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The Qualitative Pedagogical and Biomechanical Analysis of Technical Errorsin the Process of Training of Sportsmen for Complex Skills

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In sports the exercise is regarded as a system of movements (Donskoy, 1966; Ratov, 1966; Diachkov, 1974). The notion of "system", incorporating anti-elementaristic or holistic intention, is an interdisciplinary isomorphism and is widely used in all branches of science. It has an integral function that allows one to extrapolate the results and apply them wider.
Since the second half of the 20th century the systems approach has become an effective means to represent and explore complex objects. The systems approach is aimed at detection of both the elements and the diversity of their internal and external links (Bertalanffy, 1973; Blauberg, 1973; Kopnin, 1973; Rapoport, 1973; Sadovsky, 1973; Markaryan, 1980; Yudin, 1980).
The systems approach and the general systems theory have become the methodological foundation for development of systems analysis. Appeared in the 1960s, the systems analysis is considered an art and a science by many (Yudin, 1980).
A distinguished contribution to elaboration of systems approach has been made by Pyotr K. Anokhin. Developing the notion of "target reflex", introduced by Ivan P. Pavlov, Pyotr K. Anokhin articulated an idea of functional system. According to this theory the target is the acceptor of activity, but it is a useful result of an activity that is an actual system-forming factor that transforms chaotic multitude of components into a functional system (Anokhin, 1980).

Keywords:gymnastic; biomechanical Analysis.

Introduction

The idea that emerged in methodology relatively recently is a fuzzy sets theory, introduced by American mathematician Lofti A. Zadeh (Zadeh, 1965; Zadeh, 1966). Initially mathematical, the theory of fuzzy sets can be applied to diverse branches of modern science, where the information is incomplete or imprecise. The theory is based on a well-known philosophical proposition that the processes and the things of the real world – the elements and components of systems, the systems themselves, and the stages of development – have blurred boundaries (Biryukov, Novik, 1960).

The ideologies of systems approach, systems analysis, functional systems theory and fuzzy sets theory have formed the methodological basics of the present research.

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In the process of training and competitions different levels can be affected: biomechanical, physiological, psychological, pedagogical, etc., generating a scope of various technical, tactical, physical, psychological, and theoretical errors in the systems of movements. But on balance, the majority of errors are manifested as technical ones.

Different theoretical aspects of technical errors of athletes have been the subject-area for many researchers both Russian and foreign (Kurierov, 1961; Donskoy, 1966; Ratov et al., 1966; Diachkov, 1974; Nazarov, 1974; Gross, 1983; Gaverdovsky, 1986; Suchilin, 1989; Kornberg, 1995; et al.)

Within the boundaries of the given problematic issue the foundation for detection of athlete's technical errors has been laid (Nazarov et al., 1974) and the following ideas have emerged: the concept of the leading element, which is still valid in spite of limited practical use (Ratov et al., 1966; Diachkov, 1974; et al.); the notion of border positions (boundary postures), that helped to analyse technical errors in sports where the athlete's orientation in space during competition process is almost unchangeable (e.g. cross-country skiing).

Materials and Methods

In the present work the following research methodology has been employed: systems approach (Bertalanffy, 1973), systems and structure analysis (Donskoy et al., 1966), comparative pedagogical and biomechanical analysis (Suchilin, 1989), biomechanical analysis (video analysis software Silicon Coach).

Results

It is necessary to determine the notion of error. All deviations from the target of movement[1] are considered technical error. On the basis of our methodological concept technical errors are initially defined qualitatively, and then quantitatively. The main procedure here is the comparative analysis between deviation and target of movement.

On the qualitative level of diagnosing technical errors the elements of mathematical theory of inequalities have been used. The basic language operators are definitions of the type "less-more", "earlier-later", "shorter-longer", "weaker-stronger", "worse-better".

A precise definition of a technical error and its clear unambiguous treatise enables to set the limit beyond which individual peculiarities of performance and permitted deviations from perfect performance stop, being a technical error.

The essence of technical error stems from the gymnast making an element with deviation from the expected perfect performance using correct technique or performing an incorrect action for the skill. The technical errors of the first type are connected with deterioration of the characteristics as a whole of a correct (in composition) technical structure of the movement, while errors of the second type are associated with its distortion and deformation.

In the process of learning we strive for some ideal target model of movement (the standard) that exists in our mind. However in mastering an exercise we normally come up against deviations from the ideal of a general or partial nature. How do we distinguish them from errors? In complex space-coordination kinds of sports, connected with the art of movement, one can be governed by three criteria. Deviations from the standard are permissible individual peculiarities of technique if the following three conditions are met:

1) deductions for executing an exercise (an element) according competition rules are not made by the judge;

2) the technique being used enables the gymnast to master more complex exercises;

3) the movements are beautiful.

If just one of these demands is not met then deviations from ideal of movement are a technical error.

It has been discovered, small deviations in themselves do not exert a substantial influence on the basic parameters of movement and its technical structure. In majority of cases the geometry of movement, worsening its overall picture. However, if they are multiple, the style of performance as a whole acquires a negative connotation that the judges will penalise. If small deviations are disregarded, they have a tendency to grow into errors which become rooted in the technical structure of movement and become conserved. A small error, if it is not removed in time, may develop into a major error.

According to their nature technical errors may be subdivided into *systematic, chance* and *typical*. Systematic errors are made constantly, the sportsman becomes accustomed to them and they are not noticed by either the gymnast or the coach. However, the judges see them well enough and penalise the sportsman for them. Chance errors arise suddenly in disadvantageous conditions (distracting factors, stressful situations). Typical errors are made by most sportsmen (e.g., a top-class gymnasts part their knees when doing flight elements, the do not let the shoulder forward enough when departing into a double somersault on parallel bars, they begin to tuck early when pushing off the horse, etc.).

When analyzing technical errors we should establish *what* sort of mistake it is, *where* and *when* it happened (in what period, stage or phase), its *caliber* and *character*. The following step is associated with elucidation *how* the error occurred and *why* it happened. Here we need to establish whether it was a consequence of previous deviations. A search in that direction should end with defining the first link in the chain of deviations from the standard, leading to the apparent error. When the mistake is not corrected, one should remove all previous deviations from the target.

All technical errors may be divided into *parametric* and *structural*. In the first instance the basic parameters of the movement worsen (e.g. the height and length of flight diminish, rotation slows down). In the second, the quality of performing the movement as a whole or its individual details suffer.

The caliber of error (degree of its expression) should be determined by judging criteria, as well as by the scale of variation of movement characteristics. When they change within the bounds of the optimal scale there are no technical errors, there are only acceptable individual deviations. If the characteristics vary within the bounds of the permissible scale, they are classed as minor errors. If the limits are exceeded this is a sigh of large error.

When we analyse the technique of exercises in the flight phase, besides evaluating the quality of technical actions we need to characterise the basic parameters of flight (starting speed and main kinetic moment). The distance of flight is a function of the starting velocity of CoM. Horizontal shift is defined by the words "far-close" (in the middle of the norm), while vertical is defined by the words "high-low". We can only give a qualitative description to the main kinetic moment given from support indirectly according to the speed of rotation in flight. This is done using the words "fast-slow".

Parametric faults are caused by preceding structural errors with which they are closely associated. In structural mistakes we distinguish *mistakes within the margin positions* and *mistakes in leading elements of coordination*[2]. These mistakes are also inter-connected and mutually conditioned. They may have a local or total character. In the first case they have deviations from the ideal of a general character (for instance,

insufficient general bend or straightening of the body as a whole), and in the second they have local (e.g., bending the arms or legs if this is forbidden by competition rules).

When performing elements on the apparatus the gymnast normally fixes the place of grip. So to define critical positions in the phase structure in these cases it is enough to define the body's orientation in the critical positions sufficiently to use the words "early-late" in the spatial and temporal aspect. Errors of position are defined by the words "insufficient-excessive" by contrast with the geometrical target of a given critical positions.

The *leading element of coordination* is characterised by the place of applying major effort, its duration and degree of development and, therefore, it is determined with the help of spatial-temporal and force parameters. Technical actions linked with performing the leading element of coordination in a given phase can begin earlier or later, continue longer or shorter and be stronger or weaker than necessary. Hence to define faults in the leading element it is enough to use three pairs of words: "early-late", "long-short" and "strong-weak". When joined together these elementary definitions form more general definitions. For example, we often use in the coaching lexicon the word *sharply* to mean short or powerful, while the word "slack" we take to mean long and weak.

If the error is diagnosed, the way to get rid of it becomes apparent. For example, if the sportsman performs some control movement early, the coach will have to recommend to do it later, and if it is long and weak, the sportsman should be told: "Do it more sharply".

Fig. 1 shows the structure of technical errors reflecting the above-mentioned approach.

The analysis we have made shows that the following causes of technical errors are the most typical:

- the sportsman does not have a correct picture of technique in performing the given element (he lacks an adequate target of technical structure);
- in the preceding phases there are multiple deviations from the standard

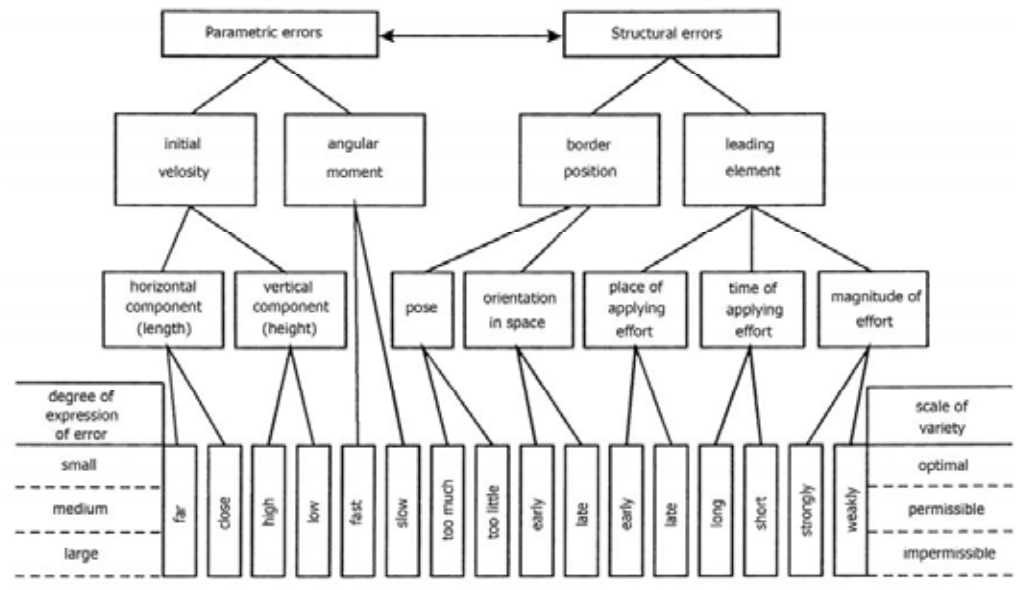


Fig. 1. Structure of technical errors

or minor errors which are not corrected in time;

- the sportsman cannot perform the required movement or action because he is not prepared for it technically, physically or psychologically;
- the sportsman does not exactly know where his fault lies and (or) what he has to do through lack of information, an inadequate feed-back or incomprehensible instructions from coach;
- the sportsman does not want to perform what the coach requires of him because he thinks it incorrect or inconsequential;
- the sportsman is scared of doing the required technical action;
- the sportsman wrongly assesses his technical action as a result of incorrect self-evaluation and (or) inadequate self-control.

The technical errors of a sportsman are caused mainly by insufficient level of preparation (technical, physical, functional, psychological, and theoretical), by inferior information, inadequate feed-back and coach's mistakes. Quite often insufficient level of special physical training is the cause of technical errors when performing complex exercises.

Let us illustrate the practical application of our methodological approach. The quantitative analysis may include computerised video analysis of sports techniques. Fig.2 gives a frame by frame recording of a dismount double salto backward straight with 2/1 twist (720°) performed by D.S., a member of Russian national Artistic Gymnastics team and Master of sport international class. The dismount is performed with large error – fall during landing. The deduction is 1.0 p.

Following the principle method of analysis "from end to beginning" (Bespalko, 1970), we start from landing.

After the moment of support (landing) the gymnast falls over on his knees, committing a large error. His movements at the phase of landing don't prevent the fall. This fall is caused by technical errors in the preceding phases.

Frame # 20 – the gymnast is in a bent position, and his feet reach the support early.

Frame # 19 – in the unsupported period in the phase of prepare for landing the gymnast rotates slowly. This insufficient rotation makes the gymnast bend in the hip joints instead of straightening out the body in flight before landing. At the same time the moment of inertia relative to transverse axis is reduced. The rotation becomes equally faster, but it does not prevent the fall over.

Frame # 18 – the gymnast finishes a turn of 720° around the longitudinal axis in flight; a double twist is successfully performed.

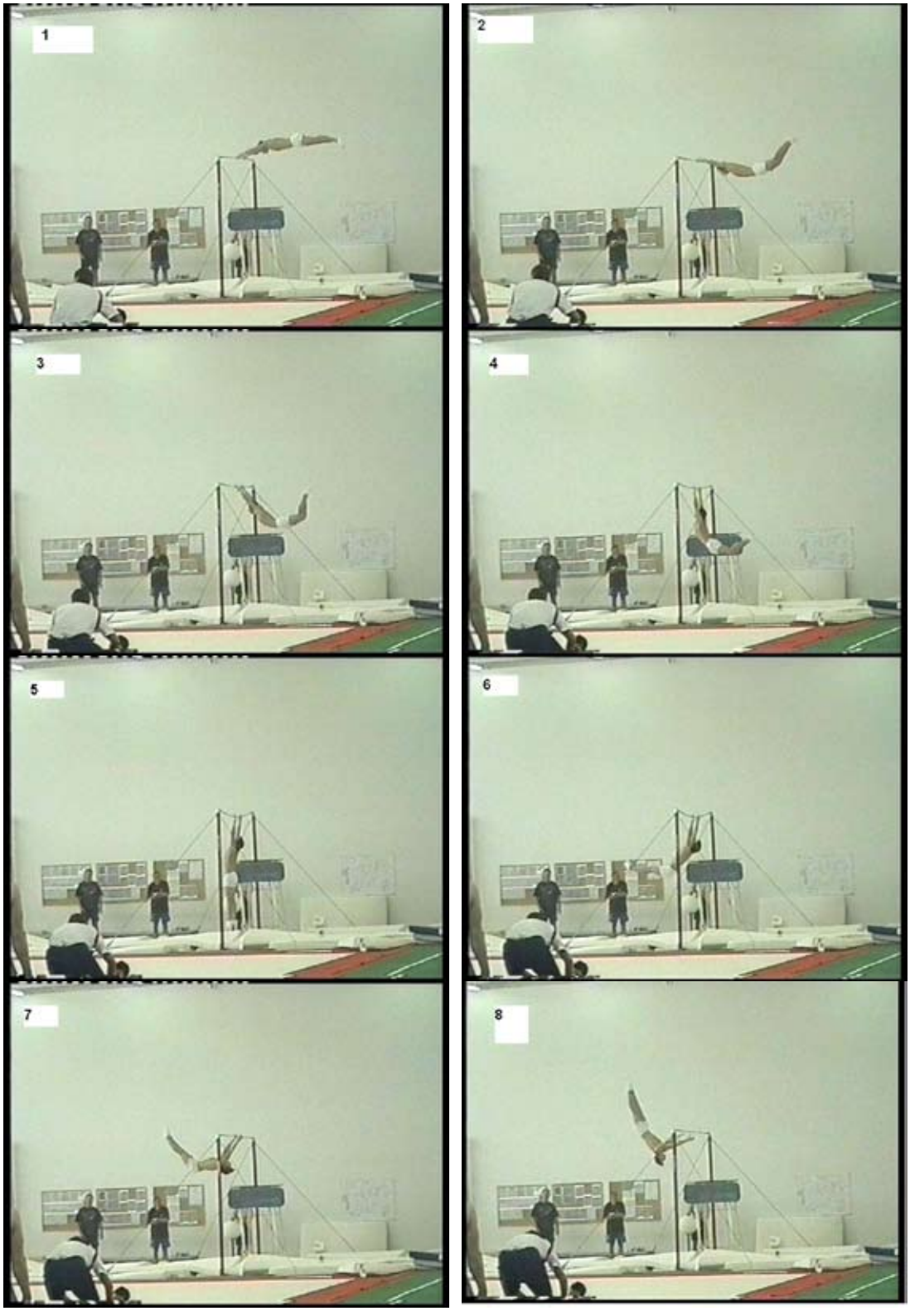
Evaluating the basic parameters of flight (length, height and rotation) (Frames # 8-21), that the gymnast can not change, we have made the following diagnosis:

- height – low (not high enough), caused by insufficient vertical starting velocity of CoM in flight, insufficient rotation;
- length – far (not close enough), caused by overwhelming horizontal starting velocity of CoM in flight due to early throw, pulling the sportsman forward, and not upward;
- rotation – slowly (not fast enough), insufficient rotation, caused by insufficient kinetic moment from support and time of flight.

Border position at the moment of release (Frame # 7):

- pose – good;
- orientation in space – too early.

The leading element of coordination in the phase of working actions (throw) is diagnosed as following: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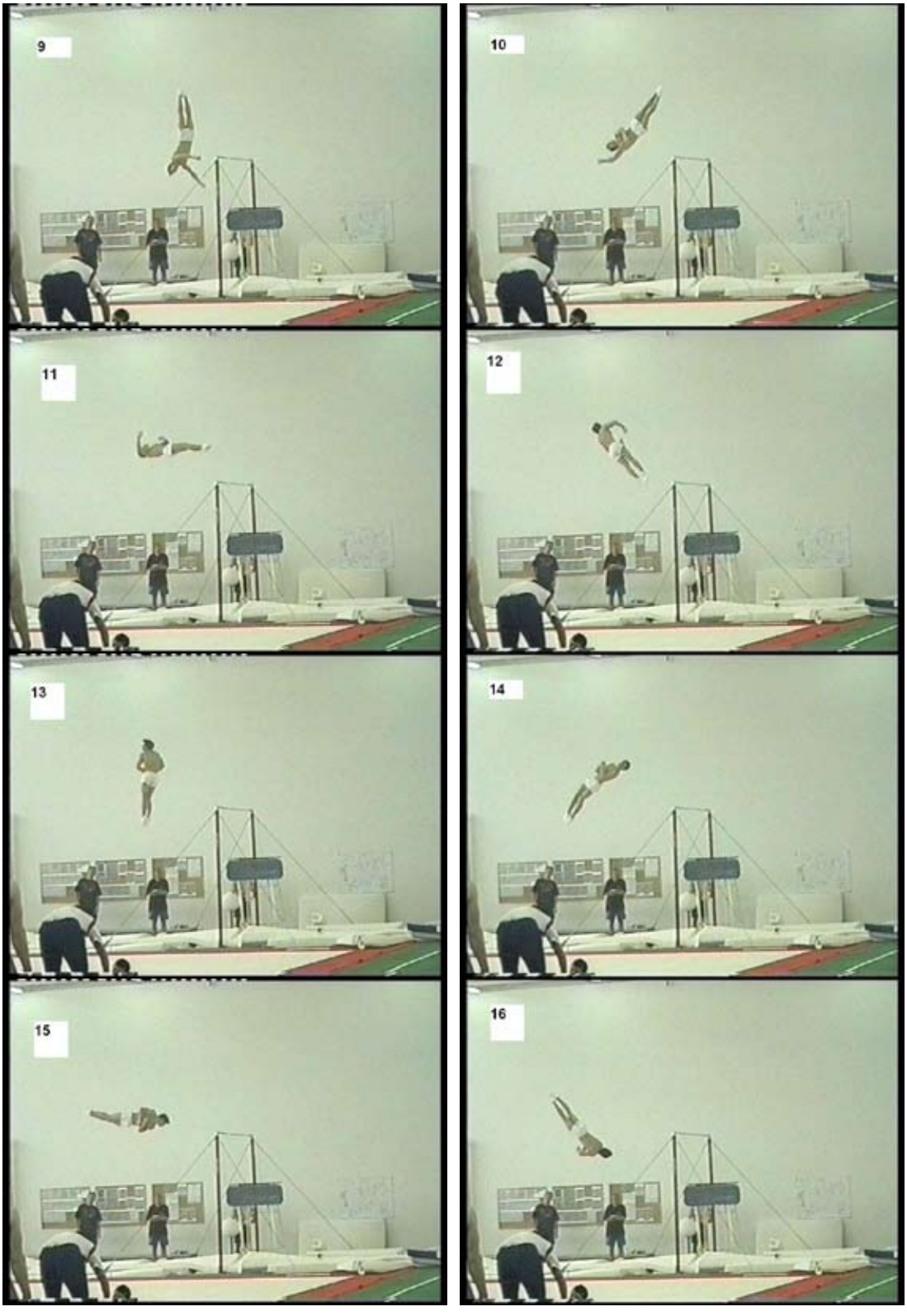
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Fig. 2. Performance of the dismount double salto backward straight with 2/1 twist on the horizontal bar.

- place of applying the effort – early;
- time of applying the effort – short;
- magnitude of effort – strongly (sharply).

Border position at the end of swing phase and beginning of the throw (Frame # 3):

- pose – too much;
- orientation in space – too early.

The leading element of coordination in the phase of preparatory actions (swing and the beginning of throw) is as following:

- place of applying the effort – early;
- time of applying the effort – short;
- magnitude of effort – strongly (sharply); the legs are too bent in knees.

Border position at the beginning of pre-swing (Frame # 1):

- pose – good;
- orientation in space – too early.

Discussion

As a result of our work, the classification of technical errors has been developed, the permissible deviations from the perfect performance and their difference from technical errors have been determined. The adequate structure of technical errors of top-class gymnasts occurring during the process of sporting activity have been worked out and their reasons have been identified.

The methodology of diagnosing technical errors on a technological level has been developed and its practical use in the process of training of top-class gymnasts has been justified (based on the example of performance of the complex element with a flight phase).

The results of qualitative analysis of technique of the exercise performed by a definite sportsman demonstrate that early, short, strong and too active swing have caused an early, short

and strong throw. In its turn it has caused an early release, low and far flight, insufficient time of flight and slow rotation. As a consequence the landing has been with a large technical error – a fall over.

Conclusion

1. It has been established that functionally connected phases of swing and throw after multiple repetitions are performed in an automatic programmed regime. The timely start of swing with moderate amplitude is a reasonable accent of control over such movement.

2. The analysis of technique of performing of the complex dismount double salto backward straight with 2/1 twist on the horizontal bar in accordance with our approach has identified the first link in the chain of deviations: early, short and strong swing. The reason is the fear of hitting the apparatus by legs in case of short flight.

3. The gymnast is recommended to do the swing later, longer and weaker. If the gymnast can not remove the mistake, the coach should point out the optimal place of landing, stand on a rise near the bar, put a safety device on the bar (e.g., a foam mat or a bar pad) and move it quickly to a potentially dangerous place after the gymnast releases the support.

4. It has been established if the gymnast is recommended to make the swing longer and start the throw later, during the swing he stretches the muscles of the front working surface of the body too much and stretch-reflex during the throw works out less effectively. As a result, the speed of rotation in flight and its height decrease.

5. We also noted that, if the gymnast is recommended to make the throw longer and release the bar later, the result of contraction of the muscles of the working surface of the body (speed and strength) during the active throw decreases (all other conditions being equal). As a result, the speed of rotation in flight and its height also decrease.

[1] The terms *technical standard*, *pattern*, *optimal programme of movement*, *expected perfect performance* are close in meaning to the term *the target of movement*.

[2] The technical structure of exercises includes three subordinate levels – *periods, stages and phases.* We may divide out *supported and unsupported periods of movement,* within the periods – *stages: accumulation and working stages,* and within the stages – *phases: border positions* or *marginal positions* and *the leading elements of coordination.*

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Качественный педагогико-биомеханический анализ технических ошибок при обучении спортсменов сложным техническим действиям

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Статья посвящена разработке и обоснованию методики диагностики технических ошибок спортсменов. Дано определение понятия техническая ошибка. Разработаны и минимизированы основные вербальные операторы, удобные для использования в тренерской практике. Разработаны критерии дифференцировок различий между техническими ошибками и допустимыми индивидуальными отклонениями от технического эталона. Разаработанная методика проиллюстрирована на примере анализа техники исполнения сложнейшего соскока с перекладины, исполненного высококвалифицированным гимнастом с грубой технической ошибкой, выявлено первое отклоение в цепи ошибок.

Ключевые слова: гимнастика; биомеханический анализ.