ELITE FEMALE VAULT FINALS FROM 2008 – 2016

Sunčica Delaš Kalinski[1], Goran Jelaska[2] and Almir Atiković[3]

[1]University of Split, Faculty of Kinesiology, Split, Croatia
[2]Virovitica General Hospital, Virovitica, Croatia
[3]University of Tuzla, Faculty of Physical Education and Sport, Tuzla, Bosnia and Herzegovina

Original scientific paper

Abstract
After Vault Qualifications (in C-I competition), the top eight scores, maximum two gymnasts from one national team, qualify for Vault Finals. During the Vault Finals, these top female vaulters need to perform two different vaults. The aim of this study was to determine: 1)trends of the Difficulty Scores (DS), Execution Scores (ES) and Total Scores (TS) of the first vault and the second vault; 2) differences between differently ranked gymnasts (Medal Winners vs Non-Medal Winners) on all major competitions held from 2008 to 2016. An increase in results of all scores, from initial competition (OG2008) to final competition (OG2016), confirms the progress in quality and complexity of the female vaults. Numerically higher values of all scores have been demonstrated for Medal Winners compared to Non-Medal Winners, but only some of them have been determined to be significant. The ES has been determined as the score that makes the difference among differently ranked gymnasts.

Key words: *women's artistic gymnastics, gymnasts rank, 2×11 ANOVA.*

Introduction

Vault is one of four apparatuses in Women's Artistic Gymnastics (WAG).Until 2001, the vault was along cylindrical structuresimilar to the pommel horse.Then it was changed to the current table. This change was made to provide safer vault preformances after several gymnasts "rammed into the horse" or misplaced their hands during the 2000 Sydney Olympics. As movements, vaults are very complex motor skills that need to be performed in a very short time (most vaults, on average, don't last more than seven seconds) and differ in terms of the time structure of one or more of seven vault phases: approach, flight to springboard, springboard actions, the first flight phase, support, the second flight phase and landing (Čuk &Karácsony, 2004). Taking this into account, the Women's Artistic Gymnastics Code of Points (WAG CoP)has classified all vaults into five groups. According to the CoP, the*Difficulty Value*(*DV*) of each vault is pre-determined based onthe number of rotations (along the transversal and longitudinal axis in the first and second flight phase) and the intended body position—tucked, piked or stretched (Atiković&Smajlović, 2011).Each vault in the Table of Vaults (WAG CoP 2009, 2013) is presented with its own number and predefined *DV*. One of the WAG CoP rules states that, if they want to qualify for the Vault Finals (C-III), during the Vault Qualification (C-I) gymnasts need to perform two vaults that show different repulsion phase (WAG CoP, 2009), that is, two vaults from different groups with different second flight phases (WAG CoP, 2013). Further, in the Vault Finals gymnasts also need to perform two different vaults. Competitorscan perform any vault, usuallythe most difficult vault that they can perform successfully. The*Total Scores (TS)* of those two vaults are parts of the equation that creates the *Final Score (FS):* $\mathrm{FS}=\frac{\mathrm{DVTS1}+\mathrm{DVTS2}}{2}$ (each vault *Total Score*is added together and then averaged). In C-I, the value of the *FS* determines who qualifies for the Vault Finals (top eight scores; maximum two gymnasts from one national team); in C-III the value of the *FS* determines the rank of the gymnasts. The complexity of the vault can also been seen through the results of Delaš Kalinski et al. (2016). The authors determined that during theperiod from 2008 to 2015, at all major competitions which were not Team Finals competitions (C-IV), the percentage of *Vault Qualifiers* was from 81.03% (WC2009) to 90.90% (WC2013), while on the other analyzed competitions, only one-fifth of competitors were *Vault Qualifiers* (22.38% at the OG2008, 23.48% at the WC2010, 16.56% at the WC2011, 14.66% at the QOG2012, 36.00% at the OG2012, 15.13% at the WC2014 and 14.36% at the WC2015).At theQOG2016 the percentage of Vault Qualifiers was 11.11% and at the OG2016 23.18%. Some previous studies of vault also analyzed: a) the quality of judging on the vault (Atiković& Čuk 2009; Leskošek, Čuk, Karácsony, Pajek, &Bučar, 2010; Bučar Pajek, Forbes, Pajek, Leskošek, & Čuk, 2011; Bučar, Čuk, Pajek, Karácsony, & Leskošek, 2012; Leskošek, Čuk, Pajek, Forbes, & Bučar Pajek, 2012; Atiković, Delaš Kalinski, Bijelić, & Avdibašić Vukadinović, 2012). They determined that in the Men's Artistic Gymnastics (MAG), the vault is the most valuable apparatus for All-Around gymnasts and an apparatus on which it is easiest to obtain a high *DS* and the highest *ES*; b) differences between female junior and senior competitors in vault performances. They determined that the increased anthropometric characteristics of senior gymnasts compared to junior gymnasts probably contribute

to better vault performances (Erceg, Delaš Kalinski, & Milić, 2014; Delaš Kalinski, 2015). Based on the assumption that among the best female vaulters there also exists a significant difference, the authors posed the problem of this paper. Accordingly, the main aim of this study was to analyse the differences between the values of the *DS*, *ES* and *TS* of the firstand the second vaults of differently ranked female gymnasts in the Vault Finals of all major competitions held from 2008 to 2016. The second objective of this study was to identify the impact of *Competitor Type* (Medal Winners or Non-Medal Winners), *Competition* and their interaction on *DS*, *ES* and *TS*at all major competitions from 2008 to 2016.

Methods

The sample included all the elite senior female gymnasts who participated in C-III competitions at the Olympic Games held in 2008, 2012 and 2016 (OG2008, OG2012, OG2016), at World Championships held in 2009, 2010, 2011, 2013, 2014 and 2015 (WC2009, WC2010, WC2011, WC2013, WC2014, WC2015) and at the Qualification Tournaments for the Olympic Games held in 2012 and in 2016 (QOG2012, QOG2016).

The sample has been divided into two groups, depending on their rank (ranked 1-3 and ranked 4-8). The variables sample is represented by a set of *Difficulty Scores(DS)*, *Execution Scores(ES)* and*Total Scores (TS)* obtained for a performance of the first and the second vaults in Vault Finals (C-III) competition.

The values of the mentioned scores have been taken from the Internet (www.gymnasticsresults.com, accessed 18th October 2016; http://www.longinestiming.com/, accessed 28th April 2015). Previous studies presented detailed descriptive parameters of analyzed variables from the same competitions (Massida& Calo, 2012; Leskošek, Čuk, & Bučar, 2013; Erceg, Delaš Kalinski, & Milić, 2014), as well as generally satisfactory metric characteristics of those scores (Bučar, Čuk, Pajek, Karácsony, & Leskošek, 2012; Bučar Pajek, Čuk, Pajek, Kovač, & Leskošek, 2013). Data analysis included calculations of Mean±Standard deviations.

Data has been checked for univariate and multivariate outliers. None was found (p>.05). Due to identification of influence of factors *Competition* (2008-2016) and *Competitor Type* (Medal Winers vs Non-Medal Winners) and their interaction on *DS,ES* and *TS*, 2×11 factorial analysis of variance (ANOVA) was applied together with post-hoc Fisher's least-squares difference (LSD) test when needed.

(Partial) η^2 was used for effect size assessment. Data were considered significant if p<.05. All calculations were performed using software package Statistica 12.0. (StatSoft, Tulsa, Oklahoma, USA).

Results

Descriptive parameters (Mean Values ± Standard Deviations) for the variables *DS, ES* and*TS* of the first and the second vaults performed bydifferently ranked gymnasts in Vault Finals, along withsignificant differences among those variables (determined at OG2008, WC2009, WC2010, WC2011, QOG2012, OG2012, WC2013, WC2014, WC2015, QOG2016 and OG2016) are presented in Figures 1-6.

Figures 1-6. Mean Values ± Standard Deviations for the variables *DS, ES* and *TS* of the first and the second vaults performed by differently ranked gymnasts in Vault Finals

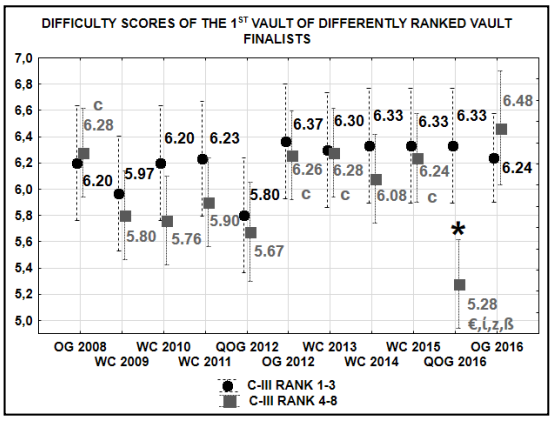

Figure 1. Difficulty scores of the first vault of differently ranked vault finalists

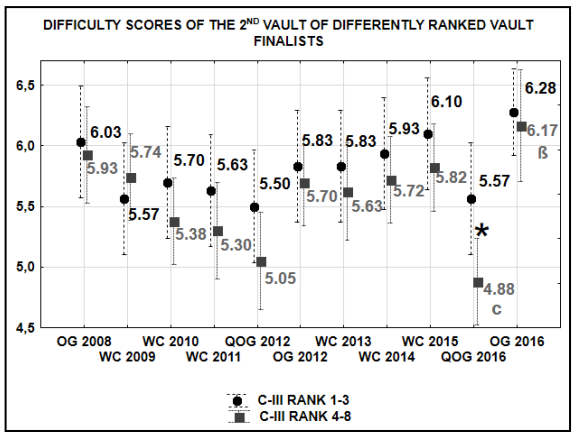

Figure 2. Difficulty scores of the second vault of differently ranked vault finalists

Figures 1-6. Data are presented as Mean±Standard Deviation. OG2008 – Olympic Games held in 2008, WC 2009 / 2010 / 2011 / 2013 / 2014 / 2015 – World Championships held in 2009 / 2010 / 2011 / 2013 / 2014 / 2015, QOG2012/QOG2016– Qualification Tournaments for Olympic Games held in 2012, OG2012 – Olympic Games held in 2012, post hoc Fisher's LSDwas used: € - significant difference from the scores determined at 2008, § - significant difference from the scores determined at WC2009, ¤ - significant difference from the scores determined at WC2010, **λ** - significant difference

from the scores determined at WC2011, **a** - significant difference from the scores determined at QOG2012, **i** - significant difference from the scores determined at OG2012, **z** - significant difference from the scores determined at WC2013, **$** - significant difference from the scores determined at WC2014, **ß** - significant difference from the scores determined at WC2015, **c** - significant difference from the scores determined at QOG2016, **d** - significant difference from the scores determined at OG2016; * - significant differences between differently ranked gymnasts at single competition.

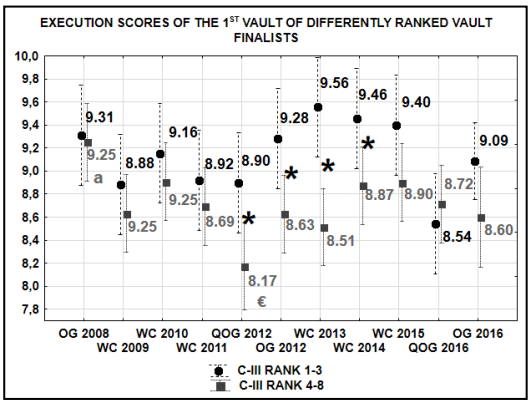

Figure 3. Execution scores of the first vault of differently ranked vault finalists

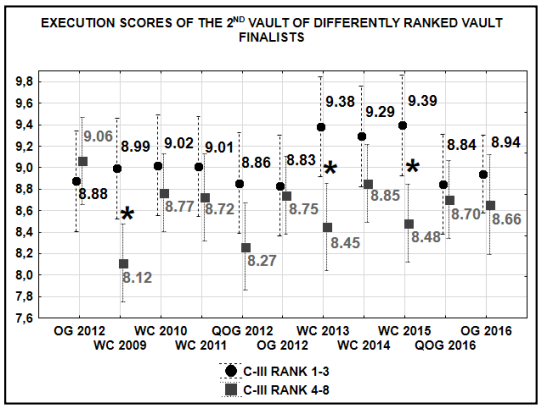

Figure 4. Execution scores of the second vault of differently ranked vault finalists

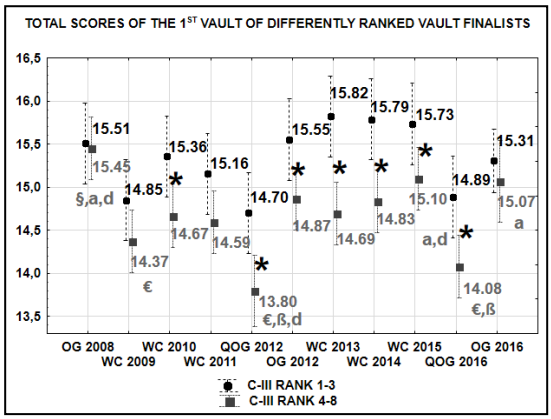

Figure 5. Total scores of the second vault of differently ranked vault finalists

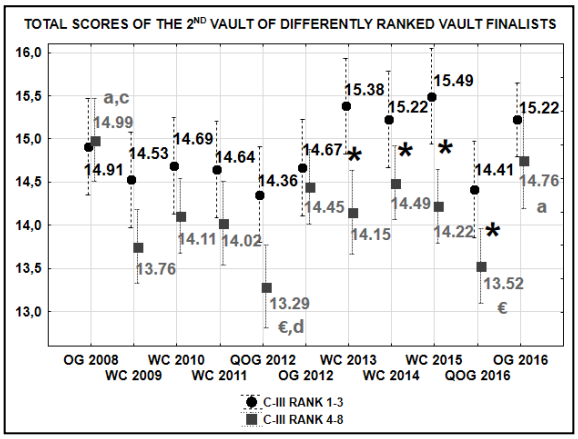

Figure 6. Total scores of the second vault of differently ranked vault finalists

Regarding to different rank of Vault Finalists, the main effect of *Competition* was found to be significant for the *DS of the first vault* ($F_{10,65}$=2.509; p=0.013; η^2=0.087), *ESof the first vault* ($F_{10,65}$=2.809; p=0.006; η^2=0.302) and for the *TS of the first vault* ($F_{10,65}$=7.132; p<0.001; η^2 =0.523). The main effect of the *Competition* was also found to be significant for the *DS of the second vault*($F_{10,62}$=4.241; p<0.001; η^2=0.406) and *TS of the second vaultVT2TS* ($F_{10,62}$=5.183; p<0.001; η^2=0.455), while was not found to be significant for the *ES of the second vault*($F_{10,62}$=1.136; p=0.351; η^2=0.155).

Regarding different ranks of *Vault Finalists*, the main effect of *Rank* was found to be significant for all variables of the first and the second vault: *VT1DS* ($F_{1,65}$=6.158; p=0.016; η^2=0.087), *VT1ES* ($F_{1,65}$=2.293; p<0.001; η^2=0.280), *VT1TS* ($F_{1,65}$=51.402; p<0.001; η^2=0.442), *VT2DS* ($F_{1,62}$=7.370; p=0.009; η^2=0.106), *VT2ES* ($F_{1,62}$=21.437; p<0.001; η^2=0.257) and *VT2TS* ($F_{1,62}$=42.695; p<0.001; η^2=0.408). Interaction *Competition*Competitor Type* appeared not to be significant for any analyzed variable: *VT1DS* ($F_{10,65}$=1.142; p=0.170; η^2=0.185), *VT1ES* ($F_{10,65}$=1.504; p=0.158; η^2=0.188), *VT1TS* ($F_{10.65}$=1.077; p=0.392; η^2=0.142), *VT2DS* ($F_{10,62}$=0.553; p=0.845; η^2=0.082), *VT2ES* ($F_{10,62}$=1.495; p=0.163, η^2=0.194), *VT2TS* ($F_{10,62}$=1.294; p=0.254; η^2=0.173).

Discussion and conclusion

At almost all analyzed competitions, Medal Winners had higher numerical values of *DS* compared to Non-Medal Winners. As expected, because only the best female vaulters qualify for Vault Finals, significant differences between differently ranked finalists have not been determined in the average values of *VT1DS* and *VT2DS* (excluding QOG2016). QOG2016 was primarily an All-Around competition, the last chance for All-Around competitors to qualify for OG2016, and the apparatus finals were organized as a 'test' for OG2016 (medals were not awarded). In the Vault Qualifications only 10 (primarily All-Around) gymnasts competed—

gymnasts who generally jump only one height *DV* vault. Accordingly, determined results are logical. Unlike *VT1DS* and *VT2DS*, during some of the analyzed competitions, significant differences have been found among differently ranked Vault Finalists in average values of the *ES* (between *VT1ES*at QOG2012, OG2012, WC2013, and WC2014; further between *VT2ES*at WC2009, WC2013 and WC2015). Since the *ES* is formed by summing the deductions for errors in the vault execution, the conclusion is that differently ranked Vault Finalists differ in the quality of their vault performance. Explanation for those results can also be seen through the format of competitions on which significant differences between differently ranked gymnasts have been determined (they were mostly Individual All-Around Finals and Individual Event Finals).During these competitions, gymnasts exclusively compete for their own results (Delaš Kalinski, Atiković, Jelaska, & Milić, 2016),and thus likely chose to perform second vaults that have not yet been developed to the same level of quality as their first vault.

By performing them, they test their chances for the upcoming Olympic cycle. The importance of the quality of the performance (as opposed to *DS* of the jump) is further enhanced by the identification of significant differences in the *TS*, between differently ranked finalists, at the same competitions as in the *ES*. The exception is a significant difference in the *TS* at QOG2016; presumably the result of the significant differences in the values of *DS* of differently ranked Vault Finalists. Through analysis of the value of the percentage of *DS* and *ES* in the *TS* it was determined that *DS*, on average, makes up about 40% of the *TS* while the *ES*, on average, makes up approximately 60% of the *TS*. This doesn't confirm results from previous studies and the conclusion that the *DS* is the score that generally determines the *TS* (Čuk & Atiković, 2009; Čuk & Forbes, 2010; Bučar Pajek, Forbes, Pajek, & Leskošek, 2011; Bučar, Čuk, Pajek, Karacsony, & Leskošek, 2012; Bučar Pajek, Čuk, Pajek, Kovač, & Leskošek, 2013; Massida & Calo, 2012). Generally, it can be concluded that quality of performance is the most important determinant for winning a medal in the female Vault Finals. That might not be completely so, as results from OG2016 confirm. In fact, at this competition two competitors (Dipa Karmakar from India and Oksana Chusovitina from Uzbekistan) performed the Produnova vault, also called 'vault of death'. It is the most difficult (and dangerous) vault, which generally demands considerable upper body strength in order to gain the needed height to rotate the body forward two times before hitting the mat (in approximately 2 seconds). Landing the Produnova is also difficult, and that is why it is said that this vault demands more power than skill. However, thanks to its difficulty, jumping the Produnova vault, even with a failure in execution, can lead to higher scores than do many other vaults from the world's top gymnasts. Whether this type of competitive manoeuvre will be devalued in vault scoring by FIG, to prevent those who cannot complete it from performing it to take advantage of scoring advantages related to its difficulty remains to be seen. During the Vault Finals higher numerical values for*DS*, *ES*and *TS*have been determined for Medal Winners.Some of these differences have been determined as significant. Additionally, the increase of numerical values of *DS* of the first and the second vault, from the beginning to the end of the analyzed period, indicates that the vault is an apparatus that constantly develops in the direction of more and more difficult vaults. However, due to the influence and the percentage of *ES* in the *TS,* it is possible to conclude that the *ES* determines the final ranking in the Vault Finals for female gymnasts. Given that at least one demonstrated exception (the Produnova vault) exists, this conclusion should be accepted with caution.

References

Atiković, A., Delaš Kalinski, S., Bijelić, S., & Avdibašić Vukadinović, N. (2012). Analysis results judging world championships in men's artistic gymnastics in the London 2009 year. *Sport Logia*, *7*(2), 93-100.

Atiković, A., & Smajlović, N. (2011). Relation between vault difficulty values and biomechanical parameters in men's artistic gymnastics. *Science of Gymnastics Journal*, *3*(3), 91-105.

Bučar Pajek, M., Forbes, W., Pajek, J., Leskošek, B., & Čuk, I. (2011). Reliability of Real Time Judging System (RTJS). *Science of Gymnastics Journal*, *3*(2), 47–54.

Bučar, M., Čuk, I., Pajek, J., Karácsony, I., & Leskošek, B. (2012). Reliability and validity of judging in women's artistic gymnastics at the University Games 2009. *European Journal of Sport Science*, *12*(3), 207-215.

Bučar Pajek, M., Čuk, I., Pajek, J., Kovač, M., & Leskošek, B. (2013). Is the quality of judging in women artistic gymnastics equivalent at major competitions of different levels*? Journal of Human Kinetics, 37*(1), 173-181.

Čuk, I., & Atiković, A. (2009). Are Disciplines in All-around Men's Artistic Gymnastics Equal? *Sport Scientific & Practical Aspects*, *6*(1&2), 8-13.

Čuk, I., & Forbes, W. (2010). How apparatus difficulty scores affect all around results in men's artistic gymnastics. *Science of Gymnastics Journal*, *2*(3), 57-63.

Čuk, I., & Karácsony, I. (2004). *Vault-Methods, Ideas, Curiosities, History.* Ljubljana: ŠTD Sangvinčki.

Čuk, I., Fink, H., & Leskošek, B. (2012). Modelling the final score in artistic gymnastics by different weights of difficulty and execution*. Science of Gymnastics Journal*, *4*(1), 73-82.

Delaš Kalinski, S. (2015). *Intracontinental and intercontinental characteristics and differences between junior and senior gymnasts*. *Proceedings, 2nd International Scientific Congress Slovenian Gymnastics Federation, 66-77,* Ljubljana: Slovenian Gymnastics Federation.

Delaš Kalinski, S., Atiković, A., Jelaska, I., & Milić, M. (2016). Performance analysis of female gymnasts' vault in elite competitions from 2008-2015. *Science of Gymnastics Journal*, *8*(2), 109-123.
Erceg, T., Delaš Kalinski, S., & Milić, M. (2014). The score differences between elite European junior and senior female gymnasts. *Kinesiology*, *46*(S1), 88-94.
Leskošek, B., Čuk, I., & Bučar Pajek, M. (2013). Trends in E and D scores and their influence on final results of male gymnasts at European Championships 2005–2011. *Science of Gymnastics Journal*, *5*(1), 29-38.
Leskošek, B., Čuk, I., Karácsony, I., Pajek, J.,&Bučar, M. (2010). Reliability and validity of judging in men's artistic gymnastics at the 2009 University Games. *Science of Gymnastics Journal*, *2*, 25-34.
Leskošek, B., Čuk, I., Pajek, J., Forbes, W., & Bučar Pajek, M. (2012). Bias of judging in men's artistic gymnastics at the European Championship 2011. *Biology of Sport*, *29*(2), 107-113.
Massida, M., & Calo, C.M. (2012). Performance scores and standing during the 43rd Artistic Gymnastics World Championships, 2011. *Journal of Sports Science*, *30*(13), 1415-1420.
*** Fédération Internationale de Gymnastique (2009). Code of points for women artistic gymnastics competitions. http://figdocs.lx2.sportcentric.com/external/serve.php?document1205.
*** Fédération Internationale de Gymnastique (2013). 2013-2016 Code of Points (Women's Artistic Gymnastics). http://bit.ly/2p9v855.
*** https://www.bustle.com/articles/178417-what-is-the-produnova-vault-the-rio-olympics-will-have-two-gymnasts-attempt-this-risky-move.

FINALA PRESKOKA U VRHUNSKOJ ŽENSKOJ SPORTSKOJ GIMNASTICI OD 2008. DO 2016. GODINE

Sažetak

Nakon kvalifikacijskog natjecanja na preskoku (tijekom C-I natjecanja) osam natjecateljica s najvišim brojem bodova, najviše dvije gimnastičarke iz jedne reprezentacije, kvalificira se za finale preskoka.U finalu preskoka moraju izvesti dva različita preskoka. Cilj ovog istraživanja bio je: 1) utvrditi trend ocjena težinskih vrijednosti (DS), ocjena za izvedbu (ES) i ukupnih rezultata (TS) dobivenih za izvedbu prvog i drugog preskoka; 2) analizirati razlike između različito rangiranih gimnastičarki (osvajačica medalja naspram neosvajačica medalja), na svim većim natjecanjima održanim od 2008. do 2016. godine. Utvrđeno je da je od prvog analiziranog natjecanja (Olimpijskih Igara iz 2008.) do posljednjeg velikog natjecanja (Olimpijskih Igara iz 2016.) došlo do numeričkog povećanja rezultata svih ocjena. Potvrđen je napredak u kvaliteti i kompleksnosti preskoka u ženskoj sportskoj gimnastici. Utvrđene su numerički više vrijednosti svih ocjena kod osvajačica medalja (u odnosu na neosvajačice medalja), ali su samo neke od njih utvrđene kao značajne. Vrijednosti ocjene za izvedbu (ES) utvrđene su kao ključne u određivanju različite rangiranost gimnastičarki u finalima preskoka.

Ključne riječi: *ženska umjetička gimnastika, gimnastičko rangiranje, 2x11 ANOVA.*

Received: January 17, 2017
Accepted: March 20, 2017
Correspondence to:
Assoc. Prof. Sunčica Delaš Kalinski, PhD
University of Split
Faculty of Kinesiology
Teslina 6, 21000 Split, Croatia
Tel: 00385 (099) 1 502 97 51
E-mail: suncica@kifst.hr