Research in Kinesiology
2016, Vol. 44, No. 2, pp. 193-195

QUANTITATIVE EVALUATION OF INERTIA PARAMETERS CONTROL IN ARTISTIC GYMNASTICS

(Original scientific paper)

Blaga Traykova
"Vassil Levski" National Sports Academy, Sofia, Bulgaria
Anatomy and Biomechanics Department

Abstract
The aim of the present study is the elaboration and official approval of a methodology for quantitative evaluation of the ability to control the inertial biomechanical parameters. Two groups of 6 gymnasts were included in the study. Group one comprised 6 male gymnasts competing at national level and group two – 6 gymnasts from the national youth team. All gymnasts performed two motion tasks (swing handstand at parallel bars and rings) ten times under standard external conditions. The video files were processed with a video computer system with modified cubic spline interpolation for data reconstruction. The specificity of the phase structures and the possibilities for transfer of a motion habit during performances at both apparatuses has been evaluated. The obtained results point to new possibilities for customization and improvement of the training process.

Keywords: *biomechanics, swing handstand at parallel bars and rings, training mastership, male, improvement of the training process, gymnastic drills, cubic spline interpolation, variation statistical analysis,*

INTRODUCTION

The biomechanical expediency of a number of gymnastic drills is determined by the efficiency of use of the inertia parameters in the movement system. The control over the inertia parameters (moment of inertia, moment of momentum) is manifested relatively "purely" in the swing handstand. This motion task is typical of performances at parallel bars and rings. Significant biomechanical difference between the two exercises is the support counter pressure. The control during performances at parallel bars gives greater possibilities for adjusting force impulses than the counter pressure and variations in the location of the rotation center.

In as much as the swing handstand at parallel bars allows for depreciation of the inertia moment until the very end of the motion we had to correct the motion task with an additional condition for even kinetic energy toning down while during the mass center movement to stationary final handstand position.

The main aim of the present study is the elaboration and official approval of a methodology for quantitative evaluation of the ability to control "the future needed".

METHODS

Data were collected on two groups of 6 gymnasts. Group one comprised 6 male gymnasts competing at national level and group two – 6 gymnasts from the national youth team. All gymnasts performed two motion tasks (swing handstand at parallel bars and rings) ten times under standard external conditions. The data were recorded and processed with a video-computer system for biomechanical analysis developed in Anatomy and Biomechanics Department with V. Levski National Sports Academy. A video-computer analysis system was used for processing the obtained video files sampling at 120 Hz. An incompletely damping digital low-pass filter with a cutoff frequency of 10 Hz was used to smooth out digitized data. Modified cubic spline interpolation was also used for data reconstruction. The results obtained from the tests about mass center path were processed with the help of a variation statistical analysis.

RESULTS AND DISCUSSION

For purely theoretical considerations, the sports mastership for "the future needed" control is contained in the persistence of the second derivative (a) with respect to the mass center path. In as much as the motions are performed independently of non-controllable external disturbances, it is possible to reliably evaluate certain bones and joints control aspects, which have led to development not only of original video-computer analysis methodology (Farana, Jandacka, & Irwin, 2013), but also to justifying mathematical approaches used for building sports mastership biomechanical models (Hiley, Wangler, & Predescu, 2009); (Hiley, & Yeadon, 2012). The specificity of the motion tasks in gymnastics allows for objective verification of the biomechanical models during the training process (Gaverdovsky (Гавердовский), 2013); Yeadon, & Brewin, 2003). In most scientific publications there are no specific studies evaluating the control with respect to the “action acceptor“ after the Anohin’s terminology or the so called “the future needed“ after Bernstein N.A. Similar quantitative evaluation would have a general theoretical significance because it would disclose internal causal relations in the behavior of the biomechanical structure.

An idealized model for optimum control over the inertia parameters requires equality between the vertical element of “a“ and the acceleration of gravity. In practice, this element is always smaller due to the counter reaction. The constant values of „a“ may be ensured at varying levels of counter reaction. The question remains as to what background of that force vector renders most active direction.

The results from the variation statistical analysis are presented in tables 1 and 2 for the two groups of gymnasts respectively. Our attention is drawn by the considerably higher variation ratios at rings performances for both groups of gymnasts. The tables also contain a new biomechanical parameter – the third derivative with respect to the mass center movement. This parameter to a certain extent determines the counter reaction background, the absolute values of the acceleration respectively, because the ideal model of inertia moment control is related to its zeroing.

Generally the variations between the two groups are contained not so much in the absolute values of the biomechanical parameters but in their volatility and variability.

Thus the data presented in the tables, as any statistical processing, disguise certain significant individual peculiarities. For example, there is a possibility for relatively constant acceleration values not to lead to a final success – final handstand position. This case appears typical of two gymnasts from the youth team. This fact is of significant importance for customization of the training process methods.

On the other hand the considerably higher values of the variation ratios of youths’ velocity parameters allows for individual specificities in the ability to control the temporal sequence of values of that parameter. The quantitative measurement of that parameter is contained in the evaluation of the location of the average velocity over the mass center path.

Fig. 1 and 2 illustrate the functions a (t) with respect to two individual performances of gymnasts from the two groups, and fig. 3 and 4 - functions a’(t). In addition to illustrating the statistical variations in the biomechanical structure visible from the data in the tables, noticeable is the fact that the adjusting force impulses of the elite gymnast ease off earlier. A more sensitive parameter for evaluation of the sports mastership is noticeable. Quantitatively it can be obtained by determining the current velocity and its location on the path, after which the acceleration vector remains relatively stable within limited borders. The comparative analysis between the two groups of gymnasts also shows a significant peculiarity, in our opinion, characterizing the forming of the motion habit. The noticeable inaccuracies of the elite gymnasts are largely due to systematic errors in the evaluation of the “future needed“. The non-elite gymnasts exhibited bigger inaccuracies in terms of absolute value, however, the high values of the variation ratios are an indication of their “random“ nature. These results have particular importance for customization of the training process. There are sufficient grounds to suppose that such a behavior of the structural organization will be noticed also in other

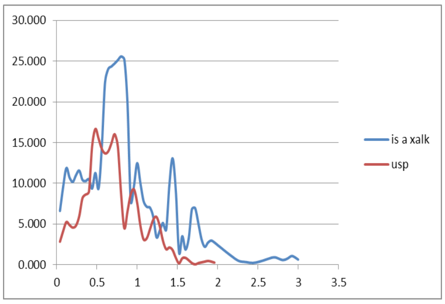

Fig.1 Men-swing handstand at parallel bars and rings – a

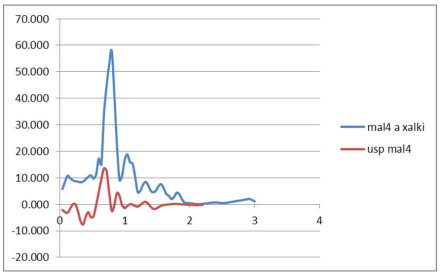

Fig.2 Youths- swing handstand at parallel bars and rings - a

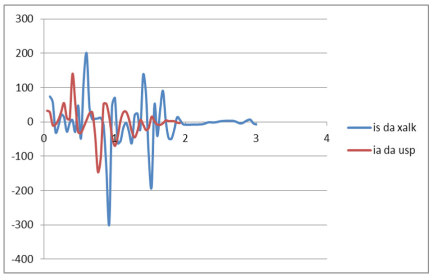

Fig.3Men-swing handstand at parallel bars and rings – a’

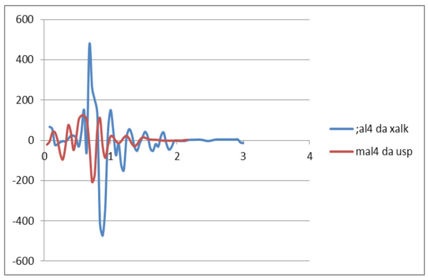

Fig.4 Youths- swing handstand at parallel bars and rings - a’

Table 1. Parallel bars

	$\bar{x}$	S	V%	$\bar{x}$	S	V%
		Youths			Men	
a	8.8	2.8	31.82	6.1	1.6	26.23
a'	-23.4	11.7	-50	-12.6	10.2	-9.53

Table 2. Rings

	$\bar{x}$	S	V%	$\bar{x}$	S	V%
		Youths			Men	
a	14.2	4.6	32.39	19.7	4.8	24.37
a'	-27.1	15.7	-57.93	-12.6	10.8	-85.71

sport actions.

The graphically presented results also show another significant control variation according to the gymnasts' qualification. The initial phase of the more experienced ones is characterized by a much higher peak (global maximum of the curve). This peak is perceived by the side viewer (the judges respectively) as "a beautiful line" and freedom of performance and is an indication of confidence in the ability to control the inertial impulse. The inertia forces are toned down with permanent frequency harmonious vibrations. The non-elite gymnasts exhibited a much smaller global maximum and it is toned down by means of unevenly distributed local maximums (fig. 1 and 2). The above differences are more pronounced at rings performances where local maximums do not exhibit a strictly diminishing function. The phase structure at parallel bars and rings has identical structural organization. It is interesting to note the behavior of the third derivative $a'a'$ (t), where unlike the non-elite gymnasts, the elite gymnasts exhibited evenly distributed variation processes close to zero of a clearly pronounced diminishing nature.

CONCLUSION

The studied biomechanical parameters show good possibilities for a quantitative evaluation of the sports mastership of inertia forces control. The average statistical values of the biomechanical parameters are not a reliable measurement of the ability for inertia impulses control due to the very high values of the global maximums. In practice it turns out that the control is exercised under different initial conditions. The identical phase structure at parallel bar and rings performances creates conditions for transfer of the skills from one apparatus to another. The noticeable individual specificities call for an individual approach in optimizing the training process.

Correspondence:
Blaga Traykova
"Vassil Levski" National Sports Academy
Anatomy and Biomechanics Department
Studentski grad, 1700 Sofia, Bulgaria
E- mail: forpibi@abv.bg

REFERENCES

Гавердовский, Ю. (2013). Биомеханика гимнастики: скрытые возможности [Biomechanics gymnastics: hidden features. In Russian.] *Журнал „Наука в олимпийском спорте"* (2), 57-64.

Dimitrova, B. (2015). Coordination abilities and selection in gymnastics. *Activities in Physical Education, 5*(2), 241-243.

Hedbávný, P., Sklenaříková, J., Hupka, D., & Kalichová, M. (2013). Balancing in handstand on the floor. *Science of Gymnastics Journal*, *5*(3), 69-80.

Hayes, K. C. (1988). Biomechanics of postural control. *Exercise and Sport Science Review*, (10), 363-391.

Hiley, M., Wangler, R., & Predescu, G. (2009). Optimization of the felge on parallel bars. *Sports Biomechanics, 8*(1), 39-51.

Hiley, M., & Yeadon, M. (2012). The effect of cost function on optimum technique of the under some results on parallel bars. *Journal of Applied Biomechanics, 28* (1), 10-19.

Hudson, J. L. (1996). Biomechanics of balance: Paradigms and procedures. *Proceedings of the XIIIth International Symposium on Biomechanics in Sports* (pp.286-289). Thunder Bay, Ontario, Canada: Lakehead University.

Herodek, K., Joksimović, A., Nejić, D., Raković, A., Marković, K., & Stanković, D. (2011). Plyometric training and it's effects on quickness. *Research in Kinesiology, 39*(2), 171-176.

Kerwin, D. G., & Trewartha, G. (2001). Strategies for maintaining a handstand in the anterior-posterior direction. *Med. Sci. Sports Exerc., 33,* 1182-1188.

Yeadon, M., & Brewin, M. (2003). Optimized performance of the backward long swing on rings. *Journal of Biomechanics, 36*(4), 545-552.

Farana, R., Jandacka, D., & Irwin, G. (2013). Influence of different hand positions on impact forces and elbow loading during the round off in gymnastics. *Science of Gymnastics, 5* (2), 5-14.

Yaedon, M.R., & Trwartha, G. (2003). Control Strategy for a Hand Balance. *Motor control*, (7), 411-430.