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HEALTH AND HUMAN PERFORMANCE

No Differences in Acute Oxygen Consumption Response between High Intensity Interval Training Formats when Matched Based on W prime Expenditure

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Introduction

- **Critical power** (CP) is a fatigue threshold measurement that is theorized to demarcate the transition from the moderate exercise-intensity domain and the severe exercise-intensity domain. **W prime** (W') is the quantification of the work capacity that can be performed above CP, before reaching volitional exhaustion. Calculations are used to define the amount of work done over CP that is needed to deplete a determined amount of W', which allows for programming that can match metabolic demands between protocols.[2]
- Current HIIT prescription parameter thresholds do not account for the physiological responses that occur in the different exercise intensity domains.
- Studies have found that varied power output HIIT training has elicited greater time above 90% of VO_{2max} compared to constant power, however protocols were not matched based on metabolic demands.[3]
- The purpose of this investigation was to **compare the acute physiological responses** (percent of time spent above 90% of VO_{2max}, peak VO_2 response (VO_{2peak}), lactate & RPE) of FSHIIT and SPHIIT formats when matched by W' depletion of 60% in each interval.
- The FSHIIT condition was hypothesized to have a higher response of percent of time spent above 90% of VO_{2max}.

Methods

- Eight participants: (N=8; 7 males, 1 female, age: 26.75 ± 5.65 yrs., height: 172.75 ± 7.74 cm, body mass: 75.40 ± 16.10 kg; VO2max: 56.87 ± 6.64 mL·kg–1·min–1, CP: 294.84 ± 34.43 W, W': 12.82 ± 2.86 W)
- **Visit 1: Incremental cycling test** (ICT) of one-minute intervals and square-wave bout verification protocol was used to establish participants VO_{2max}, gas exchange threshold (GET) and peak power output (PPO). GET and PPO were used to calculate the linear factor resistance for **the 3-minute test** (3MT). 30 minutes of rest was given between the ICT and 3MT. The 3MT is a 3 minute, all out effort test that is commonly used to determine CP and W'. CP is calculated as the mean power output over the final 30 s of the test, while W' is calculated as the work done above CP over the first 150 s of the test. The following equation was used to find W' from the 3MT: W' = ((150* (p150 - CP)) / 1000).
- **Visit 2:** Participants completed the **3MT**. Visit 2's 3MT data was used to set the parameters for the FSHIIT and SPHIIT protocols. Data collected this day: VO_2, CP, W', and HR.
- **Visit 3 & Visit 4:** Randomized order of completing either the **FSHIIT** or **SPHIIT** condition. The HIIT protocols consisted of 4 X 3-minute intervals, with 3 minutes of rest between intervals. Both protocols **depleted W' by 60%,** however the SPHIIT group had a steady power output through the interval, while FSHIIT was calculated to complete 50% of the total work within the first minute, with remaining 50% distributed evenly over the last two minutes.

Table 1. Acute Perceptual and Blood Lactate Responses to HIIT Conditions

Variable	FSHIIT	SPHIIT
% of Total Training Time Above 90% VO_{2max}	25.20 ± 8.77	26.07 ± 11.84
Peak Lactate	14.77 ± 3.43	16.02 ± 2.39
Average Lactate	12.98 ± 2.28	13.61 ± 1.55
Peak RPE	19.00 ± 1.30	18.50 ± 1.69
Average RPE	17.21 ± 1.26	17.06 ± 1.74

All values are mean ± standard deviation (SD), %: percent, VO_{2max}: maximal oxygen consumption (mL·kg^{-1}·min^{-1}), RPE: rate of perceived exertion

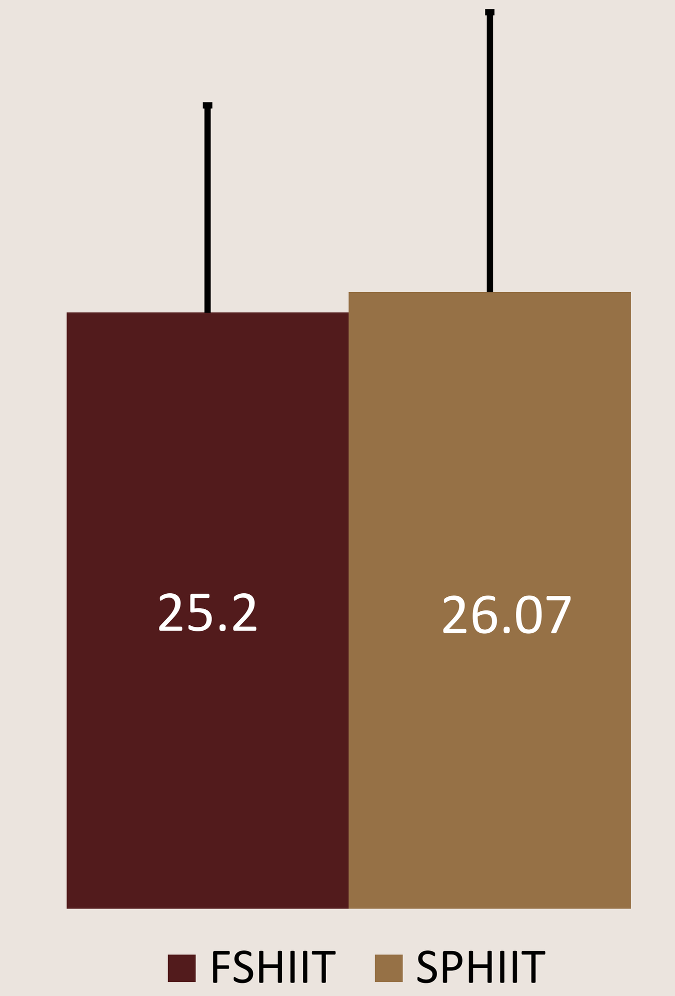

Figure 1. Percent of Total Training Time Above and Below 90% VO_{2max}

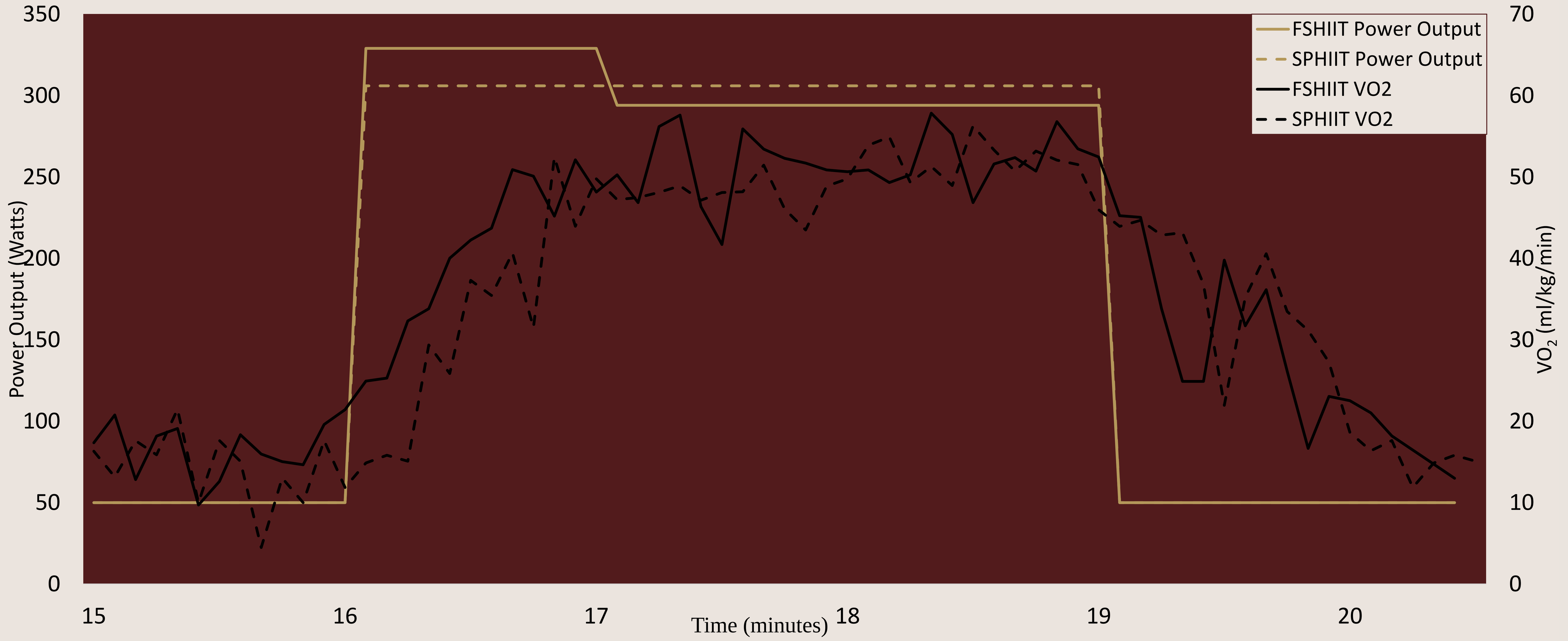

Figure 2. FSHIIT & SPHIIT Power Output and VO_2 Response of a Representative Participant

Statistical Analysis

- **A two-way repeated measures analysis of variance** (ANOVA) was used to detect potential interactions between time and condition.
- Bonferroni post hoc analyses were conducted if significant interactions were detected. Eta squared (η^2) was used to interpret effect sizes for the ANOVA, with values of 0.02, 0.13, and 0.26 indicative of small, medium, and large effects, respectively.
- **A Paired samples t-test** were used to detect statistically significant differences between FSHIIT and SPHIIT in terms of RPE, blood lactate, and time spent $\geq$ 90% of VO_{2max}.

Results

- No significant time*condition interaction was present with VO_{2peak} response and percent of time spent above 90% of VO_{2max}. SPHIIT and FSHIIT had averages of 25.20% and 26.07% of total training time above 90% of VO_{2max}, respectively.
- Significant main effect found between VO_{2peak} in minute 1 between minute 2 and minute 3, with no significant difference found between minute 2 and minute 3.
- No significant differences were found in lactate or RPE between protocols.

Conclusions

- When comparing FSHIIT and SPHIIT protocols that were matched on W' depletion there were **no significant differences in VO_{2peak} and percent of time spent above 90% VO_{2max}**.
- **A significant difference was found from minute 1 to minutes 2 and 3** due to the fast and slow component of VO_2 kinetics. **The fast component** contributes to the quick and large increase that is seen in the VO_2 response, which is the physiological response that allows for a match in energy to work demand.[1]
- **The slow componen**t, which is the response of a slight increase in VO_2 once power output is maintained. This theory suggests that when working above CP, the stress being placed on leads to an increase reliance on oxidative phosphorylation. When the oxidative system is primarily producing ATP, VO_2 subsequently increases until power is decreased, or volitional exhaustion is reached, which accounts for finding no differences between minute 2 and 3.[1]

Practical Applications

- When completing HIIT training that is matched on metabolic demands, the manipulation of the intervals power output doesn't influence the acute physiological response. Therefore, when programing HIIT interval parameters, **athletes can use either FSHIIT or SPHIIT and get the same metabolic responses when based on W' depletion.**

References

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