### 8 Conclusion

In this paper, we first obtained various physical qualities of cyclists of different types and genders through the STRAVA sports tool manufacturer, and then we performed certain preprocessing on the obtained data. In order to reflect the speed at which the rider's output power decays with time, we introduce a subjective physical quantity: fatigue T r. Next, we refer to the model proposed by Coggan, combined with the population growth model of Logistic, to propose our power curve model, and apply this model to the actual competitions. We applied the model to the following routes: the Tokyo Olympics race on rough terrain, the UCI race on flat terrain, and a short course race of our own design. In addition, we also analyzed the effects of wind and the fact that the rider did not ride strictly according to the power curve to ensure the stability of the model. In order to make our model more rigorous and accurate, we conducted a sensitivity analysis to ensure that the model has relatively strong stability, and discussed its strengths and weaknesses for reference. Finally, We will give a racer race guide to guide the rider in training and racing.

**7 Evalution of Strengths and Weaknesses**

**7.1 Strengths**

Strong universality Our model is formed by fitting a large number of statistical data, and in the simulation process of various competitions and various athletes, it is basically consistent with the actual situation. Therefore, the model can be used to predict the results of various competitions and give some guidance.

Extremely stable After slightly changing some conditions the results calculated by the model are not very different. In fact, it is difficult for the rider to perform perfectly in the competition, and the environmental conditions in the competition are constantly changing. Even under these conditions, there was little difference between the rider's performance and the predicted performance.

The relative accuracy is high every step of the model establishment has undergone strict logical reasoning, and the Coggan model we refer to is a model with high accuracy for describing the rider's power curve, Therefore, the results obtained by the riders in the simulation process differ very little from the actual results.

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**7.2 Weaknesses and Further Improvements**

Many secondary factors are ignored The influence of altitude, bad weather, etc. on the rider's power curve is not considered, resulting in a certain discrepancy between the rider's power curve model and the actual competition.

The absolute error is large There is a certain gap between the value simulated by the model and the actual situation, especially in the latter part of the power curve. The absolute error of the model is mainly caused by the inaccurate data estimation and the fitting curve.

**6 Sensitivity and Robustness Analysis**

In our model, we have to introduce a lot of estimated quantities and subjective parameters, let's analyze their sensitivity.

As mentioned earlier, the effects of wind direction, wind speed, and the rider’s behavior deviation from the power curve when riding have been thoroughly analyzed, and the model has a good ability to adapt to changes in these variables.

The maximum oxygen uptake, the lactate threshold L T, and the set value of the muscle fiber have large subjective estimation components. We take the maximum oxygen uptake and the lactate threshold L T as examples, calculate their FTP through model simulation, and establish a heatmap analysis as follows. The overall FTP gap is not large, and the variance which is relatively stable. Moreover, it can be seen from the figure that FTP, maximum oxygen uptake , and lactate threshold L T have strong linear properties and is relatively stable, and the error caused by the estimation is small.



**Figure 16：the relationship between ， and FTP**

We do not consider the more complex situations in the ground and the atmosphere. We calculate according to the data of James C. Martin [11], but these two data are related to the road conditions at that time, Road construction materials, altitude, and atmospheric humidity have complex and profound relationships. So we should discuss the effect of two parameters on the final result next. The arrival time has clear linear relationship with both. The correlation coefficients are 0.9996 and 0.9997 respectively, which are in line with common sense analysis and have good predictability. When the parameters change, the variation range does not exceed 10%, which has high fault tolerance.



**Figure 17：the relationship between and Arrival time.**

**5.5 Solution to Problem 5: solve the team competition problem**

The biggest strategy difference between the road cycling team competition and the road cycling individual time trial is that the drafting strategy is allowed in team competition, which makes more skills and changes appear. In team competition, the leader of the team is allowed to reduce wind resistance for the rest of the team at the expense of exceeding the power curve. According to Kyle's calculations, when the speed of bicycle movement exceeds 40 kilometers per hour, wind resistance accounts for more than 80% of all resistance [2], so drafting is of great signifiance. The team can also take the strategy that change the leader, so that the leader can get enough rest.

Kyle concluded that in team competitions, drafting cyclists can reduce wind resistance by about 40%. Therefore, we can establish a model to believe that in the team competition, the 6-person team is relatively closely integrated, its power output is based on the leader's power curve, and the wind resistance is reduced by 40%. Besides, you can achieve better power output in different terrains by constantly changing the leader. For example, in mountainous terrain, Climber should be the leader, in the straight road Time Trail Specialist should block the wind for everyone, and Sprinter are supposed to take the lead in the sprint stage sprint. The 6-person team should be flexibly cooperated according to the competition situation.

We take our race as an example to analyze, we choose 2 Climbers, 3 Time Trail Specialists, and 1 Sprinter to form a team according to the strategy. In the mountains in the previous part, Climber takes the lead and leads the team to start better. And because there is no need to worry about physical distribution, the Time Trail Specialist can also exert his strength to overcome wind resistance and play a better level in the mid-term. In the end, the Sprinter contributed a wonderful sprint close to 30m/s for everyone. Complete the Time Trail Specialist 2185s schedule in 1910s.



**Figure 15：The speed comparison between A Time Trail Specialist and A Team at our race.**

**5.4 Solution to Problem 4: the effect of overtaking**

Riders are unlikely to strictly follow the power curve during the race, and Deviations from the power curve are possible. If the rider's power output is slightly lower than the power curve, he can quickly adjust to the normal driving speed in a short period of time, with little impact on the race performance. Therefore, we focus on analyzing the impact of the power output temporarily exceeding the power curve on the rider's performance during overtaking.

**5.4.1 Influence of overtaking on race performance**

Assume that in a certain section of the UCI, Time Trail Specialist Accelerate halfway to overtake the driver in front, increasing his power to 1.5 times the original power for 60 seconds, but after that, he can only exert 70% of his original power within 150 seconds. We observe its local velocity curve and compare.

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**Figure 13：Speed curve for overtaking and not overtaking**

Through analysis and calculation, it can be found that after overtaking once, the rider will drive at a lower speed for a long period of time, and the final result will be about 1 second slower than the original speed overtaking. It can be seen that even if the rider does not strictly follow the output power of the power curve, the final result is not much different from that predicted by the model. The model has strong stability and is less sensitive to the influence of the rider, which is consistent with the actual situation and logical reasoning.

**5.4.2 Influence of overtaking times on race performance and FTP**

In a race, the rider may experience multiple overtaking and acceleration. According to the past race experience, we select 0-14 overtaking times for simulation, and obtain the impact of overtaking times on the race performance and the rider's FTP, then use this to infer the relationship between the number of overtaking and the performance of the rider's game.



**Figure 14：The relationship between the number of overtaking actions , arrival time and P**

After a simple analysis, it is not difficult to conclude that with the increase of the number of overtaking, the more times the rider deviates from the power curve, he or she may enter a longer "fatigue period", and the rider's competition time will become longer. Correspondingly, the rider's FTP will continue to decline, and the two are approximately linear. The final result is in line with common sense.

**5.4.3 Conclusion of the problem**

Based on the above analysis, it can be seen that when the rider's power output approximates but does not exactly follow the power curve, it will have a greater impact on the rider’s power output, which is not conducive to the competition result, that is, the result is more sensitive to the rider’s deviation from the target power distribution. . Therefore, the rider should ride strictly according to the power curve when racing.