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Is the Functional Threshold Power a Valid Metric to Estimate the Maximal Lactate Steady State in Cyclists?

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Abstract

Lillo-Beviá, JR, Courel-Ibáñez, J, Cerezuela-Espejo, V, Morán-Navarro, R, Martínez-Cava, A, and Pallarés, JG. Is the functional threshold power a valid metric to estimate the maximal lactate steady state in cyclists? *J Strength Cond Res* XX(X): 000–000, 2019—The aims of this study were to determine (a) the repeatability of a 20-minute time-trial (TT20), (b) the location of the TT20 in relation to the main physiological events of the aerobic-anaerobic transition, and (c) the predictive power of a list of correction factors and linear/multiple regression analysis applied to the TT20 result to estimate the individual maximal lactate steady state (MLSS). Under laboratory conditions, 11 trained male cyclists and triathletes ($\dot{V}O_2max$ 59.7 ± 3.0 ml·kg^{-1}·min^{-1}) completed a maximal graded exercise test to record the power output associated with the first and second ventilatory thresholds and $\dot{V}O_2max$ measured by indirect calorimetry, several 30 minutes constant tests to determine the MLSS, and 2 TT20 tests with a short warm-up. Very high repeatability of TT20 tests was confirmed (standard error of measurement of ±3 W and smallest detectable change of ±9 W). Validity results revealed that MLSS differed substantially from TT20 (bias = 26 ± 7 W). The maximal lactate steady state was then estimated from the traditional 95% factor (bias = 12 ± 7 W) and a novel individual correction factor (ICF% = MLSS/TT20), resulting in 91% (bias = 1 ± 6 W). Complementary linear (MLSS = 0.7488 × TT20 + 43.24; bias = 0 ± 5 W) and multiple regression analysis (bias = 0 ± 4 W) substantially improved the individual MLSS workload estimation. These findings suggest reconsidering the TT20 procedures and calculations to increase the effectiveness of the MLSS prediction.

Key Words: exercise performance, blood lactate, physiology, testing, ventilatory threshold

Introduction

A main challenge for coaches in endurance sports is to design effective training plans in which workloads are prescribed based on individualized physiological events that determine metabolic factors limiting performance (17). In this task, it is key to accurately identify thresholds (i.e., intensities) for setting individual training zones to produce the optimal adaptation and performance enhancement (22,40). Although ventilatory thresholds (VT_1 and VT_2) and maximal oxygen uptake ($\dot{V}O_2max$) constitute the main physiological events associated with the aerobic pathway, its proper identification requires expensive equipment such as metabolic carts and laboratory ergometers, which are economically inaccessible to most coaches and practitioners. A valid alternative to ventilatory methods is the lactate-based indicators (35), in particular the maximal lactate steady state (MLSS), which represents the highest intensity at which the blood lactate concentration remains stable during prolonged submaximal constant-workload exercise (5).

In practical terms, the MLSS is considered the physiological landmark separating the heavy from the severe exercise-intensity domain (7) and constitutes a prominent part of aerobic training in world-class, elite, and amateur athletes (21,22). Recent evidence in cyclists suggests that exercising for 30 minutes slightly above the MLSS produces alterations of metabolic responses (i.e., accumulation of the blood lactate and alterations on the ventilatory response) as well as a greater rate of perceived exertion, which excessively compromised subsequent exercise performance (25). Hence, an accurate identification of the MLSS is essential to prescribe optimal exercise intensities and estimate key performance indicators such as the time to exhaustion at a given individual power output or the expected performance in competition time trials (28). However, the MLSS requires restrictive methods (from 2 to 4 30-minute constant loads on separate days) and laboratory conditions to be properly identified (6).

Based on the theoretical assumption that the time to exhaustion at the MLSS intensity is approximately 60 minutes, Allen and Coggan (1) proposed measuring the mean power output (MPO) attained after a 60-minute time trial test (TT60) to obtain what they called the "Functional Threshold Power" (FTP), as a valid option to undertake an MLSS estimation. However, the use of a TT60 to estimate the MLSS presents 2 important limitations: (a) a TT60 is a long-duration, highly stressful effort that also requires a high degree of concentration, which limits its practical use for testing (12,30) and (b) considering the great intersubjects variability of time to exhaustion at MLSS, ranging from 37 to 66 minutes (18,20,23,31), it is questionable that TT60 would be effective to estimate MLSS for all the individuals.

An easier, widely known alternative to estimate this FTP intensity is through a 20-minute time-trial (TT20) self-paced cycling protocol and subtracting 5% of the MPO achieved

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(i.e., the 95% of the TT20 MPO; $TT20_{95\%}$) after the test (1). Although this method has been shown as practical and noninvasive for predicting the MLSS (12,39), there are important controversies concerning the protocols and data collection. First, the long-duration (~50 minutes) and high-intensity warm-up (including a 5-minute time trial and 3 fast-pedaling accelerations) originally proposed (1) was shown to cause high lactate levels before starting the test (11), which might impair the individual's performance and metabolic response—in different ways on each cyclist—in the following TT20 effort (10). Second, the assumption that $TT20_{95\%}$ corresponds to MLSS intensity has been mainly based on inappropriate methods to identify the MLSS, such as the individual anaerobic threshold or lactate thresholds that represent a different physiological pathway (35). Indeed, the assumption that the MLSS estimated from a TT20 test can be sustained during 60 minutes until exhaustion has not been fully supported by recent experiments (11), which challenges the validity of this assessment. Third, recent experiments contradict the original proposal that 95% correction of the TT20 constitutes a maximum 1-hour sustained power, suggesting greater corrections up to 90% ($TT20_{90\%}$) (30). Furthermore, despite within-subject variability for TT20 (i.e., repeatability or difference between MPO from 2 trials performed by the same cyclist) which is expected to be 2 ± 13 W (30,33), we are unaware of previous attempts to calculate individual correction factors (ICFs) for TT20 and relate it with the MLSS intensity. Altogether, these concerns question the relationship between TT20 and MLSS and the validity and reliability of the 95% correction factor to estimate the MLSS intensity.

Therefore, the aims and practical applications of this study were as follows: (a) to identify the location of the TT20 intensity in relation to main physiological events, (b) to determine the validity and repeatability of the MPO during TT20 after a shorter warm-up than the one originally proposed, (c) to calculate a list of correction factors for the 20TT to study its predictive power to estimate the MLSS, and (d) to provide practical equations to estimate the MLSS based on simple and multiple physiological parameters.

Methods

Experimental Approach to the Problem

Subjects visited the laboratory 7–8 times separated by 48–72 hours (Figure 1). On the first day, subjects completed a preliminary graded exercise (GXT_{pre}) under medical supervision to check for cardiovascular diseases and ensure subjects achieved a true $\dot{V}O_2max$ over 55.0 ml·kg^{-1}·min^{-1} by using indirect calorimetry. In the following 2 sessions, subjects performed a familiarization TT20 and an experimental GXT to determine ventilatory thresholds (VT_1 and VT_2), $\dot{V}O_2max$, and maximal aerobic power output (MAP). Thereafter, subjects came back to the laboratory 2 to 3 more times, to perform 30-minute submaximal constant workload trials, to determine the MLSS-associated power output. In the last 2 days, subjects performed 2 TT20 in the laboratory. All the tests were conducted under standardized environmental conditions (22.3 ± 2.4° C and 45.8 ± 9.4% relative humidity), at the same time of the day (±3 hours), and air was controlled (fan positioned 1.5 m from the subject's chest, wind velocity of 2.55 m·s^{-1}). All of them were asked to keep their eating habits constant following a similar type of high-carbohydrate diet during the days previous to testing, reaching at least 10 g·kg^{-1} during the previous 24 hours. The last meal was ingested 3 hours before the beginning of each testing session. Subjects completed the tests using their own bicycles attached to a Cycleops Hammer ergometer (CycleOps, Madisson, WI) (29), pedaling seated and at preferred cadence (16). Adequate hydration status (1,020 usg) was ensured before every test (19). The heart rate was continuously monitored (Polar Bluetooth H7, Oy, Finland). The mean power output (W) and cadence (rev·min^{-1}) were transmitted to a unit display (Garmin 1000; Garmin International, Inc., Olathe, KS) fixed on the handlebars, recording at a frequency of 1 Hz. To maintain physical performance during the investigation period (2–3 weeks), subjects followed an individual training protocol consisting in cycling sessions of 90 minutes every 48 hours at an individual intensity of VT_1, interspersed with efforts of 5–7 minutes at 90–95% of VT_2 intensity every 20 minutes.

Subjects

Subjects were recruited from local cycling and triathlon clubs. Enrolment criteria for participation were as follows: (a) more than 5 years of experience of regular training, (b) being familiarized with the testing procedures used in this investigation, and (c) $\dot{V}O_2max$ >55 ml·kg^{-1}·min^{-1}. Eleven trained male cyclists and

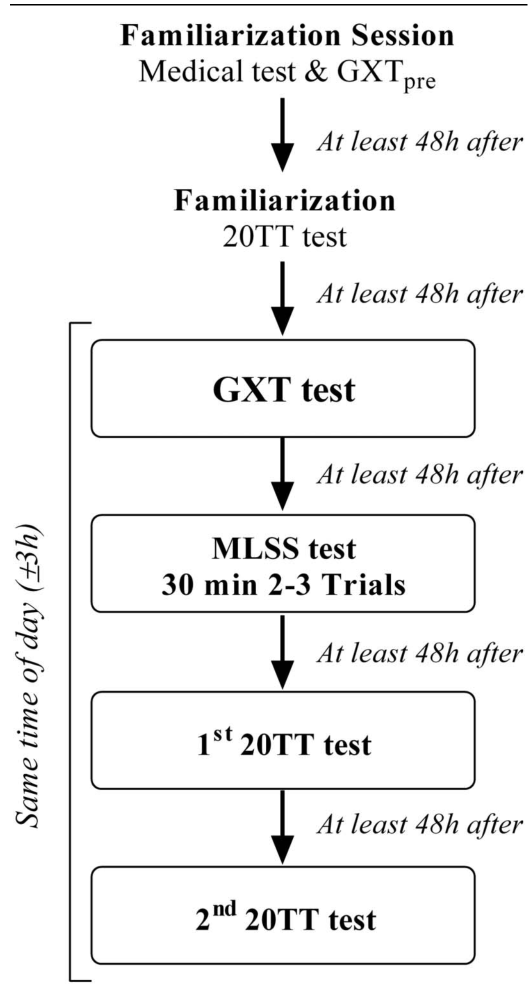

Figure 1. Experimental design.

triathletes ranged from 22.3 to 48.9 years volunteered to participate (mean ± *SD*: age 32.0 ± 10.1 years, body mass 71.4 ± 6.8 kg, body fat 8.5 ± 1.1%, $\dot{V}O_2max$ 59.7 ± 3.0 ml·kg^{-1}·min^{-1}, and MAP 369 ± 22 W). All subjects were informed in detail about the experimental procedures and the possible risks and benefits of their participation and provided written informed consent. No physical limitations, health problems, or musculoskeletal injuries that could affect training were found after a medical examination. None of the subjects was taking drugs, medications, or dietary supplements. The study complied with the Declaration of Helsinki and was approved by the ethics commission at the University of Murcia.

Procedures

Individualized Maximal GXT Protocol. Subjects performed a warm-up of 5 minutes at 50 W, after which the workload increased to 25 W·min^{-1} until exhaustion (35). Oxygen consumption ($\dot{V}O_2$) and carbon dioxide production ($\dot{V}CO_2$) were recorded using breath-to-breath indirect calorimetry (Cortex Metalyzer 3B; Cortex, Leipzig, Germany). To ensure the attainment of $\dot{V}O_2max$, at least 2 of the following maximal effort criteria were required (32): (a) a plateau in $\dot{V}O_2$ values (i.e., an increase in $\dot{V}O_2$ between 2 or more consecutive stages of less than 1.5 ml·kg^{-1}·min^{-1}; (b) a respiratory exchange ratio value ≥1.10; or (c) the attainment of maximal HR (HRmax) above 95% of the age-predicted maximum (207–0.7 × age). If verified, the MAP was determined as the first power where $\dot{V}O_2max$ was reached. In case of an uncleared $\dot{V}O_2$ plateau or early endings before the 60-second stage, MAP was computed as follows: MAP = Wf + [(t/60 × 25)], where "Wf" is the last completed load (W) and "t" is the time in seconds that the last uncompleted workload was maintained (34). The VT_1 was determined using the criteria of an increase in both the ventilatory equivalent of oxygen (VE/$\dot{V}O_2$) and end-tidal pressure of oxygen ($PetO_2$) with no concomitant increase in the ventilatory equivalent of carbon dioxide (VE/$\dot{V}CO_2$), whereas that eliciting the VT_2 was determined using the criteria of an increase in both the VE/$\dot{V}O_2$ and VE/$\dot{V}CO_2$ and a decrease in end-tidal pressure of carbon dioxide ($PetCO_2$) (14,35). For both VT_1 and VT_2 determination, the values of gas-exchange parameters were averaged for every 1-minute period and plotted against workload. Two independent experienced observers detected VT_1 and VT_2. If there was a disagreement, we obtained the opinion of a third investigator. The indirect calorimetry device was calibrated before each test.

Maximal Lactate Steady-State Tests. A total of 2 to 3 30-minute constant workloads pedaling tests were performed to determine the MLSS, identified as the highest power output at which blood lactate concentration increased <1 mMol·L^{-1} between the 10th and 30th minute of exercise (6). After standardized warm-up (5-minute pedaling, 80 and 90% of VT_1 intensities), subjects performed the first MLSS trial at 70% of the individual MAP attained during the GXT (28). Depending on the result of the first MLSS test, successive trials with a 48-hour rest between sessions were increased or decreased to 0.2 W·Kg^{-1} (~15 W) until criteria was fulfilled. Blood samples of 25 μL from the ear lobe were collected every 10 minutes (Lactate Pro, Arkray, Japan). The maximal lactate steady state was identified as the intermediate workload between the last 2 intensities (i.e., interpolation) (28).

Functional Threshold Power and Correction Factors. After standardized warm-up (5-minute pedaling, 80 and 90% of VT_1 intensities), subjects performed a TT20 test using the software provided by the ergometer (Rouvy; Cycleops), with 5% of slope simulation (1). Subjects were asked to produce the highest MPO possible for 20 minutes using their own pacing strategies, cadence and the gear ratio. Verbal encouragement was provided to achieve maximal performance. Water was allowed ad libitum. The ergometer was set in a linear mode, increasing the power output as the pedaling rate increased. Visual feedback on time completed was provided. The mean power output and cadence were recorded but blinded to subjects. Blood lactate was registered at the 10th and the 20th minute. After 48 hours of recovery, a second identical TT20 was performed to analyze the repeatability (Figure 1). The original 95% correction factor ($TT20_{95\%}$) was calculated by multiplying the MPO by 0.95, as previously proposed (1). The ICF was calculated from the coefficient between TT20 and MLSS power outputs (ICF% = MLSS/TT20); then, a new variable was calculated by multiplying the MPO by the mean of the resulting correction to each cyclist ($TT20_{ICF\%}$).

Statistical Analyses

Mean ± *SD*, and confidence interval (95% CI) were calculated for each measure. Data were screened for normality of distribution and homogeneity of variances using the Shapiro-Wilk and Levene's test. The validity analyses included 1-way repeated-measures analysis of variance (ANOVA) with pairwise comparisons (Bonferroni's adjustment), mean differences with 95% CI, and Bland-Altman bias and limits of agreement (LoA). An acceptable margin of error for 20 TT power outputs (i.e., expected typical error of measurement) was set at 5 W (30). Reliability analysis included the following calculations (2,3,37): the *SEM* (the square root of the mean square error term in a repeated-measures ANOVA), coefficient of variation (CV = *SEM*/mean × 100), the repeatability coefficient or smallest detectable change (SDC = $SEM \times \sqrt{2} \times 1.96$), intraclass correlation coefficient (ICC), and Bland-Altman bias and LoA (LoA = Bias ± *SD* × 1.96). Simple linear regression analysis was conducted to yield prediction equations and the *SEE*. The Lin's concordance correlation coefficient (CCC) was calculated to determine the agreement between correction factors and the power achieved during MLSS, by assessing how close the data were to the line of best fit. Multiple regression analysis was conducted including the physiological events analyzed (i.e., VT_1, VT_2, and MAP) to determine improvements in the goodness-of-fit. Analyses were performed using the GraphPad Prism Software version 6.0 (GraphPad Software, Inc., CA), MedCalc Statistical Software version 18.2.1 (MedCalc Software bvba, Ostend, Belgium), and SPSS Software version 21.0 (IBM Corp., Armonk, NY).

Results

All subjects reached at least 2 of the criteria for achievement of maximal efforts during the GXT test; therefore, maximal performance was verified. Repeatability of the TT20 (Trial 1 vs. Trial 2) showed a very high consistency and low bias: ICC = 0.983; CV = 1.2%, Bias ± *SD* = −2.2 ± 4.3 W; 95% LoA = −10.6; 6.2 W; *SEM* = 3.3 W; SDC = 9.1 W.

Analysis of variance yielded significant differences ($F_{(3,40)} = 78.44$; $p < 0.001$) between the power outputs reached in the different physiological events (Figure 2). Post hoc mean comparisons and Bland-Altman bias revealed important disparities in

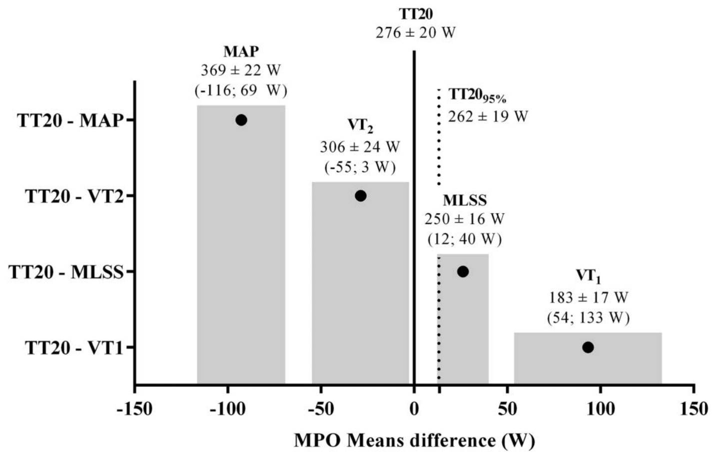

Figure 2. Mean differences between the mean power outputs (MPO, in W) reached in the 20-minute time-trial test (TT20, vertical solid line) and the outcomes reached at different physiological events. Grey bars are the Bland-Altman limits of agreement (LoA = Bias ± *SD* × 1.96). Dots are placed at the means difference. Values over the dots are the absolute means ± *SD* and Bland Altman LoA (in brackets). MAP, maximal aerobic power; VT_1 and VT_2, first and second ventilatory thresholds; MLSS, maximal lactate steady state; $FTP20_{95\%}$, mean power output reached in the 20-minute time trial test with a 95% correction factor.

all measures compared with the TT20. The mean power output from TT20 was identified as a middle point between VT_2 (Bias ± *SD* = −28.8 ± 13.3 W; 95% LoA = 55.0, 3.0 W) and MLSS (Bias ± *SD* = 26.2 ± 7.1 W; 95% LoA = 12.3, 40.0 W).

The individual correction factor (ICF%) for TT20 showed mean values of 91 ± 2%. Thus, the $TT20_{91\%}$ (i.e., multiplying the MPO achieved during TT20 by 0.91) was considered for further analysis. The correction factor tended to decline as the MPO from TT20 increased; although observable (Figure 3), this relationship was nonsignificant ($F_{(1,9)} = 3.13$; $p = 0.11$; $r = 0.51$).

The power outputs from TT20 and MLSS showed a high linear relationship ($r > 0.90$) but low CCC (< 0.50), large bias (bias >25 W), and yielded the equation: (EQ1): MLSS (W) = 0.7488 × TT20 (W) + 43.24; *SEE* = 5.2 W; (Figures 4A and 4B). Multiple regression analysis including other physiological events identified the MAP as the only factor that increased the goodness-of-fit of the simple regression model, with the equation: (EQ2): MLSS (W) = 0.5451 × TT20 (W) + 0.2186 × MAP (W) + 18.784; *SEE* = 4.4 W.

Figure 5 shows the relationship between the different TT20 correction factors ($TT20_{91\%}$ and $TT20_{95\%}$) and equations ($TT20_{EQ1}$ and $TT20_{EQ2}$) with the individual MLSS workload. The $TT20_{91\%}$ correction (Figures 5C and 5D) exhibited stronger predictive power than the $TT20_{95\%}$ (Figures 5A and 5B), by means of higher concordance correlation (from 0.74 to 0.94) and a reduction of bias (from ~12 to ~1 W). The $TT20_{EQ1}$ improved the results by minimizing the bias up to <0.1 W and improving the concordance up to 0.95 compared with both $TT20_{91\%}$ and $TT20_{95\%}$ (Figures 5E and 5F). The application of the $TT20_{EQ2}$ showed slightly better agreement than $TT20_{EQ1}$ (Figures 5G and 5H).

Discussion

In accordance with previous studies (30), it is shown that MPO from TT20 requires stronger corrections than the originally proposed 95% ($TT20_{95\%}$) to be a valid predictor of the MLSS power output in trained cyclists; concretely, a 91% correction factor ($TT20_{91\%}$) was shown as a more accurate option. Interestingly, it seems that the greater the MPO achieved during the TT20, the greater the correction required. Based on this evidence, the linear (MLSS = 0.7488 × TT20 + 43.24; bias = 0 ± 5 W) and multiple (MLSS = 0.5451 × TT20 + 0.2186 × MAP + 18.784; bias = 0 ± 4 W) regression analyses found in this study substantially improved the MLSS workload prediction. Furthermore, owing to the high repeatability (very low intrasubject variability) found for this self-paced cycling time trial (*SEM* = 3.3 W; SDC = 9.1 W), the typical small but meaningful changes that occur in the functional performance

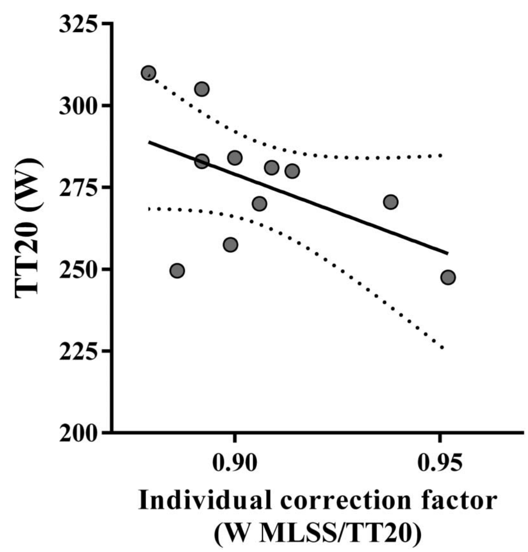

Figure 3. Relationship between the maximal power output (W) achieved during a 20-minute time-trial test (TT20) and the individuals' correction factor regarding the maximal lactate steady state (MLSS).

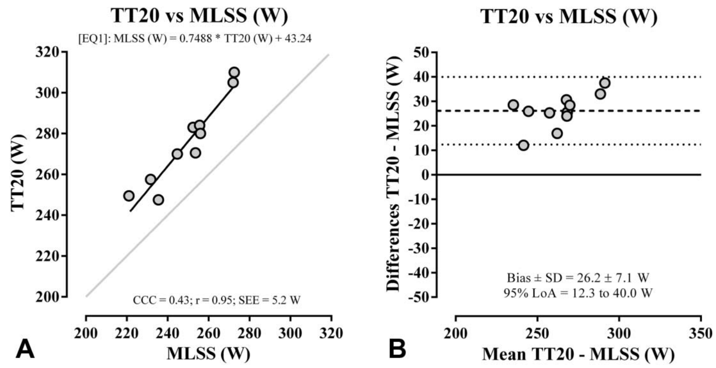

Figure 4. A) Linear regression analysis and (B) Bland-Altman plots showing the relationship between the maximal power output (W) achieved during a 20-minute time-trial test (TT20) and the maximal lactate steady state (MLSS).

of the well- and highly trained cyclist can be identified with this practical and low-cost assessment.

Despite being one of the most used performance parameters in cyclists, there is controversy over the identification of the MLSS intensity. In the current study, the MLSS constituted a midpoint between VT_1 and VT_2. These results support increasing evidence that the MLSS represents a unique physiological event (14,35,36), and thus, it requires specific testing procedures to be properly identified (6). Thus, these findings question the conclusions of previous experiments comparing the relationship between TT20 and MLSS because they conducted testing procedures that may fail to identify the MLSS intensity (11,13,26,33,39).

The present findings corroborate that the TT20 is a reliable and practical, noninvasive field test alternative to estimate the MLSS but demonstrate that these are not interchangeable in absolute values, even when applying the originally described (1) correction ($TT20_{95\%}$). It is remarkable that the current MLSS power outputs (250 ± 16 W) concurred with previous investigations (~2 W difference) in a similar sample and following the same procedures (12); by contrast, our intensities achieved at TT20 were drastically higher (+24 W difference). This may be a consequence of the reduced warm-up duration and intensity (10-minute warm-up at 80–90% of VT_1) compared with the 50-minute warm-up with a 5-minute time trial (5 TT), originally described (1) and recently replicated (12,39).

Owing to the fact that local muscle fatigue may limit a cyclist's performance and coordinative patterns (9), it could be argued that the original long-duration and high-intensity warm-up would prevent the athlete from achieving their best MPO during a TT20 test. Furthermore, although including a 5 TT during the warm-up provides coaches with another widely common performance indicator to estimate the MAP, it is difficult to ensure that all cyclists will respond and recover equally after this maximum effort because of individual physiological characteristics (i.e., the histochemical, ultrastructural, biochemical, and physiologic properties of the muscle fibers, training experience, and $\dot{V}O_2$max) (24,27). The fact that athletes may start the TT20 under suboptimal conditions and different states of fatigue recovery, it is a clear limitation that will likely decrease the predictive power of the measure. This may explain why a higher correction factor of 91% fitted better to our sample (10-minute warm-up at 80–90% of VT_1) than the 95% required after a long-duration and high-intensity warm-up (1). In addition, the use of the 5-minute high-intensity effort (i.e., time trial) to estimate the MAP in cycling has been questioned by a number of studies (8,38) suggesting that shorter tests lasting 3- to 4-minute TT will produce better estimators of maximal aerobic power performance.

A main practical application of this study is the comparison between a list of correction factors and equations from the MPO attained during the TT20 and main physiological events (VT_1, VT_2, and MAP) to determine its accuracy in predicting the MLSS. According to our findings, both applying a 91% correction factor and using the equation MLSS (W) = 0.7488 × TT20 (W) + 43.24 would be the preferred options to accurately obtain MLSS-associated power in absolute values, assuming a maximum error <5%. In addition, including the MAP in the equation slightly reduced errors up to 3.4%; however, because of the fact that the efforts required to obtain the MAP are greater than the improvements, the use of this equation seems ill-advisable.

This study confirms the good repeatability of the TT20 (30,33) and adds novel data about the errors in workload units (W) by *SEM* and SDC calculations (3,15). This measure allows us to identify within-subject scores that represent a true performance change (i.e., changes beyond measurement error) if repeating the tests after a period of time (3,4). According to our findings, a minimum measurement error (i.e., *SEM*) of ±3 W should be added to the TT20 power output result to identify an athlete's true performance change. For example, if a given cyclist achieved a TT20 power output of 280 W, one should expect a true value ranging from 277 to 283 W; thus, a follow-up assessment might be at least over 284 W to ensure that the changes are not produced by a measurement error (if reproducing the same testing conditions) and represent improvements as a response to the training program. Nevertheless, some authors suggest to magnify the *SEM* and consider the SDC as a more conservative cutoff point to identify changes over time (3,4). According to these recommendations, the current TT20 protocol with a reduced warm-up allows the identification of true changes from ±9 W, i.e., 290 W in the aforementioned example. Although the magnitude of errors is being reported as a useful performance index for training (15), this is the first time the SDC values for physiological assessment in cyclists have been

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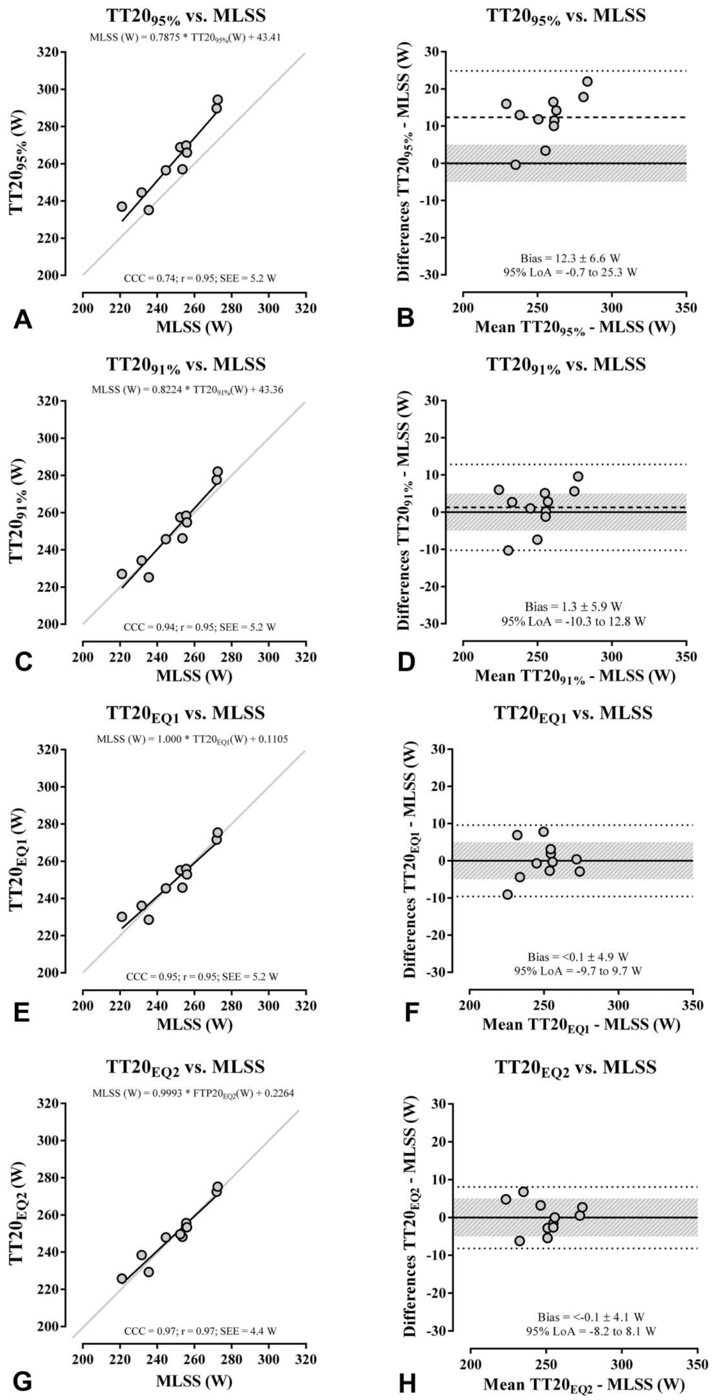

Figure 5. A, C, E, and G) Linear regression analysis and (B, D, F, and H) Bland-Altman plots showing the relationship between FTP20 correction factors and the maximal lactate steady state (MLSS). Grey diagonal line represents the perfect agreement. Black diagonal line is the correlation. Dashes lines are bias; dotted lines are limits of agreement (LoA = Bias ± *SD* × 1.96). Shaded area represents the 5-W acceptable margin of error.

reported, to the best of our knowledge. Owing to the practical application of this measure, future research is needed to replicate and confirm these findings.

In conclusion, these results suggest reconsidering the current procedures surrounding the FTP concept to increase its effectiveness to predict the MLSS, by redefining the warm-up for the TT20 and encouraging the use of ICFs from the current list provided in this study. It must be mentioned that this is a cross-sectional study that provides data from well-trained male cyclists at a given point. Future research is required to address whether the current list of correction factors can be used to identify training-induced adaptations throughout the season and the way these indexes can be extrapolated to other samples (i.e., women, recreational or highly trained cyclists, and runners).

Practical Applications

This article provides 2 main practical applications. On the one hand, it is shown that the $TT20_{95\%}$ differs substantially from MLSS intensity; hence, stronger corrections are required to predict the MLSS from a TT20 test. Our findings revealed that a 91% correction factor ($TT20_{91\%}$) would be more effective. However, owing to interindividual variability, it seems that this correction should increase as the level of the cyclist does (i.e., the greater the MPO achieved during the TT20, the greater the correction required). To account for this variability, a valid alternative might be to use the equation MLSS (W) $= 0.7488 \times$ TT20 (W) $+ 43.24$. On the other hand, we propose performing a more specific warm-up for a TT20 effort, rather than the long-duration and high-intensity one originally described, to increase the quality of the outcomes and the reliability and accuracy of the subsequent estimations.

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