# DIFFERENCES IN VAULT RUN-UP VELOCITY IN ELITE GYMNASTS

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*Original article*

***Abstract***

*The aim of this study was to compare differences in run-up velocity between Handsprings, Tsukahara and Yurchenko entry on vault. A sample consisted of 48 jumps performed on vault, 19 Handsprings, 17 Tsukahara and 12 Yurchenko entry on vault. Data were collected on a World Cup competition held in Osijek, 2017. Run-up velocity was measured by speed radar gun (Stalker ATS, S PRO II). Descriptive statistic was calculated for all variables and differences in run-up velocity were determined by one-way ANOVA and Bonferroni post-hoc test at the level of statistical significance at p<.05. Average run-up velocity at Handspring entry was 8,06 m/s, Tsukahara, 8,06 m/s and Yurchenko entry on vault table was 7,66 m/s. ANOVA showed that exist statistical significant differences in run-up velocity between handspring and Yurchenko and between Tsukahara and Yurchenko entry. The results of this study indicated that different entry on vault table has different run-up velocity, which will help coaches and scientists to improve the vault technique.*

***Keywords:*** *artistic gymnastics, vault, velocity, run-up.*

## INTRODUCTION

The vault is an apparatus in artistic gymnastics characterized by complex and very short (not much more than 7 seconds in average) dynamic movements (Čuk & Karacsony, 2004). Different from other apparatus on which gymnasts performing exercise lasting for ninety seconds, jumps on vault lasting up to five to six seconds. Gymnastic elements at the vault are classified on the structural characteristics of the jumps, which, together with the development of artistic gymnastics, have been further refined and supplemented (Živčić Marković & Krističević, 2016). Velocity is defined as a function of time where measures the distance of the object travelled through time, and measurement unit is in meters per second (m/s).

As the run-up velocity did not investigate on competitions since 2012., we wanted to see if there are some changes considering that the elements on all apparatus are more difficult to perform. Entry on the apparatus can be in the forward, backward and sideward direction to the vault. The most common entry on vault are Handsprings, Tsukahara/Kasamatsu and Yurchenko. Handsprings jumps are executed after run-up and take-off from the springboard in the forward direction with face to the vault, after that hands are placed in shoulder-width on the vault table. From that position hands do take-off from the vault table and performing the salto with different rotations. Yurchenko vaults are consisted of run-up and performing round-off which ends with a take-off on the springboard. After that gymnasts performing backward handspring with different salto from tucked to stretched salto with turns. Tsukahara jumps are consisted of run-up and take off from the springboard and performing handsprings with turn for 90° or 180° and take off from the apparatus in backward salto. Vault consist of seven phases: 1. run-up; 2. jumping on the springboard; 3. springboard support; 4. first flight phase; 5. table support; 6. second flight phase and 7. landing (Prassas & Gianikellis, 2002; Prassas, Kwon, & Sands, 2006; Čuk & Karácsony, 2004; Takei, Dunn, & Blucker, 2007; Ferkolj, 2010; Atiković & Smajlović, 2011). Each phase depends on previous, so it is important that execution of all seven phases is without mistakes. The most investigated group of jumps on the vault are Handsprings (45%), Yurchenko (10%) and Tsukahara (5%) (Fernandes, Carrara, Serrão, Amadio & Mochizuki, 2016). There is a little investigation that is conducted on the new vault table on the competition considering that the technique of the elements constantly progresses and today´s gymnasts performing much more elements with high values and complexity. In artistic gymnastic tendency of gymnasts and coaches are to perform the hardest elements which means that those elements have highest difficulty value, and also, they are much more complex for execution than elements with lower difficulty value. Run-up velocity have been studied on competition (Van der Eb, et al., 2012; Naundorf, Brehmer, Knoll, Bronst, & Wagner, 2008; Takei, et al., 2000; Sands, 2000; Krug, Knoll, Kothe, & Zocher, 1998) and on the training (Bradshaw, Hume, Carlton, & Aisbett, 2010; Brehmer, 2011).

Generally, is accepted that the speed of the run-up and take off from the springboard, linear and angular momentum are more important than contact with the vault table (Prassas, et al., 2006). After the introduction of the new vault table, the run-up velocity has significantly increased since 1997. year in both genders, excepting Yurchenko jumps where men were faster than women, so new vault table does not have the influence of the run-up velocity (Naundorf, et al., 2008). Velocity of run-up has been stabilized between 1997 and 2010, because of physical limitation or it is optimally run-up velocity for the type of the vault (Van der Eb, et al., 2012). Positive correlations between take-off velocity and final score indicate that increase in run-up velocity will influence on take-off velocity (Van der Eb, et al., 2012). This is the explanation of all phases at the vault, which have to be connected. If run-up is slow, the next phase of the vault or difficulty value of the jump will be lower. Each gymnast will develop optimal velocity by running which depends on the type and complexity of jump. The gymnast should try to attain the highest velocity that can control (Sands, 2000). The run-up velocity is related to the complexity of the jump, for example, run-up velocity is lower at Yurchenko jumps than at Handsprings jumps, but the velocity decreases in the jumps where the rotation is reversed in the second stage of the flight (Prassas & Gianikellis, 2002). Veličković, Petković, & Petković, (2011) investigated run-up velocity with 3D kinematics analyses and Optojump system, and results have shown that there are differences in run-up velocity between elite gymnasts (in the middle of the run-up was recorded a decrease of velocity), but in the average gymnast run-up velocity constantly grows. Čuk, Bricelj, Bučar, Turšič, & Atiković (2007) investigated the connection between the start value of the vault and run-up velocity in top level male artistic gymnasts, and results have shown that there is a correlation between run-up velocity and the start value of that jump.

In sports biomehanics various devices have been used for velocity measurement. Laser and radars mostly are used for measuring running velocity. Harrison, Jensen, & Donoghue, 2005 investigated validity and reliability of laser measuring system compared with the reliability of video based system during running, and have concluded that laser system are validated and reliable instrument for velocity measurements. In artistic gymnastics to determine run-up velocity are used lasers (Krug, et al., 1998; Naundorf, et al., 2008). The radar system is also used because of very simple usage (Sands, 2000). Recently are used OPTO-TRACK system which has optical sensors placed along the whole track (Veličković, et al., 2011).

Motor skills that are important for performing vault jumps are strength, especially explosive power for take-off from legs and hands, and velocity. Jumps on vault require an explosive power of upper and lower extremities. The run-up velocity is transferred to a springboard, allowing the gymnast to perform a successful jump. The aim of this paper was to determine the differences in the run-up velocity during the performance of the different groups of vaults jumps on the competition.

## METHODS

The sample consisted of 48 jumps performed on the vault of which 19 were Handsprings, 17 Tsukahara and 12 Yurchenko entry to the vault. Data were collected in competition, at the World Cup in Osijek, 2017 (MAG and WAG Artistic Gymnastics). Run-up velocity was measured by Stalker ATS, S PRO II (Applied Concepts, Inc., Texas, USA), from the beginning of the run-up to the moment of take-off, i.e. the last step before the springboard. The device was placed behind the mat for landing. Stalker radar has a speed range of 0.2 m/s to 18.0 m/s – from below 1 mph (miles per hour) to over 40 mph – with an accuracy of ±0.1 m/s. High speed is 150 mph (241 km/h, 130 knots, 67 m/s). When it was compared with photocells which are the gold standard for speed measurement, validity was $r^2 = 0.99$, p\0.01 (Chelly & Denis, 2001; di Prampero, Fusi, Sepulcri, Morin, Belli & Antonutto, 2005; Haugen & Buchheit, 2016; Morin, Jeannin, Chevallier, & Belli, 2006).

Run-up velocity was measured in km/h, and converted into m/s, with the mathematic formula: km/h x 1000/3600. Variable Hnd was used for a Handspring, Tsuk for Tsukahara and Yurc for Yurchenko vault. This study was approved by Ethical Committee of Faculty of Kinesiology.

Statistica 12 was used for data analysis. Normality of distribution was determined by Kolmogorov-Smirnov test. Variables were normally distributed. Basic descriptive parameters were calculated for all variables, and the differences of run-up velocity between groups of vault jumps were determined by the one-way ANOVA and the Bonferroni post-hoc test. Level of statistical significance was set at $p<0.05$.

## RESULTS

Basic descriptive parameters of measured variables are shown in Table 1.

Results of One-way ANOVA for Velocity of measured variables are shown in Table 2. Results indicated that there were statistical significant differences between run-up velocities of vault entry $p<.01$.

In Table 3 are shown results of Bonferroni Post Hoc test for variables group of vaults. There is a statistical significant difference $p<0.01$ difference in run-up velocity between the Handsprings and Yurchenko entry, and between Tsukahara and Yurchenko entry on vault.

Table 1
*Descriptive parameters of run-up velocity on different vault elements.*

| Variables | Valid N | Mean | Min | Max | Std.Dev. |
|---|---|---|---|---|---|
| Hnd | 19 | 8.06 | 7.40 | 8.90 | 0.36 |
| Tsuk | 17 | 8.06 | 7.08 | 8.68 | 0.41 |
| Yurc | 12 | 7.66 | 7.25 | 7.93 | 0.26 |

*Note.* Hnd: run-up velocity of Handspring entry on vault; Tsuk: run-up velocity of Tsukahara entry on vault; Yurc: run-up velocity of Yurchenko entry on vault; Valid N: number of samples; Mean: average values; Min: minimum values; Max: maximum values; Std.Dev.: Standard Deviation.

Table 2
*One -way ANOVA analysis of velocity.*

| Dependent Variable | Multiple R | Multiple R2 | Adjusted R2 | SS Model | df Model | MS Model | SS Residual | df Residual | MS Residual | F | p |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Velocity m/s | 0.45 | 0.20 | 0.17 | 1.47 | 2 | 0.74 | 5.83 | 45 | 0.13 | 5.68 | 0.01* |

*Note.* * level of significance p<0.05.

Table 3
*Bonferroni Post Hoc test.*

| Group of vaults | {1}<br>8,06 | {2}<br>8,06 | {3}<br>7,66 |
|---|---|---|---|
| 1 | | 1.00 | 0.01* |
| 2 | 1.00 | | |
| 3 | 0.01* | 0.01* | 0.01* |

*Note.* {1}: Handsprings entry on vault; {2}: Tsukahara entry on vault; {3}: Yurchenko entry on vault; * level of significance p<0.05.

**DISCUSSION**

The results showed that the run-up velocity for Handsprings entry to the vault was 8.06 m/s, Tsukahara 8.06 seconds and Yurchenko entry to the vault was 7.66 m/s. Yurchenko entry had a slightly lower run-up velocity than the Tsukahara entry. Investigations of run-up velocity have shown differences between vault type or entry on vault table, depending on weather are performing Yurchenko, handspring or Tsukahara vault (Sands, 2000; Veličković, et al., 2011; Naundorf, et al., 2008; Dolenec, Čuk, Karacsony, Bricelj, & Čoh, 2006). In the last decade, vault run velocity has changed. Those changes are influenced by new vault table and each Olympic cycle new Code of Points. Naundorf, et al (2008) have investigated run-up velocity and concluded that the run-up velocity has been significantly increased since 1997. The reason for that is in the precision of placing the hands in the first flight phase and elements which will be performed in the second flight phase. Investigation by Sands (2000; 2002), have shown that Yurchenko vaults have slower run-up velocity than Handsprings and Tsukahara vaults, because of coming with back to the apparatus and the precision of the round-off performance before the vaulting table. These results are similar to our results.
ANOVA has shown that there are significant differences in the run-up velocity between the Handsprings and Yurchenko entry, and between Tsukahara and Yurchenko entry on vault.

Handsprings and Tsukahara entry have a faster run-up velocity than Yurchenko entry to the vault for better visual control of devices and springboard which allows the gymnast greater precision of entrance at the springboard and vault table and therefore a faster run-up.
The Handsprings group requires a larger amplitude in the second flight time and is considered more difficult to perform (Farana, Uchytil, Zahradník, Jandacka, & Vaverka, 2014). The reason is that from front handsprings they are usually performed rotated around the transverse axis of the body and this is the same with the Tsukahara vault, where the rotations are performed around the transverse axis, but the rotation is performed in backward rotation. Also, an important role in achieving the optimal run-up velocity is the number of steps for each jump. In one study (Čuk & Karacsony, 2004), investigated the speed of the jump according to the difficulty of execution of the jumps and concluded that the run-up velocity should be from 7.5 to 8.5 m/s, and for the difficult jumps of 8.5 to 9.5 m/s for jumps with double salto, run-up velocity should be over 10m/s. Some gymnasts need more steps to achieve the optimal run-up velocity. In each group of vault jumps, higher run-up velocity requires jumps of higher difficulty value and the number of rotations (Bradshaw, 2004). It is important where gymnast will place the springboard for different jumps and also where will start with run-up. For some vaults gymnasts use shorter or larger run-up, it depends on own style of performance. Previous research has shown that errors occurring during the run-up and take-off are difficult to compensate in later stages of the jump (Prassas, et al., 2006). For example, if the gymnasts have a low run-up velocity and weak take-off, then they will reduce height of the jump and the inability to perform the predicted number of rotations during the second flight phase. Since we only collected this information for the optimal run-up velocity, the run-up velocity has its acceleration. The speed of the last ten steps is progressive, and the highest is in the last step at the top (elite) (9.95 m/s) and at High level gymnast is 8.57 m/s. (Veličković, et al., 2011). In the last step, gymnasts decrease run-up velocity because of some preparatory motions for take-off (Fujihara, 2016).

## CONCLUSIONS

In the development of the optimal run-up velocity, it is necessary to pay attention in the training process that the maximum speed is reached before the contact with the springboard, i.e. that it has not decreased in the last steps. Today´s popularity of performing double or triple rotations in the second flight phase is huge. Gymnasts trying to perform as high as possible difficulty values of jumps, so they can get better grades of referees and make competition attractively for watching. Considering the importance of investigations of run-up velocity and giving the feedback about key performance parts to coaches, further research should be more detailed to clarify the run-up velocity and put them in relations with other kinematical parameters especially on competitions.

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