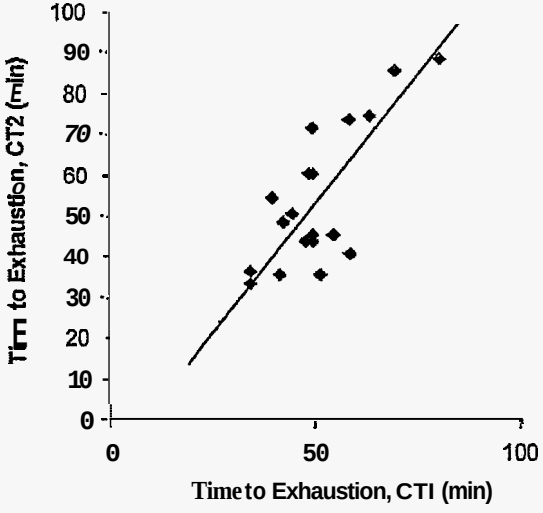

Figure 1. Relationship between CT1 and CT2 performance.

est portion of the uncoupling between the aerobic measures made in the heat versus those made in normal climates. For when the coefficients were adjusted for the attenuated reliability of CT, the correlation for CT and VO_{2max} ($L \cdot min^{-1}$) only improved fiom r = .38 to r = .46 and the common variance from 14 to 21%. Moreover, a similar finding resulted when the same correction was made between CT and the 4.8 km run, increasing the from r = .29 to r = .35. A second, and perhaps more dominant, influence on the relationship between aerobic variables was the independent effect of the subject's ability to tolerate the heat.

CONCLUSIONS

It was concluded that endurance performance in very hot-dry heat is not very reliable with a reliability coefficient of r = .71. Further, the relationships between aerobic measures in moderate climates, compared to those made in the heat, are small and insignificant. The poor reliability of CT in the heat explains only a modest degree of the decrements. Finally, a far more important reason for the uncoupling may be due to a high variability in the subject's heat tolerance, which is largely independent (r = .46) of aerobic fitness (VO_{2max}).

REFERENCE

1. Powers, S.K. 1997, *Exercise Physiology: Theory and Application to Fitness and Performance.* (Madison, WI: Brown and Benchmark, Publishers).