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Original research

The reproducibility of 10 and 20 km time trial cycling performance in recreational cyclists, runners and team sport athletes

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ABSTRACT

Objectives: This study aimed to determine the reliability of 10 and 20 km cycling time trial (TT) performance on the Velotron Pro in recreational cyclists, runners and intermittent-sprint based team sport athletes, with and without a familiarisation.

Design: Thirty-one male, recreationally active athletes completed four 10 or 20 km cycling TTs on different days.

Methods: During cycling, power output, speed and cadence were recorded at 23 Hz, and heart rate and rating of perceived exertion (RPE) were recorded every km. Multiple statistical methods were used to ensure a comprehensive assessment of reliability. Intraclass correlations, standard error of the measurement, minimum difference required for a worthwhile change and coefficient of variation were determined for completion time and mean trial variables (power output, speed, cadence, heart rate, RPE, session RPE).

Results: A meaningful change in performance for cyclists, runners, team sport athletes would be represented by 7.5, 3.6 and 12.9% improvement for 10 km and a 4.9, 4.0 and 5.6% for 20 km completion time. After a familiarisation, a 4.0, 3.7 and 6.4% improvement for 10 km and a 4.1, 3.0 and 4.4% would be required for 20 km.

Conclusions: Data from this study suggest not all athletic subgroups require a familiarisation to produce substantially reliable 10 and 20 km cycling performance. However, a familiarisation considerably improves the reliability of pacing strategy adopted by recreational runners and team sport athletes across these distances.

1. Introduction

Laboratory cycling time trials (TTs) attempt to replicate real-world race conditions, and often serve as endurance performance criteria.[1] In research settings, determining the effect of treatments or interventions on exercise (e.g., supplementation,[2] cooling,[3] heat-based training[4]) is commonly achieved using cycling TTs, irrespective of the athletic population recruited (e.g., cyclists, team sport athletes). Such investigations are reliant on the task being highly reproducible in the studied population, so to allow the detection of small but meaningful changes in performance.[5] The use of cycling TT tasks in non-cycling athletic populations might be attributed to: the space efficiency of ergometers, the capacity to safely test multiple individuals at the same time and easily accessible performance and pacing data. The Velotron Pro is a commonly used cycle ergometer for the assessment of TT performance.[2,4,6] The reliability of constant-work performance on this ergometer has been determined for distances of 4,[7] 16.1[8] and 20 km,[10,11] on simulated flat[10,11] and uphill[12–14] courses, in different cycling populations[11] and across various cycling levels.[8] In trained cyclists (VO_{2peak}: >56 ml kg^{-1} min^{-1}), completion time and mean power output have been shown to be highly reproducible on flat courses.[9–11]

The reliability of performance on the Velotron Pro has previously been examined in manner so to inform the impact of multiple familiarisations.[9–11] However, the practical constraints of human testing (e.g., visits required, time and expense) may only permit a familiarisation to the ergometer but not the TT task itself, or a single practice trial at best. Moreover, depending on the experimental design, it may not be possible to exclusively recruit trained cyclists. To the authors' knowledge, no study has quantified the reliability of TT performance on the Velotron Pro in non-cycling

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athletic populations. Therefore, the primary aim of this study was to determine the reliability of 10 and 20 km cycling TT performance on the Velotron Pro, with and without a familiarisation in recreational cyclists, runners and intermittent-sprint based team sport athletes. A secondary aim of the study was to establish the reliability of the pacing strategy adopted by these athletic groups for 10 and 20 km. We hypothesised: (1) cyclists would demonstrate the most reliable performances over both distances; and (2) a familiarisation would improve the reliability of runners and team sport athletes performance.

2. Methods

This study consisted of two parts that involved completing four 10 (10TT) or 20 km (20TT) cycling TTs. The experimental design and methods were identical for the 10TT and 20TT. During a fifth visit, participants performed an incremental cycling test (commencing at 75 W, increased by 25 W min^{-1}; Excalibur Sport; Lode, Groningen, Netherlands) with open circuit spirometry (TrueOne 2400, Parvo Medics, Provo, Utah, USA) to determine their peak oxygen consumption (O_{2peak}), peak power (P_{peak}) and peak heart rate (HR_{peak}).[15] Participants reported to the laboratory (24.5 ± 1.3 °C; 59 ± 4% relative humidity) at the same time of day (±2 h) for each TT, at least 2 days apart. Participants were instructed to avoid alcohol, caffeine and strenuous exercise in the 24 h before each visit; and asked to consume a similar diet on each testing day. During cycling, the consumption of fluids was not permitted, and no fan cooling was provided. The University Human Research Ethics Committee approved the study, and written informed consent was attained before commencing data collection.

Thirty-one male, recreationally trained athletes volunteered for this study. Eighteen athletes completed 10TT: (1) cyclists (n = 6; age: 28.7 ± 8.4 years; height: 180.1 ± 7.2 cm; body mass: 76.3 ± 5.0 kg); (2) runners (n = 5; 25.9 ± 2.4 years; 175.3 ± 2.4 cm; 72.4 ± 4.3 kg); (3) team sport (n = 7; 24.0 ± 2.1 years; 174.8 ± 6.1 cm; 69.4 ± 9.2 kg). Seventeen athletes completed 20TT: (1) cyclists (n = 5; 28.6 ± 2.8 years; 184.3 ± 4.2 cm; 82.6 ± 7.0 kg); (2) runners (n = 6; 26.8 ± 4.4 years; 177.9 ± 6.9 cm; 72.6 ± 4.0 kg); (3) team sport (n = 6; 25.5 ± 3.5 years; 177.0 ± 7.1 cm; 80.6 ± 11.3 kg]. Four participants (two cyclists, two runners) completed both 10TT and 20TT. For these individuals, there were at least 12 days between finishing 10TT and commencing 20TT.

At the time of the investigation, participants were amateur-level club athletes, training and/or competing in their respective sport at least twice per week. For team sport athletes, this included a minimum of one-structured training session (≥60 min), and one club-level competitive match each week. For 10TT, mean (±SD) training activities from the previous month: (1) cyclists: 4 ± 1 sessions $week^{-1}$, 440 ± 228 min $week^{-1}$; (2) runners: 4 ± 1 sessions $week^{-1}$, 175 ± 80 min $week^{-1}$, 38 ± 8 km $week^{-1}$; and (3) team sport: 3 ± 1 sessions $week^{-1}$, 180 ± 75 min $week^{-1}$. For 20TT, (1) cyclists: 5 ± 2 sessions $week^{-1}$, 515 ± 220 min $week^{-1}$; (2) runners: 4 ± 2 sessions $week^{-1}$, 218 ± 87 min $week^{-1}$, 41 ± 13 km $week^{-1}$; and (3) team sport: 5 ± 1 sessions $week^{-1}$, 288 ± 88 min $week^{-1}$. Runners provided their best 5 km run time achieved in the previous six-months; 10TT: 19:26 ± 1:39 min; and 20TT: 18:49 ± 1:19 min.

TTs were performed on the electromagnetically braked Velotron Pro cycle ergometer (RacerMate Inc., Washington, USA). This ergometer is highly accurate in measuring power output during constant load protocols (manufacturer reported: ±1.5% across 5–2000 W) and is commonly used in research settings.[16] Factory calibration was confirmed using the 'Accuwatt' function. During cycling, gearing was freely altered via a toggle shifter located above the right brake hood. The Velotron 3D software (Version NB04.1.0.2101, RacerMate Inc., Washington, USA) was used to design the 10 and 20 km straight flat courses. During their first visit, participants were fitted to the ergometer, and these settings (seat and handlebar height, seat setback and handlebar reach) remained the same throughout testing. The type of pedals used by a participant during this initial visit (flat or Shimano SPD-SL clipless) was also kept consistent for each subsequent TT.

Participants were pre-screened (Exercise and Sports Science Australia questionnaire) and familiarised to the perceptual measures during their first visit. These measures were: the modified profile of mood states (POMS; active, energetic, restless, fatigued, exhausted and alert); Borg's[17] 6–20 rating of perceived exertion (RPE) and the CR-10 session RPE (sRPE) scales.[18]

The procedures herein were replicated for each testing day. On arrival, participants provided a urine sample for the assessment of urine specific gravity (U_{SG}; PAL-10S; Atagi Ci. Ltd, Tokyo, Japan) and urine colour (scale: 1–8 au) as indicators of hydration status.[19] If U_{SG} > 1.020, participants were provided with 500 mL of water, and U_{SG} was reassessed after 30 min. Nude body mass (WB-110AZ; Tanita Corp., Tokyo, Japan) was recorded, and participants completed the modified POMS. Following this, a heart rate (HR) monitor and wrist watch receiver (F1, Polar, Electro-oy, Kempele, Finland) were fitted, and participants donned their cycling attire. For cyclists, this consisted of bibs (without a jersey), socks and cleats; and for runners and team sport athletes, a t-shirt, shorts, socks and rubber soled shoes. Each participants' attire was standardised across all TTs.

After a 5 min warm up (100 W with a 5 s maximal effort on every minute), participants began their TT under the instruction of completing the distance in the fastest time possible. During trials, the 3D software was used to display an avatar of each participant on a computer monitor, in addition to elapsed distance (km), gear selection, and instantaneous power (W), speed (km h^{-1}), and cadence (RPM). Elapsed time was not shown on the monitor. Minimal verbal encouragement was provided. Time and all performance data were recorded at 23 Hz. HR and RPE were recorded every 1 km. Following each TT, performance data was downloaded, and exported to Excel 2013 (Microsoft Corp., Redmond, Washington, USA), nude body mass was recorded to determine pre-post trial fluid losses, and sRPE was collected.

The normal distribution of data was confirmed using descriptive methods (skewness, outliers and distribution plots), and inferential statistics (Shapiro–Wilk test). To ensure participants arrived in a similar state each testing day, a repeated measures analysis of variance (ANOVA) was used to detect between TT differences for the baseline measures of hydration status (U_{SG}, urine colour, body mass), and the modified POMS, for the entire cohort.

Multiple methods were employed to ensure a comprehensive assessment of reliability. Firstly, a repeated measures ANOVA determined the within- and between-participant variance, partitioning error between systematic, and random error.[20] Intraclass correlation's (2,1; Eq. (1)) were calculated using a two-way fixed-effects model, where both systematic and random error were considered.[21,22]

Equation 1. Intraclass correlation coefficient (ICC; 2,1) using a two-way fixed-effects model.

$$ICC = \frac{MS_S - MS_E}{MS_S + (k-1) \cdot MS_E + \frac{k \cdot (MS_T - MS_E)}{n}}$$

where: MS_S = participant mean square, MS_E = error mean square (i.e., random error), and MS_T = trials mean square (i.e., systematic error); k = the number of trials performed by a participant; and n = group size. ICC's were used to classify reliability as: <0.10 virtu-

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