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BOOK OF ABSTRACTS **Open Access**

Reliability of acute training responses elicited by exhaustive work intervals prescribed with the delta concept

Bossi, AH.✉[1], Timmerman, WP.[1] Passfield P.[1,2] Hopker, JG.[1]

[1] School of Sport and Exercise Sciences, University of Kent, Chatham, Kent, England
[2] Faculty of Kinesiology, University of Calgary, Calgary, Alberta, Canada

✉ **Contact email:** asnb3@kent.ac.uk

Purpose:

Biomolecular research has suggested that the chronic adaptation to an exercise programme is modulated by the extent individual training sessions produce homeostatic stress. Hence, training intensity must be carefully prescribed to ensure the expected stimulus for adaptation is provided. To this end, the delta concept (%Δ) has been proposed as an intensity prescription method to minimising inter-individual variability of physiological and perceptual responses—expressed by:

$$\dot{W}_{prescribed} = \dot{W}_{GET} + [(\dot{W}_{\dot{V}O2max} - \dot{W}_{GET}) \cdot \%\Delta]$$

where $\dot{W}_{prescribed}$ is the set work rate, $\dot{W}_{GET}$ is the work rate associated with the gas exchange threshold, $\dot{W}_{\dot{V}O2max}$ is the work rate associated with the maximal oxygen uptake and %Δ is the targeted intensity. Surprisingly, the inter-individual variability of acute training responses has not been investigated during high-intensity interval training (HIIT), despite HIIT being commonly performed in the laboratory and field settings. Moreover, the intra-individual variability of acute HIIT responses has not been established in cycling, which is vital to understand whether the anticipated training stimulus is achieved whenever a session is performed.

We explored the levels of inter- and intra-individual variability of acute training responses elicited by exhaustive work intervals prescribed with %Δ.

Methods:

Eighteen male and four female cyclists [age: 36 ± 12 years, height: 178 ± 10 cm, body mass: 75.2 ± 13.7 kg, $\dot{V}O_{2max}$: 52 ± 5 ml·kg^{-1}·min^{-1}, peak power output (PPO): 4.72 ± 0.48 W·kg^{-1}] volunteered for this study. They performed a ramp test in the first visit to determine $\dot{V}O_{2max}$, PPO, $\dot{W}_{GET}$ and $\dot{W}_{\dot{V}O2max}$. The next four visits consisted of a standardised 21-min warm-up and a HIIT session performed to exhaustion [i.e. 4-min work intervals at 70%Δ ($\dot{W}_{prescribed}$ = 4.00 ± 0.43 W·kg^{-1}, 84.7 ± 0.4 %PPO), interspersed with 2-min active recovery at 0.2·$\dot{W}_{prescribed}$]. Breath-by-breath gas exchanges and heart rate (HR) were continuously measured, with ratings of perceived exertion (RPE) and blood lactate concentration ([La]) obtained after each work interval and at exhaustion. Time at >90%$\dot{V}O_{2max}$ was quantified as absolute values and as a percentage of the time to exhaustion. One-way repeated measures analysis of variance was used to test for systematic changes between HIIT sessions. Statistical significance was set at P ≤ 0.1. Reliability estimates [typical error (TE), coefficient of variation (CV), and intraclass correlation coefficient (ICC)] were obtained through Hopkins spreadsheet and are reported with 90% confidence limits. Based on the acquired data, we used G*Power software to perform sample size estimations for a two-tailed matched paired t-test, with alpha error probability set at 0.05 and power at 0.80.

Results:

Time to exhaustion, absolute and relative time at >90%$\dot{V}O_{2max}$, peak HR, peak RPE, and peak [La] were not different between HIIT sessions (all $F \leq 2.10$, $P \geq 0.13$, $\eta^2_p \leq 0.09$). Dependent variables and their reliability estimates are reported in Table 1. Sample size estimations are reported in Table 2.

Table 1. Reliability data [with 90% confidence limits] for the dependent variables.

	mean ± SD	TE	ICC	intra-individual CV (%)	inter-individual CV (%)
Time to exhaustion (s)	1219 ± 618	244 [210-294]	0.86 [0.76-0.92]	31.0	67.0
Absolute time at >90%VO_{2max} (s)	502 ± 366	137 [118-165]	0.87 [0.79-0.93]	67.0	139.3
Relative time at >90%VO_{2max} (%)	57.0 ± 22.0	14.2 [12.2-17.1]	0.61 [0.43-0.77]	63.7	109.2
Peak HR ($b \cdot min^{-1}$)	179 ± 11	2 [1.7-2.4]	0.97 [0.94-0.98]	1.2	6.2
Peak RPE	19.6 ± 0.8	0.3 [0.3-0.4]	0.85 [0.75-0.92]	1.9	4.7
Peak [La] ($mmol \cdot L^{-1}$)	14.3 ± 2.6	2.0 [1.7-2.4]	0.45 [0.25-0.65]	15.0	20.4

SD, standard deviation; TE, typical error; ICC, intraclass correlation coefficient; CV, coefficient of variation; HR, heart rate; RPE, ratings of perceived exertion; [La], blood lactate concentration

Table 2. Required sample size to detect baseline changes for a given variable analysed with two-tailed matched paired t-test, with alpha error probability set at 0.05 and power at 0.80.

	2%	5%	10%	20%	30%
Time to exhaustion (s)	1411	228	59	17	9
Absolute time at >90% VO_{2max} (s)	2854	458	116	31	15
Relative time at >90% VO_{2max} (%)	2421	389	99	27	13
Peak HR ($b \cdot min^{-1}$)	8	4	3	3	2
Peak RPE	14	5	3	3	2
Peak [La] ($mmol \cdot L^{-1}$)	724	119	32	10	6

HR, heart rate; RPE, ratings of perceived exertion; [La], blood lactate concentration

Conclusion:

Although participants consistently achieved peak values of HR, RPE, and to a lesser extent [La], there was substantial inter-individual variability in time to exhaustion, and both absolute and relative time at >90%$\dot{V}O_{2max}$. Importantly, inter-individual variability was much higher than intra-individual, suggesting a greater day-to-day consistency would still produce marked heterogeneity between participants. This raises questions over the validity of %Δ to normalise acute HIIT responses. The levels of intra-individual variability also cast doubt on the assumption that a similar stimulus for adaptation is triggered every time a standard HIIT session is performed. Besides the effect on sample size estimations, achievable only if studies aim to detect large changes, this result also suggests athletes may not need to overly adhere to the prescribed power output during HIIT.

In contrast to previous suggestions based on continuous exercise, %Δ does not produce consistent inter- and intra-individual acute HIIT responses. Future studies should consider alternative methods for training intensity normalisation. Whether day-to-day consistency in training stimulus is a pre-requisite for optimal adaptation following HIIT is another question that merits investigation.