

# Biokinematic characteristics of technique of swimming the crawl on the chest of the qualified swimmers with consequences of infantile cerebral paralysis

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**Purpose:** to determine biokinematic characteristics of technique of swimming the crawl on the chest of disabled sportsmen with consequences of infantile cerebral paralysis (ICP).

**Material & Methods:** analysis and synthesis of data of scientific and methodical literature, video filming, computer video analysis, methods of mathematical statistics.

**Results:** materials of the research of biokinematic characteristics of technique of swimming the crawl on the chest of disabled sportsmen with spastic diplegia and hemiparetic form, which are describing features of technique of swimming of disabled persons with consequences of infantile cerebral paralysis, are presented.

**Conclusions:** it is recorded that the received results of the biomechanical analysis of movements of the qualified swimmers expand knowledge of regularities of physical actions of sportsmen with consequences of ICP.

**Keywords:** biokinematic characteristics, technique of swimming, crawl on the chest, spastic diplegia, hemiparetic form, infantile cerebral paralysis.

## Introduction

Swimming is one of the most mass and popular sports among persons with disabilities. This fact is confirmed by high achievements of the Ukrainian swimmers on the international sports arena which more and more draws attention of the society [4; 7]. It is well-known that the sports result in swimming is defined by generally rational biokinematic characteristics which a sportsman is capable to reach in the course of training and competitive activity [8; 9]. Despite of the significant amount of scientific works concerning training of sportsmen with ICP, the evidence-based data on definition of biokinematic characteristics of technique of sports ways of swimming of such special group of people as sportsmen with consequences of ICP were not revealed in the available to us scientifically-methodical literature.

Taking into account the aforesaid, this problem acquires the extreme relevance in sports training of swimmers with ICP. All this became an incitement for carrying out by us the research in this direction.

### Communication of the research with scientific programs, plans, subjects

The research is carried out within the subject 1.4 "Theoretic-methodical principles of the development of sport of disabled persons" of the Built plan of the research work in the sphere of physical culture and sport for 2011–2015 according to the Order No. 4525 of 20.12.2010 of the Ministry of Ukraine of family, youth and sport (number of the state registration is 0111U006470).

### The purpose of the research:

to determine biokinematic characteristics of technique of swimming the crawl on the chest of disabled sportsmen with consequences of infantile cerebral paralysis of different forms.

We put the following *tasks of the research* for the achievement of the purpose:

- 1) to find biokinematic characteristics of technique of swimming the crawl on the chest of sportsmen with spastic diplegia and with hemiparetic form of ICP;
- 2) to compare certain characteristics of technique of labor movements in the course of swimming the crawl on the chest of sportsmen with consequences of ICP.

## Material and Methods of the research

We used the following methods of the scientific research for the solution of the put tasks: analysis and synthesis of data of scientifically-methodical literature, video filming, computer video analysis, methods of mathematical statistics.

We used video filming in the frontal and sagittal planes by means of two video cameras (Gopro HERO 3 + Silver Edition) for the quantitative assessment of indicators of motor actions of sportsmen. The received results were processed and analyzed by means of the computer program Kinovea®.

12 sportsmen with consequences of infantile cerebral paralysis of the level of sports qualification of the master of sports and candidate for the master of sports which belong to the class S7-S10 according to the classification norms and requirements of the Unified sports classification of Ukraine took part in the research.

### Results of the research and their discussion

As a result of the analysis of scientifically-methodical literature [1; 2; 6; 8; 10], we established, that it is necessary to consider the main functional and biomechanical features of human body that define the structure, kinematics and dynamics of the executed swimming movements, especially swimmers with disabilities when forming the rational technique of sports ways of swimming. Therefore it was defined and characterized the main types of motive violations depending on features of assimilation of motor actions according to the forms of ICP in our previous researches [3].

We defined such biokinematic characteristics on the basis of these statements at sportsmen with consequences of ICP during swimming the crawl on the chest: 1) postural pose of a swimmer in water: angle of attack, trunk angle of rotation around longitudinal axis; 2) situation and work of hands of a swimmer: angles of bending of the main joints and their movement; 3) situation and work of feet of a swimmer: angles of bending of the main joints and their movement; 4) integrated characteristics: cycle time, step, speed and the relation of these characteristics at the constant speed of a swimmer.

We generalized and presented the obtained data of the video analysis in tables 1–4. They characterize the main features of technique of swimming the crawl on the chest of sportsmen with consequences of ICP depending on its forms.

It was revealed by us by means of the computer video analysis what the postural pose is not streamline at sportsmen with consequences of ICP in the course of swimming the crawl on the chest, therefore the front resistance is increased. As the data of table 1 testify, the angle of attack at swimmers with spastic diplegia averages  $13,5 \pm 0,62^\circ$ . It is the consequence of bigger immersion of their lower extremities in water. This indicator is smaller for 13% and fluctuates ranging from  $8^\circ$  till  $15^\circ$  for swimmers with the hemiparetic form. The trunk carries out the fluctuation around longitudinal axis of body. The greatest angle of rotation  $46^\circ$  is recorded at swimmers with the hemiparetic form which is consequence of defeat of one side of body. The main driving planes of the swimmer are a hand and a forearm [5]. Therefore we measured the angle of attack of a hand and the angle of bending of an elbow joint (tab. 2).

The limited use of the struck side of body that results in asymmetry in the method of execution of rowing movements by arms and blows by legs is observed at swimmers with consequences of ICP. The constant spasticity of muscles of the struck party is characteristic for sportsmen with consequences of ICP, therefore contractures and numbers of motive restrictions appear. As a result, the range of a stroke by the affected hand is small; difficulties of maintenance of a hand in static position and its bringing over water exist.

The work of hands of swimmers with spastic diplegia is much more productive, than the work of hands of swimmers with the hemiparetic form of ICP. For example, the comparison of angles of bending of elbow joints at sportsmen with consequences of ICP testifies to the essential difference of these indicators. The difference of their values averages 15,6%. Also differences in indicators of angles of attack of a hand are observed, the recorded value of this characteristic by the affected extremity of swimmers with the hemiparetic form of ICP

exceeds for 26,6%, the similar indicator at sportsmen with spastic diplegia. It is consequence of the existence of constant initial angle in joints of the affected extremities.

The main driving links at the performance by a swimmer of shock foot movements is a foot and a shin. Their arrangement under the optimum angle of bending provides the swimmer's resistance on water. Also it is necessary to notice that the violation of this requirement leads to the increase in a midship section of body, what directly proportional to the counter hydrodynamic resistance to body of the swimmer [5]. Therefore we measured the angle in coxofemoral, knee and talocrural joints. The results of measurements found their display in table 3.

It is noted as a result of processing of the received video records that the healthy leg or less affected carried out the continuous movements which provided advance forward. Blows by the affected legs had the insignificant driving force. All this leads to the problem of horizontal and lateral balances.

The work of legs of swimmers with spastic diplegia is complicated because of the damage of the lower extremities, any foot movements are often almost absent. Therefore the angles of bending of coxofemoral and knee joints is actually invariable, on average  $172,4 \pm 0,98^\circ$  and  $161,3 \pm 1,12^\circ$  respectively. Comparing the value of angle of bending of coxofemoral joint of the affected extremity of sportsmen to the form hemiparetic of ICP and sportsmen with spastic diplegia, we receive that it is bigger for 11%. The difference of average values of angles of bending of knee joint between the above-mentioned forms makes – 20%.

Rate, step and speed of a movement are the important characteristics of technique of swimming. They are the most individual indicators, especially for high-class sportsmen. But these indicators separately do not give the chance to judge the efficiency of technique of the swimmer, rationality of the movements which are carried out by him. The most total characteristic of quality of technique is the step relation to rate at certain constant speed of swimming, and it is applied to the assessment of movements of swimmers with the different level of physical preparedness, any qualification and age. The increase of the relation of step to rate is positive respectively at certain speed of the movement [6; 8; 10]. The results of measurements of these characteristics are presented in table 4.

The step of swimmers with spastic diplegiya makes from 1,6 m till 2,2 m, and swimmers with the hemiparetic form from 1,2 m till 2,1 m. As we see this indicator on average is smaller for 9,7% for the second form. It is explained the fact that upper extremities with the hemiparetic form at sportsmen are more affected. The rate of swimmers of both forms of ICP does not differ significantly, the difference makes only 6,5%. As a result, the relation of step to rate for swimmers with spastic diplegia and for swimmers with the hemiparetic form of ICP averages 0,053 and 0,045 respectively. But, the cycle time at sportsmen with spastic diplegia exceeds the similar indicator of swimmers with the form hemiparetic of ICP on 13,5%.

The receiving data demonstrate to the high specificity of the educational- training process of swimming of sportsmen with consequences of ICP that it is connected with the certain features of their motive violations. Spasm of muscles of extremities, violations of motive and sensitive functions, emergence

**Table 1**

**Biokinematic characteristics of postural pose in water during swimming the crawl on the chest of swimmers with consequences of ICP (n=12)**

| Characteristics   | Form of ICP | Meaning |     | $\bar{X} \pm S_x$ |
|---|-------------|---------|-----|-------------------|
|   |             | min     | max |                   |
| Angle of attack (degree)                                  | SD          | 9       | 17  | 13,5±0,62         |
|   | HF          | 8       | 15  | 11,8±0,64         |
| Trunk angle of rotation around longitudinal axis (degree) | SD          | 29      | 43  | 34,5±1,47         |
|   | HF          | 31      | 46  | 37,3±1,39         |

**Note.** SD – spastic diplegia; HF – hemiparetic form.

**Table 2**

**Biokinematic characteristics of situation and work of hands during swimming the crawl on the chest of swimmers with consequences of ICP (n=12)**

| Characteristics                             | Form of ICP |                    | Meaning |      | $\bar{X} \pm S_x$ |
|---|-------------|--------------------|---------|------|-------------------|
|   |             |                    | min     | max  |                   |
| Angle of bending of an elbow joint (degree) | SD          | R                  | 92      | 136  | 109,3±3,82        |
|   |             | L                  | 88      | 134  | 110,5±4,04        |
|   | HF          | Affected extremity | 82      | 111  | 92,2±2,86         |
|   |             | Health extremity   | 85      | 115  | 98,6±3,40         |
| Angle of attack of a hand (degree)          | SD          | R                  | 12      | 25   | 17,3±1,14         |
|   |             | L                  | 11      | 23   | 17,9±1,12         |
|   | HF          | Affected extremity | 10      | 34   | 23,6±1,85         |
|   |             | Health extremity   | 8       | 30   | 21,1±1,70         |
| Length of a stroke (m)                      | SD          | R                  | 0,80    | 1,06 | 0,97±0,02         |
|   |             | L                  | 0,82    | 1,04 | 0,96±0,02         |
|   | HF          | Affected extremity | 0,58    | 0,99 | 0,83±0,04         |
|   |             | Health extremity   | 0,68    | 1,01 | 0,87±0,02         |

**Note.** SD – spastic diplegia; HF – hemiparetic form; П – right hand; L – the left hand.

**Table 3**

**Biokinematic characteristics of situation and footwork during swimming by crawl on breast of swimmers with consequences of cerebral palsy (n=12)**

| Characteristics                                | Form of ICP |                    | Meaning |     | $\bar{X} \pm S_x$ |
|--|-------------|--------------------|---------|-----|-------------------|
|  |             |                    | min     | max |                   |
| Angle of bending of coxofemoral joint (degree) | SD          |                    | 167     | 177 | 172,4±0,98        |
|  | HF          | Affected extremity | 126     | 170 | 153,1±3,73        |
|  |             | Health extremity   | 135     | 174 | 157,1±4,03        |
| Angle of bending of knee joint                 | SD          |                    | 154     | 166 | 161,3±1,12        |
|  | HF          | Affected extremity | 112     | 145 | 129,1±2,96        |
|  |             | Health extremity   | 114     | 150 | 135,4±3,85        |
| Angle of bending of talocrural joint           | SD          |                    | 131     | 168 | 153,6±2,89        |
|  | HF          | Affected extremity | 121     | 160 | 134,4±3,82        |
|  |             | Health extremity   | 126     | 162 | 141,1±3,40        |

**Note.** SD – spastic diplegia; HF – hemiparetic form.

Table 4

Integrated biokinematic characteristics of swimming by crawl on breast of swimmers with consequences of ICP (n=12)

| Characteristics          | Form of ICP | Meaning |       | $\bar{X} \pm S_x$ |
|--------------------------|-------------|---------|-------|-------------------|
|                          |             | min     | max   |                   |
| Step (m)                 | SD          | 1,6     | 2,2   | 1,76±0,06         |
|                          | HF          | 1,2     | 2,1   | 1,59±0,07         |
| Rate (cycle/min)         | SD          | 31      | 37    | 32,8±0,46         |
|                          | HF          | 32      | 39    | 35,1±0,59         |
| Time of cycle (s)        | SD          | 1,91    | 2,56  | 2,29±0,06         |
|                          | HF          | 1,75    | 2,33  | 1,98±0,04         |
| Relation of step to rate | SD          | 0,048   | 0,057 | 0,053±0,001       |
|                          | HF          | 0,042   | 0,050 | 0,045±0,001       |

**Note.** SD – spastic diplegia; HF – hemiparetic form.

of contractures, increase in muscle tone, decrease in animal force and working capacity in-coordination of movements are characteristic for the swimmers with consequences of ICP. As a result, features of the technique of swimming are the existence of the constant initial angle in joints of extremities, the expressed fluctuations of trunk of rather different planes.

### Conclusions

1. The analysis of scientifically-methodical literature on this subject-matter confirms the lack of the evidence-based data from the research of biokinematic characteristics of the technique of sports ways of swimming of such special group of people as sportsmen with consequences of ICP. The results of the biomechanical analysis of movements of the qualified swimmers expand knowledge of biokinematic regularities of motor actions of sportsmen with consequences of ICP.

2. It was established as a result of carrying out the research that the angle of attack at swimmers with spastic diplegia

is increased and averages  $13,5 \pm 0,62^\circ$ . It is consequence of the bigger immersion of their lower extremities in water therefore the postural pose is not streamline, the front resistance increases. This indicator makes  $11,8 \pm 0,64^\circ$  for swimmers with the hemiparetic form that is smaller on 13% of the above-mentioned similar indicator. The average value of step of swimmers with spastic diplegia made  $1,76 \pm 0,06$  m, this indicator is on average smaller on 9,7% and makes  $1,59 \pm 0,07$  m for sportsmen with the hemiparetic form. The difference of rate of swimmers of both forms of ICP makes only 6,5%. The difference of cycle time at sportsmen-swimmers with consequences of ICP makes 13,5% and makes –  $2,29 \pm 0,06$ s for the form of spastic diplegia,  $1,98 \pm 0,04$ s – for the hemiparetic form.

**Prospects of the subsequent researches in this direction.** It is necessary to consider the received biokinematic characteristics as the theoretical base for the foundation of new rational methods of study of the technique of sports ways of swimming in the subsequent researches.

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