Validity of the 8-minute time trial in determining variables for mountain bike cycling training

Validade do contrarrelógio de 8 minutos na determinação de variáveis para o treinamento de ciclismo de montanha

Validez de la contrarreloj de 8 minutos en la determinación de variables para el entrenamiento de ciclismo de montaña

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ABSTRACT
The 8-minute time trial (TT) is a methodological alternative to the 60-minute TT for evaluating the Functional Threshold Power (FTP) of cyclists, however, studies that tested its validity were not found in the researched literature. Therefore, research aims to assess the validity of the 8-minute TT. The study included 9 trained male cyclists, aged between 25.46 ± 7.49 years, who were assessed on three different days. On the first day, we measured personal data, anthropometrics, ventilatory thresholds and peak oxygen consumption. On the other days, we submitted the volunteers to the 8- and 60-minute TT. We analyzed the agreement between the procedures using the intraclass correlation coefficient (ICC) and its validity by Bland-Altman. We adopted a significance level of 5%, and we performed all analyses using the SPSS. The results suggest great agreement, especially between the second 8-minute stimulus and the reference test, for FTP (ICC: 0.792, p= 0.016), Wats per kilogram (ICC: 0.952, p< 0.001), Wats per kilogram of lean mass (ICC: 0.912, p= 0.001) and peak oxygen consumption (ICC: 0.882, p= 0.001). In addition, in all these variables, the volunteers were within the mean ± two standard deviations, as verified by the Bland-Altman plots. These results demonstrate the validity of the 8-minute TT, with more robust data being observed by the second stimulus of this protocol.

Keywords: cycling, mountain bike, power, FTP, exercise test.

RESUMO
O contrarrelógio de 8 minutos (TT) é uma alternativa metodológica ao TT de 60 minutos para avaliar a Potência de Limiar Funcional (FTP) de ciclistas, no entanto, estudos que testaram sua validade não foram encontrados na literatura pesquisada. Portanto, a pesquisa visa avaliar a validade do TT de 8 minutos. O estudo incluiu 9 ciclistas do sexo masculino treinados, com idade entre 25,46 ± 7,49 anos, que foram avaliados em três dias diferentes. No primeiro dia, medimos dados pessoais, antropometria, limiares de ventilação e pico de consumo de oxigênio. Nos outros dias, submetemos os voluntários ao TT de 8 e
60 minutos. Analisamos a concordância entre os procedimentos utilizando o coeficiente de correlação intraclass (ICC) e sua validade por Bland-Altman. Adotamos um nível de significância de 5% e realizamos todas as análises utilizando o SPSS. Os resultados sugerem grande concordância, especialmente entre o segundo estímulo de 8 minutos e o teste de referência, para FTP (ICC: 0,792, p= 0,016), Wats por quilograma (ICC: 0,952, p< 0,001), Wats por quilograma de massa magra (ICC: 0,912, p= 0,001) e consumo máximo de oxigênio (ICC: 0,882, p= 0,001). Além disso, em todas essas variáveis, os voluntários estavam dentro da média de ± dois desvios-padrão, conforme verificado pelos gráficos de Bland-Altman. Esses resultados demonstram a validade do TT de 8 minutos, com dados mais robustos sendo observados pelo segundo estímulo deste protocolo.

Palavras-chave: ciclismo, mountain bike, potência, FTP, teste de exercícios.

RESUMEN
La contrarreloj de 8 minutos (TT) es una alternativa metodológica a la TT de 60 minutos para evaluar la Potencia de Umbral Funcional (FTP) de los ciclistas, sin embargo, los estudios que probaron su validez no se encontraron en la literatura investigada. Por lo tanto, la investigación tiene como objetivo evaluar la validez del TT de 8 minutos. El estudio incluyó 9 ciclistas masculinos entrenados, con edades entre 25,46 ± 7,49 años, que fueron evaluados en tres días diferentes. El primer día, medimos datos personales, antropometría, umbrales ventilatorios y consumo máximo de oxígeno. Los otros días, enviábamos a los voluntarios al TT de 8 y 60 minutos. Se analizó la concordancia entre los procedimientos utilizando el coeficiente de correlación intraclass (ICC) y su validez por Bland-Altman. Adoptamos un nivel de significancia del 5% y realizamos todos los análisis utilizando el SPSS. Los resultados sugieren un gran acuerdo, especialmente entre el segundo estímulo de 8 minutos y la prueba de referencia, para FTP (ICC: 0.792, p= 0.016), Wats por kilogramo (ICC: 0.952, p< 0.001), Wats por kilogramo de masa magra (ICC: 0.912, p= 0.001) y consumo máximo de oxígeno (ICC: 0.882, p= 0.001). Además, en todas estas variables, los voluntarios estuvieron dentro de la media ± dos desviaciones estándar, según lo verificado por las parcelas de Bland-Altman. Estos resultados demuestran la validez del TT de 8 minutos, con datos más robustos observados por el segundo estímulo de este protocolo.

Palabras clave: ciclismo, bicicleta de montaña, potencia, FTP, prueba de ejercicio.

1 INTRODUCTION
In sports cycling, there are different modalities which include different races, each of them presenting specificities related to the pace of the race, the
characteristics of the environment, characteristics of the equipment, but all sharing the common aspect that these races develop under high intensities, thus imposing high neuromuscular and physiological demands on cyclists (JEUKENDRUP; CRAIG; HAWLEY, 2000; UCI, 2019).

Such demands characterize mountain and road cycling as a predominantly aerobic sport, with anaerobic intermittences, with maximal oxygen consumption (VO2 max), metabolic transition thresholds and power being determinants of sports success (IMPELLIZZERI et al., 2005; IMPELLIZZERI; MARCORA, 2007).

Allen and Cogan (ALLEN; COGAN, 2006) proposed the use of intensities relative to average power as a strategy for prescribing training to cyclists, which is the best and probably the most used variable to measure effort intensity in high-performance cycling (JOBSON et al., 2009).

In cycling, time trials (TT) tests are commonly applied to determine the average power, also known as the Functional Threshold Power (FTP). The gold standard test for determining FTP is the 60-minute time trial (TT60) (COYLE et al., 1991; SITKO; CIRER-SASTRE; LÓPEZ-LAVAL, 2023). However, despite its relevance, the relatively long duration of this test limits its application (MACINNIS; THOMAS; PHILLIPS, 2018).

From this perspective, shorter time trials have been proposed for FTP assessment, such as the 20 (TT20) and 8 (TT8) minute time trials (ALLEN; COGAN, 2006; CARMICHAEL; RUTBERG, 2004). These shorter protocols allow the determination of FTP from the application of correction factors to the average power obtained, with FTP representing 95% and 90% of the values obtained in the 20 and 8-minute time trials, respectively (ALLEN; COGAN, 2006; CARMICHAEL; RUTBERG, 2004).

Several studies have assessed the use of the 20-minute time trial for different purposes (BORSZCZ; TRAMONTIN; COSTA, 2019; LILLO-BEVÍÁ et al., 2019; MACINNIS; THOMAS; PHILLIPS, 2018), providing robust evidence regarding the utility and applicability of this protocol. As for the 8-minute time trial, proposed for the first time by Carmichael; Rutberg, (2004), the volume of studies is considerably smaller, such as the work of Gavin et al (2012) Klika et al (2007).
Sanders et al (2020). In this scenario, there are important gaps to be filled, and it is necessary to increase the level of scientific evidence on this topic, thus supporting an evidence-based professional practice.

In this context, information on the validity of the 8-minute time trial protocol in determining FTP from the application of the correction factor (90% of the average power) remains unclear and should therefore be investigated. In addition, a shorter procedure that provides valid data represents a logistical and economic advantage for coaches and athletes (CURRELL; JEUKENDRUP, 2008; IMPPELLIZZERI; MARCORA, 2009). Therefore, the present investigation aims to assess the validity of the 8-minute time trial test in mountain biking in a laboratory environment.

2 MATERIALS AND METHODS

2.1 SAMPLE

The study consisted of 9 subjects who met a set of inclusion and exclusion criteria, among which the following are highlighted: being male, presenting a negative physical activity readiness questionnaire (PAR-q), having low coronary risk assessed by the RISKO questionnaire, practicing cycling at least three times a week, with a weekly duration of 5 hours, covering distances between 60 and 250 km per week for at least 12 months.

In accordance with the conditions presented, all participants signed a free and informed consent form, thus complying with the requirements of the Brazilian legislation for experiments with human beings (466/12).

All procedures were initiated after the project was approved by the Human Studies Ethics Committee of the Federal University of Viçosa (Opinion number: 4,841,775).

2.2 STUDY DESIGN

In order to test the validity of the 8-minute time trial in cycling, each volunteer participated in three assessment sessions, as illustrated in Figure 1.
We conducted the sessions in the morning shift, between 6 and 10 a.m., with a minimum interval of 48 hours between them.

During the first visit, we conducted at anamnesis and risk stratification using the physical activity readiness questionnaires (PAR-q) (ADAMS, 1999) and coronary risk table (MICHIGAN HEART ASSOCIATION, 1973). Additionally, we performed anthropometric measurements and assessed body composition, in addition to two protocols, one for determining ventilatory thresholds and the other for determining peak oxygen consumption (VO2 peak). The remaining sessions focused on time trial assessments.

In all sessions, we instructed participants to follow their pre-competition routine (MACINNIS; THOMAS; PHILLIPS, 2018).

2.3 PROCEDURES
2.3.1 Anthropometric Profile and Body Composition

We measured body mass using a digital electronic scale with a capacity of 150 kilograms and a precision of 50g (Welmy, W200A, Brazil). We determined the subject’s height using a millimeter stadiometer with a length of 2 meters and a scale of 0.5 cm (Welmy, W200A, Brazil). We assessed body composition using the skinfold method, where we applied the 3-fold protocol (pectoral, abdominal, and thigh) to measure body density (JACKSON; POLLOCK, 1978). Subsequently, we converted body density into fat percentage using the formula developed by Crab (SIRI, 1961).
### 2.4 INCREMENTAL PROTOCOL - THRESHOLDS

Each volunteer performed an incremental protocol on their own bicycle, using their sneakers, socks, shorts and shirt, which was coupled to a stationary Zcycle roller (*Smart ZPRO*), with the tires inflated to 30 psi, and the information related to power (W), heart rate (HR), cadence (RPM), speed (KM/h) and duration (minutes) was transmitted in real time via a screen by the *Golden Cheetah®* software.

This exercise protocol consisted of 10-minute warm-up (3' at 50w, 3' at 75w and 4' at 100w) with an average cadence of 60 (± 5) revolutions per minute (RPM), gradually shifting the rear derailleur toward the second cog by the final minute of the warm-up. After this period, with the gear positioned on the second cog, the load was adjusted to 125 W, for the beginning of the protocol. During the exercise, the load was increased by 25 watts every 3 minutes, maintaining an average cadence of 60 (± 5) RPM until the subject reached his anaerobic threshold (GAVIN et al., 2012). From then on, the volunteer entered an 8-minute active recovery period, with a 75 W load until reaching 120 bpm to then start the stage of determining the VO2 peak. This stage began with the resistance set to 150 watts and had an increment of 25 W every minute, until voluntary exhaustion (KLIKA et al., 2007).

Throughout the procedure, we continuously measured VO2, pulmonary ventilation, and respiratory exchange ratio using the *Medgraphics BREEZESUITE CPX Ultima metabolic gas analyzer* (Medical Graphics Corporation, St. Paul, Minnesota, USA).

In order to characterize VO2 peak, the volunteer should have at least three of the following characteristics: (1) Stabilization of oxygen consumption and/or (2) heart rate by increasing the load; (3) respiratory quotient greater than 1.10; (4) heart rate with a variation of ± 8 beats in relation to the maximum calculated using the equation proposed by Jones et al (1985); (5) Subjective perception of exertion greater than 17 (6 to 20 point scale) (DUNCAN; HOWLEY; JOHNSON, 1997).

We determined ventilatory thresholds 1 (VT1) and 2 (VT2) according to the following criteria: (1) VT1 from the increase in ventilatory oxygen equivalent (VL
/ VO2) and end-tidal oxygen pressure (PetO2), without concomitant increase in ventilatory carbon dioxide equivalent (VE / VCO2); (2) VL2 from an increase in both ventilatory equivalents (VE/VO2 and VE/VCO2) and a decrease in end-tidal carbon dioxide pressure (PetCO2) (CAIOZZO et al., 1982; PALLARÉS et al., 2016).

We monitored heart rate using a Polar heart rate monitor (model Polar H10 heart rate sensor) and the values related to the heart rate were transmitted through a screen by the Golden Cheetah® software.

We determined maximal aerobic power (Pmax) as the load (W) corresponding to the last load stage completed by the subject during the incremental protocol. If the last load stage was not completed, we calculated Pmax according to Kuipers et al., (1985):

\[ P_{max} = C_c + \left( \frac{t}{60*25} \right) \]

Where:

C_c is the last completed load (W), t is the time recorded at the incomplete load(s), and 25 is the value of the increment in watts.

We conducted all procedures with hydrated volunteers (urine density below 1020) and in a thermo-neutral environment (temperature 20 - 22°C, humidity 40 - 60%) (ACSM, 2018; MCDERMOTT et al., 2017).

2.5 8-MINUTE TIME TRIAL

We conducted the 8-minute time trial according to its original version. This consists of a 23-minute warm-up alternating between high and low intensities, followed by two 8-minute time trials, with an active 10-minute interval between the efforts, as described below.
2.6 PROTOCOL FOR THE 8-MINUTE TIME TRIAL (CARMICHAEL; RUTBERG, 2004):

Specific Warm-Up: 10 minutes of initial warm-ups at light to moderate intensity (65 to 75 rpm); 1 minute of fast pedaling (in a light gear, increase the cadence as high as you can, without leaving the saddle); 1 minute of easy spin recovery (in a light gear, reduce cadence to 75 rpm); 2 minutes of fast pedaling (cadence above 100 rpm); 1 minute of easy spin recovery (in a light gear, reduce cadence to 75 rpm); 1-minute power interval (maximum intensity interval of 90 to 95 rpm; gradually increase intensity over the first 30 seconds and maintain this effort level until the end of the interval); 2 minutes of easy spin recovery (in a light gear, reduce cadence to 75 rpm); 1-minute power interval; 4 minutes of easy spin recovery (65 to 75 rpm).

CR8 – 1: First stimulus of the 8-minute time trial.

Active Recovery: 10 minutes of active recovery at low cadence and light gear.

CR8 – 2: Second stimulus of the 8-minute time trial.

Warm down: 10 minutes of active recovery in low cadence and light gear.

After both efforts, we applied a correction factor to the highest observed power value, multiplying the result by 0.90 to determine the FTP (CARMICHAEL; RUTBERG, 2004).

For this procedure, we used a Zcycle (Smart ZPRO) stationary roller, equipped with its own power meter, with an accuracy of 3%, positioned with a 2% inclination. We transmitted the information related to the monitored variables through a screen by the Golden Cheetah® software.

We measured the average and maximum heart rate, average and maximum power (ALLEN; COGAN, 2006), distance covered, average speed, average cadence, and subjective perception of exertion (6-20).

During the experimental protocols, we concealed the measured variables from the subjects to avoid influencing their pacing strategy during its execution (MACINNIS; THOMAS; PHILLIPS, 2018).
2.7 60-MINUTE TIME TRIAL

In addition to the 8-minute time trial, each cyclist also performed a 60-minute time trial (COYLE et al., 1991) on their own bicycle and with the use of the same personal individual equipment (sneakers, socks and clothes) used in the previous experimental procedures, as described below.

Protocol for a 60-minute time trial (COYLE et al., 1991):

Specific warm-up: 10 minutes of warm-up at easy spin (~65 to 75 rpm) light to moderate intensity; 3 minutes of recovery at an easy pace (< 60 rpm).

CR60: Unique 60-minute time trial stimulus.

Warm down: 10 minutes of recovery at an easy pace (< 60 rpm).

For this time trial, we used the same equipment and procedures to measure the variables obtained in the 8-minute time trial.

2.8 STATISTICAL ANALYSIS

We tested the normality of the data using the Shapiro-Wilk test, and all of them presented normal distribution.

We verified the agreement between the 8-minute time trial and the 60-minute time trial stimuli using the intraclass correlation coefficient (ICC). For the interpretation of the correlation coefficient, we used the thresholds proposed by Hopkins et al (2009): <0.09 (trivial); 0.1 – 0.29 (small); 0.30 – 0.49 (moderate); 0.50 – 0.69 (large); 0.70 – 0.89 (very large); 0.90 – 0.99 (almost perfect); 1 (perfect).

In addition to the ICC, we also assessed the validity between the procedures using Bland-Altman plots with their respective mean data and standard deviation (BLAND; ALTMAN, 1986). We performed a statistical complement to the Bland-Altman plots through linear regression analysis to check for the presence of a proportion bias.

We compared the mean of the variables analyzed in each of the stimuli of the 8-minute time trial and the 60-minute time trial using repeated measures
analysis of variance (ANOVA) with Sidak post-hoc analysis conducted at moments when statistically significant differences were identified.

We adopted a significance level of 5% for all statistical procedures, and we conducted them using the SPSS software, version 23 (Version 23, IBM 216 Corp., Armonk, NY, USA).

3 RESULTS

9 experienced and well-trained mountain bike cyclists with competition experience participated in this study, as indicated in the data presented in Table 1.

Table 1 - Characteristics of the sample of mountain bike cyclists. (n=9)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean ± Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>25.46 ± 7.49</td>
</tr>
<tr>
<td>Body Mass (kg)</td>
<td>74.71 ± 14.74</td>
</tr>
<tr>
<td>Height (meters)</td>
<td>1.74 ± 0.08</td>
</tr>
<tr>
<td>Body Mass Index</td>
<td>24.59 ± 3.65</td>
</tr>
<tr>
<td>Body Fat Percentage</td>
<td>15.78 ± 5.75</td>
</tr>
<tr>
<td>Practice time (years)</td>
<td>8.22 ± 4.24</td>
</tr>
<tr>
<td>Competitions per year</td>
<td>8.22 ± 5.72</td>
</tr>
<tr>
<td>Weekly training hours</td>
<td>11.33 ± 4.09</td>
</tr>
<tr>
<td>Weekly training days</td>
<td>5.44 ± 1.24</td>
</tr>
<tr>
<td>Weekly training mileage</td>
<td>223.89 ± 113.13</td>
</tr>
<tr>
<td>VL1</td>
<td>32.16 ± 5.98</td>
</tr>
<tr>
<td>VL2</td>
<td>46.00 ± 6.85</td>
</tr>
<tr>
<td>VO2 peak</td>
<td>53.66 ± 7.92</td>
</tr>
<tr>
<td>PO to VL1</td>
<td>193.78 ± 31.56</td>
</tr>
<tr>
<td>PO to VL2</td>
<td>301.44 ± 32.22</td>
</tr>
<tr>
<td>PO Peak</td>
<td>364.59 ± 41.40</td>
</tr>
<tr>
<td>HR to VL1</td>
<td>145 ± 14.75</td>
</tr>
<tr>
<td>HR to VL22</td>
<td>179 ± 5.79</td>
</tr>
<tr>
<td>Peak HR</td>
<td>192 ± 5.89</td>
</tr>
<tr>
<td>Parq</td>
<td>%</td>
</tr>
<tr>
<td>Positive</td>
<td>0</td>
</tr>
<tr>
<td>Negative</td>
<td>100</td>
</tr>
</tbody>
</table>

VL: ventilatory threshold; PO: aerobic power; HR: heart rate. source: the authors

Regarding the validity of the 8-minute time trial, it is evident that both 8-minute stimuli presented numerous variables with considerable agreement with the reference test, as shown in Table 2.
Table 2: Validity of the 8-minute time trial. (n=9)

<table>
<thead>
<tr>
<th></th>
<th>8TT-1 Mean</th>
<th>SD</th>
<th>60-TT Mean</th>
<th>SD</th>
<th>ICC (95%CI)</th>
<th>8TT-2 Mean</th>
<th>SD</th>
<th>60-TT Mean</th>
<th>SD</th>
<th>ICC (95%CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed (Km/h)</td>
<td>24.67</td>
<td>1.18</td>
<td>21.69</td>
<td>1.99</td>
<td>0.221 (-0.254; 0.710)</td>
<td>23.64</td>
<td>1.11</td>
<td>21.69</td>
<td>1.99</td>
<td>0.483 (-0.324; 0.863)</td>
</tr>
<tr>
<td>Cadence (rpm)</td>
<td>90.55</td>
<td>2.50</td>
<td>88.00</td>
<td>1.50</td>
<td>0.451 (-0.332; 0.850)</td>
<td>90.00</td>
<td>2.35</td>
<td>88.00</td>
<td>1.50</td>
<td>0.566* (-0.317; 0.892)</td>
</tr>
<tr>
<td>Power(w)</td>
<td>222.66</td>
<td>26.34</td>
<td>175.44</td>
<td>30.26</td>
<td>0.373 (-0.240; 0.811)</td>
<td>205.89</td>
<td>23.98</td>
<td>175.44</td>
<td>30.26</td>
<td>0.611* (-0.285; 0.910)</td>
</tr>
<tr>
<td>FTP</td>
<td>200.40</td>
<td>23.70</td>
<td>175.44</td>
<td>30.26</td>
<td>0.554 (-0.334; 0.887)</td>
<td>185.30</td>
<td>21.58</td>
<td>175.44</td>
<td>30.26</td>
<td>0.792* (0.187; 0.952)</td>
</tr>
<tr>
<td>W/KG</td>
<td>2.76</td>
<td>0.60</td>
<td>2.45</td>
<td>0.70</td>
<td>0.889* (0.230; 0.978)</td>
<td>2.56</td>
<td>0.55</td>
<td>2.45</td>
<td>0.70</td>
<td>0.952* (0.803; 0.989)</td>
</tr>
<tr>
<td>W/KGLM</td>
<td>3.27</td>
<td>0.54</td>
<td>2.88</td>
<td>0.67</td>
<td>0.804* (-0.023; 0.958)</td>
<td>3.02</td>
<td>0.49</td>
<td>2.88</td>
<td>0.67</td>
<td>0.912* (0.642; 0.980)</td>
</tr>
<tr>
<td>Average HR</td>
<td>173</td>
<td>7.35</td>
<td>161</td>
<td>14.29</td>
<td>0.168 (-0.713; 0.746)</td>
<td>172.22</td>
<td>7.16</td>
<td>161</td>
<td>14.29</td>
<td>0.188 (-0.807; 0.764)</td>
</tr>
<tr>
<td>Average VO2</td>
<td>44.38</td>
<td>7.42</td>
<td>35.91</td>
<td>7.75</td>
<td>0.891* (0.189; 0.978)</td>
<td>42.45</td>
<td>8.24</td>
<td>35.91</td>
<td>7.75</td>
<td>0.781* (-0.223; 0.957)</td>
</tr>
<tr>
<td>VO2 Peak</td>
<td>48.90</td>
<td>7.97</td>
<td>43.50</td>
<td>9.73</td>
<td>0.723* (-0.052; 0.935)</td>
<td>47.23</td>
<td>9.28</td>
<td>43.50</td>
<td>9.73</td>
<td>0.882* (0.446; 0.974)</td>
</tr>
</tbody>
</table>

FTP: functional threshold power; W: watts; Kg: kg; LM: lean mass; HR: heart rate; VO2: oxygen consumption. *: variables in which there was agreement between the tests. source: the authors
Figure 2 shows the Bland-Altman plots of power and oxygen consumption for the comparison between the first 8-minute stimulus and the 60-minute TT and between the second 8-minute stimulus and the 60-minute TT. With the exception of FTP in the first 8-minute stimulus (A), all other variables showed agreement between the methods. In addition, none of the plots exhibited a proportion bias (a- p= 0.464; b- p= 0.232; c- p= 0.395; d- p= 0.089; e- p= 0.369; f- p=0.097; g- p= 0.865; h- p= 0.769; i- p= 0.504; j- p= 0.825.)
Figure 2: Bland-Altman comparison of FTP, W/KG, W/KGLM, average VO$_2$ and peak VO$_2$ between the 8-minute time trial and the 60-minute time trial. (n= 9)

Source: the authors
Figure 3 illustrates the comparison of the mean (A) FTP and (B) coefficient of variation of the FTP at each decile between each of the three stimuli (8TT-1, 8TT-2, 60TT) performed.

Figure 3 - Comparison of the means of the FTP and the coefficient of variation at each decile between the time trials. (n=9)

(* p<0.05 (8TT-1 & 8TT-2); ¥ p<0.05 (8TT-2 & 60TT)). Source: the authors
DISCUSSION

The present investigation aimed to assess the validity of the 8-minute time trial. Based on the data obtained, we found that there is indeed a high agreement between the proposed test (8TT) and the standard test (60TT) for a series of variables (FTP, W/Kg, W/KgLM, mean $\text{Vo}_2$ and peak $\text{Vo}_2$). In addition to this finding, we observed that throughout the tests there is a similarity in the behavior of FTP, as well as a similarity in the variability of this indicator.

In cycling, the use of time trial tests to determine physiological training variables is commonplace (BORSZCZ; TRAMONTIN; COSTA, 2019; LILLO-BEVÍA et al., 2019; SANDERS et al., 2020; VALENZUELA et al., 2018). One of the most accurate and efficient variables for training cyclists is power. One of the first tests to be proposed for the determination of this variable was the 60-minute time trial. Despite its wide use to this day, many other tests have emerged as an alternative to this protocol, such as the 8 and 20 minute time trial (ALLEN; COGAN, 2006; CARMICHAEL; RUTBERG, 2004; MACINNIS; THOMAS; PHILLIPS, 2018).

Among our results, we call attention to the agreement between the data obtained in the second stimulus of the 8TT and those obtained in the 60TT for the FTP (ICC: 0.792, p = 0.016). These values suggest a strong agreement between the procedures, which is corroborated by the arrangement of the values based on the Bland-Altman plot in Figure 2-B, without proportion bias (p = 0.232).

Still on FTP, another analysis performed in this investigation that strengthens the agreement between 8TT and 60TT was the FTP behavior and its respective coefficient of variation throughout the tests, analyzing each decile (Figure 3). In the comparison between the first 8-minute stimulus and the 60TT, a series of divergent deciles (1$^{st}$, 2$^{nd}$, 4$^{th}$ and 6$^{th}$) is evidenced. On the other hand, regarding the comparison of the second 8-minute stimulus with the 60TT, there is a greater agreement of the data obtained, where a statistical difference between the means was identified only in the penultimate decile. Concerning the coefficient of variation, it is evident that the percentage of 60TT presents a greater variability in each decile if compared to both 8TT stimuli. However, we identified
statistical differences only in the first (8TT-1 vs 60TT) and in the penultimate (TT8-2 vs TT60) deciles.

Another power-related variable in which the data were interestingly presented was power relative to body mass (W/kg). In mountain biking, this variable is extremely important for successful sports performance, since body mass is a variable that influences performance (LEE et al., 2002).

When analyzing the agreement of power relative to body mass (W/Kg) between each 8TT stimulus with 60TT, we found a very strong or almost perfect agreement (8TT-1 vs 60TT- ICC: 0.889, p < 0.001; 8TT-2 vs 60TT- ICC: 0.952, p< 0.001). We also observed similar results when analyzing the power relative to lean mass between each stimulus of the 8TT and the 60TT, also with a very strong or almost perfect agreement (8TT-1 vs 60TT- ICC: 0.804, p = 0.003; 8TT-2 vs 60TT- ICC: 0.912, p= 0.001). These results are further reinforced by the arrangement of all volunteers within the range of the mean difference of the tests ± two standard deviations in the Bland-Altman figure 2C, 2D, 2E and 2F, without proportion bias (p= 0.395; p= 0.089; p= 0.369; p=0.097).

A relevant issue to be mentioned is the fact that the original 8TT protocol suggests the use of the highest result observed between the two stimuli performed as a parameter for prescription, which is usually obtained in the first 8TT stimulus (CARMICHAEL; RUTBERG, 2004). The findings of the present study corroborate the hypothesis that the highest result was obtained in the first stimulus, reinforcing the functional classification of our volunteers as trained individuals. However, it contradicts the initial suggestion of using the greatest stimulus as a parameter, since the best agreement values for the power and VO₂ peak variables were identified in the second 8TT stimulus. This fact is important, since this choice proposed by the greatest stimulus was based on the authors’ perception based on their experiences in the training of cyclists, and as far as it was possible to verify, no scientific evidence was found to prove or refute this established. Thus, this study is a pioneer in verifying that the second stimulus presented better agreement with the gold standard used until then.
In addition to power-related data, in the context of mountain biking, other variables are equally relevant when considering the physiological characteristics of the races. One of these is oxygen consumption (ACSM, 2018).

In the present investigation, we analyzed two variables related to oxygen consumption: mean VO\(_2\) and peak VO\(_2\). Regarding the mean VO\(_2\), it is possible to observe a very strong agreement between the time trials (8TT-1 vs 60TT- ICC: 0.891, p< 0.001; 8TT-2 vs 60TT- ICC: 0.781, p= 0.001), with emphasis on the data from the first 8-minute stimulus with the 60TT. We observed the same level of agreement when analyzing the peak VO\(_2\), i.e., a very strong degree of agreement between the protocols (8TT-1 vs 60TT- ICC: 0.723, p= 0.021; 8TT-2 vs 60TT- ICC: 0.882, p= 0.001), but, with the data for the second 8-minute stimulus stronger.

This higher agreement of the first 8-minute stimulus for mean oxygen consumption may be explained by the fact that the mean of this variable was closer to the second ventilatory threshold (8TT-1: 44.38 ± 7.42, 8TT-2: 42.45 ± 8.24, VT2: 46.00 ± 6.85). The same condition seems to justify the fact that the second 8-minute time trial presented a greater agreement for the VO\(_2\) peak, since in the second stimulus a value closer to the values obtained also in the second ventilatory threshold was observed (8TT-1: 48.90 ± 7.97, 8TT-2: 47.23 ± 9.28, VT2: 46.00 ± 6.85). In this scenario, for both mean VO\(_2\) and peak VO\(_2\), the performance that was closest to the mean value of the second ventilatory threshold was the one that presented the best agreement. These data corroborate the study of Gavin et al., (2012), where the author found that the 8-minute time trial occurs at the intensity relative to the second metabolic threshold.

Again, in addition to the very strong level of agreement of these variables between 8TT and 60TT observed by the intraclass correlation coefficient, Bland-Altman plots (E, F, G, and H) in figure 2 reinforce the validity, especially of the second 8TT stimulus compared to the gold standard procedure, since all volunteers were within the mean difference of the tests ± two standard deviations without proportion bias (p= 0.865; p= 0.769; p= 0.504; p= 0.825).
Differently from the variables related to power and oxygen consumption, some variables, such as average speed, average cadence, and average heart rate, showed poor agreement or no agreement between procedures. These results are expected since the pace and strategy adopted tend to vary according to the duration of the time trials, and there is no correction factor for these variables.

In view of these results, the prescription of training based on heart rate, despite being widely used and widespread, in the mountain biking environment did not prove to be a reliable strategy in the recruited sample.

The present investigation, despite its relevance and novelty, has some limitations, initially highlighting the small number of volunteers, which occurred due to logistical issues that prevented the continuity of data collection. In addition, another possible limitation was the validation of the protocols only in a laboratory environment. However, as there is no information about the validity of 8TT, testing this protocol in a controlled environment, such as the laboratory one, presents promising and reliable results, allowing us to suggest studies that seek to test the validation of 8TT in a field environment or in a velodrome, expanding its ecological validity and applicability.

5 CONCLUSION

In view of the results, we are able to conclude that the 8-minute time trial is a valid test for determining physiological variables for the training of mountain bike cyclists. In addition, the second 8TT stimulus presented lower mean values for the variables of power and oxygen consumption tested, but, they showed greater robustness compared to the gold standard, differently from the original recommendation of the protocol.

Finally, it is important to mention that the choice of the highest stimulus obtained in the 8TT is based on the perception of the authors who proposed the test, based on the daily training of cyclists, and there is no proof or refutation of this established in the scientific environment, and therefore our study is the first
to establish this relationship, indicating that the second stimulus seems to be the best to be used.
REFERENCES


IMPELLIZZERI, F. M. et al. Correlations between physiological variables and performance in high level cross country off road cyclists. British journal of


