SYSTEMATIC REVIEW OF YURCHENKO VAULT KINETIC AND KINEMATIC INDICATORS

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Review article

Abstract

The aim of this article was based on determining the most relevant kinematic indicators in the Yurchenko vault technique, using the mechanical purposes of each phase as linking elements. A systematic qualitative review was carried out with an initial search of 67 scientific documents, of which 27 were selected by matching the Yurchenko key words, kinetic, kinematic and artistic gymnastics and their respective combinations. It was concluded that the main kinetic and kinematic indicators involved in this vault are: acceleration, speed, distance, displacement, trajectory, contact time, flight time, percentage of deformation and angular momentum that exert on the center of mass. The following article is proposed as a study instrument to guide in the correct direction of kinetic and kinematic factors to be considered in the effective execution of the Yurchenko vault technique.

Key words: *yurchenko, kinetic, kinematic, center of mass, vault, gymnastic.*

INTRODUCTION

In Artistic Gymnastics (AG), the Yurchenko vault is performed by men and women, which is categorized within the vaults originated from the round-off, with or without 3/4 of turn in 1st flight and back flip with or without turn in the 2nd flight; this sports skill consists of the execution of three gymnastic elements: rondat with ¼ turn, flic-flac and backward rewinding vault (Federation International Artistic Gimnastic, 2017).

Since the inclusion of Yurchenko into the score code of AG, this exercise has been one of the most ambitious and complex to perform by gymnasts in the vault mode, for both men and women (Carrara, 2009). Its correct execution guarantees a high score value from the judges, because it requires a greater difficulty when combining acrobatic elements, with or without hands support as well as a 2nd phase of flight.

This vault, in AG is the only element that offers a deeper analysis, because it implies the execution of more than one acrobatic element (Prassas, Kwon, & Sands, 2006), which expresses a certain level of

complexity and exigency in the precision and cleanliness of the execution. Among its kinematic characteristics, this vault encompasses a series of rotational and linear movements demanding speed and inertia for the continuity of the movement (Jemni, 2013). However, as all the vaults, the key of the success is in the approach and the pre-flight (Uzunov, 2010), moreover, the specific characteristics of post-flight must have a differentiated training (Takei, 2007). This is how it is noticed that to develop a correct technique, three key characteristics must be prioritized: a) center of mass speed during the pre-flight; b) angular momentum of the pre-flight; and c) angular velocity and pushing force in the repulsion (Penitente, 2014).

It requires an understanding in each of the phases of this sports technique (ST), which are segmented by its particular objectives. Currently, the ST study should generate more analysis than just the pedagogical study (Aedo-Muñoz & Bustamante-Garrido, 2012), which is used mainly in the transmission of the phases that compose the ST, omitting essential information to orient optimally towards a technical objective.

The ST should be understood as a sequence of organized movements oriented to the resolution of a specific motor task, according to the rules of competition (Barrios & Ranzola, 1999;Bermejo, 2013). The ST has the obligation to have an overall performance goal (GPO), which corresponds to its main characteristic involved in the fulfillment of this motor task (Morante & Izquierdo, 2008); thus each ST with its respective GPO are divided into phases that have a single mechanical purpose (MP), which refer to the mechanical or muscular characteristic that implies to enforce at each stage. Each MP originates its biomechanical indicators (BI), also called biomechanical targets (BT) and these correspond to all the kinematic indicators (Klm) and kinetic indicators (Kln) derived from the MP. Klm being our object of study, it should be mentioned that these aspects can be evaluated by the biomechanics of sport emphasized in the study of movement, regardless of the causes that could modify it (Ibañez, Martin, & Zamarro, 1989; Aedo-Muñoz & Bustamante-Garrido, 2012).

The purpose of this article is to identify the Klm and KIn involved in the MPs of the Yurchenko vault technique, as a way to highlighting the importance of the biomechanical study within the GA, which provides the keys for the performance in this discipline, for this reason it was considered relevant make a searching in a priority way of the kinematic variables that intercede in this type of vault, in order to provide concrete tools that follow a pedagogical guideline specialized in their teaching.

METHODS

A qualitative systematic review of the kinematic characteristics was carried out in relation to the ST phases and their respective MP. We used information sources from the last 20 years, for instance: Journal Science of Gymnastics, Journal International Sport of Biomechanic, Research Gate, Scielo and Dialnet, PubMed, Sciencedirect, SportDiscus, Elsevier, Medline, Web of Science, considering key words and combinations attributed to: "yurchenko", "kinematic", “kinetic” and "artistic gymnastics". It is worth mentioning that studies linked to some of the categories were excluded: studies published in a summary form and/or short communications, not written in English or Spanish, and those that, in rigor and formality, did not agree with characteristics necessary for this review.

In order to reach this purpose, an initial search of 67 documents in databases was managed, and 17 documents in texts, none of them were in duplicated. Browsing the publications, 41 were projected, 17 were excluded because did not contain kinematic criteria of interest for this study. 18 articles were selected and 23 articles were exempted from the review for not offering a finished study of the subject. Applying the criteria

mentioned above, 27 studies were used to carry out this qualitative research. From the selected references, the following article of review was constructed to describe and analyze the kinematics of the Yurchenko vault.

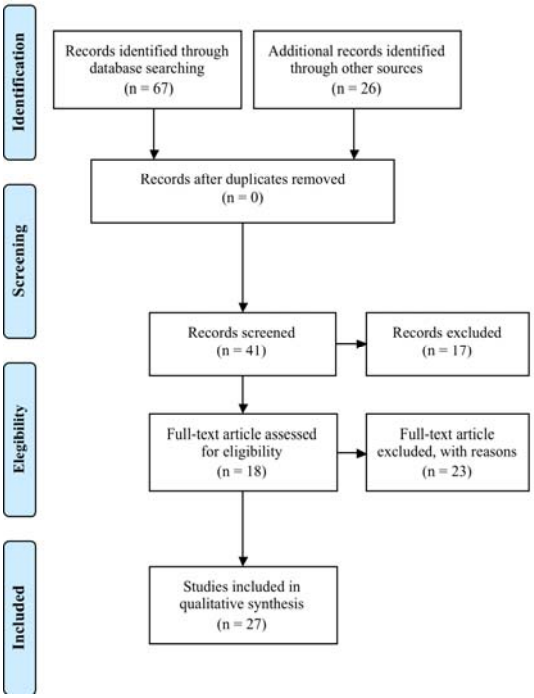


Figure 1: Flow chart of the review.

RESULTS

The GPO of the Yurchenko vault is a quick approach and an energetic repulsion in the pre-flight phase (Uzunov, 2011). Within many proposals of the phases of this ST, the most standard one divides the technical gesture into two phases: 1st flight and 2nd flight, from which the sub-phases emerge (Boldrini et al., 2016). In the individuality of its study, each phase shows MP that for its correct execution requires the knowledge of their respective Kim.

Figure 2. Yurchenko Vault Sequence (Boldrini et al., 2016)

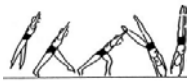
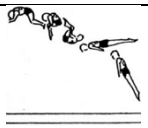
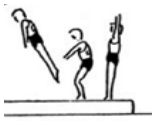
1st flight Subphase 1.1: **Run** Generate enough speed and stroke control (Federation International Artistic Gimnastic, 2017) MP: comfortable approach speed KIm: Speed and run distance.	
Subphase 1.2: **Round-off** Maintain the COM close to the ground to eliminate decelerations and allow greater trunk rotation (Uzunov, 2011). MP: Keep COM near the ground KIm: Trayectory of COM and angle relative rotation trunk. Horizontal displacement COM: 1,61±3 m. Vertical displacement of COM: 11±3 height%(Young-Kwan & Cheol-Hee, 2017)	
Sub-phase 1.3: **Springboard Support** Approximation of high impact angle - 60 ° in both angles - with minimal hip flexion and knees (Boldrini et al., 2016). MP: accumulation of elastic energy KIm: Percentage deformation springboard, Contact time with springboard, flight time and horizontal COM displacement. Contact time: 0.13±0.02 seconds Horizontal displacement COM: 0.57±0.08 m. Vertical displacement of COM: 36±5 height% Flight time: 0.12±0.02 seconds (Young-Kwan & Cheol-Hee, 2017)	
2nd flight Sub-phase 2.1: **Table Vault Support** Show a quick flex shoulders above 180 ° to touch the table through a powerful push to quickly deflect the vaulting table (Koh, 2007). MP: Energy elastic contact. KIm: Speed of COM, angle relative shoulder flexion, contact time with the table and table deformation porcentage. Contact time: 0.22±0.02 seconds COM horizontal speed: 3.0±0.045 m/s (Young-Kwan & Cheol-Hee, 2017)	
Sub-phase 2.2: **Back Flip** Started off the table, chest hides and lowered his hands to help accelerate rotation (Uzunov, 2011). MP: Accelerating rotation KIm: Angular acceleration *(a<º)*, Bending angle relative coxofemoral *(<ºcoxof)* and Flight time (*ft*).	
Subphase 2.3: **Landing** Watching the landig mat through both feet accurately. Keep your arms extended in front and legs in squatting position (Requejo et al., 2004). MP: COM KIm: COM and support base relationship.	

Figure 3. Yurchenko phases with Mecanic Purposes (MP) and Kinetic (KIn) and Kinematic indicators (KIm).

Table 1
Review summary table.

No.	Author	Sample	Method	Under study	Result
1	(Aedo-Muñoz & Bustamante-Garrido, 2012)	13 items	Qualitative literature review.	Conceptualisation of biomechanics	Tasks of biomechanics in sport are: Describe sports techniques., correct defects sports technique, propose more efficient and effective techniques.
2	(Aldazabal, 2010)	Does not have	Qualitative research method and quantitative	Kinetics	Kinetic analysis vault.
3	(Araújo, 2004)	Does not have	Qualitative research method	Artistic gymnastics	Mechanical aids in gymnastics.
4	(Barrios & Ranzola, 1999)	Does not have	Qualitative research method	Biomechanics	Manual initiation to the sport.
5	(Bermejo, 2013)	46 books, 26 articles and 2 theses	Qualitative literature review	Biomechanics	Sports technique is an ideal movement on sport and the athlete, it runs a sequence of logical pattern established based on internal and external sport and depending on prior knowledge in mechanics and practical experience rules.
6	(Boldrini, Carrara, Serrao, Amadio, & Mochizuki, 2016)	40 items with variables hand and vault	Qualitative literature review	Kinetic energy and potential energy	During preparation, the gymnast runs to increase the kinetic energy and increase mechanical linear and angular rotations to be held in the 2nd flight energy.
7	(E. Bradshaw, Hume, Calton, & Aisbett, 2010)	13 Australian high performance gymnasts	Feedback system as gymnastics vault	Speed and contact time	Speed measurements of contact with an integrated plate punch carpet, can be used reliably to assess vault in gymnastics.
8	(E. Bradshaw, 2004)	5 gymnasts Elite 13 to 15 years	2D capture system	Kinematic variables	Include exercises that improve the ability to run, vault during execution.
9	(E. J. Bradshaw & Sparrow, 2001)	5 trials for 5 gymnasts	2 reference strips were placed with alternating intervals of 50cm in black and white, on each side of the approach area over a raised platform for two qualified judges.	Diving important variables	A faster approach leads to an increase of the speed of rounding ($p \leq 0.01$), resulting in a rapid and short take-off table ($p \leq 0.01$).
10	(Carrara, 2009)	8 coach of the senior category of national teams - Portugal and Brazil	Descriptive statistics (mean and standard deviation) and inferential statistics (Mann-Whitney).	WAG Code 2001 y 2006 ,	Physical preparation, increased volume and intensity of training occurred; in the Technical Preparation, a greater variety of elements of the different groups was necessary; in the Tactical Preparation, the exercises with the greatest number of elements of greater difficulty are verified,
11	(Estapé Tous, 2002)	Does not have	Qualitative research method.	Acrobatics	Technical analysis of the vault.
12	(Federation International Artistic Gimnastic, 2017)	International levels	Method of experts and approved by the Executive Committee FIG, updated after Intercontinental Judges Course GAF (12 to 18 / Dec / 2016).	Code of Points in artistic gymnastics	Code of Points for Olympic Games, World Championships, regional and intercontinental competitions and events with international participants.
13	(Hassan, Hanna, & Ameen, 2015)	40 students University of Diyala	Method experiment using quasi-experimental design through a diving platform.	Biomechanics of vault	The theoretical biomechanical information they gave students a positive impact on their ability and performance, through the vault platform.

14	(Hedbávný & Kalichová, 2015)	14 gymnasts from 18 to 25 years	Method 3D kinematic analysis.	Speed	With the maximum speed in the take-off phase springboard, the athlete is able to better use the technique in order to properly execute the entrance to the vaulting table.
15	(Ibañez et al., 1989)	Does not have	Quantitative research method.	Physical variables	Kinematic analysis.
16	(Izquierdo, Echeverría, & Morante, 2008)	Does not have	Method of qualitative and quantitative research.	Biomechanics	Biomechanical analysis on physical activity.
17	(Jackson, 2010)	1 gymnast	A simulation model was developed in the phase contact with the table vaulting in gymnastics.	Kinematic vault	The angular momentum always decreased during the contact with the vaulting table, although the reductions were smaller when the rotation is maximized after the flight.
18	(Jemni, 2013)	Does not have	Quantitative research method.	Physical variables	Analysis of kinematics and kinetics in gymnastics.
19	(Koh, 2007)	1 gymnast	Experimental method through combined selection of parameters.	Kinematics	The angle of attack on the vaulting table remained low and previous angular momentum flight had to be increased with higher profits.
20	(Mkaouer, Jemni, Amara, Chaabene, & Tabka, 2013)	5 gymnasts high level	Through a platform synchronized force with a system of two-dimensional analysis to collect kinetic and kinematic data.	Kinematic and kinetic vault	Highest elevation of COM in the flight phase improves the performance and enliven the risk of falls. The optimal number would be rondat, flic-flac to vault in extension, which would better vault height.
21	(Penitente, 2007)	14 gymnasts	Experimental method through 3D coordinate system.	COM Kinematics	Gymnasts use the board to prevent large decrease of the horizontal speed of COM and increase the vertical speed of this.
22	(Penitente, 2014)	16 Italian gymnasts	Experimental method through deterministic model.	Kinetics phases Yurchenko	The post-flight phase is the most important phase of the vault.
23	(Requejo, McNitt-Gray, & Flashner, 2004)	3 elite gymnasts	Multi-variant dynamic model experimentally validated.	Kinematic shoulder	The modification torque shoulder during the flight phase allows gymnasts maintain lower body kinematics.
24	(Sanchez-Bañuelo, 1992)	Does not have	Qualitative research method.	Analysis sport	Sport methodology
25	(Takei, 2007)	23 gymnasts	Kinematic analysis method 3D camera shot in 16-mm to 100 Hz.	Kinematics of mortal grouped	The landing point and the official horizontal distance from later flight accounted for 86% of the variation in scores of judges.
26	(Uzunov, 2011)	1 item	Qualitative literature review.	Mechanical phase of Yurchenko	Progressions model it based on get good height at the entrance of the sprinboard with a rapid turnover in the round-off and pre-flight plus a high contact angle of attack to the table.
27	(Uzunov, 2010)	16 items	Qualitative description.	Kinematic variables Yurchenko	Key factors performance Yurchenko are: control the horizontal velocity for the obstacle and pre-element, a high angle of the body in contact springboard, angular maximum input to the table, acceleration in the rotation of the mortal more distance landing.

Table 2
Yurchenko Vault Kinetic and Kinematic Variables.

General Objective Performance Speed and elastic energy			
Phases and sub-phases of the TD		**Mechanical purpose**	**Kinematic indicators**
1. 1st flight	1.1 Run	Generate enough speed and stroke control.	• Speed • Distance
	1.2 Round-off	CM keep close to the ground.	• COM trajectory • Trunk rotation relative angle
	1.3 Spingboard Support	Accumulation of elastic energy.	• Springboard deformation percentage • Contact time with the springboard • Horizontal COM displacement • Flight time
2. 2nd flight	2.1 Table Vault Support	Elastic energy in the ignition.	• COM Speed • Shoulder flexion angle relative • Contact time with the table • Percentage deformation of the table
	2.2 Back Flip	Accelerate the rotation.	• Angular acceleration coxofemoral • Bending angle relative coxofemoral • Flight time
	2.3 Landing	Stability center of mass.	• Relationship COM with support base

DISCUSSION

From the Yurchenko since its incorporation into the Code of Points in 1982 has gained great popularity from the gymnastic community, due to its high score value and its high level of difficulty, many authors have shown that the careful study of the Yurchenko phases reveal a wide spectrum of Kinematic Indicators involved in its correct execution (Koh, 2007). Moreover, more studies about Kinematics have not been published in relation to the vaults that show a superior performance.

Through knowledge of the MP, suggests a great mechanical or muscular feature required at each stage of this ST. Due to these mechanical implications, an independent study of each KIm constitutes, in this vault´s type, one of the key factors in minimizing the difficulties of the element and effectively helping in the execution of Yurchenko vault. This is why the criterion about the KIm, which is presented in the Yurchenko vault, such as the position of entry to the exercise, the types of rotations in the longitudinal and antero-posterior axis, in addition to the COM control depending on the speed produced, make this vault an interesting source of study for the researchers in AG.

In 2001 some issues still uncertain about the distance and the measures of the apparatus itself were regularized and identified as: a) distance in focus, from the starting point to springboard, is 25 m included an approach distance from the springboard point. b) a rectangular vault

table with a surface measuring of 120 cm long and 95 cm wide (Boldrini et al., 2016). Hence, is here when the knowledge of the apparatus or devices, for both, the coach and the gymnast, lies in the effectiveness of the teaching of. Within the main kinematic and kinetic characteristics involved in the execution of the element, we have the percentage of deformation and the contact time applied in both, on the springboard and on the vault table applied (Koh, 2007), information that is often ignored by many coaches.

In some studies (Boldrini et al., 2016;Bermejo, 2013). It was noted that existing information between the liaison between AG and kinematics and kinetics is still incipient; this is because only in the recent years researchers have recognized the great influence of the kinematics and kinetics in the proper execution of a specific motor task.

During the development of this review can account for some positively correlated suggestions that add punctuation in this type of vault as: changes in the rhythm and slowdowns of the gymnast to make the transition of the race in the round, The minimum contact time on the springboard, there must be a shoulder flexion angle passed the 180° which is vital for a quick repulsion on the table, all the above added to the acceleration during the rolled movement in the mortal and a precise landing, are the appropriate pedagogical guideline and leads to obtaining an optimal and adequate competitive form of TD (Collazo, 2007).

CONCLUSIONS

The systematic analysis of each phase of the yurchenko jump, highlight the kinematic and kinetic indicators that make possible its correct execution, hence the importance of its inclusion in training sessions designed to acquire this sports technique by the gymnasts. The kinematic and kinetic indicators identified in each of the phases of the Yurchenko vault are:

- Speed
- Run Distance
- Acceleration
- Horizontal Displacement
- Trajectory
- Springboard contact time
- Table contact time
- Flight time
- Springboard deformation percentage
- Table deformation percentage
- Mass center height
- Mass center shifting
- Mass center trajectory
- Relative Angle Trunk rotation
- Relative Angle Shoulder Flexion
- Relative angle bending hip joint
- Mass center-base support

The individualized training in each of the Klm could be the key to give greater efficacy in the execution of ST. Rethinking the teaching oriented towards the OGR seems to be a great challenge in the sporting field, it must have fundamental clarity in the WP of each phase, in order to find the variables that are needed in an efficient session or technical training cycle, This is due to the complexity and variability of ST in gymnastics, it is pertinent to analyze each event separately and it is necessary to analyze the kinematic aspects of the performance, and to determine the variables that could increase the score. It is projected with this article to promote the knowledge in the Klm and KIn in the execution of the elements in AG, in any modality; it is must clarity the correction of the PM to meet assertively with the OPG. The present collection is an emergent edition of the ST analysis, determining the importance of orienting the OPG and its elements appropriately.

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