VELOCITY GRADIENT OF THE FLOOR EXERCISE

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ABSTRACT

The methodological classification of the volume of the exercises is in the basis of the multi-annual preparation in gymnastics. A number of authors (Dimitrova, 2015; Borisenko, 2000; Fisenko, 2005; Gaverdovskiy, Smolevskiy, 2014) note that for the apparatus of female all around – balance beam and floor exercise, the volume material united in different structural groups is equal. The basic motor habits differ only as regards the specificity of the particular apparatus.

The aim of the research is to establish the role of the velocity gradient for the learning algorithm in a multi-annual aspect and on floor exercise. We used kinematic analysis, comparative data analysis and variation analysis when we processed the results. The analysis of the results allowed us to establish the role of the velocity gradient for learning algorithm in the multiannual aspect and of floor exercise. Our research has shown that the basic exercises sequence on floor exercise according to the gradient velocity does not fully correspond to the methodical sequence of training used for years so far. We established the following dependence: the greater number of movements in the main action phase executed for shorter time increases the velocity gradient. It was confirmed for the apparatuses of the gymnastic all around too. The obtained values for the velocity of basic exercises of floor exercise by structural group confirmed their direct proportional dependence on difficulty.

***Key words**: floor exercise, velocity gradient, methodological classification*

INTRODUCTION

The methodological classification of the volume of the exercises is in the basis of the multi-annual preparation in gymnastics. For the successful realization of a gymnast, the proper selection of basic motor habits according to the individual qualities is of great importance. Biomechanical analysis is leading in the implementation of this process (Kuchukov, 2009; Brüeggemann, 1994). A number of authors have investigated kinematic characteristics, such as the change of the vertical and horizontal velocity of the center of gravity during take-off of backward salto (Banerjee, Ghosh, Bhowmick, 2014), the linear momentum and take-off segmental angles during impulse in the backward stretched somersault (Mkaouer et al., 2013), angular momentum of the take-off phase of double backward somersault (Hwang, Seo, & Liu, 1990). The most comprehensive studies on backward take-offs have been provided by Brüeggemann, 1983; Geiblinger, et al., 1995; Hwang, et al., 1990, Knoll, 1992; Knoll and Krug, 1990, Mkaouer et al., 2012. The authors outlined key components of the back somersault performed after round-off, flic-flac and they agreed that a speed of 5 to 6 m/s and a take-off angle between 75º and 85º were optimal to perform the backward stretched somersault. Our research on the kinematic parameters of exercises of different structural groups on uneven bars (Petrova, Dimitrova, 2012; Petrova, 2013) established the vital role of maximal hip joint velocity achieved in the phase of the main actions. On the basis of the time needed for the realization of this speed we determined the dynamics of its increase as a basic technical characteristic of gymnastics exercises. The increase in the speed per unit of time is the velocity gradient we established. The research of the velocity gradient as an objective quantitative indicator allowed the construction of the methodical classification for uneven bars. We continued the study of this kinematic parameter for two different apparatuses from the gymnastic all around – vault and balance beam (Petrova, 2013; Dimitrova, Tankusheva, Petrova, 2015; Dimitrova, Petrova, Tankusheva, 2014), which optimized the learning process. The scientific study showed that the lower the maximum speed reached in the main action phase is, the easier the exercise is to master (Petrova, Dimitrova, 2012). A number of authors (Dimitrova, 2015; Borisenko, 2000; Fisenko, 2005; Gaverdovskii, Smolevskiy, 2014) note that for the apparatus of female all around – balance beam and floor exercise, the volume material united in different structural groups is not different. The basic motor habits differ only as regards the specificity of the particular apparatus. In the routines both on a balance beam and in a floor exercise, the acrobatic exercises are about 22 - 25 (Borisenko, 2000), and in the jumps mostly split leaps and switch leaps are included (Tankusheva, 2013). In most cases, they determine the difficulty score received by the gymnast. The study of the velocity gradient of the volume material of balance beam exercises showed some specific features (Dimitrova, Petrova, Tankusheva, 2014) that directed us to the present research. The exercises of floor exercise are those which artistic gymnastics training begins with. The successful growth of a gymnast depends on the proper motor actions developed in a correct sequence. That is why the scientific study of the factors that influence this process is topical. The calculation of the velocity gradient (Petrova, 2013) and the floor exercise elements and connections will allow the construction of a scientifically based training sequence.

The aim of the research is to establish the role of the velocity gradient for the learning algorithm in a multi-annual aspect and on floor exercise. To fulfill this aim, we set the following *tasks*:

- ✓ To make a kinematic analysis and find the velocity gradient of basic exercises from the different structural groups of the floor exercise;
- ✓ To analyze the obtained results for the structural groups;
- ✓ To analyze each structural group velocity gradients obtained from the same exercises on balance beam and floor exercise;
- ✓ To optimize the existing methodological classification of exercises of floor exercise in a multi-annual aspect.

METHODOLOGY

Object of the research is the number of basic exercises of floor exercise. The *subject* is the learning algorithm in a multi-annual aspect.

Limits of the research

Five national level female 10-year-old gymnasts volunteered to take part in the present study. They had five years of training experience of participation at Bulgarian young national level gymnastics championship. Only the hip joints velocity in the main phase of exercise was examined, and on this basis the velocity gradient was calculated for each performance.

Procedure

Basic gymnastics exercises were recorded with the use of a video camera (SONY HDR-

PJ810EB). The camera frequency was 25 frames /sec. We recorded the gymnasts observing all the principles of scientific filming. The camera was placed sideways of the subject. The camera axis was positioned at the perpendicular direction of the movement.

During training, a total of eight basic exercises and three different acrobatic series were photographed. From the structural group of the jumps we included a *split leap fwd and a switch leap*. From the group of handsprings – *round-off, back handspring and handspring fwd with legs together*. From the somersaults we photographed – *somersault fwd tucked.* Three attempts were required for each of exercises and acrobatic series (*round-off, back handspring, somersault bwd tucked; round-off, back handspring, somersault bwd stretched; handspring fwd, somersault fwd tucked)*. Only the best execution of each exercise and acrobatic series was selected for the study.

For the purpose of the research a kinematic analysis was performed, and a gradient of the velocity of the exercises and series was calculated. The recorded exercises were analyzed with Ulead video studio (Version 10.0) software. The hip joins velocity was analyzed as the point closest to the center of gravity because thus, it is the most indicative of the common speed of the studied exercises of the floor exercise. The gradient of the velocity, that we first established in a scientific study of uneven bars (Petrova, Dimitrova, 2012, Petrova, 2013), is the time in the phase of the basic actions for which the highest speed is achieved when performing the exercise. Taking the time for the realization of this speed into consideration allowed us to determine the dynamics of its increase as a basic technical characteristic of the gymnastic exercise. We determined that the speed increase per unit of time was a velocity gradient.

Data analysis

The results of the research were processed with math-statistical methods (variation analysis) with the statistical package SPSS-19.0. (Gigova, 2002).

RESULTS AND ANALISIS

The result of the variation analysis showed that in half of the studied exercises (split leap fwd, switch leap, handspring, round-off before somersault bwd tucked, somersault fwd tucked and somersault bwd stretched), the sign dissipation was small, which means that the group was highly homogeneous - the coefficient of variation was between 4% and 9.63% (Table 1). As regards the other exercises, the group was approximately homogeneous, with a value of V% above 12%. For some indicators, the values of asymmetry (As) and excess (Ex) had an abnormal distribution.

Table 1. *Variation analysis of the exercises studied*

	Indexes	N	Min	Max	R	Mean	S	V%
Gymnastic jumps	*Split leap fwd*	5	9.96	10.54	0.58	10.25	0.41	4.00
	Switch leap	5	10.83	12.17	1.34	11.50	0.95	8.24
Handsprings	*Back handspring*	5	10.41	14.88	4.47	12.65	3.16	25.0
	Round-off	5	15.47	20.83	5.36	18.15	3.79	20.88
	Handspring fwd with legs together	5	17.86	20.24	2,38	19.05	1.68	8.83

Handsprings in series	*Handspring fwd*	5	20.24	26.19	5.95	23.21	4.21	18.12
	Round-off before somersault bwd tucked	5	16.31	18.47	2.16	17.39	1.08	6.21
	Round-off before somersault bwd stretched	5	19.04	29.76	10.72	25.19	5.53	21.96
	Back handspring before somersault bwd tucked	5	16.31	30.79	14.48	21.14	8.36	39.55
	Back handspring before somersault bwd stretched	5	20.24	29.75	9.51	23.80	5.18	21.78
Somersault fwd	*Somersault fwd tucked*	5	11.59	11.90	0.31	11.75	0.22	1.87
Somersault in series	*Somersault fwd tucked*	5	8.93	10.20	1.27	9.56	0.90	9.39
	Somersault bwd stretched	5	8.93	10.71	1.78	9.66	0.93	9.63
	Somersault bwd tucked	5	9.96	14.75	4.79	11.86	2.54	21.45

Table 2 and Table 3 present the velocity gradient average values of the basic exercises of the structural groups of jumps, handsprings, somersaults, and acrobatic series. For each performance, the gradient of the velocity was calculated and the average of all the studied exercises by structural groups was derived. The analysis of the obtained results showed that the methodological sequence of the magnitude of the investigated index of the floor exercise differed both from the vault and from the uneven bars, as well as from the same exercises (jumps, handsprings and somersaults) performed on the balance beam. The established direct proportional dependence of the magnitude of the gradient of the velocity on the difficulty of the exercises in uneven bars and vault, which allowed the creation of a methodological classification in a multi-annual aspect, was not confirmed on floor exercise. And here, like on the balance beam, the jumps from the different difficulty groups had a bigger gradient than the somersaults. For example, in Table 2 and 3 we can see that the split leap fwd is the least difficult "A" has a gradient of 10.25 m/s^2, but a somersault bwd tucked of 9.56 m/s^2. That shows that the same biomechanical structure of exercises reveals the same dependencies, regardless the specific performance conditions associated with the smaller supporting area. That is why floor exercise is directly proportional to the increase in values of the velocity gradient and difficulty of exercises only in the particular structural groups.

Table 2 shows that logically, the more difficult jump – switch leap had a higher magnitude of the investigated index – 11.5 m/s^2. It is interesting to note that the values obtained on floor exercise were higher than those on the balance beam, regardless of the methodological requirement for the sequence of training – first on floor exercise, then on balance beam (Figure 1).

Table 2. *Velocity gradient of the gymnastic jumps on floor exercise*

Group exercises	Name	V max (m/s)	Gradient (m/s^2)
Gymnastic jumps	*Split leap fwd*	2.05	10.25
	Switch leap	2.30	11.5

These results are logical, because on floor exercise the jumps are performed more calmly from a psychological point of view and therefore they are with a higher speed. The balance beam with a height of 1.2 m., a width of 10 cm. and a length of 5 m., requires more precise and moderate motor actions. The successful preservation of the equilibrium on the limited supporting area requires a change in some kinematic parameters of the exercises. This is the reason for the established differences in the performance of the same motor habits of floor exercise and balance beam, as well as for the established greater gradient of the velocity of methodically easier for execution exercises of the floor exercise.

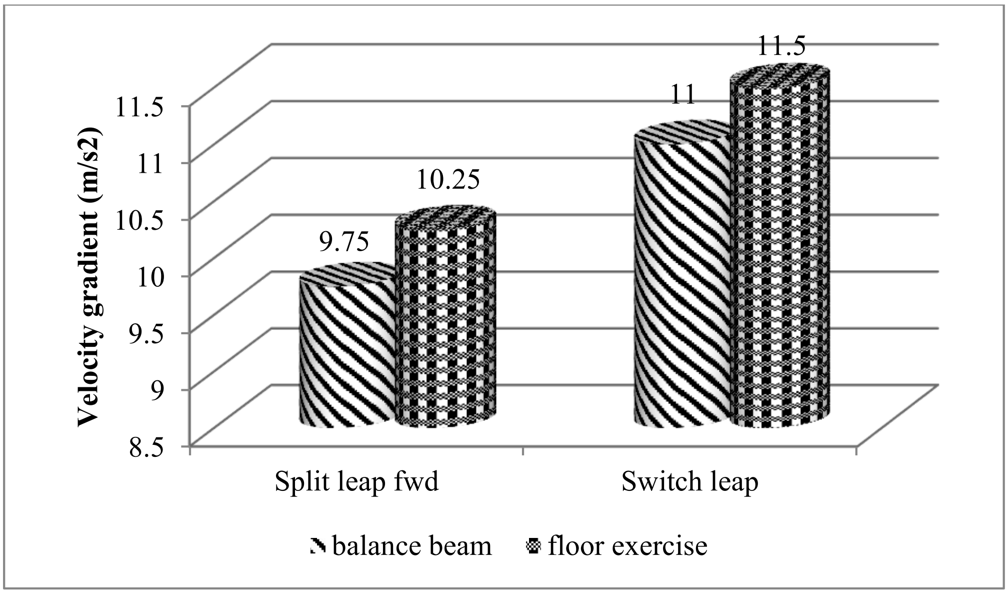


Figure 1. *Velocity gradient of the gymnastic jumps on balance beam and floor exercise*

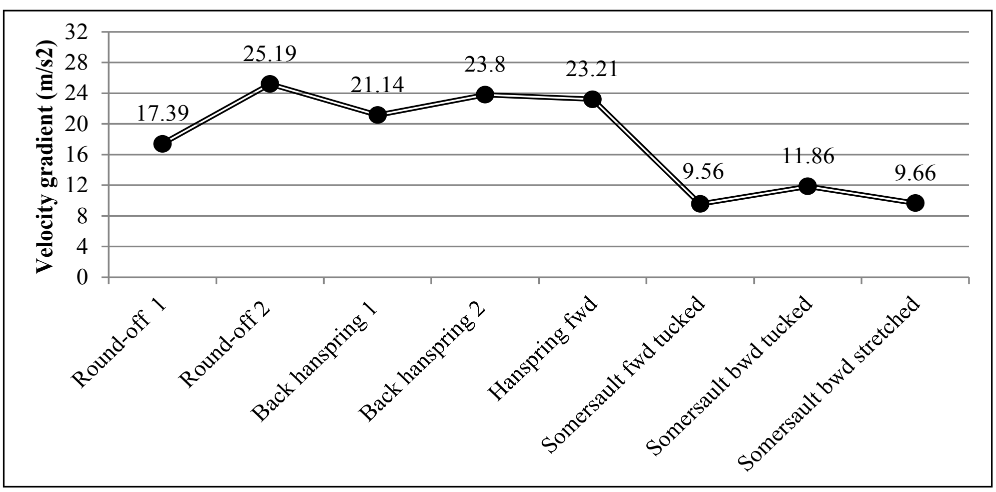
In the group of handsprings (Table 3) we researched the exercises performed in one place and in series. An interesting fact is that the back handspring had the smallest velocity gradient (12.65 m/s^2), making it the easiest to learn from acrobatic exercises. This, however, is not confirmed by the many years of practical experience in the arrangement of volume material of floor exercise. In many cases, round-off is the first successfully performed acrobatic exercise. From a biomechanical point of view, however, there is a turning around two axes, and the specificity of the motor action requires a greater speed of movement at the center of gravity. This proves that the established relationship between the velocity gradient and the difficulty of the motor habit is correct. The obtained results from the structural group of the somersaults are interesting. The somersault fwd tucked performed after running had a larger gradient (11.75 m/s^2) than that performed in a series (9.56 m/s^2) – a direct connection from several exercises – in this case, handspring fwd, somersault fwd (Table 3). The exercises were included in a series, so as to achieve a greater horizontal and after the rebound vertical speed required for the realization of more difficult acrobatic exercises. In this case, however, in performing one salto after running, conditions are created to achieve optimal speed for motor habit. In the series, after running and a jump forward, there is an intermediate motor activity (handspring fwd) and then the salto, which we think reduces the magnitude of the velocity gradient. To construct a correct, multi-year methodical classification, we need to consider separately the connections of acrobatic exercises in their different complexity and sequence.

Table 3. *Velocity gradient of the acrobatic exercises on floor exercise*

Group exercises	Name	V max (m/s)	Gradient (m/s²)
Handsprings	*Back handspring*	2.023	12.65
	Round-off	3.214	18.15
	Handspring fwd with legs together	3,809	19,05
Handsprings in series	*Handspring fwd*	4.642	23.21
	Round-off before somersault bwd tucked	3.478	17.39
	Round-off before somersault bwd stretched	4.285	25.19
	Back handspring before somersault bwd tucked	3.405	21.14
	Back handspring before somersault bwd stretched	3.967	23.80
Somersaults fwd	*Somersault fwd tucked*	3.69	11.75
Somersaults in series	*Somersault fwd tucked*	2.857	9.56
	Somersault bwd stretched	3.253	9.66
	Somersault bwd tucked	3.333	11.86

In the back somersaults (Table 3, Figure 2), the established gradient of velocity showed a difference from the methodological classification of floor exercise used so far. According to the code of points, the somersault bwd tucked, somersault bwd piket and somersault bwd stretched are basic exercises from group "A". The experience of coaches and gymnastics specialists has established that the somersault bwd tucked must be learned first. It is assumed that it is easier to perform the rotation around the side axle, because the radius of the turning is smaller. However, the reduction in the radius of movement, according to the laws of biomechanics, leads to a higher speed. The research we conducted logically showed that the somersault bwd stretched had a lower gradient of velocity of 9.66 m/s^2, whereas for the somersault bwd tucked the magnitude was 11.86 m/s^2.

The result was justified in further studies. The new recorded data from the kinematic analysis and the magnitude of the velocity gradient confirmed the already established values and we think that there is a logical explanation. The lower value of velocity of the somersault bwd stretched achieved for a longer time has lesser dynamics, which is an indicator for the easy learning of the exercise.



Legend: *1 – before somersault bwd tucked; 2 – before somersault bwd stretched*

Figure 2. *Velocity gradient of the acrobatic exercises (in series) on floor exercise*

In coordination, tucked and piked somersault require greater precision in motor activity, which is related to folding the hip, shoulder and knee joints, turning momentum, unfolding and landing. U. Gaverdovskiy came to a similar opinion (2002). He recommends learning somersault bwd stretched or ungrouped somersault as a base for somersaults bwd. His statement found its scientific explanation in our research.

DISCUSSION

The analysis of the results allowed us to establish the role of the velocity gradient for learning algorithm in the multiannual aspect and the exercises of floor exercise. It was proven that the maximal magnitude of the kinematic hip joint velocity parameter reached for a unit of time in the basic action phase and defined as a velocity gradient is indicative of the exercises in each individual structural group. Figure 2 shows the diagram of the basic exercises sequence on floor exercise according to the gradient of the velocity. Our research has shown that it does not fully correspond to the methodological sequence of training in the multiannual preparation used so far. Like on the balance beam, it is necessary to make classification of the exercises by structural groups.

Table 4 shows the learning algorithm of the most commonly performed basic exercises on floor exercise according to structural groups. Our study revealed the need for a separate methodical algorithm for acrobatic exercise connections. This is related to the different situations created by the changing phases of preparative and concluding actions of the executive motor actions.

Table 4. *Learning algorithm of basic exercises on floor exercise*

Age / Group exercises	**6-7 years**	**8-9 years**	**9-10 years**
Gymnastic jumps	*Split leap fwd*	*Switch leap*	*Switch leap with ½ turn*
Handsprings		*Back handspring; Round-off*	*Handspring fwd*
Somersault bwd		*Somersault bwd stretched*	*Somersault bwd tucked*
Somersault fwd		*Somersault fwd tucked*	*Somersault fwd piked*

CONCLUSIONS

The research allowed us to draw the following conclusions:

The established dependence that the larger volume of movements in the main actions phase executed for shorter time increases the velocity gradient was confirmed for this apparatus of the gymnastic all around too.

The obtained values of the velocity gradient of basic exercises of floor exercise by structural group confirmed their direct proportional dependence on difficulty.

We established that the role of the gradient of the velocity of basic exercises in floor exercise is logically related to that of the balance beam.

A new methodical learning algorithm is needed of the acrobatic exercise connections (series) of floor exercise, which will be subject of our future research.

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