Efficiency of the bicycle operation under various tactical variants

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Abstract

Purpose: to determine the efficiency of the cyclist in various tactical options.

Material: In the experiments participated athletes (n = 6) of high qualification (mean age - 19.8 ± 1.3 years, mean weight - 71.4 ± 3.5 kg). As a model of the individual pursuit race at 4 km, a five-minute pedaling on the bicycle ergometer was used. Series of loads was set on the modernized mechanical bicycle ergometer "Monark". The five-minute bicycle ergometer test is similar to the individual pursuit race at 4 km: according to the time of the exercise; on the frequency of pedaling (110-120 rpm); on the frequency of heartbeats.

Results: Tactical variants in the pursuit race at 4 km are considered. The total work in a free test was on average 106.38 ± 3.57 kJ. The operating energy consumption is on average for 379.0±16.1 kJ. The operating efficiency (economy) of the exercise attained on average for 28.0 ± 0.75%. This corresponds to the effectiveness of aerobic work of moderate power. The ratio of aerobic and anaerobic contributions to the provision of work was 77.3 and 22.7%. The smallest work was done in a test with step-increasing power. The athletes performed the closest work to the given job in the test with a variable (±15%) operating mode. The shortfall in it was on average for 0.46%. The absence of reliable differences in the economics of the work did not allow us to identify a rational variant of power distribution for an exercise lasting 5 minutes.

Conclusions: Tactical options in the pursuit race for 4 km depend on the features of the power systems of the rider. When optimizing tactics, it is necessary to select an individually optimal variant of the distribution of forces at a distance.

Keywords: cycling, tactics, energy expenditure, economy, aerobic, anaerobic

Introduction

Many experts recognize the need for scientifically based development of optimal layout of the passage of individual distances [1, 5]. To solve this problem by means of pedagogical observations and analysis of performances of athletes at the competitions is not completely possible. All the recommended distances are largely hypothetical. The objective comparison of the various tactical options have not much attempts [3, 8, 12]. The loads in these studies were not applied to the limit. This reduced the importance of the received information for the practice of sports.

Economy is the most common criterion of optimality. Economic efficiency quantitatively characterizes the ratio of the result of activity and an expenditure of achieving this result [16]. Quantitative indicator of the economy of movements is considered to be the mechanical efficiency of the work. Mechanical efficiency is calculated as the ratio of the useful work to the energy expended. For the quantitative estimation of profitability, varieties of the coefficient of mechanical efficiency are used [16]. The expenditure of moving segments of the moving person body is taken into account in determining the operational efficiency [3]. When pedaling on the bicycle ergometer, the overall efficiency factor does not exceed 20÷22%, the net efficiency factor is 25% [11, 15].

Tactical variety of options for the action of athletes is most fully manifested in competitive activities. Equally important is the use of the competitive method in training athletes [21], in physical education classes for students [20, 29, 35], and schoolchildren [18, 24, 37]. The effectiveness of such occupations depends on psychological factors [26, 44], the emotional state of athletes [34], the attractiveness of physical exercises [32, 33]. The success of athletes in competitive activity will be determined by morphofunctional features [25, 36, 38], individual characteristics of physical fitness [40], physiological and energy indicators [42], performance [41].

To optimize the competitive activities in cycling, it is necessary:

- to determine the energy cost of limiting work in a given power zone [6];
- to determine the profitability of limiting work in a given power zone [7];
- to reveal the ratio of the contributions of various energy mechanisms that ensure the performance of competitive exercises [14];
- to compare the energy cost of limiting work under different tactical options [13].

An aim of the work is to determine the efficiency of the cyclist's work with various tactical options.

Material and methods

Participants. In the experiments participated athletes (n = 6) of high qualification (mean age - 19.8 ± 1.3 years, mean weight - 71.4 ± 3.5 kg).

Organization of the study.

As a model of the individual pursuit race at 4 km, a five-minute pedaling on the bicycle ergometer was used. Series of loads was set on the modernized mechanical bicycle ergometer *"Monark"*. The five-minute bicycle ergometer test is similar to the individual pursuit race at 4 km: according to the time of the exercise; on the frequency of pedaling (110-120 rpm); on the frequency of heartbeats. This made it possible to follow the dynamics of the performance of athletes. Individual abilities of athletes were revealed [10, 11].

Determined performance in a specific area of relative power. The load conditions were calculated. Athletes should perform the maximum amount of work in 5 minutes: forced resistance and arbitrary distribution of the

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pedaling frequency (free test). In the following tests: the given operating modes were calculated from the total work done by the athlete in free test. The change in the power of work was carried out by adjusting the force on the pedals of the bicycle ergometer. The speed of the pedals was kept constant for the whole exercise. The speed of the pedals is equal to the average pedaling frequency in free test. The athletes performed the following modes of operation: fixed power *(A)*, high power mode at the beginning of exercise *(B)*, step-increasing *(C)* power, variable power *(D)*. The frequency of pedaling was controlled by athletes on the speedometer and recorded by the indicators of the electromechanical speed counter. Variants of work (except *D*) corresponded to the basic tactical layout of the athletes' distance in the individual pursuit race at 4 km [9].

The oxygen and carbon dioxide content of the air samples was determined on the Beckman analyzer. The volume of exhaled air was established using a dry spirometer. Calculation of consumed oxygen was carried out according to the standard procedure [17]. Analysis of samples of capillary blood (before and after the load), was carried out according to the Barker-Simmerson method in the Strohm modification [17]. The calculation of working energy expenditure was determined by summing up energy supply sources [17].

The following were recorded: pulse (f_h), oxygen consumption (VO_2) and carbon dioxide emission, quantity (A) and power (N) of the work performed. The following were determined: the level of lactate (*Lac*) in the athlete's blood; oxygen debt; oxygen cost per unit of work (VO_2/A); the oxygen demand for the work performed (ZO_2) and the oxygen deficit (DO_2).

Results

All 6 athletes did not perform free test with a uniform layout. Graph *A* (Fig. 1, 2) shows the dynamics of power work for 30-second segments (according to average data). The athletes performed the highest work in the first 30 seconds. At the same time, the average working level exceeded 17.5%. The lowest power level was maintained on the 8th and 9th segments. The change in capacity was 9.1%.

The greatest "underfulfillment" in tests with preset regimens was noted at the same site of the exercise (ie, from 3.5 to 4.5 minutes).

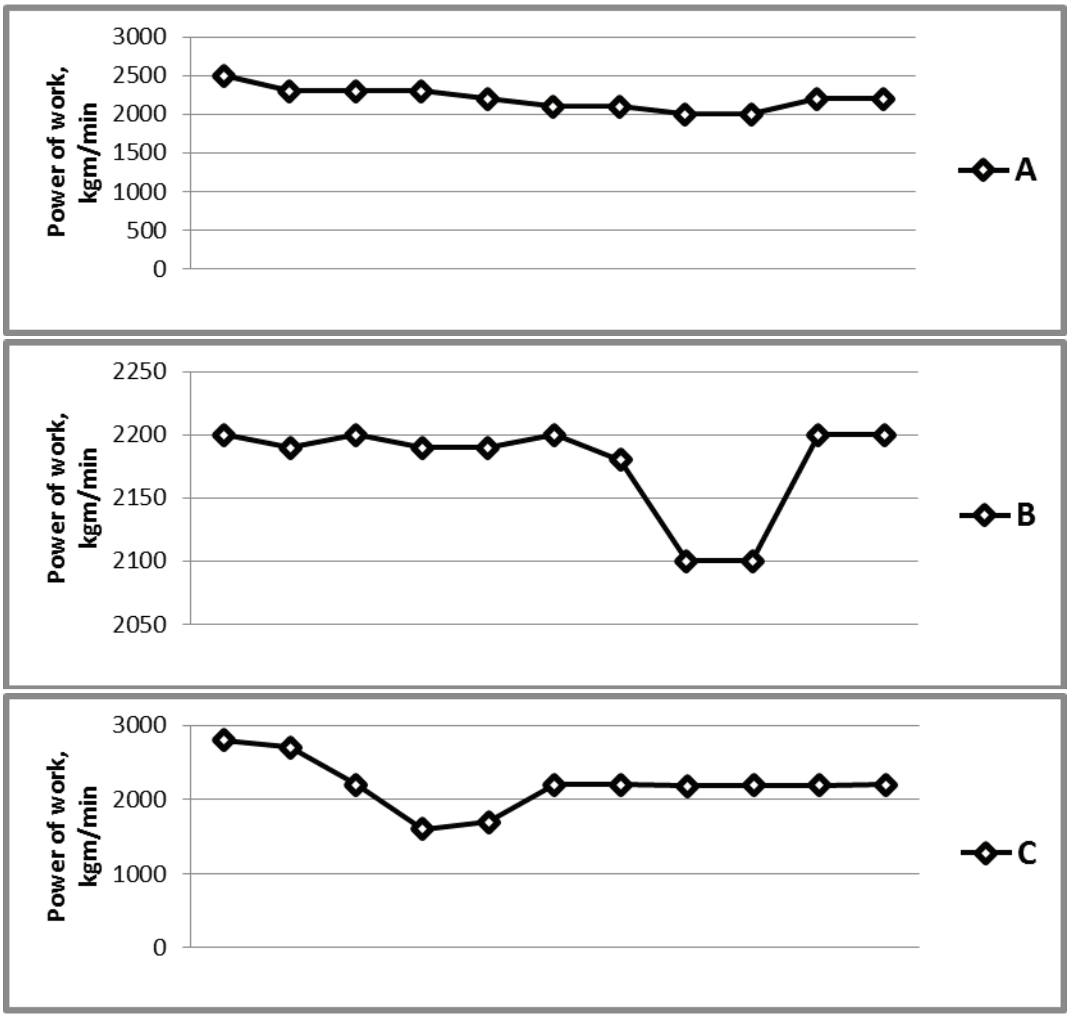

Fig. 1. Distribution of the actual pedal power at 30-second intervals: *A* — free test; *B* — fixed power test; *C* — test with intensive start.

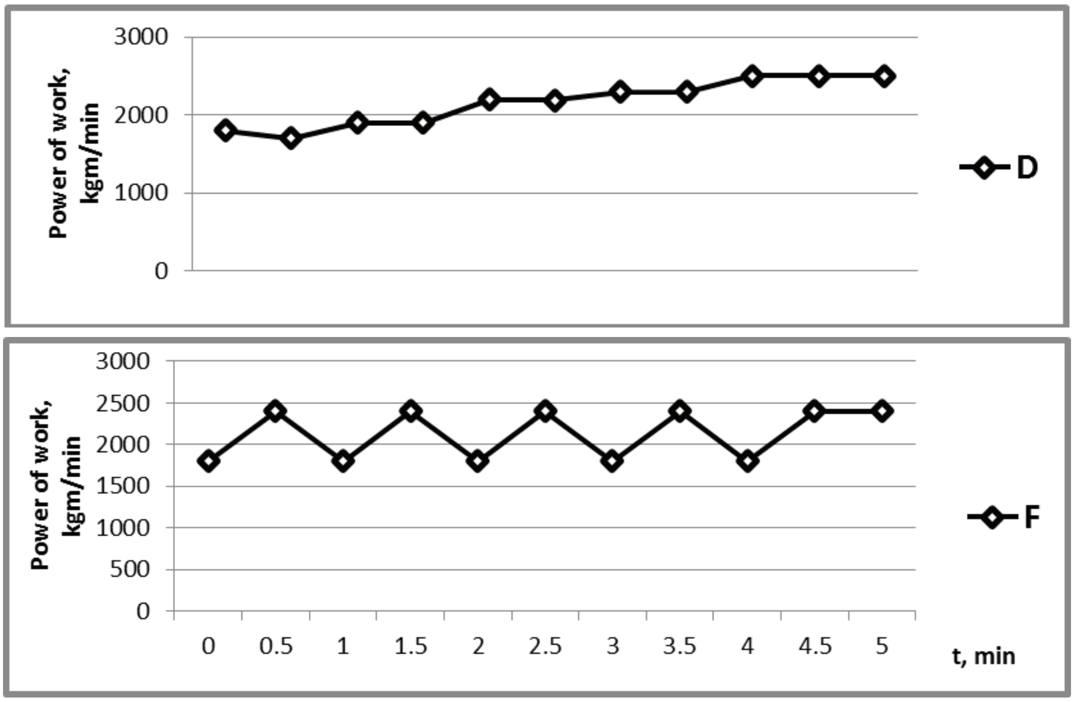

Fig. 2. Distribution of the actual pedal power at 30-second intervals: *D* — step-increasing power test; *F* — variable power test.

The total work in free test was on average for 106.38 ± 3.57 kJ. The operating energy consumption is on average for 379.0 ± 16.1 kJ. The working efficiency (economy) of the exercise is on average for 28.0 ± 0.75%. This corresponds to the effectiveness of aerobic work of moderate power.

The ratio of aerobic and anaerobic contributions to the provision of work was 77.3 and 22.7%, respectively. The smallest work was done in a test with step-increasing power. The athletes performed the closest work to the given work in the test with a variable (± 15%) operating mode. The shortfall in it was, on average, 0.46%. The lactate component contributed the greatest contribution to free test and test with fixed power. Alaktat component contributed the most to loads with variable and increasing power. The aerobic component had the greatest influence in exercises with an overestimated onset (Table 1).

The absence of reliable differences in the economics of the work did not allow us to identify a rational variant of power distribution for an exercise lasting 5 minutes. Working with a fixed power did not find advantages over other options.

At different athletes the most effective were the tests with different layout options (Table 2). For L-v athlete the most preferable was variable-power work. In it, he was

Table 1. Total energy expenditure (KJ) ratio of various components of energy production (%)

Tests	Operating energy consumption	Aerobic	Alaktat	Lactate
Free	377,7	77,3	7,5	15,2
With fixed power	387,9	77,3	7,6	15,1
With intensive start	387,7	80,0	7,2	12,8
With step-increasing power	384,8	78,4	8,0	13,6
Variable	378,7	78,0	8,0	14,0

Table 2. Individual ranking of indicators of the performed work (I, II, III, IV) and economy (1, 2, 3, 4, 5)

Athletes	Tests				
	Free, A	With fixed power, B	With step-increasing power, C	With intensive start, D	Variable, F
N-v	2	I/4	IV/1	III/5	II/2
K-v	3	II/1	IV/5	III/2	I/4
G-h	1	I/2	IV/4	III/5	II/3
L-v	1	III/5	II/3	IV/4	I/2
B-v	4	IV/5	III/2	I/3	II/1
O-v	1	III/4	V/5	II/2	I/3

able to perform the full amount of work with economy, which is slightly inferior to the economy in free test. For athlete G-h, the most effective was working with a fixed power.

Discussion

In studies of cycling problems, it was found that the relationship between recovery and stress factors varies greatly over a relatively short period of time. These factors dynamically affect performance in multi-stage competitions [22]. Other studies have shown that the increase in performance of athletes is affected by: the level of self-esteem [23], the use of feedback for decision-making [27]; planned adaptation to endurance training [31]; psychosocial factors [46]. The results obtained by us confirm the necessity of taking into account various factors for increasing the productivity of athletes.

In a study by Waldron M. et al. [45] was highlighted the sprint characteristics of cyclists, which can be explained by mechanical and anthropometric parameters. The authors cite tests and equations that can be taken by trainers to predict performance and determine the appropriate intensity of training. Bini R.R. et al. have developed a model of a strategy to mitigate asymmetry in pedaling [19]. Knaier R. et al. have investigated the effect of bright or blue light on the maximum speed of cycling in a 12-minute test [28]. This approach allows elitist athletes to better support work during the 12-minute cycle. Leruite M. et. al. have determined the average socio-demographic profile of cyclists and triathletes [30]. The authors propose to change the policy in the sports federations, as well as initiatives to improve the competition conditions for these athletes. Pollastri L. et. al. have investigated the interrelation of water consumption with a maximum capacity of different duration of time [39]. The authors note that due to improved thermoregulation, the productivity at the last stages increases. Turpin N.A. et al. have evaluated muscle activity in a wide range of output powers for sedentary and standing positions on a bicycle [43]. The authors note that the number and structure of muscle synergism play secondary role in using standing position when pedaling at high power outputs. Such approaches in many respects coincide with our ideas about modeling the training of cyclists.

According to some studies [1, 3], the coefficient of overall economy of work is 22-25%, the coefficient of net profitability is 26-28%. The results of our study are close to these values. The total work in free test was on average for 106.38 ± 3.57 kJ. In the studies of other authors the similar results were obtained [2, 16]. The ratio of aerobic and anaerobic contributions to the provision of work was 77.3% and 22.7%, respectively. This is close to the ratio that was obtained by R. Astrand and K. Rodahl [4]. The received data confirm mobilization of all mechanisms of power supply.

Conclusions

1. Tactical options in the pursuit race at 4 km are defined as individually optimal.
2. Tactical options in the pursuit race for 4 km depend on the features of the power systems of the rider.
3. When optimizing tactics, it is necessary to select an individual-optimal variant of the distribution of forces at a distance.

Conflict of interest

The authors state that there is no conflict of interest.

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