CONNECTION BETWEEN SOME KINEMATIC PARAMETERS AND SUCCESSFUL PERFORMANCE OF THE TSUKAHARE JUMP

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Abstract
The aim of this study was to determine the influence of kinematic parameters, morphological measures and some motor tests on the success of performing a complex element on the jump - the Tsukahara jump. For this purpose, a study was conducted on a sample of 10 young gymnasts aged 12 to 14 years. In total, ten kinematic variables obtained by video were analyzed. Each respondent jumped three jumps, whose attempts were recorded in the preparation of the national team in Čakovec. The results were processed by regression analysis, which found that there was a significant multiple correlations between the set of kinematic parameters and the Tsukahara jump. The individual influence of six kinematic parameters on the criterion variable was also determined.

Key words: *gymnastics, kinematics, Tsukahara jump.*

Introduction

Leap jumps are one of the most attractive elements in sports gymnastics and can be performed in different rotations and body positions at different stages. It is believed that the kinematic variables of the jump on the jump may vary depending on the jump group or the body position of the gymnast. Kinematic jump variables can be diversified according to the mode of entry into a horse or position depending on the jump, but little has been studied about biomechanical differences, comparing and describing behaviors at different stages (Fernandes, Carrara, Serrão, Amadio, & Mochizuki, 2016).

The Tsukaharu jump is characterized by body rotation in the first phase of flight, which means a loss of speed compared to the other jump groups. Setting hands makes gymnasts spend more time on horseback. However, the jump group in which Tsukahara is located contains a higher value, a.k.a. a higher initial rating than the jump group in which Yurchenko is located and can be more easily developed by beginners due to visual contact with the horse. Boosting happens when a gymnast jumps on a mat and completes the jump.

Landing, a.k.a. completion, is a basic evaluation criterion, as it depends on the performance of the first and second stages of flight. It is one of the most important segments of the jump because it accumulates errors from all stages of the jump jump. The high-quality performance of the Tsukaharu skip is the result of a sequence of realized movements of body parts and the entire gymnast's body. Biomechanical analysis of the jump in two-dimensional space will provide valuable and important information on the temporal, spatial and kinematic characteristics of the jump. Many researchers have studied structural and biomechanical analysis of gymnastic jumps, for example: (Naundorf, Brehmer, Knoll, Bronst, & Wagner, 2008) state the importance of the run-in phase, which allows the highest horizontal speed to be achieved when jumping. Generally, gymnasts generate kinetic energy during a sprint, which is divided into linear and angular momentum during the reflection phase of the board. These moments dictate the linear and angular momentum exerted into the horse. (Atiković, 2012). Velickovic, Petkovic D. and Petkovic E. (2011) analyzed the speed of running in the last ten steps for gymnasts who were in the finals of the World Cup (elite) and World Cup (high level).

In the last ten steps, gymnasts have progressively increased speed and peaked in the final step, elite (9.95 m / s) faster than high-level gymnasts (8.57 m / s). Therefore, elite gymnasts are more prepared to perform the jump better, due to higher end speed and momentum, better adaptation and precision running. Sano, Ikegami, Nunome, Apriantono, and Sakurai, 2007 state in their research the importance of jumping on a springboard where the goal is to transfer the impulse produced on the run and on the springboard to the 1st and 2nd stages of flight. When the gymnast's feet touch the springboard, the maximum force is about ten times the body weight (Greenwood and Newton, 1996).

In the jump group in which Tsukahara belongs, there is a chance that gymnasts will touch the horse first with one hand, then with the other hand, which could be the reason for longer support for the horse. This fact helps gymnasts to turn on a horse 180 ° (Farana, Uchytil, Jandacka, Zahradnik & Vaverka, 2012). Farana and Vaverka (2011) made a study consisting of two factors. The first factor was the mass center (CM) trajectory in the first phase of flight, and the second factor was the

center of mass trajectory (CM) in the second phase of flight, identified at the second level of gymnast quality and related to judges' ratings at the first level. The CM trajectory in the pre-flight phase depends on the resulting velocity during board reflection, the relative height of board reflection, and the timing of the first stage of flight (Level 3). The resulting velocity at reflection from the board is the vector sum of the horizontal and vertical velocity at reflection.

The relative height of the reflection is determined by the CM height at the reflection from the board and the CM height at the contact of the horse. The timing of the first phase of flight is determined by the height of the CM, the vertical speed of reflection from the board, and the height of the CM when touching the horse (4th level).

Yeadon, Jackson, and Hiley (2014) found that increased touch velocity and angular momentum affect the height of the second phase of flight and thus the additional potential rotation. With higher altitude in the second phase of flight, the gymnast has more time to perform complex rotations about the transverse or longitudinal axis, and thus control the boom. (Velickovic, Petkovic & Petkovic, 2011).

The main objective of this research is to analyze kinematic parameters in 2D space and to determine their influence on the performance of the Tsukahara jump in the best young gymnasts in Croatia aged 12 to 14 years.

Methods

Subject sample
For the purposes of this research, a sample of entities consisted of 30 high jump gymnasts, ages twelve to fourteen. Each of the 10 respondents jumped three jumps, whose attempts were recorded in preparation for the national team in Čakovec.

Therefore, a total of 10 gymnasts were measured from GK "Rijeka", GK "Marjan" from Split, ZTD "Hrvatski sokol" from Zagreb and GK "Vita" from Rijeka. Respondents are competitors of the top A program, ages 12-14. Out of the total number of respondents, 7 of them belong to a representative group of gymnasts, so we can characterize them as top gymnasts in Croatia.

Sample of kinematic variables
Display of kinematic parameters of Tsukaharu jumps

1. VD- the duration of contact with the board
2. V1FL- duration of 1st phase of flight
3. VU- duration of resistance on horseback
4. V2FL- 2nd phase flight time
5. VCS- the duration of the entire jump
6. KKD1 - angle in the hook on the board
7. KL-elbow angle during resistance to horse (first hand)
8. KK2FL- angle in the hip during the 2nd phase of flight
9. KKD2 - angle on the hook on the drop
10. VCM - the height of the center of mass at its highest point during the 2nd phase of flight
11. VD - was measured from the first to the last touch of the board
12. V1FL- was measured from the last touch of the board to the first touch of the horse with his hands
13. The VU was measured from the first touch of the hands to the last
14. V2FL- was measured from the last touch of the horse's hands and the first foot contact with the ground
15. VCS - a gauge from the first touch of the foot to the board to the first touch of the feet
16. KKD1- was measured at the time of maximum force on the board, and the points at which the angle was measured were acromion, trochanter, and Latin maleolum.
17. KL- was measured at the moment when both hands were on a horse. The hand that first touched the horse was measured. The points at which the angle was measured were acromion, olecranon, and wrist
18. KK2FL- was measured at the point when the gymnast had already started to turn into a somersault
19. KKD2- was measured at the time of the jump, when the practitioner completed the jump. The point at which the angle was measured were acromion, trochanter, and Latin maleolum
20. VCM - height of the center of mass was measured in phase 2 of the flight when the trainee reached its highest height.

Two Panasonic video cameras were used to record when performing the Tsukahara jump. The camera's aperture speed was adjusted to 1/500 with open focus. The first camera was set up to record the first four stages of the jump, while the second camera was set up to record the other three stages of the jump.

The kinematic parameters were recorded in the left sagittal plane of the subjects' body. Video calibration was performed for vertical and horizontal directions before and after recording. The tapes from the S-VHS tape were switched to a digital system. All gymnast jumps were digitized at 50 Hz using APAS version 13.3 software for 2D data analysis.

The criterion variable (jump judge's score - Tsukaharu), each jump was evaluated by a judge of the Croatian gymnastics team.

Results and discussion

In Table 1 the basic statistical parameters of kinematic variables of young gymnasts are presented. Unfortunately, the obtained values from this research could not be compared with the results of other studies, because to the best of the authors' knowledge there were no similar studies on the population of the same age. In each case, the kinematic variables applied satisfy the basic metric characteristics and are also normally distributed and can serve as a specific standard for the formation of a biomechanical Tsukahara jump model.

Table 1. Basic descriptive parameters of kinematic variables.

	N	AS	MIN	MAX	Std.Dev.
KKD1	30	141,60	131,00	155,00	6,43
KL	30	113,13	87,00	146,00	15,52
KK2FL	30	69,60	51,00	83,00	7,75
KKD2	30	120,37	78,00	159,00	24,27
VCM	30	143,16	123,85	167,00	11,54
VD	30	0,52	0,10	12,00	2,17
V1FL	30	0,11	0,04	0,19	0,03
VU	30	0,306	0,20	0,57	0,07
V2FL	30	0,77	0,72	0,85	0,03
VCS	30	1,31	1,23	1,69	0,08
GRADE	30	11,58	9,00	12,70	0,99

sample (N), arithmetic mean (AS), minimum (MIN), maximum (MAX.), standard deviation (Std.Dev.)

The results of the regression analysis of the criterion variable in the space of kinematic parameters are presented in Table 4. A high multiple correlation was achieved between the system of ten kinematic variables that represented the predictor set and the criterion variables / Tsukahara jump /. The coefficient of association was 0.93 with a coefficient of determination of 0.88. The connectivity is significant at the 1% error rate, /p=0.001/. Of the ten predictor variables, six have a significant impact on the performance of the Tsukahara jump. The highest beta regression coefficient and the highest prognostic value were obtained by the variable VU / duration of resistance on a horse. The Tsukahara jump is characterized by the movement of the gymnast with body rotation and the inevitable loss of speed if we compare this jump with other jumps on the jump. Certainly placing your hands on a horse forces gymnasts to spend more time on horseback. So a solid and solid and long enough contact with the horse will allow for optimal movement of the body in subsequent parts of the jump. In this way, it is possible to explain the primary and paramount importance of this predictor variable to the quality performance of the Tsukahara jump, in this case the criterion variable. The duration of the first and second parts of the jump, and thus the entire jump, largely defines the performance itself. Quality performance is possible if we finish the jump in as little time as possible. An explosive and fast reflection from the springboard with strong pushing away from the horse will allow you to reach a higher position of the center of mass of the body in the jump. With a higher CM body position, gymnasts are left with more time to perform additional rotation-jump elements and to prepare themselves for the boom. Kinematic Parameters / Duration 1 and 2. The jump stages as well as the whole jump, as well as the height of the center of mass of the body at the highest point of movement in the second stage / made a significant and relatively high impact on the

performance of the Tsukahara jump. Also the variable KKD2 / angle in the hip when it comes down / plays a significant and crucial role in the final evaluation of the performance of the criterion variable. The actual realization of the jump depends on previous performances that make the leap. A well-executed boom is unlikely to be achieved if there are difficulties or defects from the very beginning of the jump. The higher the angle at the hip joint on the downhand, the better the performance is judged. Of course this angle does not exceed 180 degrees.

Table 4. Regression analysis of the Tsukahara jump in the space of kinematic parameters.

	b*	p-value
Intercept		0,01
KKD1	-0,102	0,349
KL	0,02	0,855
KK2FL	-0,119	0,217
KKD2	0,456	0.012
VCM	0,405	0,004
VD	0,002	0,979
V1FL	0,939	0,002
VU	1,188	0,048
V2FL	0,628	0,038
VCS	-0.955	0,015

standardized regression coefficient (b), level of significance (p)

R	0,94
R2	0,88
Adj. R2	0,82
F (10,19)	14,27
p<	0,00

level of significance (p), determination coefficient (R2), connection coefficient (R)

Conclusion

Finding an adequate Tsukaharu jump model to determine the modalities of the training process, as well as adopting a performance technique and determining the demanding values on which success in the final evaluation of this gymnastics element depends, is a major problem faced by sports coaches and biomechanics. The high-quality performance of the Tsukaharu jump depends on many factors such as motor skills, and in particular, the application of certain biomechanical models to the realization of the elements of the skip technique will contribute to better performance.

The aim of this research was to determine the influence of kinematic parameters, morphological measures and some motor tests on the success of performing a complex element on a jump - Tsukahara jump. For this purpose, a study was conducted on a sample of 10 young gymnasts aged 12 to 14 years.

In total, ten kinematic variables obtained by video were analyzed. Each respondent jumped three jumps, whose attempts were recorded in the preparation of the national team in Čakovec.

The results were processed by regression analysis, which found that there was a significant multiple correlation between the set of kinematic parameters and the Tsukahara jump. The individual influence of six kinematic parameters on the criterion variable was also determined. From a scientific point of view, it is certain that the information obtained from this research will be significant and valuable given that the skips of young high-quality gymnasts were analyzed.

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