

Conference Paper

# Optimizing the high-intensity interval session through workload alterations in well-trained female and male cyclists

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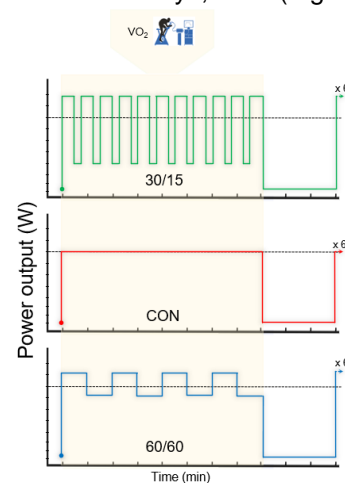
## 1. Introduction

High-intensity interval training (HIT) is well-known to improve endurance performance (Buchheit & Laursen, 2013). Moreover, it is suggested that the percentage of maximal oxygen consumption ( $\dot{V}O_{2max}$ ) attained and the time achieved  $\geq 90\%$  of  $\dot{V}O_{2max}$  during HIT sessions could serve as a good criterion for judging the effectiveness of the HIT session (Thevenet et al., 2007). Previous studies on male endurance athletes have shown that HIT sessions with varied workloads within the work periods of HIT sessions (VAR) are well-suited for this purpose (Almquist et al., 2020; Bossi et al., 2020; Rønnestad et al., 2021). However, the optimal VAR design and whether female cyclists respond in a similar manner as male cyclists is currently unknown. Therefore, this study aimed to investigate the oxygen consumption ( $\dot{V}O_2$ ) response during three different 6x8-min HIT sessions matched on mean power output (PO) in female and male cyclists.

## 2. Materials and Methods

Nineteen participants (♀; n=11, average  $\dot{V}O_{2max}$  62.5 (6.4) mL·min<sup>-1</sup>·kg<sup>-1</sup> and ♂; n=8,

average  $\dot{V}O_{2max}$  81.0 (5.2) mL·min<sup>-1</sup>·kg<sup>-1</sup>), were enrolled in and completed the study. After the initial two screening visits in the lab to determine the participant's performance level, three different 6x8-min HIT sessions at a mean PO corresponding to the individual participants' 40-min maximal PO were performed in a randomized order on three consecutive days, (Figure 1).



**Figure 1.** Overview of the three different 6x8-min high-intensity interval sessions used in the present study. 30/15, continuously altering 30-sec work periods separated by 15-sec recovery periods; CON, one continuous work period; 60/60, continuously altering 60-sec work-periods;  $\dot{V}O_2$ , oxygen consumption measurements.

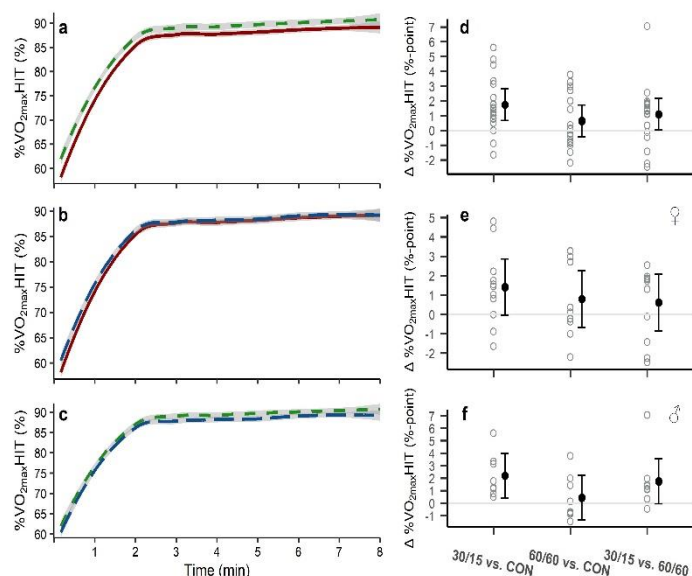
All three HIT sessions were performed on the participants' personal bikes connected to stationary trainer devices (Tacx Neo 2T, Wassenaar, the Netherlands).  $\dot{V}O_2$  was measured continuously during all 8-min work periods using a gas mixing chamber metabolic cart (Oxycon Pro, Erich Jaeger, Hoechberg, Germany). Across all work periods during each HIT session, mean  $\dot{V}O_2$



was calculated and expressed as a percentage of  $\dot{V}O_{2max}$  ( $\% \dot{V}O_{2max}HIT$ ), and subsequently, time  $\geq 90\%$  of  $\dot{V}O_{2max}$  was quantified for each session. Descriptive data are presented as means with standard deviations (SD). Pairwise comparisons from mixed linear models with Tukey-adjusted p-values were used to compare  $\dot{V}O_2$  responses between HIT sessions (lme4 version 1.1 and emmeans version 1.8.2 packages for R, version 4.2.1).

### 3. Results

Mean PO in the work periods during all HIT sessions was 268 (49) W. The higher and lower PO during the 30/15 session was 316 (57) W and 161 (29) W, respectively, while the higher and lower PO for the 60/60 session was 295 (53) W and 241 (43) W, respectively.



**Figure 2.** Comparisons of the mean percentage of maximal oxygen consumption elicited during the 8-minute work periods ( $\% \dot{V}O_{2max}HIT$ ) between (a) 30/15 (green dashed line) and CON (red solid line), (b) 60/60 (blue long dashed line) and CON, and (c) 30/15 and 60/60. Pairwise comparisons of the %point differences ( $\Delta$ ) in  $\% \dot{V}O_{2max}HIT$  between the different HIT sessions are shown for (d) all, (e) female, and (f) male participants. The light gray areas in a, b and c, and the error bars in d, e and f indicate 95% confidence intervals.

Overall, 30/15 accumulated a mean  $\% \dot{V}O_{2max}HIT$  of 86.7 (10.1)%, which was higher than both CON (85.0 (10.4)%;  $p=0.001$ ; Figure 2a/d) and 60/60 (85.6 (10.0)%;  $p=0.045$ ; Figure 2c/d). No difference in  $\% \dot{V}O_{2max}HIT$  was observed between 60/60 and CON ( $p=0.317$ ; Figure 2b/d). When female and male participants were stratified in separate analyzes, males showed a higher  $\% \dot{V}O_{2max}HIT$  during 30/15 compared to CON ( $p=0.017$ ; Figure 2f), while there for the

female cyclists was a tendency for the same observation ( $p=0.059$ ; Figure 2e). Within sexes, no differences were observed between 60/60 and CON ( $\text{♀}$ ,  $p=0.371$ ;  $\text{♂}$ ,  $p=0.798$ ; Figure 2 e & f, respectively) or 30/15 and 60/60 ( $\text{♀}$ ,  $p=0.541$ ;  $\text{♂}$ ,  $p=0.057$ ; Figure 2 e & f, respectively). Overall, 30/15 accumulated longer time  $\geq 90\%$  of  $\dot{V}O_{2max}$  compared to CON (18.7 (13.1)-min vs. 14.7 (13.0)-min, respectively;  $p=0.001$ ) and 60/60 (15.3 (12.4)-min;  $p=0.042$ ), while there was no difference between 60/60 and CON ( $p=0.892$ ).

### 4. Discussion

The main findings are that 30/15 led to a higher  $\% \dot{V}O_{2max}HIT$  and longer time  $\geq 90\%$  of  $\dot{V}O_{2max}$  than both 60/60 and CON. The observation of 30/15 translating into a greater  $\dot{V}O_2$  response compared to CON, is consistent with previous findings (Almquist et al., 2020; Rønnestad & Hansen, 2016). However, it was somewhat surprising that 60/60 did not elicit a greater  $\dot{V}O_2$  response compared to CON, considering that both Bossi et al. (2020) and Rønnestad et al. (2021) observed this using a similar protocol. Noteworthy, the total duration of the work periods was longer in the present study compared to the aforementioned studies (48 min vs. ~25 min). Furthermore,  $\% \dot{V}O_{2max}HIT$  was only significantly higher during 30/15 compared to CON in the male participants. In the female participants, there was only a tendency to differ. Whether this was a random finding due to a lack of sufficient statistical power or due to sex-specific differences currently remains unknown.

### 6. Conclusions

In conclusion, 30/15 led overall to a higher  $\% \dot{V}O_{2max}HIT$  and longer accumulated time  $\geq 90\%$  of  $\dot{V}O_{2max}$  compared to both 60/60 and CON, suggesting that the 30/15 HIT session provides the most effective exercise stimulus. It is likely that the 30/15 session is superior for both sexes.

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**Conflicts of Interest:** The authors declare no conflict of interest.

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