Assessing the Repeatability of a Running Heat Tolerance Assessment in Trained and Untrained Populations

Mr Tom Palin, Dr Dan Snape, Prof David Woods, Dr Barney Wainwright, Prof Mike Stacey, Prof John O'Hara
Carnegie School of Sport, Leeds Beckett University.

Introduction

- There is a growing need to develop measures for assessing performance and health status under heat stress, as heat-related health risks increase with global warming.[1]
- The ACSM recommends that a tailored heat tolerance assessment (HTA), based upon participants' fitness levels, should be applied for individual's affected by heat related illness.[2]
- Aerobically-trained athletes show features of heat adaptation at baseline and, in our experience, a standardised HTA to provide robust heat stress and challenge fitter individuals is lacking.
- We designed a progressive HTA to be performed in uncompensable conditions, in order to minimise differences attributable to variation in body size and increase comparability.[3]
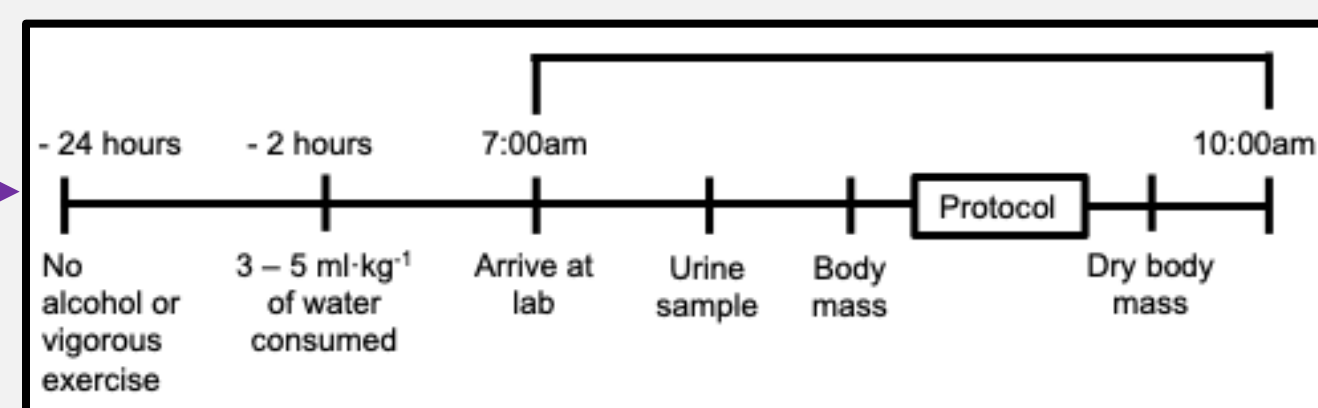
Aims

- Generate initial normative data for a running based HTA constructed using lactate thresholds (LTs)
- Investigate the repeatability of this test in well trained (WT) and recreationally active (RA) individuals.

Methods

6 participants grouped based on VO_{2max} → 1 dropout

WT (*n*=2, 100% males) | RA (*n*=3, 66% males)
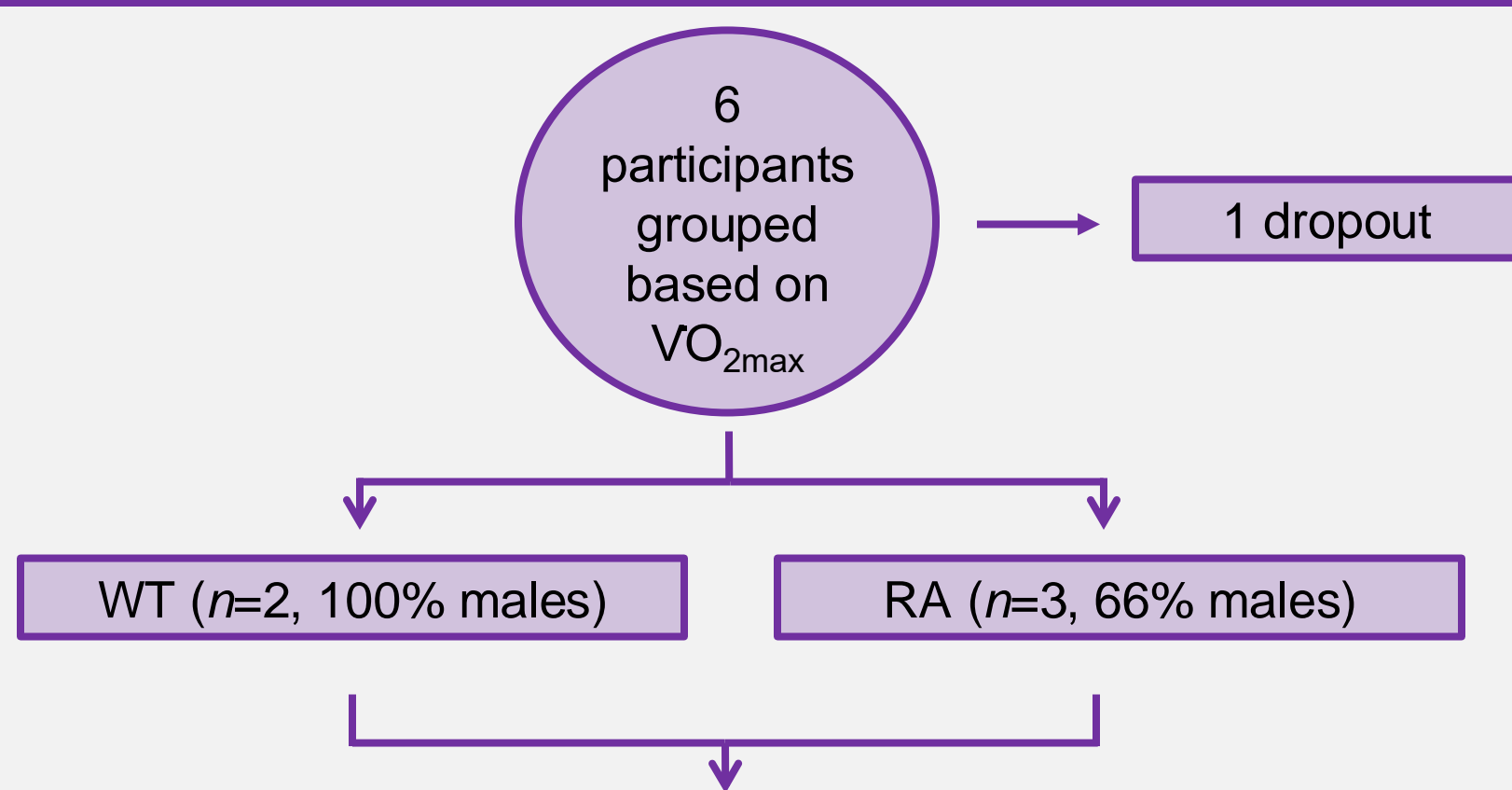
Visit 1	Pre exercise screening and VO_{2max} test.
Visit 2	Lactate threshold test in heat chamber.
Visit 3	Heat tolerance assessment 1.
Visit 4	Heat tolerance assessment 2.

Both testing sessions were identical and followed this order.

- 24 hours / - 2 hours / 7:00am — 10:00am
No alcohol or vigorous exercise | 3 – 5 ml·kg⁻¹ of water consumed | Arrive at lab | Urine sample | Body mass | Protocol | Dry body mass

- VO_{2max} was assessed using a motorised treadmill starting at a 1% gradient and increasing 1% every minute.
- LTs were determined by blood lactate (BLa) in 40°C and 40% RH.
- HTA consisted of 30 minutes running at LT1 immediately followed by 30 minutes at LT2 in 40°C and 40% RH.
- Core temperature, skin temperature, heart rate (HR), blood lactate, sweat rate (SR) as well as RPE, thermal comfort (TC) and thermal sensation (TSS) were recorded every 5 minutes.
- The end exercise intra-class correlation coefficient (ICC) and typical error of measurement were calculated for all physiological and perceptual variables.

⊕ The use of lactate thresholds allowed for the individualisation of HTA, aiming to minimise the influence of exercise intensity.

⊕ Measuring BLa allowed us to approximate differences in metabolic efficiencies.

⊖ In the RA group LTs were harder to determine, leading to potential errors in standardising running speeds.

Results

- Uncompensable conditions were achieved in all participants, with a statistically significant difference in end exercise T_{core} between the WT and RA groups ($p = 0.04$, $d = 1.72$).
- ICC values for T_{core}, T_{skin}, HR and SR were all above 0.90 indicating an acceptable level of reliability for the HTA (Figure 1).
- End exercise ICC values for BLa were slightly lower at 0.8.
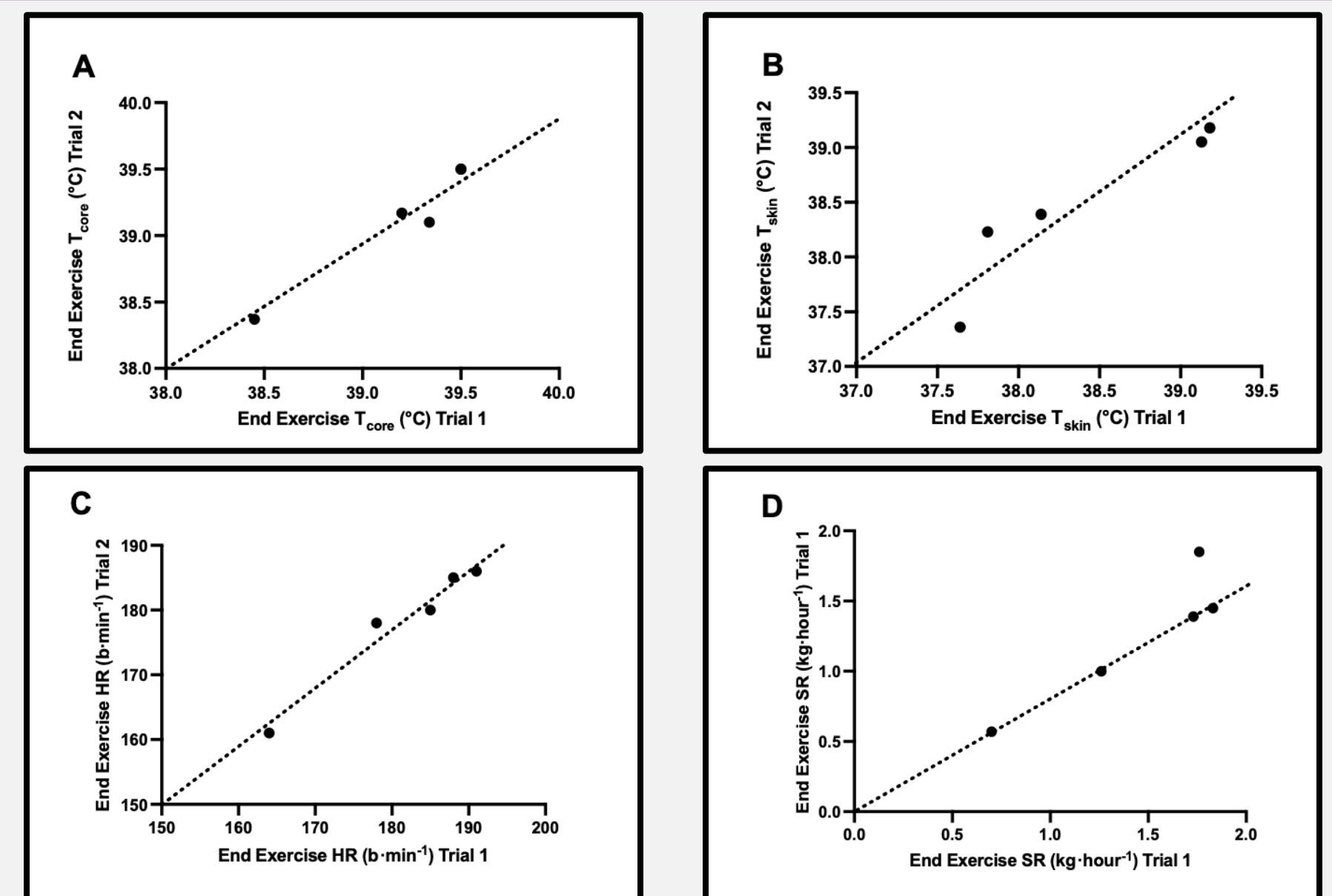- Strong correlations were also evident in pre-post TSS (0.97***) and mean TC (0.93*) between trials.

Figure 1. ICC statistics for end exercise T_{core} (0.99***), T_{skin} (0.96**), HR (0.99***) and SR (0.96**).

Table 1. Reliability statistics for inter group physiological responses.

			Mean (SD)	*P*	*d*	TEM (CV%)	Bias (LoA)
T_{core} (°C)	End Exercise	Well-trained	39.50 ± 0.00	0.04	1.72	0 (0.00)	-0.30 ± 0.02
		Recreationally active	38.94 ± 0.42			0.30 (1.18)	
T_{skin} (°C)	End Exercise	Well-trained	38.56 ± 0.54	0.28	0.34	0.45 (1.96)	0.17 ± 0.11
		Recreationally active	38.32 ± 0.84			0.54 (2.20)	
HR (b·min⁻¹)	End Exercise	Well-trained	182.30 ± 6.01	0.73	0.43	3.58 (3.30)	3.25 ± 10.25
		Recreationally active	177.80 ± 13.61			8.78 (7.66)	
BLa (mmol·L⁻¹)	End Exercise	Well-trained	2.07 ± 1.13	0.71	0.22	0.92 (54.79)	0.34 ± 1.00
		Recreationally active	2.36 ± 1.51			0.97 (63.81)	
SR (kg·hour⁻¹)	End Exercise	Well-trained	1.47 ± 0.48	0.21	0.36	0.29 (32.52)	-0.37 ± 0.18
		Recreationally active	1.28 ± 0.56			0.37 (43.70)	

- Most physiological variables showed small mean bias and LoA between the two trials.
- WT showed lower coefficient of variation and predominantly lower typical error of measure when compared against RA.

Conclusion

- The HTA showed good agreement, significant correlations, and little variations across repeated trials.
- TEM values for both physiological and perceptual markers indicated little inter-participant variability.
- The absolute reliability of the test was higher in individuals with higher fitness levels.

Future Research

- HTA geared to lactate thresholds should be investigated (1) in populations affected by heat illness, and related to return-to-sport outcomes, and (2) with progressive acclimatisation.

References

1. Morimoto, T., Nakai, S. and Itoh, T. (2001) Global warming and deaths from heat stroke. *Thermotherapy for Neoplasia, Inflammation, and Pain*, pp. 107-110.
2. ACSM (2023) ACSM Expert Consensus Statement on Exertional Heat Illness: Recognition, Management, and Return to Activity. *Current sports medicine reports*, 22(4), pp. 134-149.
3. Ravanelli, N., Cramer, M., Imbeault, P. and Jay, O. (2017) The optimal exercise intensity for the unbiased comparison of thermoregulatory responses between groups unmatched for body size during uncompensable heat stress. *Physiological reports*, 5(5), p. e13099.