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The Compound Score in elite road cycling

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1. Introduction

Elite road cycling is characterized by racing over varied terrain, ranging from flat races to extremely mountainous terrain[1,2]. Researchers have frequently attempted to quantify the performance characteristics of cyclists to predict race success based on external and internal load metrics including power output, heart rate and speed [3–6]. Recent research reported a strong relationship between the power profile and race performance[7,8]. However, to date, there is still an ongoing debate whether absolute power output; a mass exponent, or relative power; power output normalized to body mass, is more advantageous. For this reason, the current study used both absolute and relative power output to calculate a compound score to investigate its predictive ability for race performance.

2. Materials and Methods

Power output data were recorded from power meter system (SRAM Red, Quarq, Spearfish, South Dakota, USA) fitted to the participants bicycle (Revelator Alto Elite, KTM Fahrrad GmbH, Mattighofen, Austria) during training and racing in a competitive racing session. Body mass (Kern DS 150k1, Kern & Sohn, Germany) was recorded in conjunction with racing events. Data from training and racing data were analyzed (WKO5, Trainingpeaks LLC, US) together with a novel adaptation of these data - the compound score. In a second step absolute, relative power output and the compound score were compared to performances in races to assess whether individual variables were correlated with performance, and to derive positive and negative predictive values.
The Compound Score can be calculated as follows:

Compound Score [$W^2.kg^{-1}$] = absolute power output [W] × relative power output [$W.kg^{-1}$]
Equation (1)

Race performances during the season for each participant were screened to select the best 3 single day race results. Results were log transformed and weighted accordingly as follows:

Table 1. represents weighting factors according to single day race categories

Single Day	
Cat	Weighting
1.1	2
1.2	1.5
1.2 U23	1.1
NC	1
1.2 NC	0.8

Cat – category, NC – nation cup

Subjects — Thirty male U23 professional cyclists participated in the study (age, 20.1±1.1, body mass 69 ± 6.9 kg, height 182.6 ± 6.2cm) All participants provided informed written consent and were active members of

a UCI Continental team during the cycling season(s) analyzed.

Statistical Analysis — All values are expressed as mean ± standard deviation and or mean difference (MD). A Pearson product correlation was used to investigate the relationship between 5-min MMP, (W, W.kg^{-1}), compound score of 5-min and the best single day result score. The correlation coefficient was interpreted according to Hopkins[9] for a small (<.3), medium (.3-.5) or large (>.5) effect. The performance threshold was calculated as the ratio from the true to false observations, which were below or above the corresponding cut offs relating to 5-min MMP, (W, W.kg^{-1}) and compound score. All statistical analyses were completed using GraphPad Prism (version 8.0.0 for Mac OS, GraphPad Software, San Diego, USA). The alpha level of statistical significance was set as p >.05 two tailed.

3. Results

Table 1. demonstrates the participants' descriptive performance characteristics.

5-min MMP (W)	5-min MMP (W.kg^{-1})	Compound Score (W^2.kg^{-1})
445 ± 36	6.6 ± 0.3	2995 ± 264

5-min MMP – 5-minute mean maximum power

Absolute MMP (r=.52, p=.003) and the compound score (r=.54, p=.002) significantly correlated with the best single day result score, while relative MMP did not (r=.11, p.550). Positive/negative performance thresholds were >470W, 50.0/90.0%; for absolute MMP, >6.4 W.kg^{-1}, 20.8/50.0% for relative MMP and >3110 W^2.kg^{-1}, 66.7/95.2% for the compound score respectively – see figure 1.

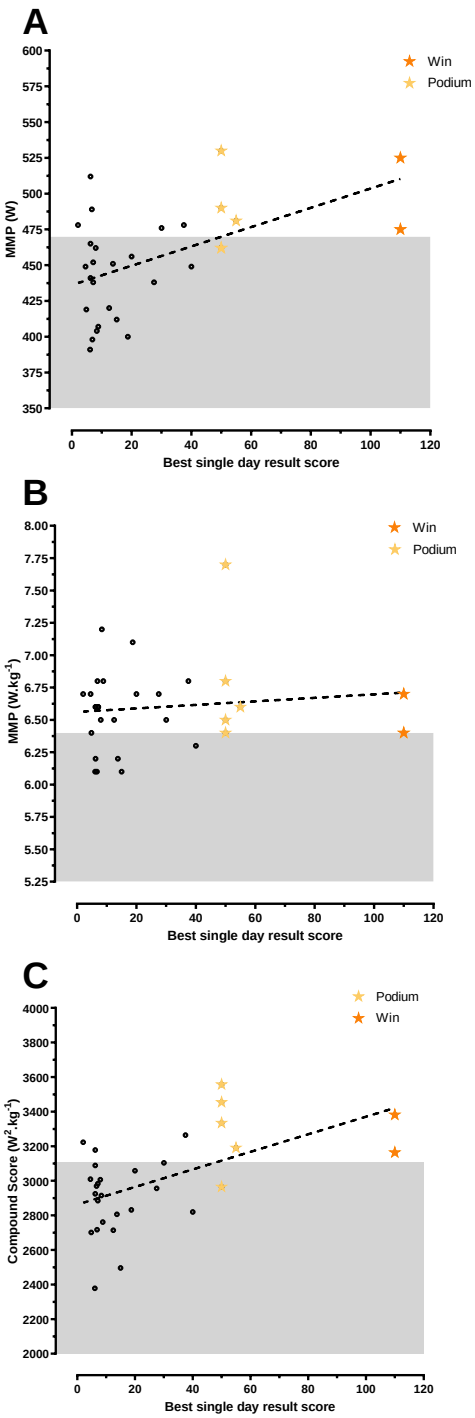

Figure 1. Illustrates the relationship between absolute (A); relative (B) mean maximum power (MMP); compound score (C) and the best single day result score. The grey shaded area represents the performance threshold for the variable used to predict a race podium or win.

4. Discussion

In keeping with our hypothesis that both a high absolute power output as well as a high relative power output are important in determining performance, we have demonstrated that the product of these two variables has a greater correlation with and is able to predict a successful race outcome to a greater extent than either variable alone. The two greatest forces a cyclist is required to overcome are gravitational force and drag. The former requires a high relative power output while the latter requires absolute power. As relative power output scales inversely to mass and absolute power output scales proportionally with mass, these two variables represent a diverging set of performance characteristics relative to the mass of the rider. As such, there may be a mass at which cyclists exhibits an optimal balance between these two characteristics to achieve the highest performance characteristics. The compound score seeks to provide a variable with which the balance of these diverging performance variables can be measured. We have demonstrated that for U/23 professional cycling, a compound score of 3110 $W^2.kg^{-1}$ has a 66.7% positive predictive value for the achievement of a podium or race win result. Conversely, a compound score less than 3110 $W^2.kg^{-1}$ is associated with a 95.2% negative predictive score. i.e., a compound score below this value is associated with only 4.8% likelihood of a race podium result. To our knowledge, the compound score is able to measure performance characteristics for U23 one day racing success. Further research is required to assess whether the compound score is able to predict stage race success or whether other factors such as the power profile[8] or fatigue resistance[10–12] provide greater insight.

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

References

(1) Padilla, S.; Mujika, I.; Cuesta, G.; Goiriena, J. J. Level Ground and Uphill Cycling Ability in Professional Road Cycling. *Med Sci Sport. Exerc* **1999**, *31* (6), 878–885. https://doi.org/10.1097/00005768-199906000-00017.

(2) Nimmerichter, A.; Eston, R.; Bachl, N.; Williams, C. Effects of Low and High Cadence Interval Training on Power Output in Flat and Uphill Cycling Time-Trials. *Eur J Appl Physiol* **2012**, *112* (1), 69–78. https://doi.org/10.1007/s00421-011-1957-5.

(3) Sanders, D.; van Erp, T. The Physical Demands and Power Profile of Professional Men's Cycling Races: An Updated Review. *Int J Sport. Physiol Perform* **2021**, *16* (1), 3–12. https://doi.org/10.1123/IJSPP.2020-0508.

(4) Jobson, S. A.; Passfield, L.; Atkinson, G.; Barton, G.; Scarf, P. The Analysis and Utilization of Cycling Training Data. *Sport. Med* **2009**, *39* (10), 833–844. https://doi.org/10.2165/11317840-000000000-00000.

(5) Sanders, D.; Heijboer, M. Physical Demands and Power Profile of Different Stage Types within a Cycling Grand Tour. *Eur J Sport. Sci* **2019**, *19* (6), 736–744. https://doi.org/10.1080/17461391.2018.1554706.

(6) Gallo, G.; Leo, P.; Mateo-March, M.; Giorgi, A.; Faelli, E.; Ruggeri, P.; Mujika, I.; Filipas, L. Cross-Sectional Differences in Race Demands Between Junior, Under 23, and Professional Road Cyclists. *Int J Sport. Perform Anal.* **2022**, *aop* (1), 1–8.

(7) Leo, P.; Spragg, J.; Simon, D.; Lawley, J.; Mujika, I. Climbing Performance in U23 and Professional Cyclists during a Multi-Stage Race. *Int J Sport. Med* **2021**, *in print*.

(8) Leo, P.; Spragg, J.; Menz, V.; Simon, D.; Mujika, I.; Lawley, J. S. Power Profiling and Workload Characteristcs in U23 and Professional Cyclists during the Multistage Race "Tour of the Alps." *Int J Sport. Med* **2020**.

(9) Hopkins, W. G. A Scale of Magnitudes for Effect Statistics. *A new view Stat.* **2002**, *502*, 411.

(10) Leo, P.; Spragg, J.; Simon, D.; Mujika, I.; Lawley, S. J. Power Profiling, Workload Characteristics and Race Performance of U23 and Professional Cyclists during the Multistage Race Tour of the Alps. *Int J Sport. Physiol Perform* **2021**, *in press*.

https://doi.org/https://doi.org/10.1123/ijspp.2020-0381.

(11) van Erp, T.; Sanders, D.; Lamberts, R. P. Maintaining Power Output with Accumulating Levels of Work Done Is a Key Determinant for Success in Professional Cycling. *Med Sci Sport. Exerc* **2021**, in press.

(12) Muriel, X.; Mateo-March, M.; Valenzuela, P. L.; Zabala, M.; Lucia, A.; Pallares, J. G.; Barranco-Gil, D. Durability and Repeatability of Professional Cyclists during a Grand Tour. *Eur. J. Sport Sci.* **2021**, 1–8.

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