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BIOMECHANICAL CHARACTERISTICS OF KAYAKING

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Abstract- The objective of this paper is to determine the kinematic characteristics of kayaking and the effect of these components on the competitive result.

The effect of the kayaking components on each other can lead either to the improvement in the sporting result, or to its deterioration. The definitions of this effect will help to reduce the negative interaction of stroke parameters on each other and to strengthen the positive actions to achieve the goal.
Moreover, this will enable to select the most appropriate means and methods of training to improve the kayaking performance.

Keywords- kayaking, kinematic characteristics, support phase, boat run

I. INTRODUCTION AND IMPORTANCE OF RESEARCH

Price of the victory in kayaking is determined sometimes by tenths, and other times even by hundredths of a second. The search for additional reserves, which contribute to increasing the level of athlete's training and achieving the maximum competition form, is the most important task in organizing the training process. One of the components of solving this task is biomechanical parameters of kayaking [4, 5]. Over recent years, the most relevant is the alignment of model characteristics of the driving influences of movement [8, 9, 11]. Previous researches have allowed for revealing the dependence of rational techniques of movements on the functional state of skeletal muscles [1, 3]. Over recent years in various sports a significant number of experimental researches have been devoted to the development and identification of the effectiveness of applying the model characteristics of the technique of movements [2, 6, 7]. At the same time, the proposed model characteristics are often determined by a level of fitness and take little account of the biomechanical component of the result.

A. Rationale of the paper

The training process quality depends to a large extent on the range of the information obtained of a different nature. The data of pedagogical parameters of the load, medical and biological component, kinematic and biodynamic features of movement have impact on a level of fitness and the sporting result as the ultimate goal of this process. The most interesting are the performance indicators of athletes (speed, pace, power, etc.) when passing both the entire distance and its sectors. Change in these indicators throughout a distance is a consequence of the load the body receives. Parameters of the cardiovascular system and muscle activity can serve as the basis for these changes.

B. Aims and objectives

Objective of this paper was to study the features of kinematic structure of a stroke movement.

Aims of the research:

1. To identify the kinematic characteristics of kayaking.
2. To determine the model components of the kinematic characteristics of a stroke.
3. To identify changes in techniques of movement against the accumulated fatigue.

C. Research hypotheses

It was assumed that the determination of the kayaking model characteristics would help optimizing the means and methods of training rational techniques. Identification of a nature of the change in techniques of movement against the fatigue will promote selecting the means for correcting the training process.

D. Research areas

The research areas were biomechanical features of the kayaking stroke movement.

E. Definition of terms:

As a result of testing paddlers, the following parameters were determined:

Speed – speed of covering a distance (m/s).

Power – power of each stroke developed by a paddler (Watt).

Pace – number of strokes per one minute (str./min).

Total time of stroke – duration of one stroke (s).

Time of stroke support phase – duration of a paddle presence in water given one stroke (s).

Time of stroke airborne phase – duration of a paddle presence in the air given one stroke (s).

Length of boat run in one stroke – distance covered by a boat in one stroke (m).

Length of stroke support phase run – distance covered by a boat during a stroke support phase (m).

Length of stroke airborne phase run – distance covered by a boat during a stroke airborne phase (m).

II. RESEARCH METHODOLOGY AND RESEARCH ORGANIZATION

A. Research methodology

Movement video analysis system was used as the main method of research.

B. Research group and samples

Seven (7) highly-qualified kayak paddlers took part in the research.

C. Means of data collection and devices used

Video analysis of movements was carried out using:

1. Speed camera.
2. Software of data video capture by method of tracing articular centers using and not using tracers.
3. Calculation of movement data (position, path, speed, acceleration, etc.).

D. Exploration experiment:

The explorations were conducted at the Physical Culture and Sport Laboratory of Francisk Skorina Gomel State University. The explorations were carried out within the framework of the State Scientific Research Program of the Republic of Belarus “Convergence – 2020”.

E. Main experiment:

The speed of a kayak throughout a distance is the key parameter. One can evaluate activity of a paddler and a level of his/her fitness by the speed of a boat running and its variation in each cycle of stroke movements. When a high average speed is reached and in the course of a distance it hardly changes, it is considered the best running of a boat. In this case, the average speed approaches the maximum one. Figure 1 shows that the maximum speed is achieved in the first half of a distance, especially at the first two hundred meters. In the second half of the distance, due to the arrived fatigue, there is a significant decrease in speed, which at a sector of 600 meters is 96.7% of the average speed. And only at the very end of the distance, thanks to the final acceleration, the speed of the kayak is approaching the average speed throughout the distance.

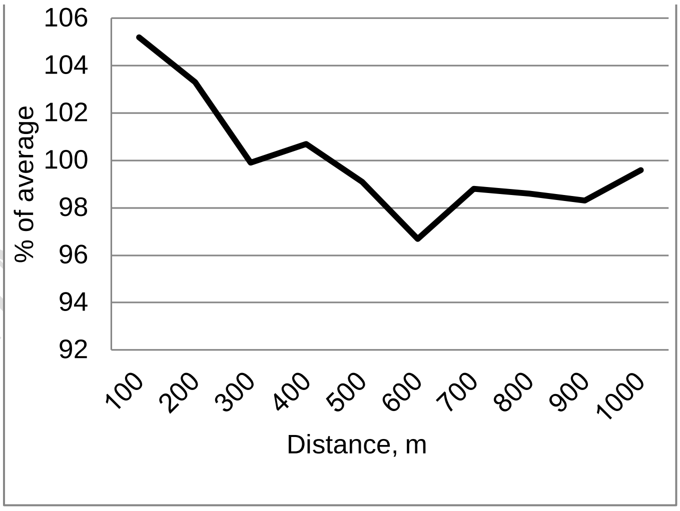

Figure 1. Change of speed at a distance of 1,000 m

Considerable attention in cyclic kind of sports is given to the pace of activity movements. The kayaking pace can be an indicator of both technical competence and functional fitness of athletes.

The earlier researches resulted in determination of the relation of movement pace along with qualification of athletes and a level of their technical skills with the ability to alternate tension and relaxation of muscles [10]. Also, the inverse dependence of the pace on the kayaking technique indicators was revealed.

The pace magnitude and dynamics throughout a distance is determined by individual qualities of paddlers and their tactics. In general, paddlers who take high places in various competitions, pass the second half of a race at a slower pace than the first one. Figure 2 shows that the first half of the distance is covered with a significant excess of the average pace, while in the second half at a sector of 600 meters there is a sharp drop to 94.7%. Then there is a gradual increase to an average pace at 800 meters and again a drop to 96.6%

at a sector of 900 meters. As a result of the final acceleration, the pace again rises. But as a result of this increase (the pace in the last 100 meters exceeds the average by 1.3%) the average speed of the boat is not achieved. In our opinion, this is due to the fact that at the end of the distance there is fatigue and at the same time the pace increases. This leads to violation of the most optimal structure of stroke movements and deterioration of other parameters of the stroke.

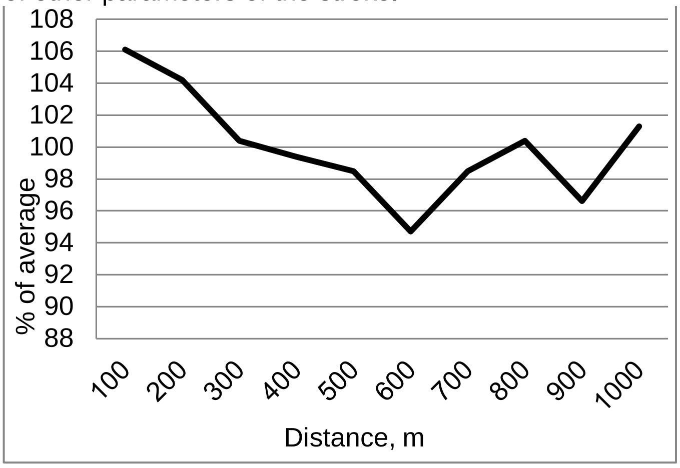

Figure 2. Change of pace at a distance of 1,000 m

Figure 3 shows the simultaneous change of pace and speed at a distance of 1,000 meters. The most illustrative is sector of 700-800 meters, where the speed decreased from 98.8% to 98.6%, while the pace increased from 98.5% to 100.4% of the average one. On that basis, it can be concluded that with increasing the pace at this sector other parameters suffered significantly, that led to the decrease in speed.

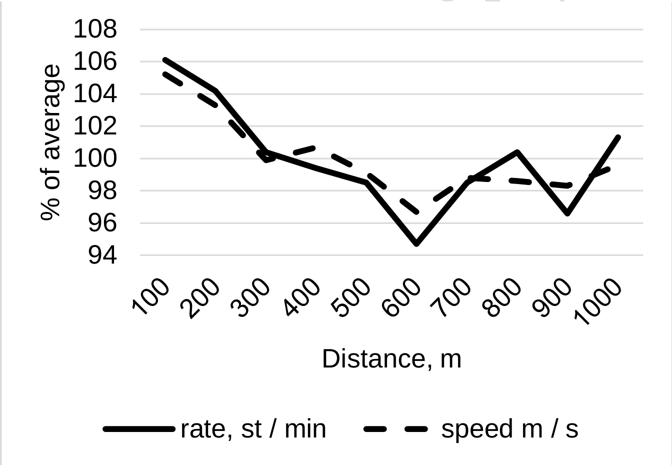

Figure 3. Change of pace and speed at a distance of 1,000 m

The power developed by paddlers throughout a distance is also one of the basic stroke parameters. This parameter characterizes the strength endurance which is one of the leading qualities of a paddler. Figure 4 shows the change in power at a distance of 1,000 m. Its maximum value is observed at the first 100 meters of the distance and exceeds the average one by 12.7% (this is the biggest change from all parameters and is explained by the high starting power). A gradual decrease of power occurs up to a sector of 700 meters. From 800 meters there is an increase to 100.8%, and then the maximum drop to 93.2% at a sector of 900 meters. It can be assumed that the sharp drop in power was due to the final acceleration which is performed from 700 meters to the finish line, as a result of which there is often not enough strength and at a sector of 900 meters there is a drop in power, pace and speed.

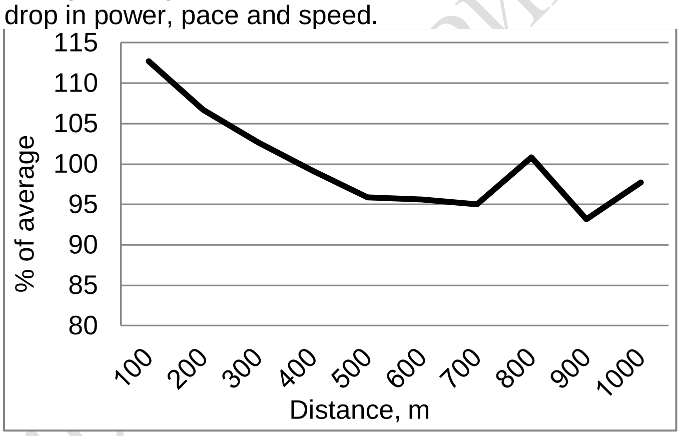

Figure 4. Change of power (Watt) at a distance of 1,000 m

Figure 5 illustrates the change in power and speed at a distance of 1,000 meters. As it was already said, at a sector of 700-900 meters there are sharp fluctuations in the power 95% - 100.8% - 93.2%, while the speed here varies slightly with gradual drop 98.8% - 98.6% - 98, 3%.

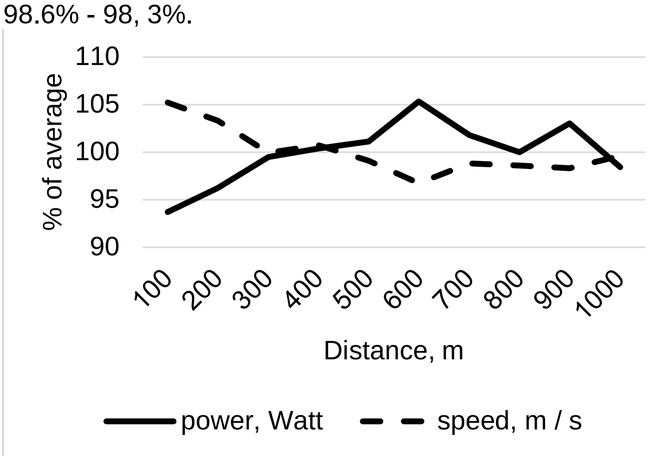

Figure 5. Change of power and speed at a distance of 1,000 m

Figure 6 shows the change in pace, speed and power at a sector of 700-800 meters. As can be seen from the figure, the increase in pace and power at a sector of 700-800 meters not only does not lead to the increase in speed, but it even falls, albeit insignificantly.

Therefore, one can say with confidence that there are other parameters that determine the speed at this sector.

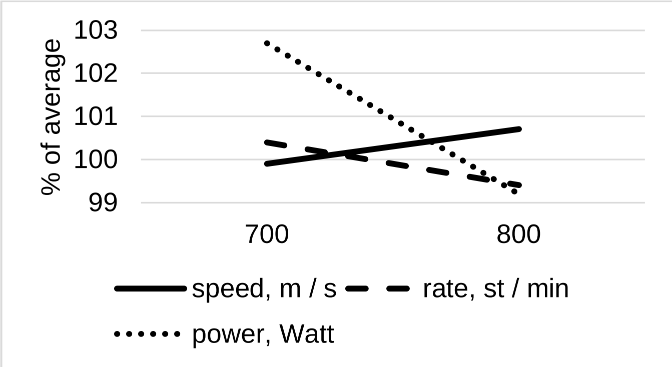

Figure 6. Change of pace, speed and power at a sector of 700-800 meters at a distance of 1,000 m

Figure 7 shows the change in the total time of a stroke throughout a distance of 1,000 meters. As you know, a stroke from one side consists of support and airborne phases. This parameter characterizes the duration of one stroke, i.e. support and airborne phases together.

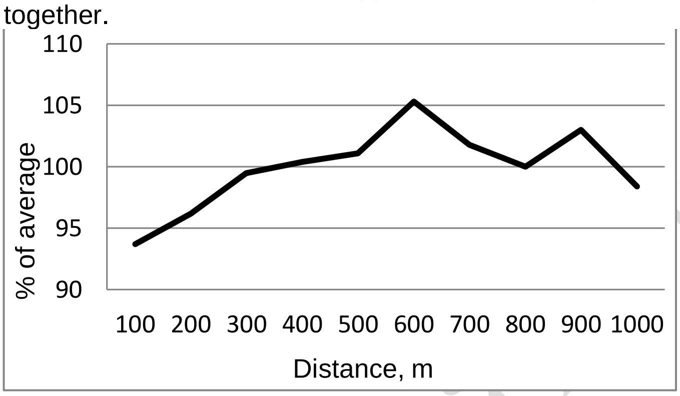

Figure 7. Change of total time of stroke at a distance of 1,000 m

Total time of a stroke and pace are two interdependent parameters, since the pace characterizes the number of strokes over time, while the total time of the stroke is the time of these very strokes. This is clearly seen in Figure 8.

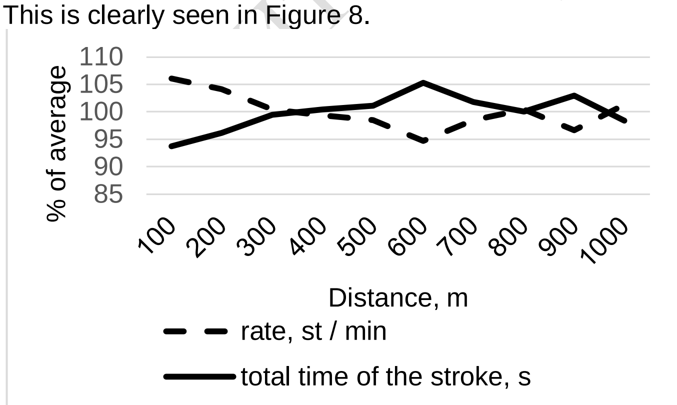

Figure 8. Change of pace and total time of stroke at a distance of 1,000 m

As can be seen from Figure 9, the shortest stroke time is observed at the first 100 meters of the distance (93.7%), where the maximum values of speed (105.2%) is also recorded. And the longest stroke time is at a sector of 600 meters (105.3%), where the lowest values of speed (96.7%) are noted. Here it is hard to escape the conclusion: the shorter time of the stroke, the faster speed, and vice versa. This is most clearly seen at sectors of 100-300, 500-700 and 900-1000 meters, where a sharp drop in one parameter causes an increase in the other, and vice versa. But with a closer look it can be seen that at a sector of 300-400 meters the first and the second parameters simultaneously increase, while at a sector of 700-800 meters they simultaneously fall. Consequently, the shortest stroke time will not contribute to the highest speed. It also becomes more interesting owing to what parameter the speed at a sector of 300-400 meters increases, if the pace and power drops and the total time of the stroke increases, which also negatively affects the speed.

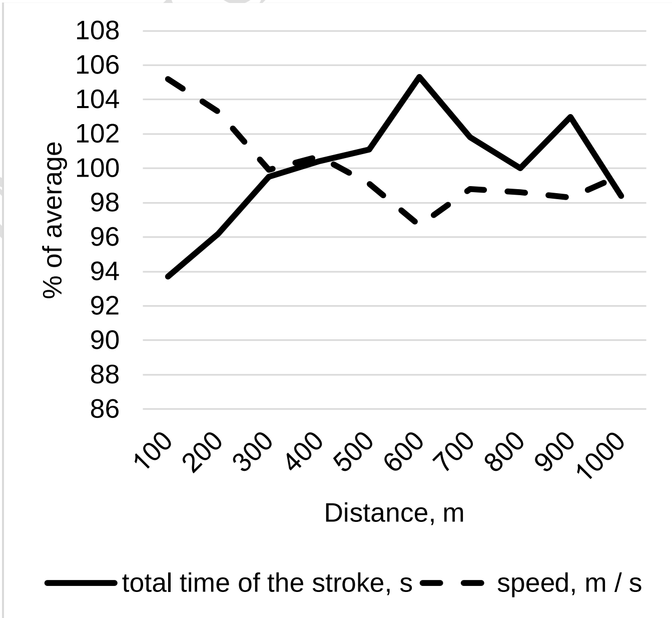

Figure 9. Change of total time of stroke and speed at a distance of 1,000 m

Parameters of the support and airborne phases were studied for a more detailed presentation of the total time of a stroke.

Time of stroke support phase (Figure 10) is non-constant throughout a distance and varies considerably. The largest changes occur at sectors of 200-300 meters, where the increase in the time of stroke support phase reaches more than 6%, and at 600-700 meters, where its decrease reaches 8.6% of the average value at the distance.

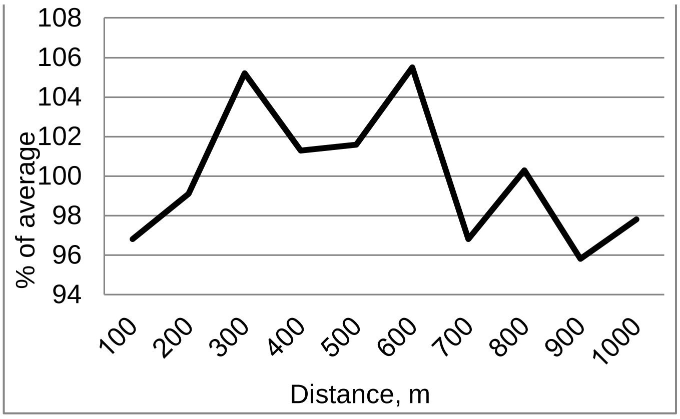

Figure 10. Change of stroke support phase time at a distance of 1,000 m

If we assume that the time of stroke support phase is a part of the total time of the stroke, which depends on the pace, it can be assumed that the stroke support phase time also depends on the pace. At a sector of 200-300 meters, where there is the increase in the stroke support phase time by 6.1%, the pace is reduced by 3.8%. At a sector of 600-700 meters, the stroke support phase time decreases and the pace increases by 3.8%. At the same sectors of 300-400 and 700-800 meters, the stroke support phase time and the pace simultaneously decreases (300-400 meters) and simultaneous increases (700-800 meters). Consequently, the dependence of the stroke support phase time on the pace is less or absent completely (Figure 11).

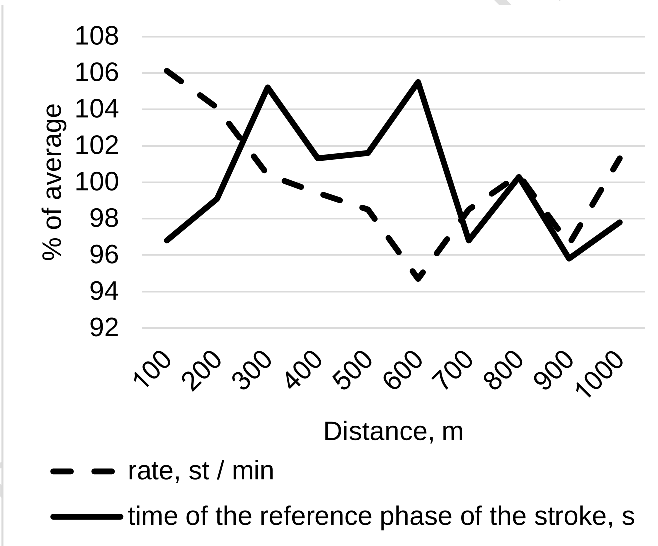

Figure 11. Change of stroke support phase time and pace at a distance of 1,000 m

Time of stroke airborne phase (Figure 12) is without significant fluctuations from the very start and gradually increases to a sector of 700 meters. This characterizes the dynamics of the change in power throughout the distance.

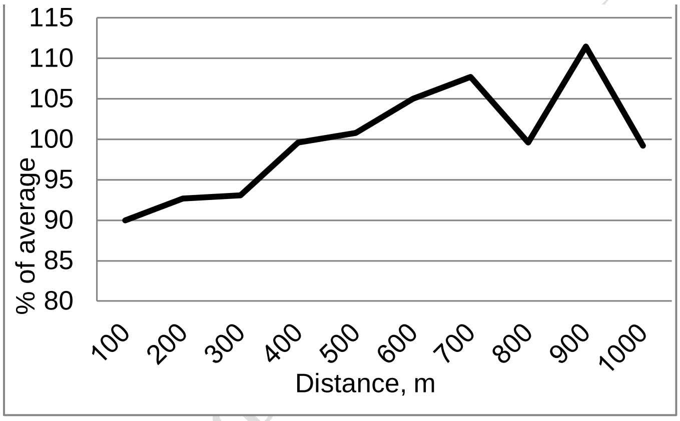

Figure 12. Change of stroke airborne phase time at a distance of 1,000 m

Indeed, with decrease in power the time of stroke airborne phase increases, and vice versa (Figure 13).

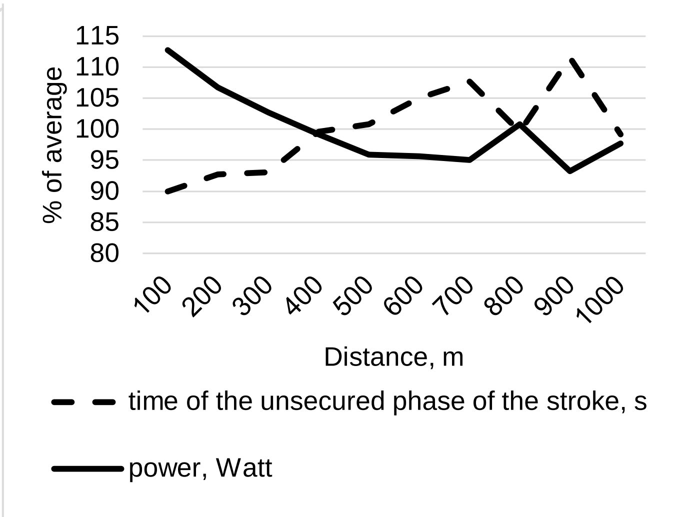

Figure 13. Change of stroke airborne phase time and power at a distance of 1,000 m

Length of run is one of the key parameters characterizing the distance covered by a boat in one stroke.

It can be seen from Figure 14 that this parameter varies insignificantly throughout the entire distance and the range of its variation is 3.3% of the average value throughout the distance. This indicates a certain stability of this indicator.

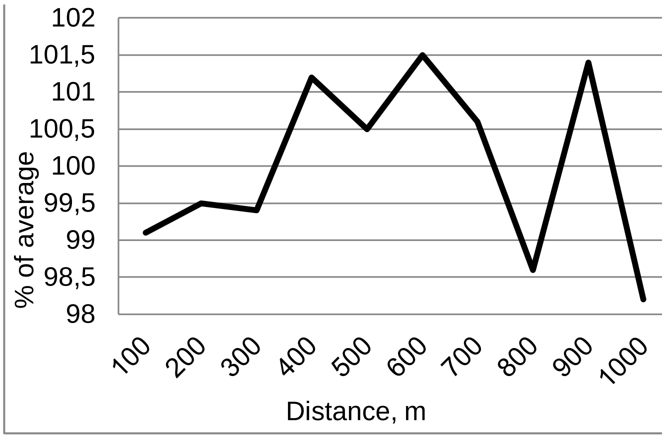

Figure 14. Change of boat run length in one stroke at a distance of 1,000 m

In our opinion, this stability is achieved owing to the fact that the length of boat run depends on the kayaking power and pace, i.e., the increase in power should also cause the increase in the length of run owing to the increase in the boat speed. But the increase in power also causes the increase in the pace, which leads to the reduction of the stroke time; as a result, the length of run changes insignificantly. When the power decreases, the pace decreases too, the stroke time increases, the speed decreases; as a result, there are no significant changes in the boat run length.

From the above it may be concluded that generally the increase in power leads to the decrease in the boat run length (Figure 15), while the decrease in the pace leads to the increase in the stroke time and the boat run length in one stroke, and vice versa (Figure 16).

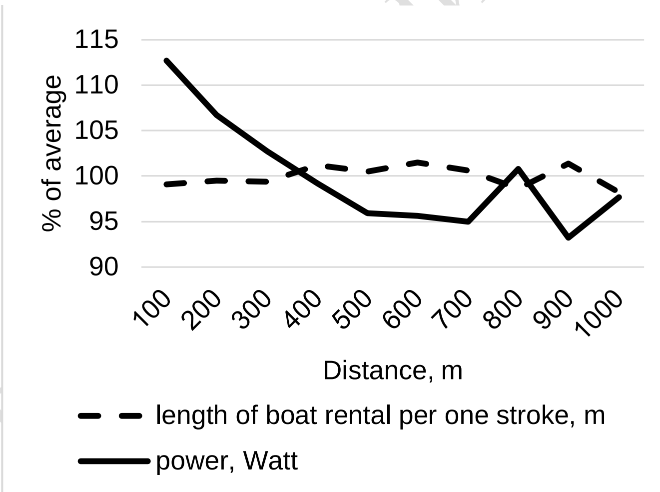

Figure 15. Change of boat run length in one stroke and pace at a distance of 1,000 m

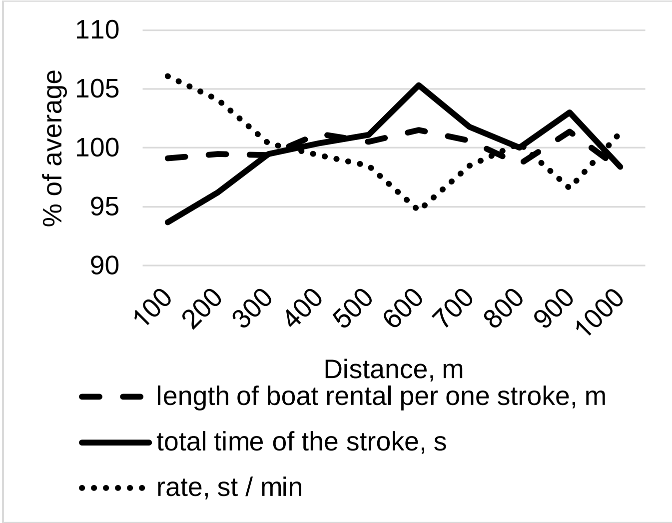

Figure 16. Change of boat run length in one stroke, total time of stroke and pace at a distance of 1,000 m

Length of boat run during the support phase characterizes, first of all, the efficient performance of the stroke itself, which depends on the efforts expended and the speed developed in doing so. As we can see from Figure 17, the boat run length during the support phase varies more significantly than the boat run length in one stroke, and its range is 10.4% of the average value throughout the distance. These fluctuations depend on both the change in power and pace throughout the distance and the change in the contribution of the support or airborne phases to the total length of the run.

The largest values of the boat run length during the support phase are observed in the first half of the distance, where its values exceed the average ones. In our opinion, this is due to the fact that these sectors have high values of power. But the first half of the distance is also passed owing to more efficient performance of the stroke itself, and in the second half of the distance owing to the fatigue developed the efficiency of this stroke is reduced, which proves the decrease in the average values of the boat run length during the support phase in the second half of the distance.

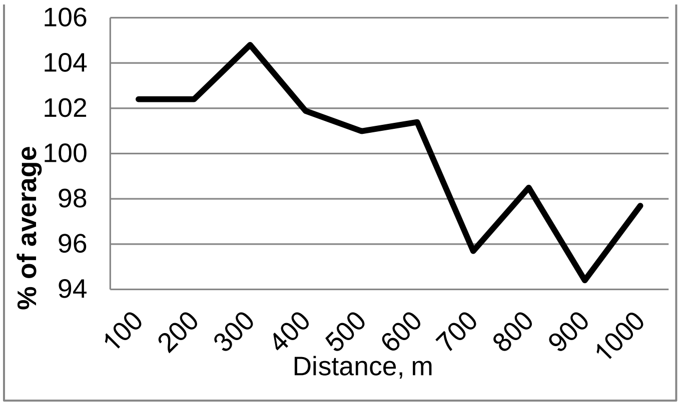

Figure 17. Change of boat run length during stroke support phase at a distance of 1,000 m

Length of boat run during the airborne phase (Figure 18) is also of great importance, since it is characterized by airborne position of a paddle, where the amount of energy expended by a paddler is much less than in the support phase. Hence, the larger the distance the boat will cover in this period of time, the less efforts the paddler will spend in subsequent work. The boat run length during the airborne phase depends, first of all, on the stroke performance in the support phase, where the necessary speed is given to the boat, which is lost in the airborne position. The run length during the airborne phase also depends on time given to this phase: the longer time and speed, the larger distance covered. But increasing the airborne phase time will certainly lead to the decrease in speed, since during this period only its decrease occurs. So, on the one hand, the increase of the boat run length during the airborne phase leads to a more economical expenditure of forces, while, on the other hand, leads to the decrease in speed. Consequently, it is necessary to find the best combination of the support and airborne phases of a stroke over time, which will reduce the amount of energy expended and will not lead to a significant drop in speed.

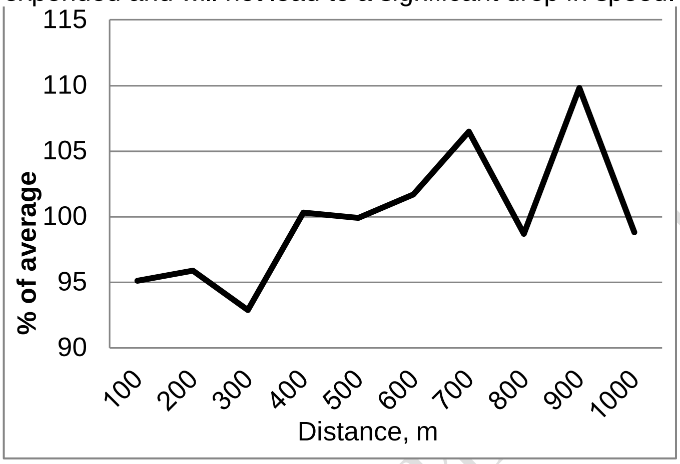

Figure 18. Change of boat run length during stroke airborne phase at a distance of 1,000 m

B. Conclusions:

1. The revealed kinematic characteristics of kayaking stroke allowed determining the model characteristics of the movement.
2. Based on the analysis, the most informative are sectors of 300 - 400 and 700 - 800 meters of a distance.
3. The drop in pace causes the increase in the total time of stroke, and because of the reduction in power, the time of the support phase decreases. These two factors result in the significant increase of the airborne phase time.
4. Along with the total time of stroke, the total length of run in one stroke increases too, and the length of run during the support phase decreases, which leads to a considerable increase in the length of the boat run during the airborne phase.
5. Throughout a distance the accumulated fatigue affects the trajectory of the movement of the body units and the relationship between the kayaking kinematic parameters against each other.

C. Recommendations

The carried our researches have allowed determining several recommendations:

1. To improve the training process management, it is necessary to identify the model characteristics of kayaking techniques at different distances.
2. Using the interrelation of different kinematic indicators of a stroke will help to find a rational structure of movements during a competitive race.
3. Ability of a paddler in each stroke cycle to alternate the tension of muscles during the support phase with their relaxation in the airborne phase is very important for the preservation of his/her performance throughout a distance. The increase of rest time in the stroke airborne phase leads to later fatigue.

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