Kinematic analysis of swimming technique based on synchronous video recording of linear motion

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Abstract

Objective of the study was to evaluate and select swimming technique models that are most adequate to the swimmer's individual motor predisposition based on the measurement of hydrodynamic parameters and synchronous video recording of linear movement.

Methods and structure of the study. The application of methods for fixing the kinematic and dynamic structures of the swimmer's movements is considered on the example of the swimming technique of the test swimmer-master of sports, specializing in freestyle swimming for medium distances. The registration of variables was carried out by means of synchronous video recording of the swimmer's underwater movements during linear swimming.

Results and conclusions. As a result of comparison of various technical variants of arm stroke in front crawl swimming, the possibility of using methods of fixing the kinematic and dynamic structures of stroke movements for an individual choice of a swimming technique model, the most adequate individual motor predisposition of the swimmer, has been established. As a personal effective technical option for swimming, an extended arm stroke along an S-shaped trajectory to the hips with the following statistical indicators is proposed: positive inertia force - 275 N; force of negative inertia - 146 N; average speed - 1.64 m/s; standard deviation - 0.12; coefficient of variation - 6.6%; efficiency of swimming technique - 75.4%.

Keywords: *swimming technique, synchronous video recording of swimmer's movements.*

Introduction. When organizing a modern swimmer's training, the technical movements of the body, the features of the work of the arms and legs under water are not available for obvious visualization. For this reason, coaches and athletes do not objectively evaluate the efforts developed by a swimmer to overcome water resistance and achieve the required speed [1, 4].

The stability of speed and power is considered an objective criterion of the reference swimming technique [2, 5]. The more stable the variations in the speed and power of the swimmer's efforts (hands, feet, in coordination) during each stroke, the more perfect his technique [6]. Water resistance depends on speed and acceleration, and the inertia force depends on the power of stroke movements [3, 7].

In this regard, research and fixation of the kinematic and dynamic structures of the swimmer's movements seem to be extremely relevant.

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Methods and structure of the study. The application of methods for fixing the kinematic and dynamic structure of the swimmer's movements is considered on the example of the swimming technique of the test swimmer - a master of sports specializing in freestyle swimming for medium distances.

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Based on the records of speed and acceleration at a 25-meter distance, the parameters of those swimming segments were printed, in which the speed and acceleration of the swimmer did not depend on the increase in speed after repulsion from the pool wall. The survey protocol contained the necessary swimming parameters of an athlete - average speed, standard deviation, coefficient of variation, swimming technique efficiency coefficient (%), variance, achieved percentage of personal maximum speed.

The test subject sought to develop the highest possible average speed for each measurement (swimming with one arm, one leg, in full coordination), so that it was close to or exceeded their competitive speed.

The *standard deviation (m/s)* characterizes the deviation from uniform velocity; it should be as small as possible.

The *coefficient of variation* (%) is the ratio of the average speed to the standard deviation, expressed as a percentage. Due to the large range in each stroke and swimming element, this is a very sensitive indicator of swimming technique. The coefficient of variation should be as small as possible.

Dispersion (m/s). The variation reports the amount of energy required to maintain a constant speed. The higher the dispersion, the more energy the swimmer needs to apply to maintain average speed. This data is especially important for long distance swimmers and should be kept to a minimum.

The effectiveness of swimming technique (%) was calculated based on the work done during swimming. This is the amount of work at constant speed divided by the actual amount of work corresponding to the measured actual variable speed. In each measured element of swimming technique, it should be as close as possible to 100%.

A selected portion of the speed records was printed. This was followed by a synchronous graphic recording of the acceleration, obtained using the velocity correlation. Recording the acceleration provided an opportunity to evaluate the effectiveness of the swimming technique; a smaller spread in terms of acceleration indicated a better swimming technique. The calculation of the positive or negative inertial force, obtained by multiplying the acceleration value at the selected recording point by the swimmer's mass, gives the inertial force value in newtons (N).

A record of a video recording of the athlete's measured swimming technique at the moment of fixing his lowest speed (the most serious mistake in swimming technique) was compiled.

Results of the study and their discussion. The swimmer used various hand stroke techniques in front crawl swimming. The trajectory and length of the stroke by hand were different. In the first variant, the arm stroked in a perpendicular position under the midline of the body; in the second version, the limb moved along the bend closer to the hips; in the third version, the rowing link moved along a shortened trajectory with a powerful stroke at a high frequency of movements. The swimmer used the first version of the stroke technique, starting from the basic training stage. The second and third options were considered to identify the optimal swimming technique, taking into account the athlete's motor predisposition.

Statistical indicators based on a graphical recording of the swimming technique for the assessed section of the freestyle stroke with a perpendicular trajectory under the midline of the body: over a period of 9.16 s; performed 10 stroke cycles by hand; positive acceleration increased six times to 2.8 m/s ; the magnitude of the positive inertia force was 184 N; the magnitude of the force of negative inertia was 186 N; average speed - 1.68 m / s; standard deviation - 0.05; coefficient of variation - 4.7%; efficiency of swimming technique - 78.6%.

Statistical indicators based on a graphical recording of the swimming technique for the assessed section of the stroke with hands along an S-shaped trajectory to the hips: for a period of time 9.16 s; performed 10 stroke cycles by hand; positive acceleration increased seven times to a value of 3.6 m/s ; the magnitude of the positive inertia force was 275 N; the magnitude of the force of negative inertia was 146 N; average speed - 1.64 m / s; standard deviation - 0.12; coefficient of variation - 6.6%; efficiency of swimming technique - 75.4%.

Statistical indicators based on a graphical recording of the swimming technique for the estimated section of stroke with hands along a shortened trajectory with a powerful effort at a high frequency of movements: for a period of time 9.16 s; performed 14 rowing cycles by hand; positive acceleration increased seven times to a value of 3.6 m/s; the magnitude of the positive inertia force was 234 N; the magnitude of the force of negative inertia was 217 N; average speed - 1.56 m / s; standard deviation - 0.20; coefficient of variation - 6.9%; efficiency of swimming technique - 72.3%.

The decrease in speed in the second measured section highlights the fact that the swimmer has not mastered the third stroke. The undesirable increase in the third standard deviation confirms that the new version of the freestyle armstroke is not stable and is worse than in the first two versions of the technique. The coefficient of variation reliably confirms the unstable control of the short stroke technique. The 6.2% decrease in the efficiency of swimming technique in the second attempt is too large. This also confirms that the new stroke technique in the crawl method has not been mastered. Analysis of the video recording shows that the swimmer unevenly changes the length of arm movements.

It can be assumed that after fully mastering the technique of an extended stroke with arms along an S-shaped trajectory to the hips, the athlete will be able to achieve the highest results in crawl swimming for medium distances. Observations from international competitions confirm that the world leaders in freestyle swim with arm strokes in an S-shaped trajectory to the hips.

Based on the low value of the coefficient of variation and the increased percentage of the effectiveness of the swimming technique, it is possible to determine the physical readiness, mental state, functional readiness, the swimmer's ability to minimize hydrodynamic resistance.

Conclusions. The developed software evaluates the controlled technical parameters. In addition to extensive basic measurements, each swimmer, in cooperation with the coach, can solve and objectively evaluate individual individual problems in swimming technique.

The method of measuring speed, evaluated results, the contribution of significant information to improving the efficiency of performances at the main competitive distance will allow athletes to cope with the volume and intensity of the load by improving the swimming technique.

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