9/3 Minutes Running Critical Power Test: Mechanical Threshold Location Respect to Ventilatory Thresholds and VO2max.

Running Head: Running Critical Power and Ventilatory Thresholds

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Funding

This work is related to the EDUSport Research Project (ref. PID2020-115600RB-C21) which has been supported by MCIN/AEI/10.13039/501100011033. In addition, SARA is supported by the Spanish Ministry of Education under grant [FPU19/00542].

Abstract

The critical power (CP) concept has been extended from cycling to the running field with the development of wearable monitoring tools. Particularly, the Stryd running power meter and its 9/3 minutes CP test is of great popularity among the running community. Locating this mechanical threshold according to the physiological landmarks would help to define each boundary and intensity domain in the running field. Thus, this study aims to determine the CP location concerning anaerobic threshold (AT), respiratory compensation point (RCP), and maximum oxygen uptake (V_{O2max}). A group of 15 high-caliber athletes conducted the 9/3 minutes Stryd CP test and a graded exercise test (GXT) in two different testing sessions. AT, RCP, and CP were located at 73 (5.41) %, 86.82 (3.85) %, and 88.71 (5.84) % of V_{O2max}, respectively, with a V_{O2max} of 66.3 (7.20) ml/kg/min. Non-significant differences were obtained between CP and RCP in any of its units (i.e., W/kg and ml/kg/min) ($p \geq 0.184$). In conclusion, CP and RCP represent the same boundary in high-caliber athletes. Further CP and GXT test combinations are required to consolidate this relationship considering potential confounding variables such as the number, duration, and recovery between predictive trials, the work rate slopes applied, or the athletic level of the runners.

Keywords

Wearable, endurance training, exercise physiology, exercise testing.

Introduction

Running intensities are characterized by an individualized response of the cardiorespiratory system which enables to delimit four intensity domains: Moderate intensity associated with a steady-state oxygen uptake (VO2); Heavy intensity related with a delayed steady-state due to the VO2 slow component; Severe intensity characterized by the attainment of the maximum VO2 (V_{O2max}); and Extreme intensity where fatigue emerges before reaching V_{O2max} (1).

These running intensity domains are delimited by certain physiological boundaries. Delimiting the moderate and heavy intensity domains, the anaerobic threshold (AT) represents the breakpoint where anaerobic metabolism complements the regeneration of the ATP molecules by aerobic metabolism (2,3). The glycolysis activation involves the increase of protons (H^+) and the activation of the bicarbonate system to balance the reduced pH with the creation of carbon dioxide (CO2) molecules that are summed and expelled to the ones produced by the mitochondrial oxidation via an increase in ventilation (VE) (4). If the work rate increases, a second boundary can be found that delimits the heavy and severe intensity domains characterized by the bicarbonate system collapse, reflected by a second increase in VE developing the so-called respiratory compensation point (RCP) (4,5).

Athletes can sustain each intensity domain over a specific time period (i.e., time to exhaustion). At a work rate equal or lower than AT, the inability to continue results mainly from dehydration, hyperthermia, or simple boredom (6). Between thresholds, muscle fatigue is highly correlated with muscle glycogen depletion (6). Above RCP, the phosphocreatine hydrolysis and the resulted phosphate ions (Pi) accumulation impairs muscle contractile by reducing calcium sensitivity and release from the reticulum sarcoplasmic (6). These human physiology limitations can be illustrated in the hyperbolic relationship between velocity and time sustained of athletic world records (Figure 1) (7).

-Figure 1 about here-

If this plot is created with several time to exhaustion trials of an athlete, the horizontal asymptote of the hyperbolic relationship denotes the so-called critical velocity (CV) or critical power (CP) concept (8). Defined as the highest work rate in which fatigue-induced metabolites stay under critical levels, the CP represents the boundary between the heavy and severe intensity domains (8). Jones et al. (9) showed the muscle response to this threshold with a group of six healthy male subjects performing a knee extension exercise 10% below and 10% above CP. Subjects lasted 14.7 (7.1) minutes above CP, whereas 20 minutes were successfully completed under it (9). From baseline values, phosphocreatine dropped untill 27 (17)%, Pi rises to 564 (167)%, and pH changed from 7.07 (0.03) to 6.87 (0.10) at the end of the exercise, showing this metabolic instability (9).

As outlined above, a precise CP estimation is crucial due to the narrow range of works rates that delimits this metabolic perturbance. To pursuit this purpose, several considerations have been stated as essential for a proper determination such as the number, duration, and resting period between predicting trials (8). Due to these facts, CP works rates differing up to 20% have been reported for the same group of athletes (10).

Nowadays, the CP concept has emerged in the running field with the development of wearable monitoring tools. The power output data estimated from these devices could represent more precisely the running intensity influenced by the context (i.e., surface, gradient, weight), which could consolidate the functionality of this CP narrow threshold. Particularly, the running power meter (Stryd Summit Power Meter, Boulder, CO, USA) is receiving much attention from the running community due to its tight relationship with VO2 and its repeatability across different running conditions compared to different commercially available devices (11).

To determine CP, the Stryd™ group proposed a test based on two all-out efforts of 9 and 3 minutes duration with 30-minute active recovery in between (12). Then, based on a CP percentage, five training zones are established (i.e., Zone 1 Easy: 65-80%; Zone 2 Moderate: 80-90%; Zone 3 Threshold: 90-100%; Zone 4 Interval: 100-115%; Zone 5 Repetition: 115-300%) (12). As outlined above, the CP determination is highly influenced by the protocol used (i.e., Number, duration, and recovery between predictive trials). From a performance and training perspective, a wrong estimation could condition the time limit at this work rate and a wrong training zones definition. Thus, in order to clarify this physiological and mechanical thresholds relationship, this study aims to determine the CP location concerning AT, RCP, and V_{O2max} obtained from the 9/3 Stryd CP test. In this way, the running intensity domains obtained through the Stryd power meter and its specific test would be defined according to the physiological landmarks.

Methods

Experimental design

Two laboratory sessions were used to determine the CP, AT, RCP, and V_{O2max}. On the first testing day, subjects´ anthropometry measures were made before starting the 9/3 minutes Stryd CP test. Of note, subjects were encouraged to release from vigorous activity in the following 48 hours before the second testing session. A graded exercise test (GXT) was done to determine AT, RCP, and V_{O2max}. Both testing sessions were conducted on a treadmill (WOODWAY Pro XL, Woodway, Inc., Waukesha, WI, USA) under the same environmental conditions (~22°C and ~60% humidity), footwear, and time of day (± 1 hour).

Subjects

A group of 15 high-caliber athletes (age: 30.7 ± 9.7 years, height: 1.75 ± 0.1 m, body mass: 70.6 ± 5.5 kg, lean mass: 48.5 ± 3.3 %, fat mass: 14.2 ± 5.6 %, V_{O2max}: 66.33 ± 7.20 ml/kg/min) participated in the study. The following inclusion criteria were established to select high caliber athletes (13): (i) > 3 years of regular running experience; (ii) > 4 sessions / week; and (iii) 30-42 minutes in 10km. Athletes were used to running on treadmill as part of their training routine. All subjects were informed about the research purpose and procedures of the study prior to signing a written informed consent form. The study protocol adhered to the tenets of the Declaration of Helsinki and was approved by the institutional review board.

Procedures

Body composition: Body mass, % fat mass, % lean mass

The anthropometric characteristics of the subjects (i.e., body mass [kg], percentage of lean mass [%] and percentage of fat mass [%]) were obtained using the bioimpedanciometer (Inbody 230, Inbody, Seoul, Korea), which has been previously validated by a dual-energy X-ray system (14).

Stryd Critical Power Test

Subjects warmed up for 10 minutes at low-to-moderate intensity (i.e., intensity corresponding to easy long-running sessions). Then, 3-4 high-intensity 1-min short bouts with 2 min of active rest were done to complete the warm-up. After, the running power meter (Stryd Summit Power Meter, Boulder, CO, USA) was attached on the laces of the right footwear prior to conducting two all-out efforts of 9 and 3 minutes duration with 30-minute active recovery between them (12). Before beginning, they were asked about the initial pace they would establish in both trials. Time began to register once velocity was stabilized. Then, the running velocity was regulated at the runner´s will.

Graded Exercise Test

Subjects started with the aforementioned warm-up procedure. Then, they were fitted with the Stryd running power meter and the validated portable metabolic analyzer (PNOE, ENDO Medical, Palo Alto, CA) (15). Before testing, the device was properly calibrated according to the manufacturer’s instructions. From a starting velocity of 9 km/h, increases of 1km/h every 3 minutes were conducted until volitional exhaustion.

Critical Power, Ventilatory Thresholds and VO2max

Absolute (W) and relative (W/kg) average power were registered in the 9 and 3 minutes time trials. From the Stryd platform (https://www.stryd.com/powercenter), these two values were exported into an excel spreadsheet and plotted to determine the power-time relationship. From the linear *Power-1/time* transform, CP and the work capacity reserve (W′) were determined as the *y-intersection* and the *slope* respectively. Average W and W/kg were also registered in the GXT during the last minute of each stage.

The following data procedure was applied in previous studies (16,17). The breath-by-breath data of each record were exported from the Pnoe platform (https://platform.mypnoe.com/) into an excel spreadsheet. To exclude errant breaths, values outside the 95% confidence interval of the local mean were removed. Then, breath-by-breath data were linearly interpolated to give 1-s values and then averaged into 10-s time bins. V_{O2max} was considered the highest 30-s rolling mean value. To determine ventilatory thresholds (VTs), a minimum of two experienced scientists evaluated each graph in search of the following considerations: AT was defined as the minimal load at which VE/VO2 exhibited a systematic increase without a parallel increase in VE/ VCO2 (3). RCP was established as the minimal load at which the increase in VE/VO2 was followed by an increase of VE/VCO2 (5).

Statistics

Descriptive statistics are represented as [mean (SD)]. The normal distribution of data and homogeneity of variances were confirmed through the Shapiro-Wilk test and Levene's tests, respectively. Linear regressions were applied to determine the W-VO2 relationship during the GXT. A one-way repeated-measures analysis of variance (ANOVA) with Bonferroni post hoc corrections was conducted to compare AT, RCP, CP, and V_{O2max} values. The sphericity was confirmed by the Mauchly test. The level of significance used was ($p < 0.05$). Data analysis was performed using the SPSS software (version 25, SPSS Inc., Chicago, IL., USA).

Results

9/3 CP test

Table 1 shows the data reported by the athletes during the 9/3 Stryd CP test. On average, participants completed the 9 and 3 minutes time trials at 17.60 (1.48) and 19.80 (1.70) km/h, respectively, which involved a CV of 16.60 (1.58) km/h. These velocities correspond to 4.91 (0.42) and 5.39 (0.44) W/kg in the 9 and 3 minutes time trials, and to 4.67 (0.42) W/kg in the estimated CP with a W′ of 8.91 (2.04) kJ.

-Table 1 about here-

GXT test

Table 2 shows the data reported by the athletes during the GXT. AT and RCP were located at 72.86 (6.01)% and 86.40 (4.34)% of VO2max, respectively, with a V_{O2max} of 66.3 (7.20) ml/kg/min.

-Table 2 about here-

CP and VTs location

The average R^2 obtained for the linear regressions applied between VO2 and power (W) during the GXT was 0.97 (0.01). The CP was established at 58.83 (7.56) ml/kg/min, 88.71 (5.84) % of $V_{02max.}$ The repeated measures ANOVA showed significant differences between thresholds ($p < 0.05$), but not between CP and RCP in any of its units (i.e., W/kg and ml/kg/min) ($p \geq 0.184$) (Table 2). The results obtained in the Stryd CP and GXT tests are illustrated in Figures 2 and 3.

-Figure 2 about here-

-Figure 3 about here-

Discussion

This study aimed to determine the CP location estimated from the 9/3 minutes Stryd CP test concerning the ventilatory thresholds (i.e., AT and RCP) obtained from a GXT. The main findings are as follows: (i) AT, RCP, and CP were located at 72.86 (6.01)%, 86.40 (4.34)%, and 88.71 (5.84)% of V_{O2max}, and (ii) CP did not differ significantly from RCP in a group of high-caliber athletes.

The CP location concerning to V_{O2max} (%V_{O2max}) has been recently determined in running through an instrumented treadmill (18). For this aim, Patoz et al. (18) determined 3 different powers: external power (W_{ext}), calculated from ground reaction forces; internal power (W_{int}), estimated from the equation purposed by Nardello et al. (19); and the sum of both to obtain the total power (W_{total}). Since each CP values were close to the one corresponding to CV (≈ 82% of VO2peak), the authors concluded that the CP concept represents the same metabolic rate independently of the type of metric used. This implies that CP can be derived from the estimated W_{int}, which predictive parameters can be easily obtained in a valid and reliable way from inertial sensors (i.e., ground contact time, stride frequency, and duty factor), and specifically, from the Stryd device (20).

Since its market launch, knowing which type of power does Stryd report has been of great interest among the running community. Cerezuela et al. (21) determined the relationship between the power output reported from five commercial power meters and two theoretical power models varying speed, weight, and slope. The Stryd power meter showed the greatest sensitivity among others to these factors ($r \geq 0.947$), showing that this device report W_{ext}. Thus, Stryd has shown a great relationship with VO2 when measured during a GXT varying speed as well as in the present study (r^2= 0.97) (11,22). However, it seems that it is less sensitive to reflect a change in VO2 caused by a change in W_{int} as Baumgartner et al. (22) tested varying the arm swing, stride frequency, and ground contact time. However, there is a need to highlight that the sensitivity of the device was determined by the expected VO2 in response to the increment in power outputs developed in each stage of the GXT (+0.5 $m.s^{-1}$), compared to the VO2 and the power output response to the altered technique condition. With the altered technique conditions, authors did not obtain an equal change in power outputs as in the incremental stages so comparing the VO2 response in these two conditions seems to be invalid to get further conclusions. However, it would be of great interest to compare the power response to an altered W_{int} measured by Stryd and compare it to the aforementioned model that estimated W_{int} (19) to determine if Stryd also reports W_{int} as Cerezuela et al. (23) did with the altered W_{ext} (i.e., speed, slope, weight) and the theoretical W_{ext} models.

Relative to the CP location with respect VTs, few studies have determined a close proximity to RCP in cycling (24). However, due to the sensitivity of CP estimation and RCP location to the protocols used, there is a need to highlight the dependent essence of these results according to the predictive trials and GXT test used. Bishop et al. (21) stated that predictive trials used should last at least three minutes to not overestimate CP due to the aerobic inertia. Jones et al. (15) also justified the possible mechanical power generation limitation of trials less than 2 minutes and the motivational component of trials over 20 minutes for a proper estimation. In addition, results from the GXT could be influenced by the rate of increases, giving different power outputs for the same VO2 at RCP (16,25). With these considerations, Mcllean et al. (26) and Dekerle et al. (27) used 4 predictive trials at 90-95-100-110-120% of V_{O2max} to determine CP. The time to exhaustion was approximately between 2 and 15 minutes, resulting in similar CP values of 82.2 (2.6)% and 85.4 (4.8)% of V_{O2max} respectively in regularly active students. Mcllean et al. (26) determined that AT (72.4 ± 4.4 % of V_{O2max}) was located approximately 10% lower than CP (82.2 ± 2.6% of V_{O2max}), whereas Dekerle et al. (27) stated that CP (85.4 ± 4.8% of V_{O2max}) was close to RCP (85.3 ± 5.6% of V_{O2max}) determined from a GXT with increases of 25 W.min^{-1}, being both of them over the maximal lactate steady-state (74.3 ± 4.0% of V_{O2max}). Despite the different disciplines (i.e., cycling and running), our results are in line with this close proximity between CP and RCP. However, it is worth mentioning that these thresholds vary substantially across young healthy males ranging from 45-73% for AT, and 69-96% of V_{O2max} for RCP (4). In high caliber middle-distance and long-distance runners, it has been reported that AT is located at 69.5 (7.7)% and 74.6 (9.1)% of V_{O2max}, RCP at 88.2 (6.4)% and 88.3 (6.2)% of V_{O2max}, with maximum values of 65.9 (4.5) ml/kg/min and 71.6 (5.0) ml/kg/min respectively, similar to the values obtained in this sample of high-caliber athletes (23).

The aforementioned methodological considerations should also take into account the ecology aspect of the CP determination and the functionality of a proper estimation. As outlined above, predictive trials of 15-20 minutes could have a motivational component that could influence the athlete disposal, and consequently, a wrong CP estimation. To address this issue, some protocols have advocated for inducing exhaustion in shorter times. Vanhatalo et al. (28) showed that in a 3-min all-out trial, power output decline to a steady-state level within ≈135s, which did not differ significantly from a CP value determined from five constant work rates ranging from 2 to 15 minutes time to exhaustion. However, there is a need to highlight that this protocol requires a GXT performed on a separate day to determine the resistance of the pedals in the 3-min all-out trial. Bergstrom et al. (29) applied this protocol to determine the CP location concerning RCP, finding no significant differences between the 83 (6) and 84 (6) % of VO2max values obtained respectively. Another alternative that induces rapid exhaustion is the one established by Morton et al. (30) where CP is determined from the relationship between the maximum power achieved from at least 3 GXT and the square root of the different ramp-incremental slopes that should be implemented. Leo et al. (16) applied this model to compare the estimated CP with the RCP values obtained from three GXT differing on their work rates slopes (i.e. Slow: $15W.min^{-1}$; Medium: $30W.min^{-1}$; Fast: $45W.min^{-1}$). The CP (247 ± 43W) was significantly different from the RCP value obtained at fast (292 ± 41W) and medium (268 ± 37W) work rates slopes, but not with the slow (243 ± 35W). Keir et al. (25) with five constant work rates CP determination and with a medium work rate slope GXT ($25W.min^{-1}$) also found significant differences in power output but not in VO2 values. It seems that slow incremental protocols ($<30W.min^{-1}$) involve the manifestation of the VO2 slow component in work rates above AT, resulting in the attainment of lower power outputs for a given VO2 (16). Our results showed no significant differences between CP and RCP with a two all-out effort CP determination (i.e., 9/3 time trials), and a GXT with a slow work rate slope (i.e., ≈ $7W.min^{-1}$). This could have implied the development of the VO2 slow component resulting in a lower RCP power output. Thus, further CP and GXT test combinations as the ones mentioned above should be developed to consolidate this relationship.

There is also a need to highlight that despite this non-significant difference between CP and RCP, 33% of the athletes showed a CP work rate ≥ 5% concerning RCP, which could have involve different metabolic responses if in these cases both thresholds would have been treated as equals. Regarding this, Hill et al. (31) reflected this issue performing two constant work rates at CP and 5% above in a group of active university students. Compared to the V_{O2max} achieved in a previous GXT (3.17 ± 0.80 $L.min^{-1}$), the V_{O2peak} reached on the CP trial was significantly lower (2.90 ± 0.57 $L.min^{-1}$), but not at the work rate 5% above (3.03 ± 0.60 $L.min^{-1}$) (31). Jones et al. (9) also showed how work rates just 10% over CP detriment cellular homeostasis, rising Pi to 564 (167)% from baseline values and lowering pH from 7.07 (0.03) to 6.87 (0.10) compared to the Pi and pH values of 314 (216)% and 7.01 (0.03) at work rates 10% below CP. Poole et al. (32) also reflect this close limit between metabolic stability and instability by performing two times to exhaustion bouts at CP and CP +5% work rates. Subjects completed 24 minutes without appreciable duress at CP, meanwhile +5% above, fatigue was reached in 17.7 (1.2) min with a V_{O2peak} similarly to the V_{O2max} previously determined on a GXT (32).

Analyzing the time limit that athletes could sustain over these intensity ranges could contribute to further understanding this thresholds relationship and intensity domains delimitation. Pepper and Housh (33) determined the CV of a group of 10 male adults (CV: 13.43 ± 2.04 km/h; V_{O2max}: 54.4 ± 6.6ml/kg/min) from 5 exercise bouts ranging from 13 to 22km/h on treadmill. Time limit at intensities of 70-85-100-115-130% of CV were >60 / 55.12 (10.29) / 16.43 (6.08) / 7.16 (2.84) / 3.43 (1.40) minutes. Despite these time limits correspond to a CV value obtained from 5 exercise bouts compared to our CP value determined from 2-time trials, this could constitute a close reference being necessary to further analyze each time limit according to the protocol used. As well as maximal lactate-steady state is corroborated from exercises bouts lasting 30 minutes without an increase of $1mmol.l^{-1}$ in the last 20 minutes (34), CP can be corroborated by the fact of reaching a delayed but steady-state VO2 in case of being at a work rate equal or under it, or by the fact of reaching V_{O2max} in case of overpassing it (31).

Lastly, there are a few limitations that should be highlighted. As indicated above, results should be interpreted with caution due to the influence of the protocol chosen on the CP determination and the RCP work rate value. The 9/3 Stryd test is a user-friendly method to estimate CP but further protocols combinations with predicting trials ranging from 2-15 minutes time to exhaustion and different GXT work rates are required to consolidate this relationship. Furthermore, these tests were conducted on a treadmill and with athletes using the same footwear, which remains unknown how varying these factors could influence the power output data. Regarding this, Aubry et al. (35) did not find any significant difference in power outputs values obtained on a treadmill and outdoor track conditions. However, this study was conducted with the power meter model "Stryd Pioneer", which consists of a tri-axial accelerometer embedded on a chest strap. It is well known that athletes tend to keep constant their bounce of the center of mass when running on different surfaces by altering their stiffness what could have conditioned the obtaining of different power output data (36). However, the power meter model used in the present study was the last commercial version called "Stryd Wind", attached to the laces of the footwear, which could constitute a better place for a tri-axial accelerometer to react to different surfaces. Furthermore, it is well-known how the use of minimal and maximal footwear alters running kinetics and kinematics parameters (37). Since power outputs are derived from these data, it would be necessary to explore how these factors could influence the CP metric. Notwithstanding these limitations, the current study provides some insights into the CP concept, and to our knowledge, this was the first study to investigate the relationship between the CP value and VTs in running.

In conclusion, the CP estimated from the 9/3 minutes Stryd CP test was located at 88.71 (5.84) % of V_{O2max}, which does not differ significantly from RCP (86.40 ± 4.34 % of VO2max) determined from a GXT with a slow work rate slope (i.e., $0.33 km/h.min^{-1} \approx 7 W.min^{-1}$).

From a practical standpoint, these results suggest that coaches and athletes can determine in an easy and accessible way the metabolic perturbance threshold that CP and RCP represent. Applied to running performance, athletes can use this threshold to regulate their efforts precisely by the feedback that sports watches report when synchronized to the Stryd power meter. Applied to training, coaches can easily test athletes´ performance and update training zones with a unique session. As illustrated in *figure 3*, AT (≈ 80% of CP) would represent the boundary between easy (70-80% of CP) and moderate (80-90% of CP) zones. RCP (≈ 97% of CP) and CP would delimit the so-called threshold (90-100% of CP) and interval (100-110 % of CP) zones. Finally, the repetition zone (>110% of CP) would be differentiated from the interval zone (100-110% of CP) by the fact of inducing exhaustion before reaching V_{O2max} (105% of CP).

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List of abbreviations

VO2: Oxygen uptake

V_{O2max}: Maximum oxygen uptake

AT: Anaerobic threshold

CO2: Carbon dioxide

VE: Ventilation

RCP: Respiratory compensation point

Pi: Phosphate ions

CP: Critical power

CV: Critical velocity

GXT: Graded exercise test

W´: Work capacity reserve

VTs: Ventilatory thresholds

W_{ext}: External Power

W_{int}: Internal Power

W_{total}: Total power

Table 1. Critical power and work capacity reserve determined by the 9/3 Stryd test.

	9´	3´
Distance (km)	2.64 (0.22)	0.99 (0.08)
Pace (km/h)	17.60 (1.48)	19.80 (1.70)
Power (W/kg)	4.91 (0.42)	5.39 (0.44)
% CP	105.10 (1.27)	115.41 (3.81)
CP (W/kg)	4.67 (0.42)	
CV (km/h)	16.60 (1.58)	
W´ (kJ)	8.91 (2.04)	

CP: Critical Power; CV: Critical Velocity; W´: Work capacity reserve

Table 2. Location of critical power, ventilatory thresholds, and V_{O2max}.

	AT	RCP	CP	V_{O2max}	p-Value
ml/kg/min	48.31 (6.61)*	57.35 (7.15)	58.83 (7.56)	66.33 (7.20)*	<0.001
% VO2max	72.86 (6.01)*	86.40 (4.34)	88.71 (5.84)	100	<0.001
W/kg	3.88 (0.42)*	4.56 (0.42)	4.72 (0.42)	4.95 (0.36)*	<0.001
% CP	82.27 (6.57)^	96.72 (5.95)	100	105.04 (4.08)^	<0.001

*Denotes significant differences from CP; ^ Denotes significant differences from RCP; AT: Anaerobic threshold; RCP: Respiratory compensation point; CP: Critical power; V_{O2max}: Maximum oxygen uptake.

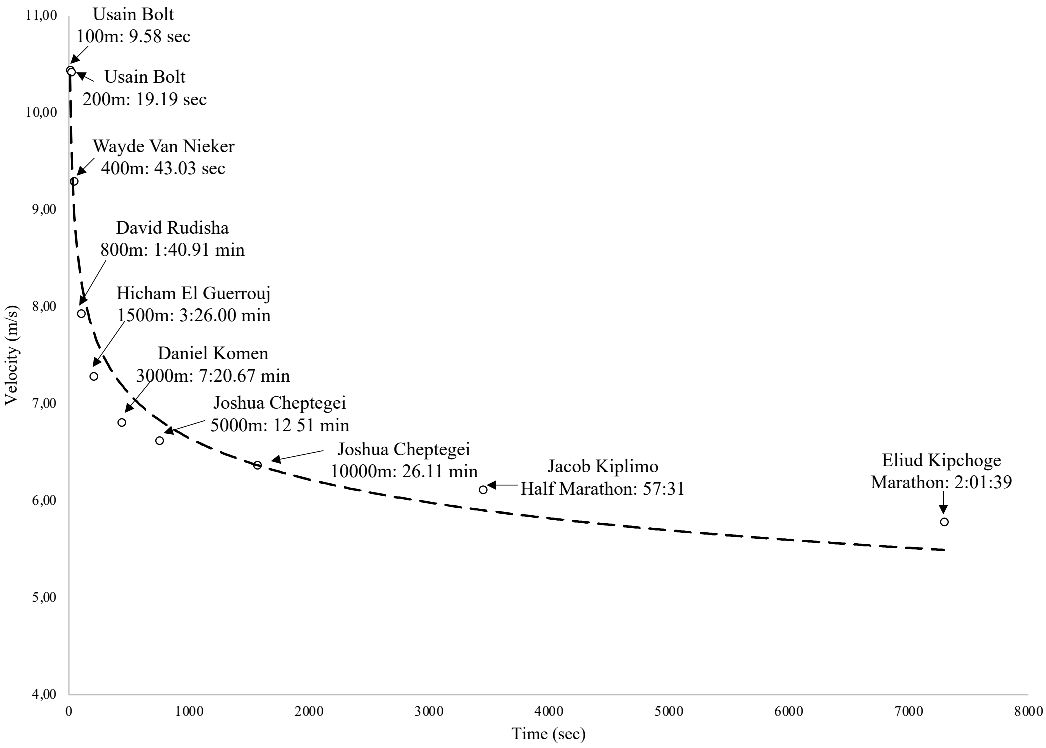

Figure 1. Hyperbolic relationship between velocity and time sustained of athletic world records.

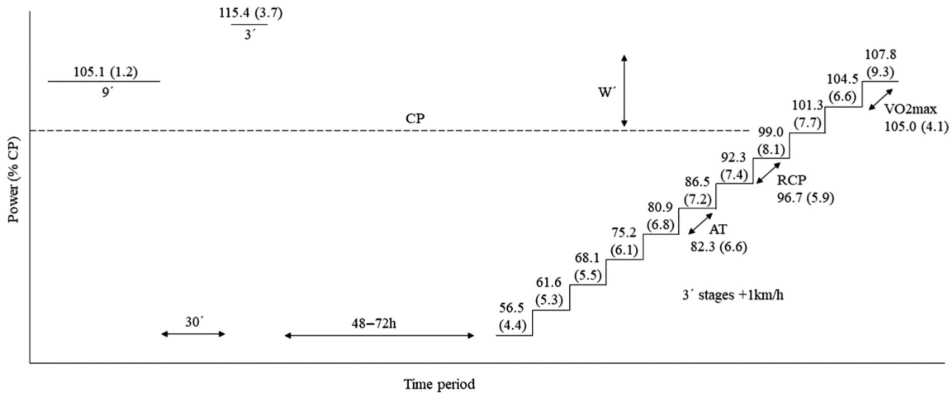

Figure 2 — Illustration of power outputs at 9/3-minute time trials and each stage of the graded exercise test concerning CP. AT indicates anaerobic threshold; CP, critical power; RCP, respiratory compensation point; VO_2max, maximum oxygen uptake; W´, work capacity reserve.

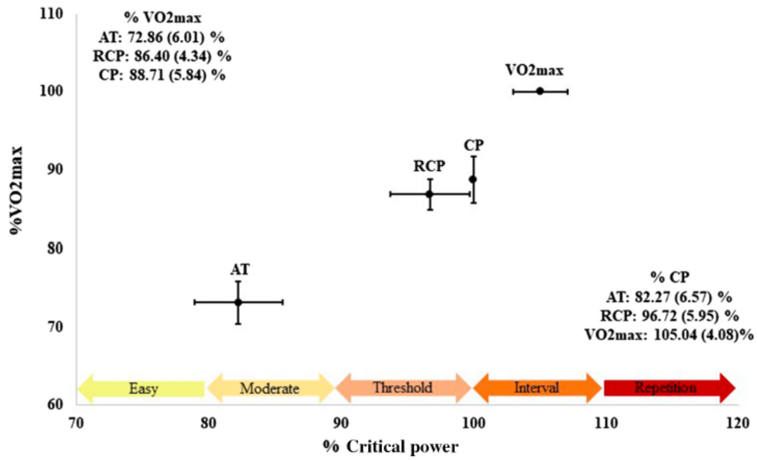

Figure 3 — AT, RCP, CP, and VO_2max location concerning Stryd training zones. AT indicates anaerobic threshold; CP, critical power; RCP, respiratory compensation point; VO_2max, maximum oxygen uptake.