Capabilities of «motion capture» systems in identifying features of cyclists pedaling techniques

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Dr. Hab., Professor **V.P. Sushchenko**[1]
PhD **D.A. Lukashevich**[2]
Master of Education **D.I. Guseynov**[3]
[1]Peter the Great St. Petersburg Polytechnic University, St. Petersburg
[2]«Scientific and Technological Park BNTU «Polytechnic», Minsk, Republic of Belarus
[3]Belarusian State University of Physical Culture, Minsk, Republic of Belarus

Corresponding author: DOCENT-07@mail.ru

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Abstract

Objective of the study was to determination of kinematic parameters characterizing pedaling technique using «motion capture» systems.

Methods and structure of the study. To solve this problem, a pilot study was organized with the participation of 2 athletes who had experience competing at major international cycling competitions. Each athlete performed a test with a progressive increase in power to failure on a bicycle ergometer using a Cyclus 2 bicycle station and a Simi Aktisys motion capture system.

Results and conclusions. Analysis of the obtained video sequences after their computer processing made it possible to identify the most variable biokinematic links in the dynamics of performing a test on a bicycle ergometer with a linearly increasing load (15 W/min). The most pronounced changes were observed for the ankle joint and the position of the torso relative to the horizontal. The results obtained allow us to draw logical conclusions about the possibility of using «motion capture» systems to obtain accurate data characterizing the features of the kinematic parameters of pedaling, without affecting the biomechanical structure of the athlete's movements. The use of new approaches in the study of kinematic characteristics of pedaling will improve the efficiency of monitoring the technical readiness of highly qualified cyclists.

Keywords: *kinematic parameters, motion capture, cycling, pedaling.*

Introduction. Peculiarities of pedaling technique on the road and track at different distances are associated with the need to develop both the maximum and optimal pedaling frequency for each type of race when rotating the pedals, using cranks of different lengths and different gear ratios. But in any type of race, when pedaling, the knee joints must move in strictly vertical and parallel planes [5]. If this requirement is met, a dynamic stereotype is developed, and movements become lighter and freer. A common condition for all cyclists is the expediency and economy of movements and the associated correct alternation of tension and relaxation of individual muscle groups involved in pedaling [1, 2].

Objective of the study was to determination of kinematic parameters characterizing pedaling technique using motion capture systems.

Methods and structure of the study. In assessing pedaling technique, the primary task is to determine the features of the kinematic parameters that characterize it [1]. A pilot study was conducted with the participation of two athletes with experience of performing in major international cycling competitions. Each athlete performed a test with a linearly increasing load to failure on a cycle ergometer using a Cyclus 2 exercise bike and a Simi aktisys motion capture system. The testing procedure included the following steps: installing the athlete's personal bicycle on the exercise bike; 15-minute warm-up on the cycle ergometer; attaching markers (active and passive) to key anatomical landmarks: shoulder joint; ilium of the pelvis; upper thoracic region; lower thoracic region; hip joint; knee joint; ankle joint; little toe joint; bicycle crank; performing a test with a linearly increasing load

(15 W/min) and a regulated pace (n=70 rpm) until failure (the starting load was 120 W).

«Motion capture» was performed in the sagittal plane using an industrial video camera with a data recording frequency of n=100 frames/sec, mounted on a tripod at a distance from the athlete in such a way that the size of the object of study occupied at least 70% of the measurement volume. A marker was attached to each anatomical landmark with double-sided hypoallergenic tape, which was tracked by the motion capture system during pedaling.

Then, minute-long segments of pedaling were isolated from the general video sequence, after analyzing which the following parameters were calculated: values of joint angles (ankle, knee and hip); torso tilt in the sagittal plane relative to the horizontal; angle of rotation of the bicycle crank.

Results of the study and discussion. Identification of the kinematic features of pedaling technique is inextricably linked with rational pedaling technique, which involves effective performance of the motor task mainly due to the main control movements with minimization of auxiliary ones [3]. The presence of auxiliary movements can be the reason for the imperfection of the technical training of the athlete, and also characterize the process of fatigue during the exercise. Therefore, the proposed test on a bicycle ergometer is informative for identifying the most variable biokinematic links, determining the presence of auxiliary movements, their localization, nature and possible causes of occurrence [1, 4]. Based on the results of the analysis of video sequences recorded using the «motion capture» system and their computer processing, the most pronounced changes in the measured joint values in the dynamics of the test task were revealed for the ankle joint and the position of the body relative to the horizontal. In order to clearly reflect the dynamics of the measured values, we constructed graphs reflecting the work for each athlete in the first and last minute of pedaling, and also determined the amplitude of these movements. The analysis of the results allowed us to identify the regular changes in pedaling technique in the last minute of work, which are typical for all athletes, accompanied by high-amplitude auxiliary movements. As an example, the graph of one of the athletes is presented, which reflects the identified patterns (Fig. 1-3).

The graph shown in Fig. 1 shows that the magnitude of the tilt of the trunk and the amplitude of its oscillations by the end of the test task (against the background of fatigue) changes significantly, which characterizes the change in landing and is an indicator of the occurrence of auxiliary movements aimed at stronger pressing of the pedal in the press area with significant involvement of body weight.

In Fig. 2 and 3, the nature and amplitude of vibra-

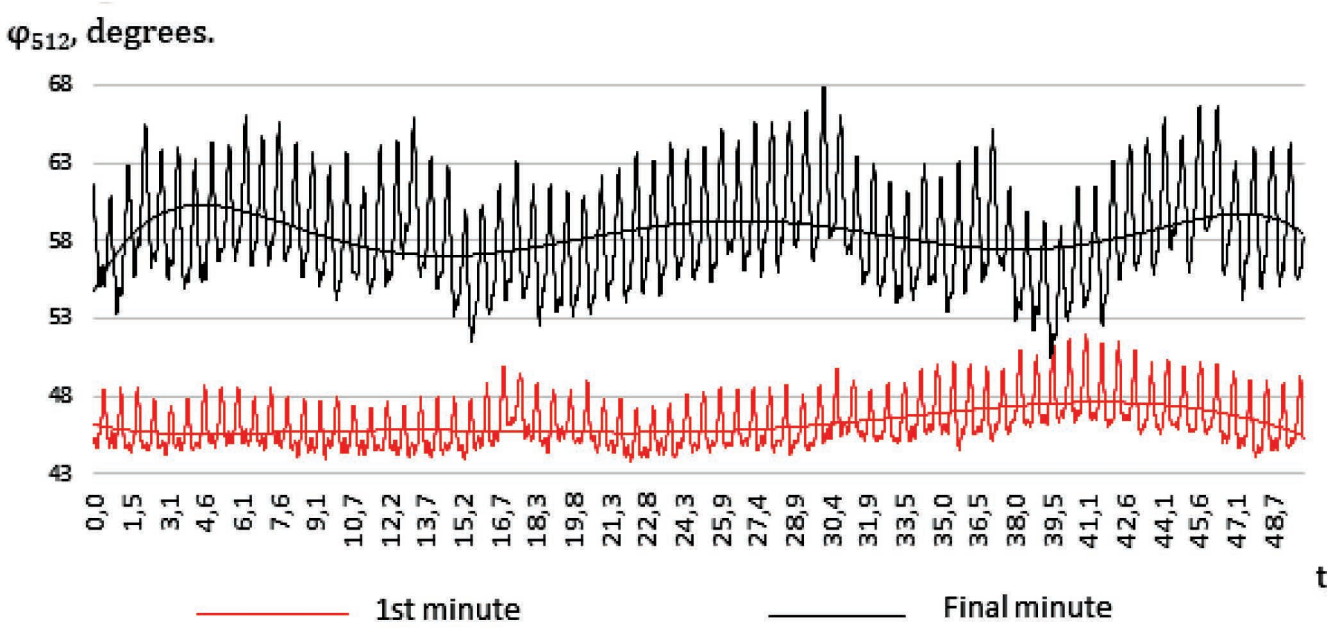

Fig. 1. Dynamics of the angle of inclination of the body relative to the horizontal when performing a load test on a bicycle ergometer

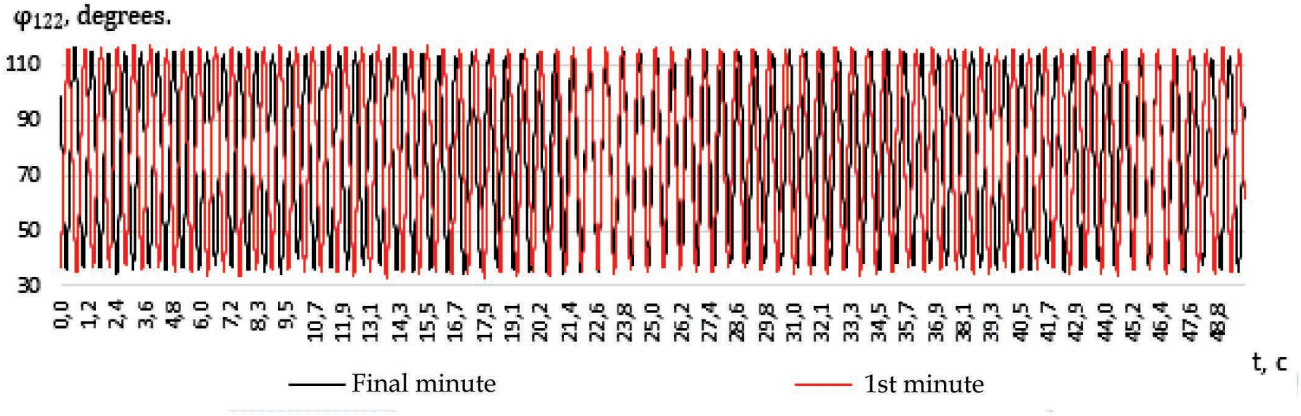

Fig. 2. Dynamics of the angle in the knee joint during the load test on a bicycle ergometer

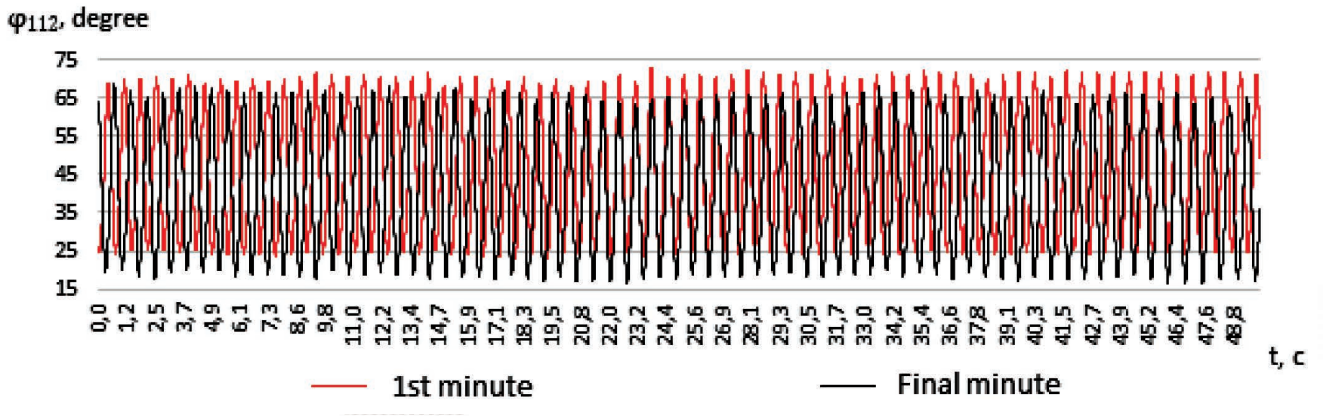

Fig. 3. Dynamics of the angle in the hip joint during the load test on a bicycle ergometer

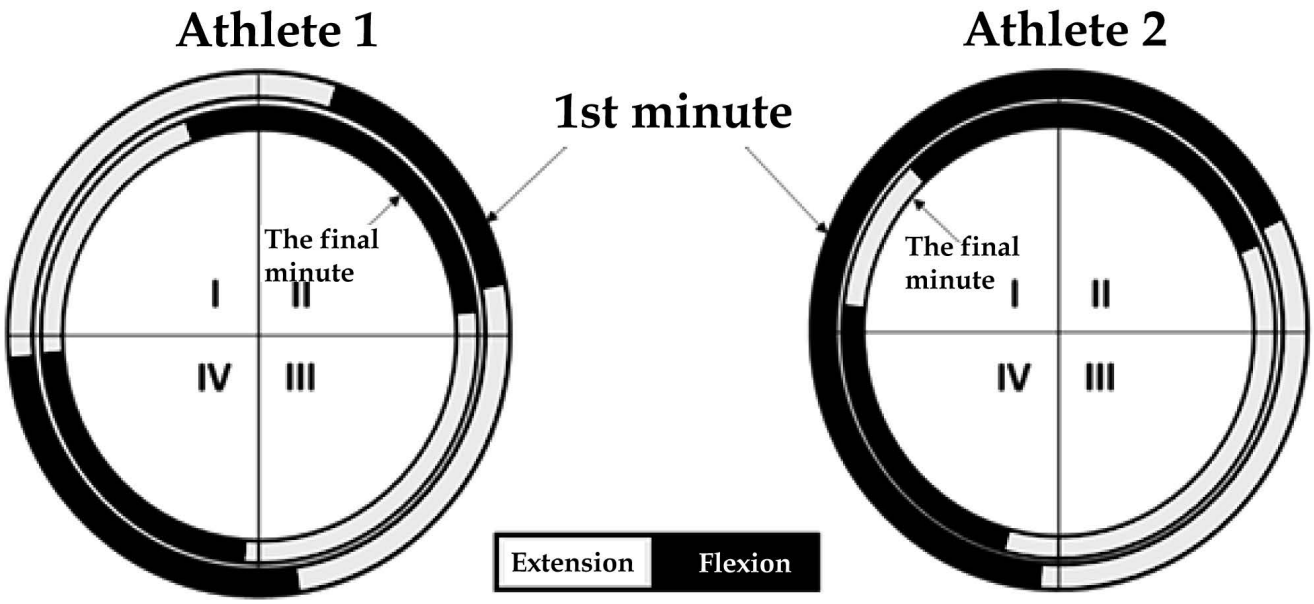

Fig. 4. An annular diagram of the dynamics of flexion-extension of the ankle by pedaling phases in different athletes

tions in the dynamics of pedaling with a change in load did not change significantly, which allows us to conclude about the relative stability of these biokinematic links.

The most variable nature of the work according to the results of the study was revealed for the ankle. When pedaling, the nature of the work may vary significantly. The differences in pedaling stereotypes among different athletes, as well as the high variability of the ankle when performing a test task with an increasing load, are clearly reflected in the ring diagrams shown in Fig. 4.

The key points for constructing the diagram are the boundary positions of the bicycle connecting rod, determined by the change in the nature of the ankle during pedaling in each motor cycle (alternating flexion and extension in the ankle joint in different phases). From the point of view of rational and effective technique, the work of the first athlete is more preferable, since he works effectively with his ankle not only in the pushing phase (III), but also in the pull-up phase (I).

Conclusions. Pedaling on a bicycle ergometer in a test to failure is informative for identifying the most variable biokinematic links, determining the presence of auxiliary movements, their localization and nature. Determination of the kinematic features of the pedaling technique is inextricably linked with a rational pedaling technique, which involves effective performance of the motor task mainly due to the main control movements with minimization of auxiliary ones. The greatest variability in the pedaling process is characterized by movements associated with a change in the angle of inclination of the body relative to the horizontal and the amplitude of ankle movements, which is associated in the first case with a change in the athlete's posture, and in the second - is determined by the established individual motor stereotype. Progress in the study of kinematic characteristics and the development of applied technologies is an important component of the training process of professional cyclists, which allows coaches to improve the methods of monitoring the training process and contributes to an increase in the performance of athletes.

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