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The reliability of an intermittent sprint cycling protocol on a Wattbike Pro in hot conditions

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Abstract: The reliability of sport science tools are important where meaningful change is assessed. However, there is little research identifying the reliability of an intermittent high intensity protocol in a hot environment, therefore the purpose of this study was to investigate these factors using a Wattbike Pro. Twelve healthy, males completed three trials, of intermittent sprint protocols (ISP) of: 18 × 4-s maximal sprints in an environmental chamber (35.9 ± 0.7°C, RH 38.0 ± 1.9 %). Each 4-s sprint was followed by 116-s of active recovery. During each sprint, Power, Heart Rate (HR), thermal comfort and thermal sensation (-3/+3 scales), and RPE were assessed. Peak Average power (highest mean 4s sprint out of 18) 1435W, mean power 1028W, Coefficient of Variation (CV) 3.7 % meaningful change 37W. Peak power (highest instantaneous power of any 4s sprint) peak power 1556W, mean power 1151W, CV4.1 % meaningful change 46W. Average power output (mean average power of 18 sprints) peak power 1355W, mean power 938W, CV4.6 % equating to a meaningful change of 40W and also Average Peak (mean of highest instantaneous power of each 18 sprints) peak power 1454W, mean power 1052W, CV3.6 % 36W. This study confirms the reliability of the intermittent high intensity protocol in a hot environment.

Keywords: Hot environment; Reliability; Hyperthermic; Intermittent; Wattbike; Sprint

1. Introduction

Repeated sprint protocols have long been used to assess and train team-sport players (Spencer et al., 2011; Schneiker et al., 2006). In the applied team-sport setting cycle ergometers are commonly used for performance testing and monitoring (Spencer et al., 2011; Schneiker et al., 2006), and also off-feet conditioning (Cust et al., 2018). It is argued that eccentric muscle loading is reduced without compromising the physiological stimulus and subsequent adaptions (Chan et al., 2018; Bijker et al., 2002), therefore they are seen as a viable alternative, or complimentary addition, to more traditional on-feet running conditioning for the team-sports athlete (Hopker et al., 2010; Jones et al., 2016). Time-motion analysis has allowed practitioners to optimise cycle ergometer sessions to the respective sport (Schneiker et al., 2006).

For coaches to accurately monitor and prescribe training protocols, then objective markers of cycling performance need to be reliable and valid. Reliability of performance markers refer to the reproducibility over multiple occasions, with a measure of reliability commonly being typical error of measurement (TEM) (Driller et al., 2014). Sources of TEM have been identified to be random and/or systematic errors Wainwright et al., 2017). The random error including the inability for the athlete to perform the protocol in an identical trial. Whilst the systematic error may relate to the inability of the ergometer to accurately measure power output (Driller et al., 2014). The Wattbike is readily used in the applied setting as a testing and training tool (Cust et al., 2018; Hopker et al., 2010; Driller et al., 2014), and more recently it has seen a number of research articles (Hopker et al., 2010; Wainwright et al., 2017) reviewing its reliability for these purposes.

The Wattbike Pro cycle ergometer (Wattbike, Nottingham, UK) is a popular air and magnetic resistance cycle ergometer. It was designed with British Cycling for the performance assessment and training of cyclists. Cycle ergometers, such as the Wattbike, have allowed sport science and strength & conditioning practitioners to use power output instead of heart rate to specify training intensity in cycling (Bird et al., 2008; Duc et al., 2007).

Heat has long been identified as a major limiting factor in both team based repeated sprint sports (Morris et al., 2000; Hornery et al., 2007) as well as endurance sports (Montain et al., 2007). Normal thermoregulatory responses to exercise in the heat are an increase in sweat rate and skin blood flow to allow for greater heat dissipation to the surrounding environment. These responses lead to an increase in physiological strain and may lead to dehydration during prolonged exercise. It has been demonstrated that heat stroke alone could impair exercise performance (Périard et al., 2011; Nybo et al., 2014). A consequence of this is that work rate is reduced in hotter environments as shown on marathon running (Ely et al., 2007), football performance (Nassis et al., 2015), tennis performance (Morante et al., 2008), and on cycling time trial (Racinais et al., 2015). It has been demonstrated that hyperthermia reduced power output across repeated cycle ergometer sprints (Drust et al., 2005), and also identified that reduction on performance was likely due to central nervous system function rather than accumulation of metabolic fatigue agents. Therefore, quantifying the extent of decrements, or variation, in sprint performance under heat stress would provide coaches, strength & conditioning coaches, and sports scientists with valuable knowledge to optimise athletes' preparation for competition in the heat (Reilly, T., 1997). This study aimed to identify the day to day reliability of an intermittent sprint cycling protocol in a hot environment with recreationally active male participants.

2. Materials and Methods

The study was a reliability study where twelve recreationally active, non-heat acclimated, male team-sport athletes (age 29 ± 6 y, mass 82.0 ± 6.3 kg, height 180.4 ± 6.5 cm) completed three trials of intermittent sprint protocols (ISP) of: 18 × 4-s maximal sprints in an environmental chamber (35.9 ± 0.7°C, RH 38.0 ± 1.9 %). Each 4-s sprint was followed by 116-s of active recovery. Diet was standardised using a food diary (MyFitnessPal.com) for the 7 day period before the first trial and participants were asked to avoid caffeine for 12 hours and, alcohol and vigorous exercise 24 hours prior to testing. They were asked to replicate this for every subsequent trial. Each experimental session was conducted at the same time of the day to avoid circadian variation in any of the performance measures (Fanger, P., 1970). Power, HR, thermal comfort and thermal sensation (-3/+3 scales), and RPE were assessed. Peak and mean power from the 18 sprints was used to calculate performance decrement. Data was analysed and meaningful change and coefficient of variation (CV) calculated.

All participants provided written informed consent to participate following local ethical approval and in accordance with the Declaration of Helsinki. Upon arrival the participants nude body mass (kg) were measured (Seca Medical 770 scales) prior to the start of the trial. Participants wore a Polar FT1 heart rate chest strap for the entirety of the trial. Ambient temperature was maintained at 20.2 ± 0.4°C, RH at 38.0 ± 1.9 %. Prior to the start of the protocol participants were familiarised with the following perceptual scales; Borg 6-20 RPE scale (Borg, G., 1982), the Thermal Comfort (TC) scale (Fanger, P., 1970), and the Rating of Perceived Thermal sensation (TS) scale

(Roberts, B., 1959). RPE was used to assess, total whole body (overall) and leg only (peripheral). The TC scale is +3 'Very comfortable' through to -3 'Very uncomfortable', whilst TS is graduated from +3 'Hot' through to -3 'Cold', whilst. Scores were recorded at regular 2 min intervals throughout the protocol.

Following completion of the preparation period, subjects immediately entered the climate chamber (35.9 ± 0.7°C, RH 38.0 ± 1.9 %). The warm up consisted of 2 min self-paced pedalling, and participants were instructed to increase intensity until they achieve an RPE of 15-16. The Intermittent Sprint Protocol (ISP) commenced immediately after the warm-up (WU). The total duration was 36 minutes comprising of: 18 × 4 sec maximal sprints commencing every 2 min (derived from Schneiker et al., 2006; Figure 1). Each 4-s sprint was followed by 116 sec of active recovery (continuous easy cycling at 80-90RPM). Typical team sport activity are characterised by maximal, or near-maximal, efforts (1-6 secs) with brief recovery periods (Schneiker et al., 2006). Utilisation of this protocol ensured some element of ecological validity to a team-sports environment. The participants self-selected the air resistance (in accordance with feedback from the initial familiarisation) on the Wattbike and were instructed to produce the highest possible W for the entire 4 sec. Magnetic brake resistance was fixed at 1 on the dial. HR was recorded at rest during the pre-test, and then continuously during the exercise, and recovery periods. 30 sec prior to the start of each sprint RPE (whole body and leg only), TC, TS, Tre, and air temperature were recorded.

Immediately following the completion of the ISP, nude body mass was measured, with towel dried skin to remove excess sweat, to allow an assessment of total fluid loss. The protocol (figure 1) shows the complete 38 min protocol.

Upon completion of each trial data was downloaded from the Wattbike and transferred onto a Windows laptop, and subsequently managed using Microsoft Excel. Peak and mean power averages were calculated for both individual 4-s sprints and also the cumulative 18 sprints. PEAK AVERAGE power (highest mean 4s sprint out of 18), PEAK power (highest instantaneous power of any 4 sec sprint), AVERAGE power (Average power of all 18 4s sprints) and AVERAGE PEAK (mean of highest instantaneous power of each 18 sprints) were calculated. Peak and mean power from the 18 sprints was used to calculate performance decrement (Bishop et al., 2005). HR data was also collated with peak (highest measured) and mean (across whole protocol including exercise and rest periods) values calculated (Figure 2).

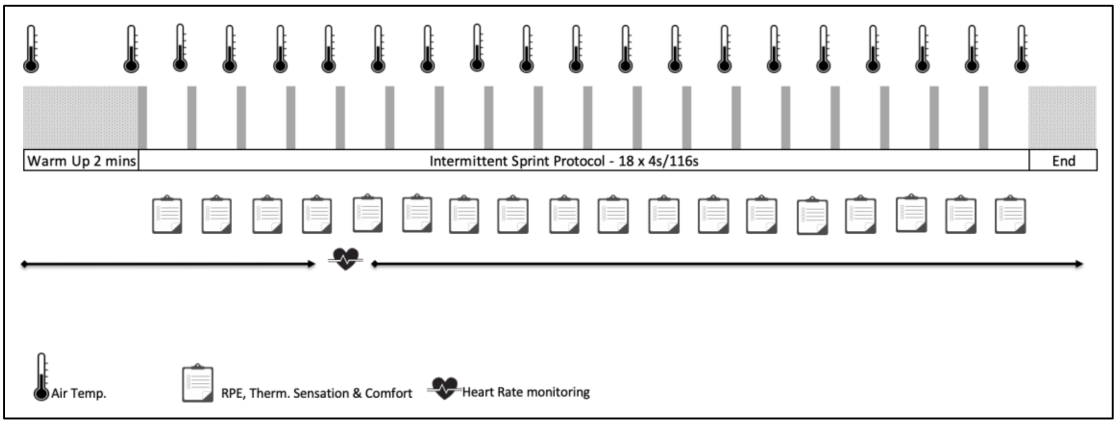
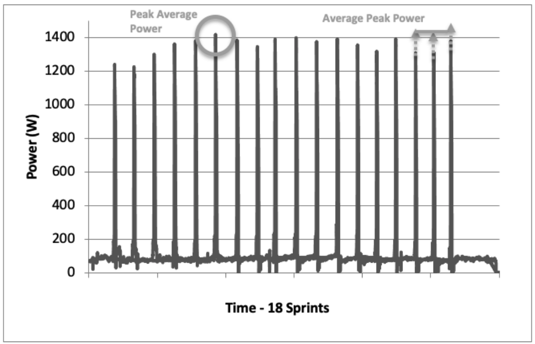


Figure 1. Schematic of the ISP testing protocol.



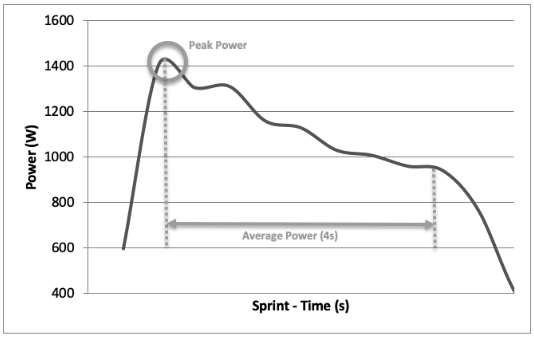


Figure 2. Schematic of Power output metrics during the entire protocol (A) and a single sprint (B).

In addition, performance decrement is calculated by dividing the total power done (Sum of power for 18x4s) by the ideal (highest 4s power x18) resulting in a performance % decrement (Bishop et al., 20404.

Decrement (%) = 100 (Total/Ideal x 100)

Performance decrement has relatively recently been identified as the most reliable and valid measure of assessment of fatigue during a repeated sprint protocol (Glaister et al., 2008). HR data was also collated with peak (highest measured) and mean (across whole protocol including exercise and rest periods) values calculated. Temperature change was calculated from PC/WU and also WU/Peak.

In order to examine differences between the conditions, performance (W), air temperature and perceptual variables (RPE, TS and TC) were analysed using one-way ANOVA with repeated measures. Data was checked for normal distribution and a level of $P<0.05$, with 95 % confidence intervals (CI), was considered significant and all analysis was completed using the Statistical Package for Social Sciences (SPSS) version 24. In addition, Cohen's d effect size were calculated, defined as trivial (<0.20), small (0.20-0.49), moderate (0.50-0.79) or large (≥0.80) according to the cut-offs (Tolusso et al., 2015).

3. Results

3.1. Air temperature

Air temperature was measured at 2-min timepoints throughout every trial. Cumulative trial 1 mean temp was 35.8 ± 0.5°C, trial 2 was 35.7 ± 0.9°C and trial 3 was 36.1 ± 0.7°C. The overall mean temperature for all trials was 35.9 ± 0.7°C . Following statistical analysis air temperature showed trivial differences between trials ($F_{2,22}$ = 1.817; P = 0.186; partial eta squared = 0.14).

3.2. Performance data

Power data is presented in Table 1. PEAK AVERAGE power (highest mean 4s sprint) 1435W, mean 1028W, CV3.7 % meaningful change 37W. PEAK power (highest maximal power of any 4s sprint) 1556W, mean 1151W, CV4.1 % meaningful change 46W. AVERAGE power output (mean average power of 18 sprints) peak power 1355W, mean 938W, CV4.6 % meaningful change 40W and also AVERAGE PEAK (mean of highest power across 18 sprints) peak power 1454W, mean 1052W, CV3.6 % 36W. Mean decrement across 18 sprints was CV24 % and actual decrement 2.4 %. Individual response is presented in figures 3 and 4.

Table 1. Power metric mean and ± SD

Power	Mean	SD
Peak Power	1151 W	46 W
Peak Average Power	1051 W	36 W
Average Peak Power	1028 W	37 W
Mean Power	938 W	40 W
Peak Power Decrement (%)	18.8 %	2.8 %
Mean Power Decrement (%)	9.1 %	2.4 %

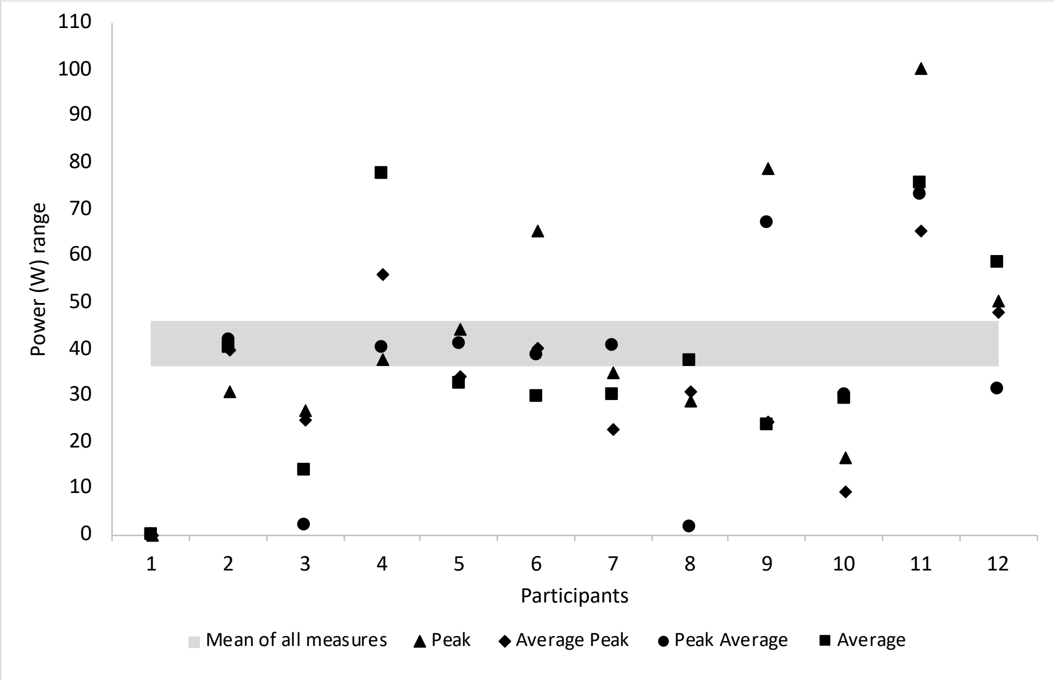


Figure 3. Power metric mean and SD by individual.

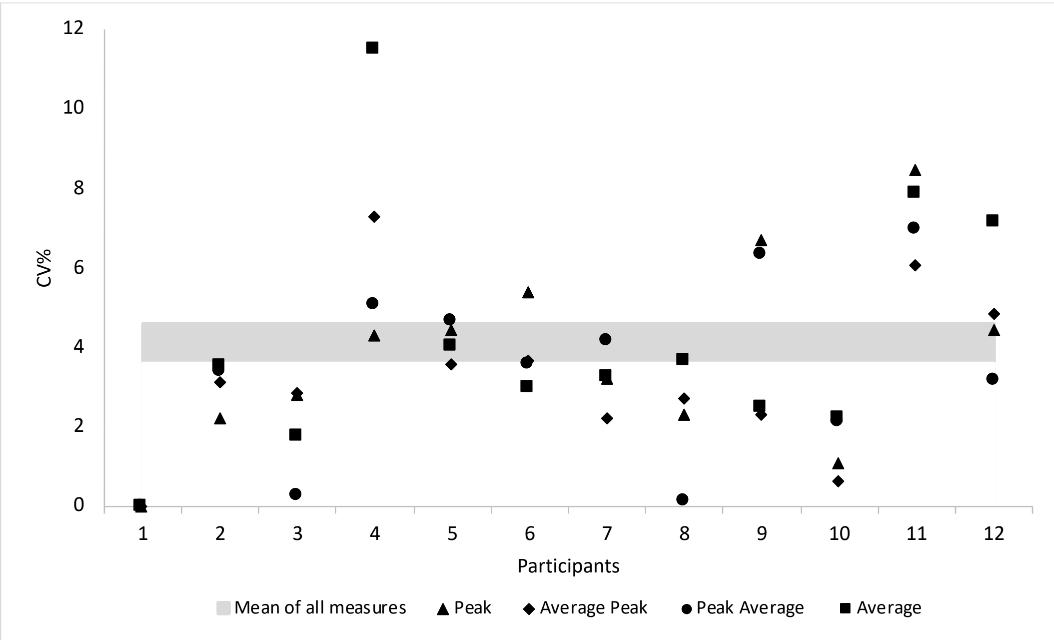


Figure 4. CV of power metric mean and SD by individual.

3.3. Perceptual measures

Perceptual measures were taken at 2-min timepoints, throughout every trial. Cumulative trial 1 mean RPE for the legs and whole body was 14 ± 1.2, trail 2 was 13 ± 1.2 and trial 3 was 13 ± 1.2. Peak RPE achieved for trial 1 was 17 ± 1.9, trial 2 was 16 ± 1.8 and trial 3 was 16 ± 1.7. Thermal sensation for all three trials had a mean of 2 ± 0.4, and a peak of 3 ± 0.3, 3 ± 0.5, and 3 ± 0.5 for trials 1, 2 and 3 respectively. The data for Thermal Comfort was mean for trials 1 and 2 was -1 ± 0.7 and trial 3 was -2 ± 0.8.

For any perceptual measure there were no statistical differences between trials for RPE total ($F_{2,22}$ = 2.200; P = 0.135; partial eta squared = 0.17), and TC ($F_{2,22}$ = 2.200; P = 0.135; partial eta squared = 0.17). Statistical analysis of TS showed that there was no difference between the trials T1 = T2 (P=1.00, 95 %CI: 0, 0) and T2 = T3 (P=0.246, 95 %CI: -0.6, 0.12), despite there being a significant difference identified in analysis (F2,22 = 3.667; P = 0.042; partial eta squared = 0.25).

4. Discussion

This study aimed to identify the day to day reliability of an intermittent sprint cycling protocol in a hot environment with recreationally active male participants. We can conclude that for power output variables there was a coefficient of variation of between 3.6 % and 4.6 % (mean and peak power respectively). This equates to a meaningful change of between 36W and 46W, respectively for either the mean or peak power output. Performance decrement varied on average by 9 % within each trail and CV % was 2.4 %. Environmental temperature showed only trivial differences between trials, and as such, it is unlikely that the performance was impacted by changes in environmental factors. There was variation in perceptual measures between trials, so it should be considered that they may have contributed to variance in performance (Cohen, J., 1992).

Previous studies (Watt et al., 2002; McGawley et al., 2006) investigating reliability of repeated sprint protocols in normothermic environments have identified somewhere between CV of 2.5 % and 3.0 %. As already highlighted (Drust et al., 2005), there is evidence to suggest that hyperthermia reduces power output across repeated cycle ergometer sprints. There is also converse evidence to identify that elevated muscle temperature, likely to be present during repeated sprints in a hot environment, can enhance sprint performance up to a threshold core temperature (Drust et al., 2005). Below this threshold the elevated muscle temperature enhances repeated baby (Drust et al., 2005). The negative influence of an elevated core temperature may be attributed, at least in part, to an indirect inhibitory effect of the sensory afferent feedback (group III/IV muscle afferents) originating from heated muscles (Nybo et al., 2014). This study identified a CV of between 3.6 and 4.6 % within the test population. It is within the expected range for studies of a similar, albeit normothermic, nature (Watt et al., 2002; McGawley et al., 2006; Abbiss et al., 2008).

5. Practical Applications.

This study confirms the reliability and highlights that the mean and peak power values are the most reliable variables for assessing changes within a 4s repeated sprint performance in hot conditions. This protocol provides a reliable assessment of repeated sprint performance in the heat. This can be beneficial in the sports science and strength & conditioning fields, when power changes in repeated maximal efforts, performed on a Wattbike Pro, are assessed or monitored. Changes greater than 46W can be concluded as meaningful.

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

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