THEORY AND METHODS OF SPORT

Simulation of the technique of pedaling of cyclists on the basis of visual control of the correspondence of the rhythm of angular movements in the links of a kinematic chain

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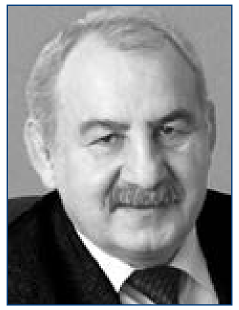

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Abstract

Objective of the study was to substantiate the possibility of correcting the movements of the links of the kinematic chain of the motor apparatus of cyclists when performing the technique of circular pedaling based on visual control over the compliance of the realized movement with the ideal model of the power graph.

Methods and structure of the study. The work was carried out in the laboratory of ergonomic biomechanics of the Adyghe State University, 19 cyclists of the first category and CMS took part. Athletes were asked to demonstrate the technique of circular pedaling on the WATTBIKE bicycle ergometer, which allows real-time visualization of the power graph. At the same time, based on the results of visual control of the power graph, the athlete can make corrections to the technique of the performed action and control its quality.

Results and conclusions. The stability of the manifestation of the rhythm of angular movements in the knee and hip joints is manifested in all methods of pedaling and is typical for all subjects. When pedaling in accordance with the visual comparison of one's own movements with the power graph model, the rhythm of angular movements in the knee and hip joints increases due to a decrease in the time spent on the implementation of one cycle of pedal rotation, as well as a decrease in the magnitude of angular movements in the knee and hip joints, correction of rhythmic structures of implementation of angular movements in the ankle joint and in the best athletes - correction of the spatial structure of the rhythm.

Keywords: *pedaling technique of cyclists, angular movements in the knee, ankle and hip joints, time of angular movements, kinematic chains, rhythmic cycle.*

Introduction. The pedaling technique is a cyclic order of angular movements in the kinematic chains of the cyclist's motor apparatus, which ensure the rotation of the pedal crank. The cycle is based on a rhythmic sequence of actions that ensure the implementation of one revolution of the pedal crank. The content of a single cycle of actions can be conditionally divided into four phases:

1) pushing the pedal;
2) pedal press;
3) summing up the pedal;
4) pulling up the pedal.

However, all these phases are not always used by cyclists to influence the pedal. So, in a study (Martin Hillebrecht, Ansgar Schwirtz, Björn Stapelfeldt, Wolfgang Stockhausen, Martin Bührle, 1998) it is shown that even highly skilled riders do not act on the pedal after passing the crank angle of 200 degrees in the direction of travel, the magnitude of the pedal force is reduced to a minimum or has completely negative values, which indicates that the racer uses this phase as a pause to prepare for the implementation of the future effort [3]. In this regard, a dilemma arises when determining the content of training at various stages of sports improvement: one should develop the ability to show efforts in all phases of the rhythmic cycle of pedaling, or it is necessary to develop the quality of implementation in those phases where more favorable biomechanical conditions are noted for realizing the potential of the kinematic chain of an athlete.

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Methods and structure of the study. The work was carried out in the laboratory of ergonomic biomechanics of the Adyghe State University, 19 cyclists of the first category and CMS took part. Athletes were asked to demonstrate the technique of circular pedaling on the WATTBIKE bicycle ergometer, which allows real-time visualization of the power graph. At the same time, based on the results of visual control of the power graph, the athlete can make corrections to the technique of the performed action and control its quality.

Pedaling quality is assessed in the form of a polar power graph, which reflects the impact of the kinematic system of the athlete's motor apparatus on the pedal in one pedaling cycle (moving the pedal crank by 360 degrees). In accordance with the method of recording the power graph on the WATTBIKE exercise bike, its shape, close to the figure eight, characterizes the discrete way of pedaling, and the shape of the power graph, close to the circle, characterizes the continuous way of implementing the analyzed motor action [2]. During the experiment, the subjects were asked to demonstrate the technique of circular pedaling in an arbitrary form and the technique of performing the same action while visualizing the power graph. It was assumed that the biomechanical and qualitative results of the implementation of the technique would have significant differences.

The subject made two attempts. In the first one, the task was to demonstrate the technique of arbitrary circular dominance, and in the second, the technique of circular pedaling corresponding to the power graph. All attempts were filmed on two video cameras, and the resulting video sequence was processed on the basis of the Ortho_3D software from Biosoft, a three-dimensional model of pedaling technique was created [1].

Results of the study and their discussion. The study of graphic trajectories of angular movements in the hip and knee joints in the process of transition from voluntary pedaling to the implementation of movement in accordance with the power graph made it possible to establish that the manifestation of rhythm during flexion and extension in the hip and knee joints is characteristic of all subjects with all methods of pedaling. That is, the dynamics of angular displacements in the knee and hip joints is characterized by the repetition of the same kinematic parameters of movement at regular intervals (Figure 1).

Comparison of graphic trajectories of changes in angular movements in 87% of the subjects allows us to establish that when switching from voluntary pedaling to pedaling according to the power graph, the rhythm of angular movements increases. The basic unit of the rhythm of angular movements in the joints is the rhythmic cycle, which includes one flexion and one extension. During the same time (Fig. 1), when pedaling arbitrarily, the athlete performs seven rhythmic cycles, and when pedaling according to the power graph, already nine. In addition, an increase in the rhythm of angular movements was observed during the transition from voluntary pedaling to the construction of movement according to the power graph (see Fig. 1, 2), and a decrease in the amplitude of angular movements also occurred.

Thus, it has been established that during the

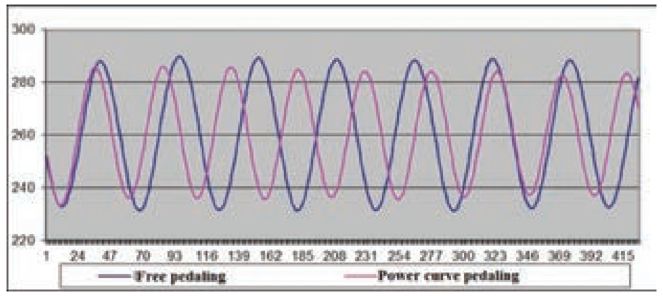

Figure 1. *Dynamics of angular displacements in the knee joint during voluntary pedaling and performing a motor action according to the power graph*

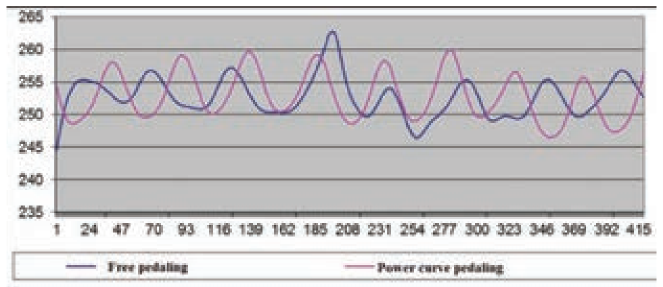

Figure 2. *Dynamics of angular movements in the ankle joint during voluntary pedaling and pedaling in accordance with the power graph*

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Table 1. *Parameters of angular movements in the hip joint during the implementation of arbitrary circular pedaling and pedaling according to the power graph*

Pedaling methods	Angle of flexion in the knee joint, degrees	Angle of extension in the knee joint, degrees	Angular movement in the knee joint, degrees	Implementation time of one cycle, s
Free circular pedaling	71,4 ±4,3	132±5,5	60,6±5,9	0,3±0,03
Power curve pedaling	73,4±4	128±2,7	54,1±5,2	0,28±0,03
Reliability of differences, p	≥0,05	≤0,01	≤0,01	≤0,01

Table 2. *Parameters of changes in angular displacements in the knee joint during the implementation of arbitrary circular pedaling and pedaling according to the power graph.*

Pedaling methods	Angle of flexion in the hip joint, degrees	Angle of extension in the hip joint, degrees	Angular movement in the hip joint, degrees	Implementation time of one cycle, s
Free circular pedaling	107,5±4	146,2±3,7	38,7±2,9	0,31±0,03
Power curve pedaling	109,9±4	144,4±2,7	34,5±3	0,28±0,03
Reliability of differences, p	≤0,05	≥0,05	≤0,01	≤0,01

transition from voluntary pedaling to pedaling according to the power graph, the rhythmic structure of angular movements is preserved, the rhythm of angular movements increases, and the amplitude of angular movements decreases.

The study of the parameters of angular displacements in the hip joint in the process of transition from arbitrary circular pedaling to movement detail when visualizing the power graph model allows us to establish a decrease in the flexion angle in the hip joint,

a decrease in the angular displacement in the hip joint, a decrease in the time required for the implementation of one cycle of pedaling (Table 1).

The study of changes in the spatio-temporal order of angular displacements in the knee joint during the transition from arbitrary circular pedaling to pedaling according to the power graph allows us to establish a decrease in extension in the knee joint, a decrease in angular displacement in the knee joint and a decrease in the time required to implement one movement cycle (Table 1). 2).

The dynamics of the rhythm of angular movements (Fig. 2) during flexion and extension in the ankle joint occurs differently. There is an instability of the parameters of angular displacements, which manifests itself in the instability of the magnitude of angular displacements in cycles and the time boundaries between cycles.

When switching to pedaling according to the power graph, the number of subjects who are characterized by the manifestation of rhythm increases to 20%. Thus, the reproduction of rhythmic cycles of flexion and extension in the ankle joint is not available for this qualification group of athletes. Moreover, the appearance of a visual possibility of comparing one's own movement parameters with an ideal schedule leads to an increase in rhythm.

That is, the insufficient manifestation of rhythm during the implementation of movement in the ankle joint is a consequence of insufficient attention to the formation of the technique for performing this part of the integral movement and, most likely, an increase in its significance only after the athlete learns to use larger muscle groups in an optimal way. Of interest is the fact that the transition to pedaling according to the power graph has little effect on the typical manifestation of the rhythm of flexion and extension in the ankle joint. The number of repetitions of the same parameters of angular displacements at equal time intervals increased by only 20%.

It is possible that the manifestation of the rhythm of flexion and extension in the ankle joint, as an element of the pedaling technique, is the most difficult in terms of implementing sensory corrections based on the visualization of the power graph, since during flexion and extension in the knee and hip joints, the rhythm of angular movements when visually compared with the graph power is increased.

At the same time, among the leading athletes, determined according to the coach's opinion and on the basis of sports results, a more distinct manifestation of the rhythm was revealed. The manifestation of the rhythm of flexion and extension in the ankle joint, which was found in 20% of the subjects, who, according to the coaches, are the leading athletes, determines the need to include in the training means such exercises that provide an idea of the technique of the ankle joint and form it as an important element of the holistic technique. pedaling.

Conclusions. The stability of the manifestation of the rhythm of angular movements in the knee and hip joints is manifested in all methods of pedaling and is typical for all subjects. When switching from voluntary pedaling to pedaling according to the power graph, the rhythm of angular movements in the knee and hip joints increases. The number of rhythmic cycles of angular movements performed by athletes during voluntary pedaling (seven cycles) steadily increases (up to eight) when it becomes possible to visually compare the results of their activity with the power graph model by reducing the time spent on the implementation of one pedal rotation cycle (from 0, 31±0.03 s to 0.28±0.03 s).

When switching from voluntary pedaling to pedaling according to the power graph, there is a decrease in the magnitude of angular displacements in the knee and hip joints, which is characterized by a decrease in the amplitude of flexion and extension in the hip joint, a decrease in the angle of flexion in the hip joint, a decrease in the amplitude of flexion and extension in the knee joint, and a decrease in the angle extension at the knee joint.

Manifestations of the rhythm of angular movement in the ankle joint during voluntary pedaling are not detected. When switching to pedaling in accordance with the power graph, the manifestation of rhythm in the ankle joint is found in 20% of the subjects.

Correction of the rhythmic structure of the implementation of angular movements in the ankle joint includes actions to correct the temporal and spatial structure of the rhythm. All subjects cope with the correction of the temporal structure, and only 20% cope with the correction of the spatial structure of the rhythm.

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