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MEETING ABSTRACT Open Access

Metabolic costs of physiological heat stress responses - Q_{10} coefficients relating oxygen consumption to body temperature

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Introduction

Q_{10} describes the influence of temperature on physiological processes as the ratio of the rate of a physiological process at a particular temperature to the rate at a temperature 10 °C lower [1]. In terms of rates of oxygen consumption (VO_2) related to rectal temperatures (t_{re}), this can be written as [2]:

$$Q_{10} = (VO_2/VO_{2,ref})^{10/(tre-tre,ref)} \quad (1a)$$

or equivalently,

$$VO_2 = VO_{2,ref} \cdot Q_{10}^{(tre-tre,ref)/10} \quad (1b)$$

Q_{10} varies between 2 and 3 in biological systems [2], and Q_{10} = 2 is applied in modelling the rate of metabolic heat production in relation to body temperature [3,4]. This paper aims to determine Q_{10} for the influence of body temperature on oxygen consumption for light work in warm environments.

Methods

Data originated from 216 laboratory experiments [5] consisting of individual series of 14 to 39 trials performed by eleven acclimatised semi-nude young males (I_{cl}=.1 clo) who walked 4 $km.h^{-1}$ on the level for at least 3 hours under different combinations of water vapour pressure (range 0.3 - 5.2 kPa) and air temperature (range 20 - 55 °C) with air velocity of 0.3 $m.s^{-1}$ and mean radiant temperature equal to air temperature. Mean values of t_{re} and VO_2 over the third hour of exposure were submitted to linear regression analyses, which were performed separately for the 11 individual series relating VO_2 directly to t_{re} and also using the logarithmised Eq. 1b (with $t_{re,ref}$ = 36.8 °C). Overall regression parameters were calculated by random coefficient linear mixed models considering the correlation within the individual series. Q_{10} coefficients were obtained as the exponentiated slopes of the fitted logarithmised Eq. 1b.

Results

Regression analyses showed a statistically significant ($p < 0.01$) increase of VO_2 with t_{re} (Figure 1A) with inter-individually varying slopes, which resulted in Q_{10} values varying largely between 1 (indicating no influence of t_{re} on VO_2) and 10 (Figure 1B). The overall Q_{10} was 2.1 with 95% confidence interval (CI) 1.3 - 3.5.

Discussion and conclusion

The results support the setting Q_{10} = 2 [3,4] under steady state conditions for light work in the heat, however, considerable intra- and inter-individual variability was observed.

Thus, the data base should be extended, also towards other workloads and populations (female, elderly).

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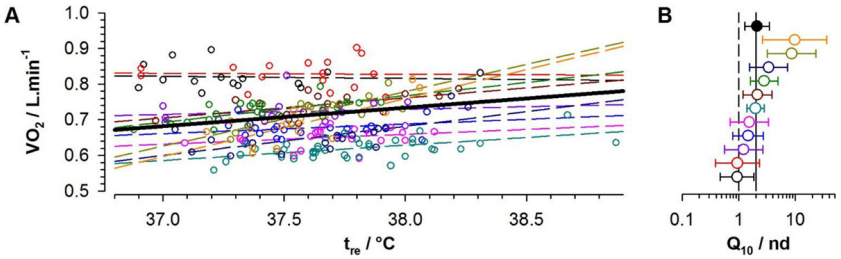

Figure 1 VO_2 related to t_{re} with overall regression (solid, VO_2 = 0.671+0.052(t_{re}-36.8)) and individual lines (dashed) for 11 participants (A), and Q_{10} with 95% CI for 11 individuals (open symbols) and for the total sample (filled symbol) with reference lines indicating the neutral value (Q_{10} = 1, dashed) and Q_{10} = 2 (solid) (B).

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