KINEMATIC EFFICIENCY OF THE “MOZNIK” ELEMENT PERFORMANCE

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Abstract
The aim of this research was to determine objective kinematics parameters of “Moznik” element which differ a successful performance from an unsuccessful one. For the purposes of this research twelve typical performances of the “Moznik” element were selected. Acquisition of kinematics parameters was done with the software system DartFish (Video Analysis Solutions). On the basis of the obtained data a set of 37 kinematics variables was formed. The results of this study showed that the angle of the hand in relation to the bar in a successful performance significantly differs from the one in an unsuccessful performance. It is evident that in the case of the successful performances, the so-called “whip” begins a bit later. It has also been found that after the release of the bar, the angles in the shoulders are considerably more open in successful performance than in an unsuccessful one.

Key words: gymnastics, horizontal bar, biomechanics, angles, shoulders, hips

Introduction
There are six apparatus in men artistic gymnastics. In all-around competitions, the horizontal bar is the last apparatus at which gymnasts compete. Horizontal bar is often considered as one of the most exciting gymnastics event due to the power exhibited by gymnasts during giant swings and spectacular flight elements and dismounts that often include multiple sommersaults and twists. Known for its specificity, complexity and attractiveness, horizontal bar is popular called a “royal discipline”.

The standard height of the bar, measured from top of the mat, is 2.6 meters, or 2.8 meters measured from the floor. The horizontal bar routine consist of at least nine elements and the dismount. Skill complexity is evaluated by the International Gymnastics Federation Code of Points (FIG 2013.), using an ordinal scale, where ‘A’ is the least difficult and ‘G’ is the most difficult element. Each routine on the high bar must contain at least one element from each of the five different groups of elements, whereby it may contain a maximum of four elements from the same group. One of those groups is called “Flight Elements”, in which gymnast must release the bar, make a specific movement in the air, grasp the bar and continue with the routine. The gymnasts do connect elements through all exercise, and sometimes they connect two or three “Flight Elements” to achieve a bonus or bigger start value for the routine. Considering their attractiveness and the high skill level required, there has been comparatively much biomechanics researches of performance efficiency in elements from the “Flight Elements” group (Hraski 1992., Čuk 1992., Prassas et al. 2006., Hiley et al. 2007., Gittoes et al. 2013.).

In the gymnastics Code of Points every element has a detail description and some elements are named after the gymnasts who first registered and performed the element at the official FIG event - World Cup, World Championships, Olympic Games. The “Moznik” element belongs to the “Flight Elements” group, and was registered and performed for the first time at the World Championships in Stuttgart, 2007. It has an “E” value for difficulty. It was included in the FIG Code of Points from January 1, 2009, under the name “Moznik”, as the first element named after a Croatian gymnast. The full name of the “Moznik” element is – Tkachev straight with ½ turn to mix grip uprise to handstand. The specificity of its performance is manifested in the position of the head right before grasping the bar, where the head turns, disabling visual control with the bar. Due to this, as well as its extremely complex structure – the flight backwards over the bar with forward rotation of the body along with rotation due the longitudinal axis – the efficiency of its performance depends on a number of biomechanical details.

The aim of this research was to determine objective kinematic parameters of this element which distinguish a successful performance from an unsuccessful one.

Methods
The data of the “Moznik” element performances were collected from video materials, which were recorded at the same location, in an identical manner, during the two weeks of training right before the beggining of the competition season. The recordings was carried out with one single camera positioned in extension to the rotational axis (the bar) or vertical to the direction of the gymnast’s movement. The recording speed was 50 frames per second.
The subject of this study was an elite gymnast, 22 years old, 183 cm tall and weighs 80 kg. He is the first gymnast in the world who performed this element, which was therefore included in the FIG Code of points under his name.

From a large number of successful and unsuccessful recorded performances of the “Moznik” element, twelve typical performances were selected for the purposes of this research. The selection was done by a team of experts made out of one coach and two gymnastics judges. The main criterion for assigning a performance to the category of successful execution was whether the element, after the flight phase, was executed successfully by regrasping the bar and finished upright to handstand. A typical unsuccessful execution was classified as such according to the criterion of unsuccessful regrasping of the bar as a result of the gymnast’s too distanced position from the bar in the phase of regrasping the bar.

Acquisition of kinematics parameters was done with the software system DartFish (Video Analysis Solutions). The space was calibrated by the markers positioned on and around the horizontal bar. For each of the 6 typical positions in each of the 24 video recordings, the reference points of the vertex, shoulders, hips and feet were manually marked. After that shoulders and hips angles were measured, as well as spatial positions of the palms, shoulders, hips and feet in relation to the bar. Determination of the reference points and the measurement of the kinematic parameters was done three times for each frame of the video, and the arithmetic mean of registered values was used for further analysis. On the basis of the obtained data, a set of 37 kinematic variables was formed, which was later processed (descriptive statistics, T-test) by means of the Statistica for Windows program. The selection of the variables was formed according to the structure of the analyzed element, i.e. on the fact that, during the execution of the “Moznik” element, the body of the gymnast moves by mutual interaction of the three segments of the body: the arms, trunk and legs. In this respect, in examination of six typical positions of the “Moznik” element execution, the set of kinematic variables consists of:

- **F1** – Position of the last contact with the bar (F1AA - arms angle, F1SA - shoulders angle, F1HA - hips angle, F1SH - shoulders height, F1HH - hips height)
- **F2** – Position right after releasing the bar (F2AA – arms angle, F2SA – shoulders angle, F2HA – hips angle, F2SH – shoulders height, F2HH – hips height)
- **F3** – Position of the maximum flight height (F3AA – arms angle, F3SA – shoulders angle, F3HA – hips angle, F3SH – shoulders height, F3HH – hips height)
- **F4** – Position at the beginning of rotation (F4AA – arms angle, F4SA – shoulders angle, F4HA – hips angle, F4SH – shoulders height, F4HH – hips height)
- **F5** – Position of the first (left) hand contact with the bar (F51HA – first (left) hand angle, F52HA – second (right) hand angle, F5PH – palm height, F5SH – shoulders height, F5HH – hips height, F5FH – feet height, F5SD – shoulders distance, F5HD – hips distance, F5FD – feet distance)
- **F6** – Position of the second (right) hand contact with the bar (F61HA – first (left) hand angle, F62HA – second (right) hand angle, F6SH – shoulders height, F6HH – hips height, F6FH – feet height, F6SD – shoulders distance, F6HD – hips distance, F6FD – feet distance)

**Results**

**Last contact with the bar**

According to the results, it is evident that significant difference between variables exist in the arms angle (F1AA), shoulders angle (F1SA) and hips angle (F1HA). The successful executions of the “Moznik” element in relation to the unsuccessful execution are characterised by a somewhat lower arm angle in relation to the bar (33º compared to 37º), and somewhat minor shoulders (173º/182º) and hips angles (208º/212º).

**Releasing the bar**

In the position after releasing the bar a significant difference between variables occurred only in terms of the height of the shoulders (F2SH) and it is amounted to 3 cm.

**Maximum flight height**

As in the first analyzed position F1, the significant difference between variables are shown in the arms angle (F3AA), shoulders (F3SA) and hips angle (F3HA).

**Beginning of turns around the longitudinal axis**

In the position where the turn around the longitudinal axis begins significant difference between variables exists in four out of five arithmetic means of the analysed variables. The arm angle (F4AA) in successful performances of the “Moznik” element is 10º greater than in unsuccessful ones. Furthermore, the shoulders angle (F4SA) is 12º greater. In this position the shoulders height (F4SH) and hips height (F4HH) differ to a significant extent for the first time.
First (left) hand contact with the bar

In the successful performances, the angle of the hand which first comes into contact with the bar (F51HA) is greater than the one in unsuccessful performances of the “Moznik” element (149º compared to 124º). Differences between variables exist in the hips and the feet height as well. Also, a difference is shown in the height of the hips (F5HH) and of the feet (F5FH), which are 5 cm lower in the successful executions in the case of the hips, and 27 cm in the feet case. Finally, all the variables measuring the horizontal distance of the shoulders (F5SD), hips (F5HD) and feet (F5FD) from the bar are different and are logically less in successful than in unsuccessful performances.

Second (right) hand contact with the bar

In the position where the second hand comes into contact with the bar it is shown that a difference between variables exists in six out of nine analysed variables. In this position, as well as in the the previous one, the angle of the hand which first comes into contact with the bar is greater in successful than in unsuccessful executions (195º compared to 170º). Furthermore, the measurements which define the height of the body in that position are different to a relevant extent. The shoulders are 4 cm lower (F6SH), the hips 13 cm lower (F6HH) and the feet as much as 32 cm lower (F6FH) in the succesful performances.

Discussion and conclusion

Last contact with the bar

The variations in arms, shoulders and hips angles in this phase can be explained in terms of premature hyperextension of the hips at the unsuccessful performances, which later resulted in the earlier opening of the shoulders angle, occuring as a consequence of an earlier realisation of the so called “whip” (the fast hyperextension of the hips which is also followed by the opening of the shoulders angle). The earlier realisation of “whip” causing premature release of the bar and that caused insufficient flight distance from the bar. The gymnast need enough distance from the bar for successful performance of turn, catch the bar and continue in back uprise to handstand, so this premature release caused unsuccessful performance of “Moznik” element.

Releasing the bar

Considering that the kinematic characteristics of the parabole of the flight are defined during the last contact with the bar, it is not unusual that there are no statistically significant variations between succesful and unsuccessful executions of the “Moznik” element during this early flight phase. In this connection, statistically significant 3 cm greater height of the shoulders in the unsuccessful performances was the consequence of the aforementioned premature hyperextension of the hips right before the release of the bar. Premature “whip” in unsuccessful performance caused flight direction of shoulders more vertical in this phase.

Maximum flight height

Compared to the overall comparative analysis of successful and unsuccessful performances of the “Moznik” element, the greatest variations were shown in this phase of the element performance. However, the highest values of standard deviations were registered as a result of the problematic position evaluation for the maximum flight height during manual digitalization of the reference points on the one hand and the fast opposite acts of arm and body movement during the flight phase on the other hand. The subsequent hyperextension of the hips at the moment of release results in faster opposite movement of some parts of the body in the flight phase – the arms and upper part of the trunk in a forward direction and the hips and legs backwards.

Beginning of turns around the longitudinal axis

Obviously, the start of the turns arounds in succesful performances begins by pronounced pushing the arms in a forward direction, along with a higher position of the shoulders (for 7.6 cm) and a somewhat lower position of the hips (for 3.2 cm).

First (left) hand contact with the bar

Pushing the arms in a forward direction or the opening of the shoulders angle is shown to be of great singificance, and the hand which comes into contact with the bar is 25º more open in the successful than in unsuccessful performances.
Second (right) hand contact with the bar

In the most unsuccessful element performances, the second hand didn’t reach the bar because the body was too far from the bar.

Finally, analysing the chosen kinematic parameters which determine the execution of the “Moznik” element, it is shown that in all positions the angle of the arms figures as a variable which distinctly distinguishes successful from unsuccessful executions (Figure 1). Considering that all spatial positions of the body are dominantly determined by the actions in the shoulders and hips, it is evident that in the case of the successful performance the so called “whip” begins somewhat later. It has also been found that after the release of the bar, the angles in the shoulders are considerably more open in successful performances than in unsuccessful ones (Figure 2). This is a consequence of a powerful forward shift of the arms which produces better conditions for the realization of turns around the longitudinal axis of the gymnast, as well as better conditions for achieving the grasp of the bar.

![Arm angle in relation to the bar](image1)

*Figure 1: Arms angle in relation to the bar*

![Shoulders angle distribution](image2)

*Figure 2: Shoulders angle distribution*

The element “Moznik” was first performed in 2007. Due to the extremely complex structure of this element, the efficiency of its performance depends on a number of biomechanical details. The results of this study will directly help in the training process for the purpose of more focus detection and correction of mistakes in performance.

References