KINEMATIC ANALYSIS OF MOZNIK ELEMENT ON HIGH BAR

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Abstract

In men artistic gymnastics high bar is often described as the most exciting discipline for spectators. Today contemporary high bar routine can include up to five flight elements. As the elements have to be different, also search for new elements is important. The flight elements Tkatchev (executed from front swing, backward vault with split legs to hang) have been developed in the last forty years in different ways. The last version of Tkatchev in Code of Points is since 2007 under Marijo Možnik's name as at World Championship in 2007 he performed stretched Tkatchev with 180^{o} degrees turn into mixed grip. With Možnik's career end and for the purposes of original inventor biomechanics characteristics of Moznik element, we did a kinematic analysis of Moznik element performed by element author. We measured the movement with Qualisys measuring system. Over 70 reflecting markers were attached to specific anthropometrical locations on the athlete's body. Their location was then calculated using 12 synchronized QTM cameras set at maximum of 178Hz and Qualisys software. Marker location was exported to Visual 3D software where with additional athlete's weight and height skeletal model was build. From these model trajectories, velocities, angles, angular velocities, angular momentum and moment of inertia were computed. According to results difficulty of the element is properly set as E value in Code of Points. The first 3D kinematic analyze of Moznik element in the world gave data for evaluation of technique, its methods and to set gymnasts physical preparation.

***Key words**: kinematic, Qualisys, Tkatchev, FIG*

Introduction

A contemporary horizontal bar exercise must be a dynamic presentation that consist entirely of the fluid connections of swinging, turning, and flight elements alternating between elements performed near to and far from the bar in a variety of hand grips so as to demonstrate the full potential of the apparatus (International Gymnastics Federation (FIG), 2017a). The standard height of the bar, measured from the floor is 2.8 meters (FIG, 2017b). According to the Code of Points (FIG, 2017a) gymnasts routine should consist of elements from the four different element groups, and each element is evaluated using an ordinal scale, from “A” (the least difficult) to “H” (the most difficult). The second Element group is called “Flight elements”– elements where gymnasts release the bar, make a specific movement in the air and regrasp the bar. In the FIG Code of Points every element has a detail description but some elements are also named after the gymnasts who first registered and successfully performed it at the official FIG competition. An element where gymnast performs from front swing vault backward straddled over bar to regrasp in back swing is named by Russian gymnast Alexander Tkatchev, who did this element at the European Championship 1977. Originally element was designed by scientist Gaverdovskij in 1962 and first performed by Soviet gymnast M. Pitamcev in 1968 (in tucked position) (Gaverdovskij, 1987, p.429). Since the first presentation of Tkatchev element it was upgraded by Yogo in 1979 (Nakasone, 2015) performing Tkatchev from stoop circle (but named by Piatti 1984 (Karacsony Čuk, 2105)), by Ljukin and Nakasone in 1988, they performed Tkatchev stretched, and at same year Ljukin also did Tkatchev stretched with 1/1 turn. In 1992 Lynch performed Tkatchev with ½ turn, in 2007 Možnik performed Tkatchev stretched with ½ turn into mixed el-grip, in 2009 Kierzkovski did Piatti stretched to mixed el-grip and in 2010 Kulesza performed Tkatchev stretched with ½ turn to double el-grip (Nakasone, 2015). In 2009 an article about possible performance of Tkatchev salto tucked was published by Čuk, Atiković & Tabaković, but up to today nobody performed it. Čuk and Colja (1996) prepared a model of developing new element in gymnastics, which consisted of seven phases: an idea of a new gymnastics element; a definition of the hypothetical biomechanics model of a new element; a consistency of the new element with the present Code of Points; a design of methodic, training until successful execution, collecting and analyzing biomechanical data; a definition of optimal biomechanics model of the new element and saving it into data base. Same authors also stated that the first phase is usually random by nature, when coach and gymnast according to their experience and logical thinking want to promote the gymnast with a new element. In year 2006 Tigran Gorički, coach of Croatian national team gymnast Marijo Možnik, came up with the idea of the new element on horizontal bar. To accomplish the new element it took him one year of training and he successfully performed this new element at the 2007 World Championships in Stuttgart and since than it has an “E” value for difficulty. Element was included in the 2009 FIG Code of Points under name – “Moznik” (Figure 1).

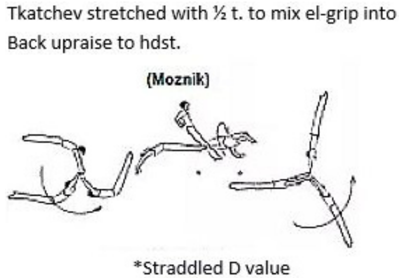


Figure 1. Moznik element as it is described in Code of Points (FIG, 2017a)

Since then Mario Možnik's results at the top level competitions rose: 2015 European Champion; 2014 World Championships bronze medalist; 2012 European championships silver medalist; 2010, 2013 and 2014 World Cup Overall Winner. Precondition for safe and successful learning of "Moznik" element is highly reliable performance of Tkatchev stretched. In the terms of safety for gymnast it is very important to be in the optimal distance from the bar during regrasp, otherwise there is a risk of hitting the bar with the head, or falling on mats. The second major risk is the potential loss of hand contact with the bar due to unfinished turn (fall on mats is a consequence; however landing with turned body is highly risky for spine injuries). Proper initiation and ending time of the turn before regrasp is very important also in the terms of the successful performance of the element (without deduction from the judges). In previous researches many authors did analysis of different Tkatchev element variations, but up to now only Možnik and Hraski (2014) did 2D kinematic efficiency analysis of the Moznik element performance. With new technology (as this element has movement in all three axis) we stated aim to perform a reliable and valid kinematic analysis of Moznik element in order to get data to evaluate technique, and to get data for gymnasts physical preparation.

Methods

Subject of measurement was Marijo Možnik, born 18th January 1987, 183 cm height, and 79 kg weight. We measured the movement with Qualisys measuring system (Qualisys AB, Göteborg, Sweden). Over 70 reflecting markers (Figure 2) were attached to specific anthropometrical locations on the athlete's body according to C-motion protocol (van Sint Jan, 2007). After initial calibration, markers' locations were calculated using 12 synchronized QTM cameras set at maximum of 178Hz and Qualisys software. Marker locations were exported to Visual 3D software (Visual3D v6 Professional, C-Motion, Germantown, USA) where with additional athlete's weight and height skeletal model was build. The first and last frames for the analysis were hang (arms vertical) before release and after the regrasp on the high bar. From those model trajectories, velocities, angles, angular velocities, angular momentum, moment of inertia were calculated. Parameters such as center of mass, moment of inertia and speed of chosen segment and point were computed. The moment of release was defined as moments when the position of the marker placed on the first knuckle of the index finger moved for more than 5 cm relatively to the position of the bar which was defined in the V3D system. When this distance was smaller than 5 cm, this counted as a regrasp. While this was case study, descriptive data was used only.

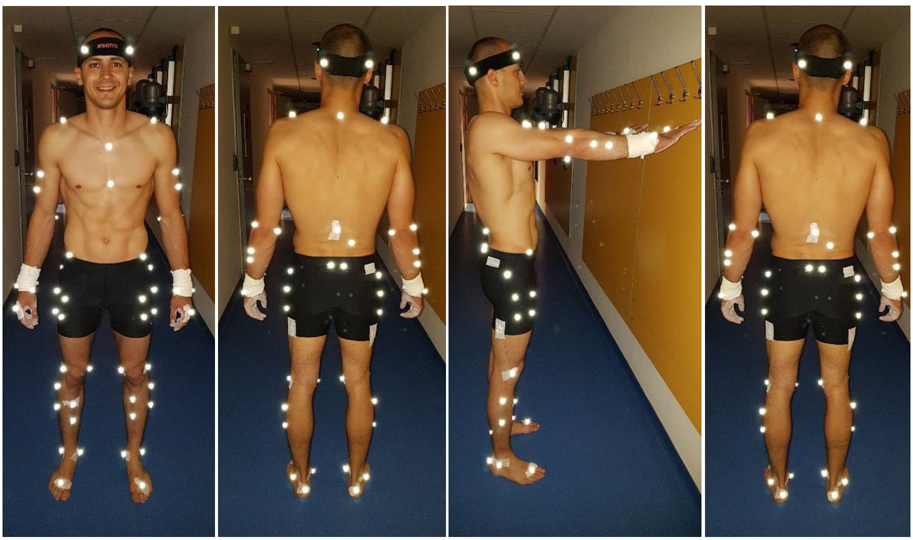


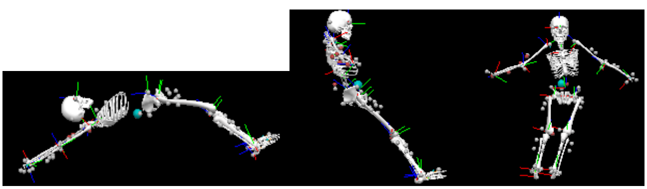
Figure 2. Reflective body markers positions

All measurements were held at Faculty of Sport, University of Ljubljana, Slovenia on 19. 6. 2017 in evening hours, with proper temperature 25^{o} Celsius and humidity of 40% in gym hall. Evening time was selected to avoid sun light reflections on markers. QTM cameras were located around gym hall to cover each marker with at least 3 cameras simultaneously (Figure 3).

Figure 3. Positions of 7 QTM cameras

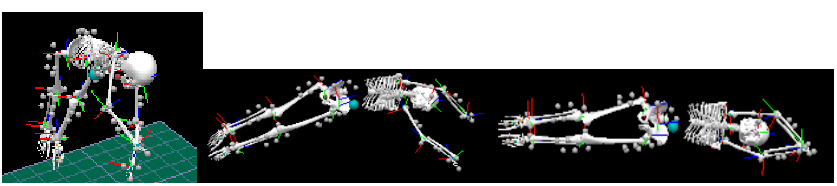
Results

After analyzing positions following ones are important for further analysis: moment of release (Figure 4a), moment of maximum height (Figure 4 b and Figure 4 c), arms crossing beginning (Figure 5a), regrasp with left hand (Figure 5b), and regrasp with right hand (Figure 5c). Temporal parameters for Moznik element are: time of full flight from release to left hand regrasp 0.74 s, and to regrasp with right hand 0.81 s; time from release to start initiation of turn is 0.47 s. Difference between left hand regrasp and right hand regrasp is 0.07 s. From analysis it is worth to note there is not symmetric regrasp with both hands, but there is a delay, however very short one that if human eye is not directly focused only on regrasp, it is hard to notice it, and this depends also on spectators view.



a b c

Figure 4. a - moment of release, b and c – maximum height different views



a b c

Figure 5. a – moment of crossing arms, b – regrasp with left hand, c – regrasp with right hand

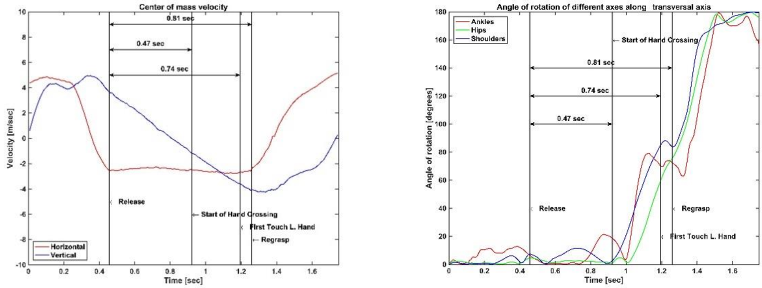


Figure 6. a – Body center of mass (BCM) velocity in x and y axis, b – joint angle in xyz axis

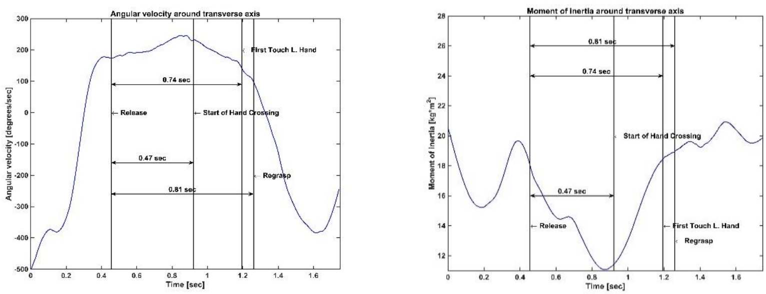


Figure 7. a – angular velocity around transverse axis, b – moment of inertia around transverse axis

Discussion

According to data from Atiković (2006) flight time of straight Tkatchev is between 0.64 s up to 0.76 s with an average of 0.70 s and our data show higher time is needed to perform Moznik element with an extra 180 degrees turn. Comparing Moznik element with stretched Tkatchev at release it is noted that velocity in y axis of BCM for Moznik is much higher 3.72 m/s than with Tkatchev 2.44 m/s – 3.01 m/, while horizontal BCM velocity is very similar (Čuk, Atiković, Tabaković 2009) with 2.49 m/s (Figure 6a). On Figure 6b are angles of ankle, hip and shoulder axis (axis left to right) in relation to high bar axis. Turning effect is made mostly according to Yeadon (1999) tilt turn, however it is important to notice that performing Moznik element while performing ½ salto forward, also counter turn direction movement in shoulder and hip axis before start turn was noticed, and Moznik element was also performed with combination of cat turn (Yeadon, 1999). Similar activity is noticed also with change of moment of inertia during flight around transverse axis, where with hip forward and side bending, shoulder adduction, subject lowers moment of inertia for 38% (from 18.03 to 11.06 kgm^2) (Figure 7b). Angular velocity around transverse axis (at release $176.6^0 s^{-1}$, and it is in middle range comparing with previous researches 147.8 – 229.3 $^0 s^{-1}$, Qian, Cai, Tang and Zhou (1987), Čuk, Piletič (1995)) is related with higher moment of inertia at release and during the flight with lowering moment of inertia (Figure 7b), when calculating angular momentum it is very high, in moment of release 56.02 $kgm^2 s^{-1}$ and much higher again according to previous researches (34.1 $kgm^2 s^{-1}$ +-7,6SD, Kerwin, Irwin, Samuleson 2007). It is important to note that measured subject is much taller and heavier than subjects in previous research (Možnik, Hraski, M. and Hraski, Ž. (2013) and therefore is also cause for higher values of most variables. While it is very hard to notice the difference between hands in regrasp with human eyes, it is also hard to notice the angle of the turn finished with shoulders and hips. In the moment of both hands regrasp less than half of the turn is completed (angle shoulder axis horizontal bar 83.4^0, hip axis 77.4^0) and whole 180^0 turn is concluded by reaching the lower hang position.

Conclusions

Flight element Moznik in its original performance is highly demanding in sense of biomechanics kinematic values. By most of the variables comparing to stretch Tkatchev higher values for Moznik were found. However judges' evaluation of performance according to Code of Points in terms of one hand regrasp first and in amount of completed turn in moment of full regrasp is difficult, as only 178 Hz cameras revealed significant differences with the rules. From biomechanical perspective the higher difficulty value in Code of Points comparing to stretch Tkatchev is proper. Turning within Moznik is combination of cat and tilt turn (according to Yeadon (1999) description of turning mechanics), which in literature up to now was not described in practice. For coaches and gymnasts these results can serve as a guideline in technique and methods, how to initiate turn in the element and to focus them to upgrade performances to be completely in accordance with Code of Points.

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