УДК 796.015.134

Yuriy Litvinenko

Modern Approaches to Modelling of Motor Action Technique in High Performance Sport

National University of Physical Education and Sports of Ukraine (Kiev)

Introduction. In most sports, the increase of athletic performance is largely due to the improvement of sport and technical skill [3, 10].

At present this process is closely related to the development and implementation of more effective and efficient models of sports technique into the training process [7, 8]. A method of modelling is widely applied in sports practice for solving this problem.

There are many definitions of the term «modelling» in scientific literature. In its broadest sense, the modelling can be defined as a study of the objects of cognition, which involves the construction and study of models of real objects, processes or phenomena in order to obtain an explanation for these phenomena, as well as to predict the phenomena of interest to the researcher. Currently, a lot of data on the development of models of sports technique is accumulated. However, the question of systematization and generalization of the main trends and approaches of modelling techniques of motor actions, and finding the most popular among them is still attracting the interest of scientists.

The aim of the study was to present the main directions and approaches of modelling of sports technique based on the literature data.

Methods of investigation: To address this goal, we used the method of analysis and generalization of data of specialized scientific and methodological literature and experience of best practice.

Results of investigation and discussion. The data of specialized scientific and methodological literature suggests that at present there is no single classification of modelling approaches. As noted by some experts [1, 2, 6] classification can be carried out by using the characteristics of the models, the nature of the simulated objects, and the application areas of modelling.

For example, the author [6] notes that the simulation may have a mental or material nature, and therefore encourages all kinds of modelling in sport-educational practices to be divided into three main groups: mental ideal-theoretical modelling, material realistic and practical modelling, and aggregation modelling. At the same time, each group consists of appropriate methods of modelling. These methods include: visual modelling (mental images, hypothesis); symbolic modelling (block diagrams, flowcharts, graphs and graphic plans, schedules, biocharts, etc.); mathematical modelling (perform the function of forecasting and calculating the likely parameters of exercises with new properties); prototype modelling (to test hypotheses or theoretical positions); physical modelling (reflection of physical similarity of processes); analogue digital (mixed-mode) modelling (based on the isomorphism of mathematical equations); simulation (the creation of a simulation model in the form of a computer program); computer modelling.

It should be noted also that the most frequently used in practice is modelling of motor actions technique based on a comparative biomechanical analysis of sport movements in athletes of different skills, which involves the use of so-called discriminative features, i.e. those which change regularly with increasing sportsmanship and differ in athletes of different skills [3].

Regardless of the modelling method, the process must be constructed according to the criteria of similarity. It should also be guided by a particular algorithm of modelling. R. Ballreich , W. Baumann, 1996 [1] recommends to divide the modelling process into three main steps: formulation of the problem, development of the model, its evaluation and simulation. In addition, the author notes that for modelling it is necessary to define the concept and form of the model.

However, as shown by the literature data, scientists in the process of their own experimental work use by themselves and recommend to others to use a particular way of modelling, considering it the most effective. Examples of successful use of certain modelling methods are presented below.

For example, in gymnastics when performing a variety of jump elements athlete is subjected to heavy loads that largely responsible for the premature wearing out of interarticular cartilages, one function of which is to reduce the impact. In this regard, the definition of internal loadings in athlete motor system arising at the time of landing, according to K. Gruber, H. Ruder, J. Denoth, K. Schneider, 1998 [4], is one of the important tasks of biomechanical studies. The solution to this problem the authors see in the possibilities of computer

simulation. Their believe that the accuracy of calculations depends on the correctness of construction of the model which represents the athlete's body.

To determine the internal forces acting on the athlete's body at the time of landing, and for the calculation of the model, the authors used a special kind of direct dynamics. This kind of analysis involves the development and introduction of a system of mathematical equations to determine the torques in the joints and the support reaction. The accuracy of the information obtained were determined by comparing and multiple «adjustment» of simulated motion to observed execution of motor actions (Fig. 1).

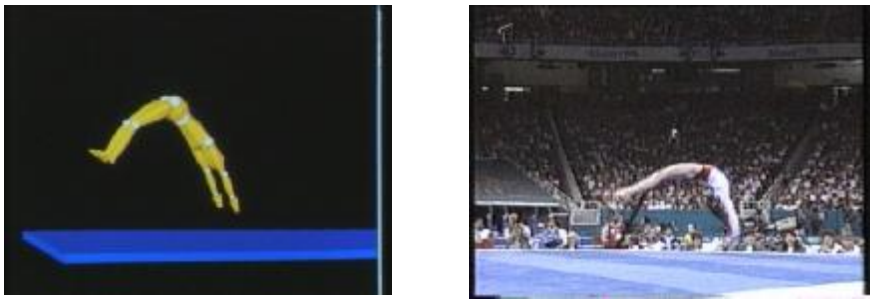

Fig. 1. *Comparison of the model with the real performance of motor actions by gymnast [4]*

According to Khaled M. Zahran, 2003 [5] the use of computer simulation in the practice of athletic training of weightlifters is one of the most promising ways to increase and improve sports equipment. The author notes that the technique of each specific competitive exercise is individual. It is largely determined by the body size and several anthropometric data of athlete, which means that such important biomechanical characteristics of sports technique as the trajectory of the athlete's centre of mass and the bar in the sagittal plane will also be unique. Therefore, the solution of this issue carried out by means of obtaining quantitative indices of competitive exercise performance using optical and optoelectronic registration systems, followed by the computer simulation (Fig. 2).

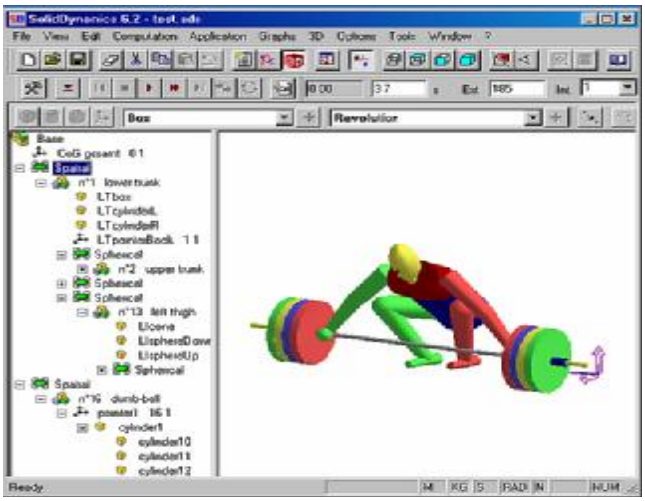

Fig. 2. *Biomechanical model of the «weightlifter-barbell system» [5]*

The authors [9] believed that one of the best ways to describe the technique of motor actions of athlete as an autonomous system is their presentation in the form of a system of differential equations. On the example of gymnastic exercise (back giant) by using the method of optimal control of dynamic systems, namely the method of local variations, the authors presented the most effective technique of the exercise under study.

In the study of race walking technique [3] it was found that the locomotor act may be carried out by the method of repulsion and attraction/repulsion from the support. Justifying an experimental model of race walking technique by the method of attraction/repulsion, the author notes its advantages over other known methods. In particular, there is no braking phase in the motion of the body center of mass in the horizontal component of support reaction when walking by the method of attraction/repulsion (Fig. 3).

A B

Fig. 3. *Vector plot of resultant support reaction when walking by the method of repulsion (A) and attraction/repulsion (B) [3]*

Conclusions. Most researchers have no doubt on the need for modelling of sports technique, in particular technique of physical exercises, in sports training. Modelling method is widely used in sports practice that allows to expand understanding of the phenomenon under study, as well as make adjustments and changes in educational-training process.

Currently, a number of authors proposed various classifications of modelling methods of sports technique. Although there is no unified classification, expert opinion has no contradictions on the subject, but only complement each other.

The literature data revealed that across a variety of different methods of sports technique modelling, some of the most recent and most popular methods are simulation and computer modelling. Their use make it possible to carry out comparative biomechanical analysis with subsequent development of average group, qualification, and individual models of sports technique.

List of the used Literature

1. Ballreich R. Grundlagen der Modellmethode / R. Ballreich, W. Baumann // Grundlagen der Biomechanik des Sports. Probleme, Methoden, Modelle. – Stuttgart : Enke, 1996. – P. 119–159.
2. Bohn C. Biomechanische Untersuchungen des leichtathletischen Laufs oberschenkelamputierter Athleten: Inauguraldissertation zur Erlangung eines Doktors der Philosophie im Fachbereich 05 Psychologie und Sportwissenschaften der Johann-Wolfgang-Goethe-Universit ät zu Frankfurt am Main / C. Bohn. – 2003. – 207 S.
3. Gamalii V. Modelling of motor actions technique in the sport (on example of walking) / V. V. Gamalii // Science in the Olympic Sports. – 2005. – N 2. – P. 108–116.
4. Gruber K. A comparative study of impact dynamics: wobbling mass model versus rigid body models / K. Gruber, H. Ruder, J. Denoth, K. Schneider // Journal of Biomechanics. – 1998. – № 31. – P. 439–444.
5. Khaled M. Zahran Computersimulation zur biomechanischen Diagnose des Gewichthebens: Dissertation zur Erlangung des akademischen Grades des Doctors der Sozialwissenschaften an der Universit ät Konstanz, Fachbereich Geschichte und Soziologie / Khaled M. Zahran. – 2003. – 119 S.
6. Laputin A. N. The gravity training / A. N. Laputin. – K. : Znannia, 1999. – 316 p.
7. PIatonov V. N. Technical preparedness of highly skilled athletes in training process / V. N. PIatonov, A. N. Laputin, M. M. Bulatova // Proceedings of Third Annual Congress of the European College of Sport Science: From Community Health To Elite Sport. 1998. – P. 418.
8. Voronov A. V. Simulation modeling as a method for biomechanical study of human motor actions / A. V. Voronov // Theory and Practice of Physical Culture. – 2004. – N 2. – P. 36–40.
9. Zagrevskii V. I. Technology of the search for the best technique of gymnastic exercises in a simulation mathematical modeling of human movement / V. I. Zagrevskii, D. A. Lavshuk, O. I. Zagrevskii // Theory and Practice of Physical Culture. – 2007. – N 3. – P. 68–72.
10. Zatiorsky V. Kinetics of Human Motion / V. Zatiorsky // Human Kinetics, 2002. – 672 p.

Annotations

Improvement of sports and technical skill is connected with development and introduction in educational and training process of the most rational samples of sports technique. Dug out there is a question of ordering and generalization of the main directions and approaches of technique modeling. A research objective is to present the main directions and approaches of sports technique modeling on the basis of special literature data. It is established that

now there is no uniform classification of modeling types. Ways of modeling it is necessary to carry to the most widespread are evident, symbolical, mathematical, natural, physical, analog-digital, imitating, computer.

Key words: *modelling, motor action, technique.*

Юрій Литвиненко. Сучасні підходи до моделювання техніки рухових дій у спорті вищих досягнень. *Удосконалення спортивно-технічної майстерності пов'язане з розробкою й упровадженням у навчально-тренувальний процес найбільш раціональних зразків спортивної техніки. Відритим залишається питання систематизації та узагальнення основних напрямів і підходів моделювання техніки. Мета дослідження – на підставі даних спеціальної літератури представити основні напрями та підходи моделювання спортивної техніки. Установлено, що сьогодні не існує єдиної класифікації видів моделювання. До найбільш поширених способів моделювання слід віднести наочне, символічне, математичне, натурне, фізичне, аналого-цифрове, імітаційне, комп'ютерне.*

Ключові слова: *моделювання, рухова дія, техніка.*

Юрий Литвиненко. Современные подходы моделирования техники двигательных действий в спорте высших достижений. *Совершенствование спортивно-технического мастерства связано с разработкой и внедрением в учебно-тренировочный процесс наиболее рациональных образцов спортивной техники. Отрытым остаётся вопрос систематизации и обобщения основных направлений и подходов моделирования техники. Цель исследования – на основании данных специальной литературы представить основные направления и подходы моделирования спортивной техники. Установлено, что в настоящее время не существует единой классификации видов моделирования. К наиболее распространённым способам моделирования следует отнести наглядное, символическое, математическое, натурное, физическое, аналого-цифровое, имитационное, компьютерное.*

Ключевые слова: *моделирование, двигательные действия, техника.*