PERFORMANCE ANALYSIS OF FEMALE GYMNASTS' VAULT IN ELITE COMPETITIONS FROM 2008 TO 2015

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Original article

Abstract

*Vault is an apparatus that slightly differs from other in women's artistic gymnastics in the way of judging, duration of performance, but also in the requirements for certain biomotor abilities of the competitors. Accordingly, the question of number of competitors in the Vault Qualifications arises. Of all the major competitions in the period from 2008 to 2015 only at the competitions that were Individual All-Around Finals and Individual Event Finals (WC2009 and WC2013) a high percentage of Vault Qualifiers (WC2009 = 81.03%; WC2013 = 90.90%) has been identified. At other competitions (OG2008, WC2010, WC2011, QOG2012, OG2012, WC2014, WC2015) only approximately 20% of the elite competitors competed Vault Qualifications. Furthermore, due to identification of the impact of Competitor type (Vault Qualifiers or All-Around competitors), Competition (OG2008, WC2009, WC2010, WC2011, QOG2012, OG2012, WC2013, WC2014, WC2015) and their interaction with vaults Difficulty Scores, Execution Scores and Total Scores between-between 2*9 factorial ANOVA was applied. Finally, it was concluded that biomotor skills and competitors' selected tactics probably generated the obtained significant differences. The results should be guidelines in planning and programming of training sessions for female elite competitors who aspire towards the Vault Finals.*

Keywords: *female, artistic gymnastic, vault, development.*

INTRODUCTION

Women Artistic Gymnastics (WAG) is a multidisciplinary sport where the All-Around competition (competition on all four apparatuses: vault, uneven bars, balance beam and floor) is considered to be the basic one. However, in accordance with their abilities, tactics and competition format, gymnasts have the possibility to choose to compete or not on all four apparatuses. Major competitions in WAG (Olympic Games and World Championships) are divided into several phases: Preliminaries (C-I competition), Individual All-Around Finals (C-II competition), Individual Event Finals (C-III competition) and Team Finals (C-IV competition), which are held on different days. Among those, the C-I competition is probably the most important event since all individual athletes and teams compete in it and the scores from that

competition determine who qualifies for other competitions.

The result in WAG competitions comes from judges' evaluation. In 2006, a new way of scoring was introduced in artistic gymnastics and in 2009 (FIG, 2009) it was slightly modified. According to it, *Final Score* (*FS*) on each apparatus is obtained by summing up the *Difficulty Score* (*DS*; the sum of the highest 8 difficulties, compositional requirements and connection values) and *Execution Score* (*ES*; deductions for errors in execution and artistry are added together and then deducted from 10.00P). Certain exceptions from this model of evaluation exist in judging Vault Qualifications and Vault Finals. Namely, each vault is presented in the Table of Vaults (CoP), together with its own number and predefined *Difficulty Value* (*DV*). Before performing each vault, according to the CoP (FIG, 2009; FIG 2013), a gymnast is responsible for flashing the intended vault number. In this way the judges, before the vault performance, know the *DV*, i.e., the *DS* of the vault. After the vault performance, judges need to: 1) determine whether the announced vault was performed; 2) determine whether the *DV* of the performed vault equals the *DV* of the announced vault; 3) determine the *ES* of the performed vault.

Although WAG CoP for the vault reflects certain changes in each Olympic cycle, it generally prescribes the following: a) gymnasts in Preliminaries must perform one vault or two vaults if they want to qualify for the Vault Finals; b) the 1st vault score counts toward the Team and/or All-Around Total Score; c) in Preliminaries, with the aim of qualifying for the Vault Finals, gymnasts need to perform two vaults that show different repulsion phase (take off position from the vaulting table) (FIG, 2009), respectively two vaults from different groups and with different second flight phase (FIG, 2013); d) *FS* determines the rank of the gymnasts; e) *FS* in Preliminaries and Vault Finals is obtained by the simple average of the two vault's scores performed: $FS = \frac{FS\,VT1 + FS\,VT2}{2}$; e) top eight *FS* (achieved during Vault Qualifications at C-I) qualify for the Vault Finals (maximum of two gymnasts per national team).

Major deduction for vault execution was introduced in CoP 2009 - 2012 (rules for landing in different places in/or outside of the Corridor Line) and has been slightly changed in WAG CoP 2013 – 2016.

As movements, vaults are very complex motor skills that need to be performed in a very short time (most vaults, on average, do not last more than 7 seconds) and differ in time structure of one or more of 7 vault phases: approach, flight to springboard, springboard actions, the 1st flight phase, support, the 2nd flight phase and landing (Čuk & Karácsony, 2004; Atiković, 2011; Atiković, 2014). Taking this into account, the WAG CoP have classified all vaults into five groups: Group 1 – Vaults without salto (Handspring, Yamashita, Round-off) with or without longitudinal-axis turn in 1st and/or 2nd flight phase; Group 2 – Handspring forward with or without 1/1 turn (360°) in 1st flight phase – salto forward or backward with or without longitudinal-axis turn in 2nd flight phase; Group 3 – Handspring with ¼ - ½ turn (90° - 180°) in 1st flight phase (Tsukahara) – salto backward with or without longitudinal-axis turn in 2nd flight phase; Group 4 – Round-off (Yurchenko) with or without ¾ turn (270°) in 1st flight phase – salto backward with or without longitudinal-axis turn in 2nd flight phase; Group 5 – Round-off with ½ turn (180°) in 1st flight phase – salto forward or backward with or without longitudinal-axis turn in 2nd flight phase (FIG, 2013). Regardless of the group that they belong to, judges evaluate only four phases of vaults: the 1st flight phase, the repulsion phase, the 2nd flight phase and the landing.

Compared to other apparatuses, the vault is the most analysed apparatus (Prassas, Kwon, & Sands, 2006). Čuk and Karácsony (2004) and Atiković and Smajlović (2011) presented the results of

various authors who analysed different stages and characteristics of vaults.

Beside those studies, there are studies that analysed the quality of judging on the vault. Research conducted in Men's Artistic Gymnastics (Leskošek, Čuk, Karácsony, Pajek, & Bučar, 2010; Bučar Pajek, Forbes, Pajek, Leskošek, & Čuk, 2011; Leskošek, Čuk, Pajek, Forbes, & Bučar Pajek, 2012; Atiković, Delaš Kalinski, Bijelić, & Avdibašić Vukadinović, 2012; Perederij, 2013) have determined that: a) the vault is the most valuable apparatus for All-Around gymnasts; b) it is the easiest apparatus on which to obtain a high *DS* (Čuk & Atiković, 2009) and the highest *ES* (Atiković, Delaš Kalinski, Bijelić, & Avdibašić Vukadinović, 2012; Atiković, Delaš Kalinski, Kremnicky, Tabaković, & Samardžija Pavletič, 2014).

Previous study in WAG have determined that the Vault and Floor Finals were sessions with the highest scores and the lowest scores dispersion and it has been suggested that they should be inspected with special care in future judging analyses (Bučar et al., 2012). Another WAG study analysed the differences between junior and senior female gymnasts. It determined that senior gymnasts generally perform vaults better than junior gymnasts. They ascribed this to the increased anthropometric characteristics of senior compared to the junior gymnasts (Erceg, Delaš Kalinski, & Milić, 2014, Delaš Kalinski, 2015).

The authors of this paper posed the problem of the paper on the empirical fact that only a small number of gymnasts compete two vaults, with the aim of qualifying for the Vault Finals. Accordingly, the first objective of this study was to determine the proportion of women gymnasts (from all C-I competitors) that compete two vaults. The second objective was to identify the impact of *Competitor type* (Vault Qualifiers or All-Around competitors), *Competition* and their interaction (*Competitor Type*Competition*) with competitors scores achieved in C-I competitions, at all major competitions, from 2008 to 2015.

METHODS

The sample included all the elite senior women gymnasts who participated in C-I competitions at the Olympic Games in 2008 and 2012 (OG2008, OG2012), at World Championships in 2009, 2010, 2011, 2013, 2014 and 2015 (WC2009, WC2010, WC2011, WC2013, WC2014, WC2015) and in the Qualification Tournament for the Olympic Games in 2012 (QOG2012). Elite competitors were divided into two groups (All-Around competitors and Vault Qualifiers) depending on their participation in All-Around or in both All-Around and Vault Qualifications.

The variable sample is presented by: a) a set of *Difficulty Scores* (*AA VTDS*), *Execution Scores* (*AA VTES*) and *Final Scores* (*AA VTFS*) obtained for the performance of the 1st (and the only) vault of All-Around Competitors in C-I competition; b) by a set of *Difficulty Scores* of the 1st and the 2nd vault (*VTQ VT1DS/VT2DS*), *Execution Scores* of the 1st and the 2nd vault (*VTQ VT1ES/VT2ES*) and *Total Scores* of the 1st and the 2nd vault (*VTQ VT1TS/VT2TS*) of Vault Qualifiers in C-I competition. For the purpose of this study, *Total Score* (for Vault Qualifiers) presents a score of each vault, while *Final Score* for Vault Qualifiers (*VTQ FS*) is the average of the two vaults performed.

The values of the mentioned scores were taken from the Internet. Reliability of those scores, that are the results of expert judging, have been established as generally satisfactory in previous studies (Bučar, Čuk, Pajek, Karácsony, & Leskošek, 2012; Bučar Pajek, Čuk, Pajek, Kovač, & Leskošek, 2013). Detailed descriptive parameters of the analysed variables, from the same competitions, have also been presented in some previous studies (Massida & Calo, 2012; Leskošek, Čuk, & Bučar, 2013; Atiković, Delaš Kalinski, Kremnicky, Tabaković, & Samardžija Pavletič, M., 2014; Erceg, Delaš Kalinski, & Milić, 2014).

Data analysis included calculations of Mean±Standard deviations. Significance of

differences between the observed frequencies of performed vaults was also presented. Data was checked for univariate and multivariate outliers. None was found ($p > .05$). Due to identification of influence of factors *Competition* (OG2008, WC2009, WC2010, WC2011, QOG2012, OG2012, WC2013, WC2014, WC2015) and *Competitor Type* (All-Around competitors or Vault Qualifiers) and their interaction with *DS*, *ES*, and *FS/TS*, between-between 2*9 factorial ANOVA was applied together with Bonferroni post hoc correction when needed. (Partial) η^2 was used for effect size assessment. Data was considered significant if $p < .05$. All the calculations were performed using the Statistica 12.0. software package (StatSoft, Tulsa, OK, USA).

RESULTS

The number of female competitors who, at C-I competition, competed only All-Around (and performed only one vault) and those who competed Vault Qualifications (and performed two vaults), during major competitions from 2008 to 2015, is shown in Figure 1.

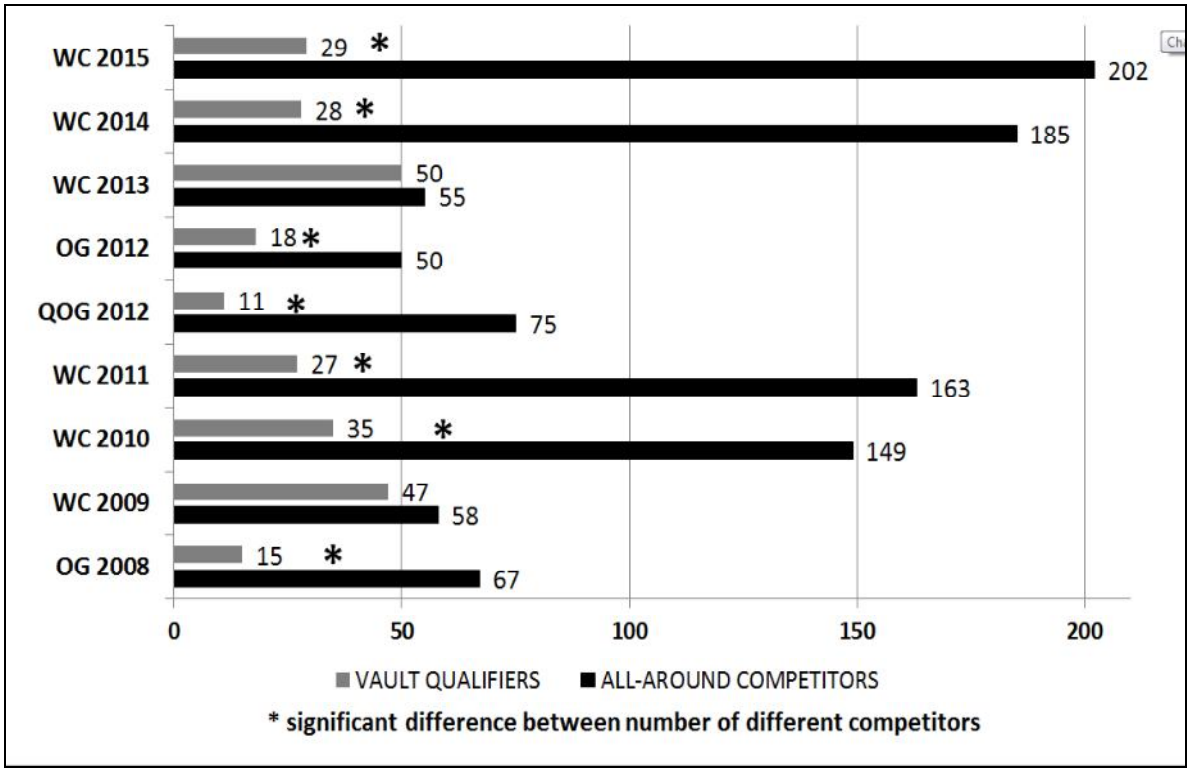

Figure 1. Number of All-Around women gymnasts and Vault Qualifiers in C-I competitions at different major competitions from 2008 to 2015.

Since a different number of competitors competed at the analysed competitions, the percentage of those who competed two vaults, compared to those who competed only one vault, is the best indicator of the portion of Vault Qualifiers within all competitors at C-I, in the analysed competitions.

Accordingly, the following was calculated: the highest percentage of gymnasts who competed two vaults was at the WC2009 (81.03%) and at the WC2013 (90.90%). In other competitions, significantly lower percentages of gymnasts who competed two vaults compared to those who competed only one vault, were determined: at the OG2008 – 22.38%, at the WC2010 – 23.48%, at the WC2011 – 16.56%, at the QOG2012 – 14.66%, at the OG2012 – 36.00%, at the WC2014 – 15.13% and at the WC 2015 – 14.36%.

Descriptive parameters (Mean Values ± Standard Deviations) of variables *DS*, *ES*, *FS* and *TS* respectively, achieved at C-I, and differences between gymnasts who competed All-Around and those who competed Vault Qualifications (determined at OG2008, WC2009, WC2010, WC2011, QOG2012, OG2012, WC2013, WC2014, WC2015), are presented in Figures 2-4.

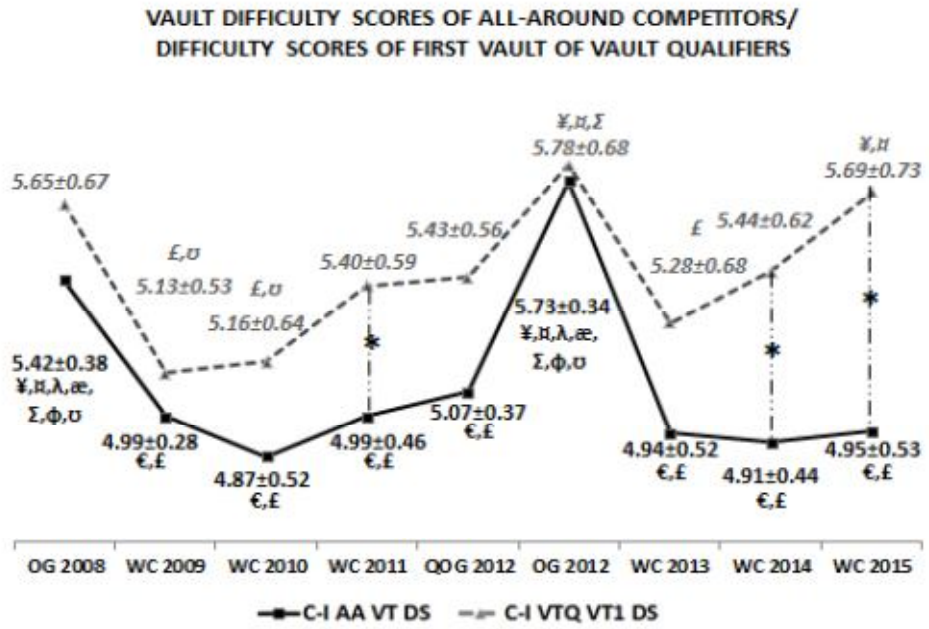

Figure 2. Difficulty scores on vault (all-around competitors vs first vault qualifiers).

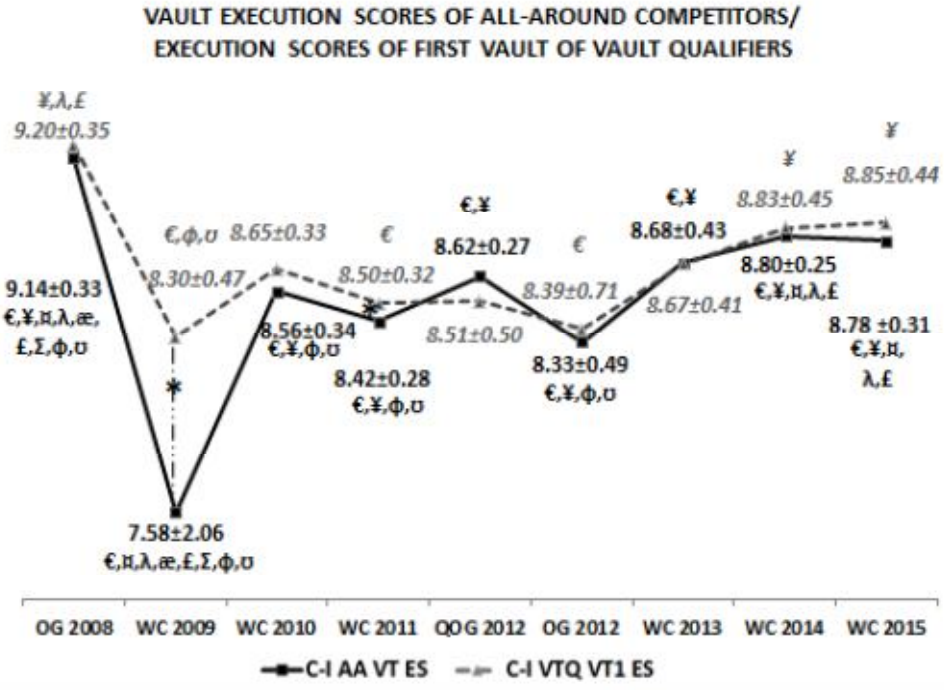

Figure 3. Execution scores on vault (all-around competitors vs first vault qualifiers).

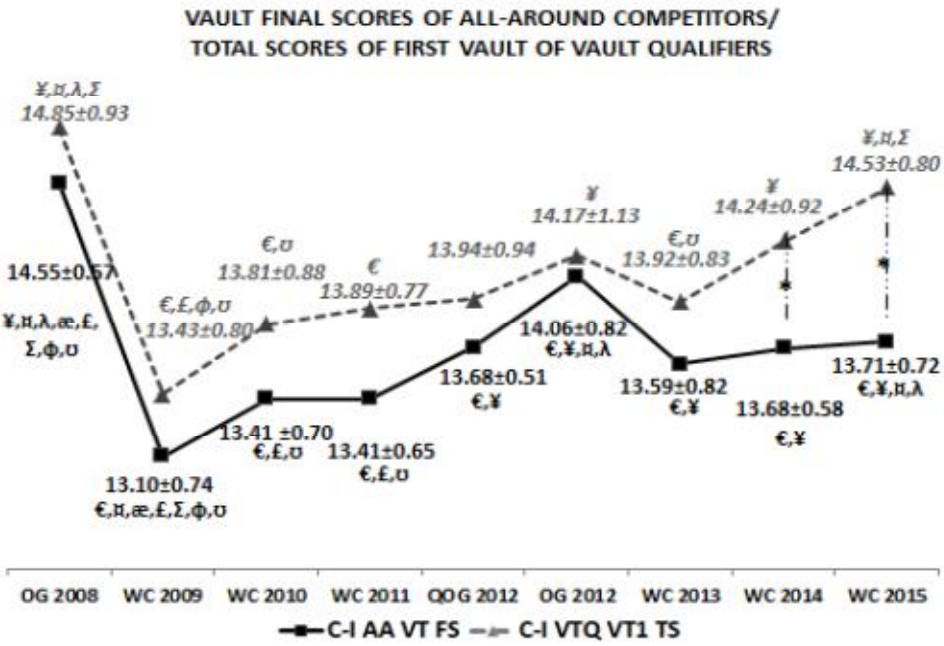

Figure 4. Final scores on vault (all-around competitors vs first vault qualifiers).

Figure 2-4. 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, QOG 2012 – Qualification Tournament for Olympic Games held in 2012, OG2012 – Olympic Games held in 2012, AA – All-Around Competitors, VTQ – Vault Qualifiers, € - significant difference from the scores determined at OG2008, ¥ - 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, æ - significant difference from the scores determined at QOG2012, £ - significant difference from the scores determined at OG2012, Σ - significant difference from the scores determined at WC2013, ϕ - significant difference from the scores determined at WC2014, υ - significant difference from the scores determined at WC2015, *- significant differences between only vault of All-Around competitors and first vault of Vault Qualifiers. Significance of differences was examined by using Bonferroni post hoc correction of main effects and interaction effects of 2*9 factorial ANOVA.

For the *DS* of the 1st vault of All-Around competitors and the 1st vault of the Vault Qualifiers, main effect of *Competition* was found to be significant ($F_{8,1246}$ = 14.923; $p < .001$; $\eta^2 = .087$), together with main effect of *Competitor Type* ($F_{1,1246}$ = 77.754; $p < .001$; $\eta^2 = .059$) and interaction *Competition*Competitor Type* ($F_{8,1246}$ = 3.738; $p < 0.01$; $\eta^2 = .023$). Similarly, for the *ES* of the 1st vault of All-Around competitors and the 1st vault of Vault Qualifiers, main effect of *Competition* was found to be significant ($F_{8,1250}$ = 29.618; $p < .001$; $\eta^2 = .159$), as well as main effect of *Competitor Type* ($F_{1,1250}$ = 6.482; $p = .011$; $\eta^2 = .005$) and interaction *Competition*Competitor Type* ($F_{8,1250}$ = 4.235; $p < 0.001$; $\eta^2 = .026$). For the *FS* of the 1st vault of All-Around competitors and the *TS* of the 1st vault of Vault Qualifiers, main effect of *Competition* ($F_{8,1246}$ = 22.812; $p < .001$; $\eta^2 = .128$) and of *Competitor Type* ($F_{1,1246}$ = 50.534; $p < .001$; $\eta^2 = .039$) was found to be significant. For the *FS* of the 1st vault of All-Around competitors and the *TS* of the 1st vault of Vault Qualifiers interaction *Competition*Competitor Type* was not significant ($F_{8,1246}$ = 1.651; $p = .106$; $\eta^2 = .010$).

Descriptive parameters (Mean Values ± Standard Deviations) of variables *DS*, *ES* and *FS* of the only vault of All-Around competitors together with *DS*, *ES*, and *TS* of the 2nd vault and the *FS* of Vault Qualifiers, achieved at C-I, and differences between those variables (determined at OG2008, WC2009, WC2010, WC2011, QOG2012, OG2012, WC2013, WC2014, WC2015), are presented in Figures 4-7.

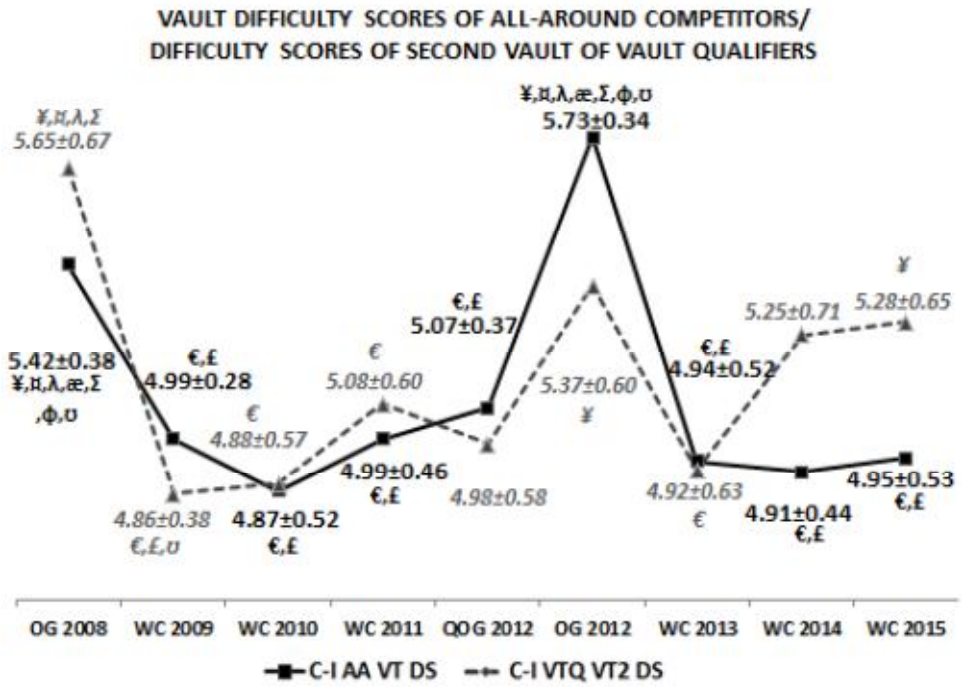

Figure 5. Difficulty scores on vault (all-around competitors vs second vault qualifiers).

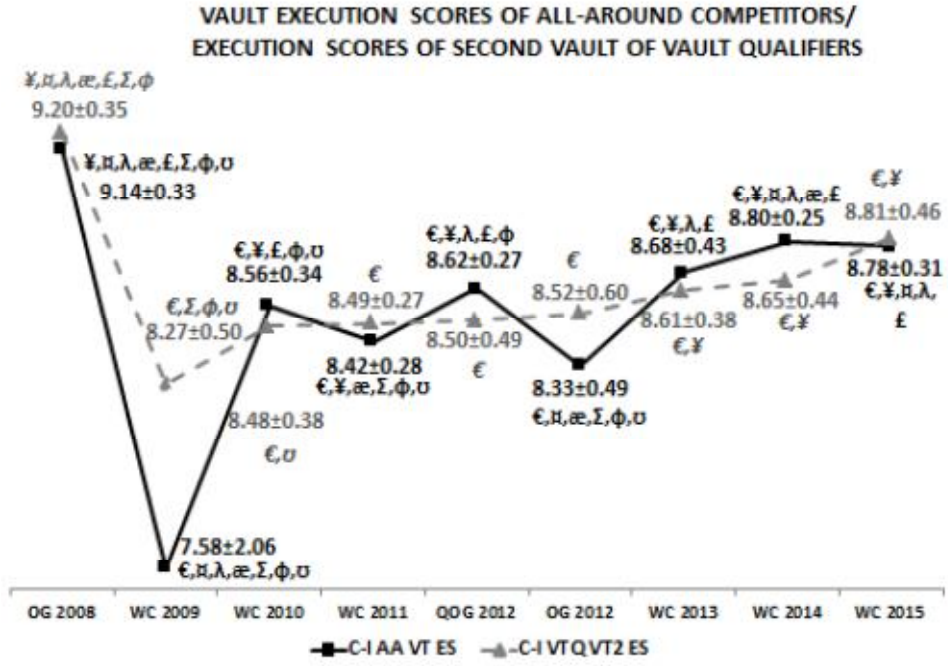

Figure 6. Execution scores on vault (all-around competitors vs second vault qualifiers).

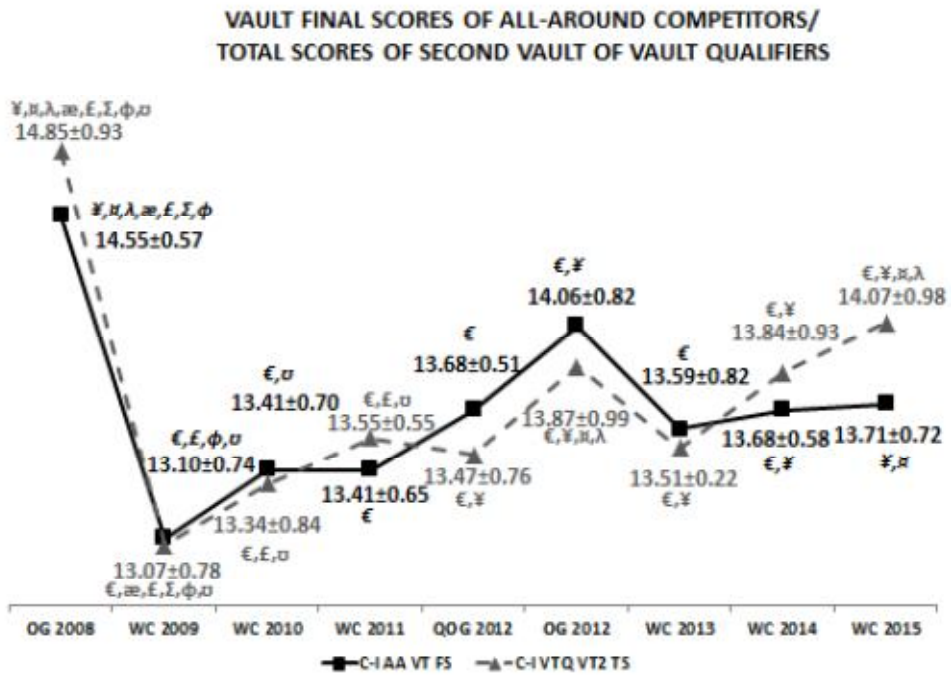

Figure 7. Final scores on vault (all-around competitors vs second vault qualifiers).

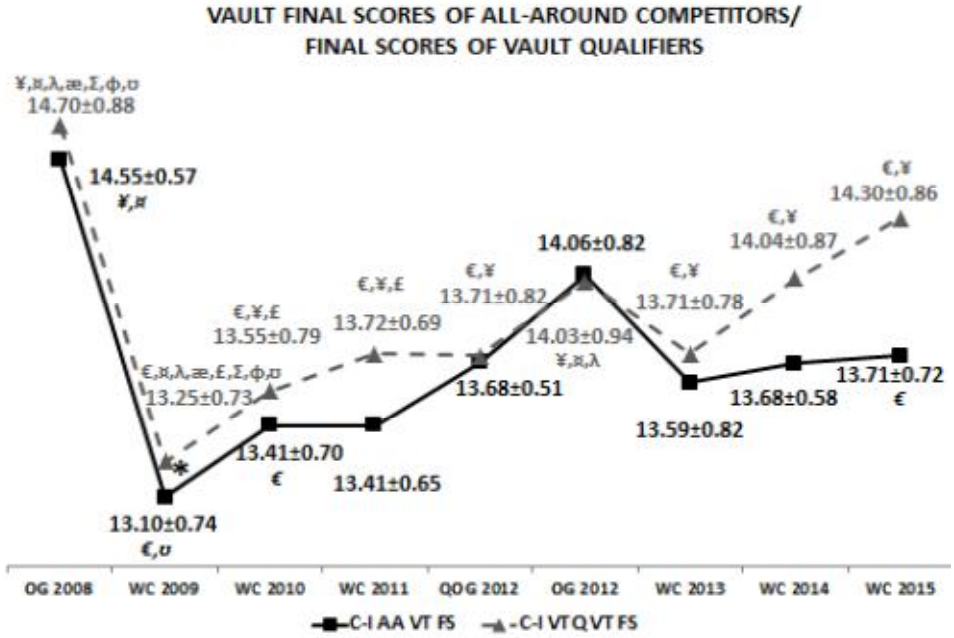

Figure 8. Final scores on vault (all-around competitors vs vault qualifiers).

Figures 5-8. 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, QOG 2012 – Qualification Tournament for Olympic Games held in 2012, OG2012 – Olympic Games held in 2012, AA – All-Around Competitors, VTQ – Vault Qualifiers, € - significant difference from the scores determined at OG2008, ¥ - 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, æ - significant difference from the scores determined at QOG2012, £ - significant difference from the scores determined at OG2012, Σ - significant difference from the scores determined at WC2013, ϕ - significant difference from the scores determined at WC2014, υ - significant difference from the scores determined at WC2015, *- significant differences between only vault of All-Around competitors and second vault/average score of Vault Qualifiers. Significance of differences was examined by using Bonferroni post hoc correction of main effects and interaction effects of 2*9 factorial ANOVA.

Regarding the 1st vault of All-Around competitors and the 2nd vault of Vault Qualifiers, main effect of *Competition* was found to be significant for the *DS* ($F_{8,1246}$ = 16.576; $p < .001$; $\eta^2 = .096$), *ES* ($F_{8,1246}$ = 43.658; $p < .001$; $\eta^2 = .219$) and the *FS/TS2* ($F_{8,1246}$ = 27.513; $p < .001$; $\eta^2 = .150$). Main effect of *Competitor Type* was not found to be significant for the *DS* ($F_{1,1246}$ = 1.359; $p = .244$; $\eta^2 = .001$), *ES* ($F_{1,1246}$ = .153; $p = .695$; $\eta^2 = .000$) and the *FS/TS2* ($F_{1,1246}$ = .642; $p = .423$; $\eta^2 = .001$). Interaction *Competition*Competitor Type* was significant for the *DS* ($F_{8,1246}$ = 4.135; $p<0.01$; $\eta^2 = .026$), *ES* ($F_{8,1246}$ = 2.322; $p = .018$; $\eta^2 = .015$), but not for the *FS/TS2* ($F_{8,1246}$ = 1.503; $p = .152$; $\eta^2 = .010$). By analysing the *FS* of the 1st vault of All-Around competitors and the *FS* of Vault Qualifiers, main effect of *Competition* was found to be significant ($F_{8,1250}$ = 20.142; $p < .001$; $\eta^2 = .114$) together with main effect of *Competitor Type* ($F_{1,1250}$ = 14.486; $p < .001$; $\eta^2 = .011$) and interaction *Competition*Competitor Type* ($F_{8,1250}$ = 2.334; $p = .017$; $\eta^2 = .015$).

DISCUSSION

Regardless of the fact that the vault is the most studied apparatus and also the best understood one (Prassas, Kwon, & Sands, 2006), the number of gymnasts who compete two vaults is probably lower than the number of competitors who compete on other apparatuses in order to qualify for Apparatus Finals. However, this conclusion requires further scientific research.

Determined percentages of the gymnasts who competed Vault Qualifications (and performed two vaults), compared to those who competed All-Around (and performed only one vault), according to the authors, are the result of: 1) the rules and different formats of the analysed competitions; 2) specific biomotor characteristics of competitors that are needed in order to perform structurally more complex vaults; vaults of higher *DV*; 3) competitors' and national (expert) teams' tactics.

Different rules and systems of qualification for major events, together with different subjective factors of gymnasts, resulted in a different number/percentage of Vault Qualifiers at C-I competition. Competitions with the highest percentage of Vault Qualifiers (WC2009 and WC2013), by their format, were Individual All-Around Finals (C-II competition) and Individual Event Finals (C-III competition). In general, these are competitions where the results have no impact on competitors' future participation at the following Olympic Games (probably the main goal of most gymnasts and their national teams). At such competitions, gymnasts exclusively compete for their own results and test their knowledge/skills/chances for the upcoming Olympic cycle. A large number of Vault Qualifiers, in the aforementioned competitions, is most likely the result of the fact that the 2nd vault score (according to the CoP's) does not jeopardize their All-Around Results, but provides them information on their position within the group. In accordance with the previous results, expert teams should (and probably they did) plan and program further training of their competitors. By identifying that a competitor does not have a real chance of entering the Vault Finals in the following major competitions, they probably did not spend too much time on their training sessions in improving both vaults. This conclusion primarily relates to the periods before major competitions in which competitors competed only All-Around.

In contrast to the abovementioned competitions (C-II and C-III competitions), in Team Finals (C-IV competition), national (expert) teams (and accordingly gymnast) do not have space for any calculation and/or experimentation with uncertain performances on any apparatus of All-Around (including the vault). Confirmation for these conclusions can be perceived from the results of all other major competitions (from 2008 to 2015) which, in addition to C-II and C-III competition, were also the Team Finals (C-IV competition). As shown in Figure 1, in those competitions, less than

20% gymnasts competed in Vault Qualification.

Generally speaking, a review of results in Figure 1 and 2 shows that the trend in the results of AA VTDS, VTQ VT1DS, AA VTFS and VTQ VT1TS were very similar, while the trend in AA VTES and VTQ VT1ES results were slightly different (Figure 3). At the same time, it is important to point out that the results of *VTQ VT1DS* and *VTQ VT1TS*, in all the analysed competitions, were numerically higher and in some competitions even significantly higher in comparison to the results of *AA VTDS* and *AA VTFS*. Since the scores of the 1st vault of Vault Qualifiers count for Team Result and Individual All-Around Result (FIG, 2009, 2013), it is not surprising that for the 1st vault they chose vaults whose *DVs* are numerically higher (and sometimes significantly higher) from those performed by All-Around Competitors.

The size of the determined differences between All-Around Competitors and Vault Qualifiers become additionally important if we take into account two facts: 1) possible weak discrimination of competitors in the *DS*; 2) non-differentiation among Vault Qualifiers and All-Around competitors in the *ES*.

Namely, if we assume that there is a similarity between the MAG CoP and the WAG CoP, and if we review the results of some previous studies on the MAG scores (according to which in the Vault Qualifications there is not enough discrimination between competitors in the *DS*; Čuk & Atiković, 2009; Čuk & Forbes, 2010; Bučar Pajek, Forbes, Pajek, & Leskošek, 2011; Bučar, Čuk, Pajek, Karácsony, & Leskošek, 2012; Bučar Pajek, Čuk, Pajek, Kovač, & Leskošek, 2013), then we can conclude that the determined differences are large; independently from the fact that they numerically range only from 0.23 (OG2008) to 0.74 (WC2015). The fact that significant differences were not determined in the *ES* values between Vault Qualifiers and All-Around Competitors suggests that All-Around Competitors perform their only and less demanding vault technically and aesthetically as well as the Vault Qualifiers.

The results of this study showed that the *DS*, on average, makes around 36.85% of the *FS/TS1/TS2* (percentage range of the *DS* in the *FS/TS1/TS2* is from 36.16% (WC2014) up to 40.74 (OG2012)) while the *ES*, on average, makes approximately 63.29% of the *FS/TS1/TS2* (the *ES* percentage in the *FS/TS1/TS2* range from 59.61% (OG2012) up to 64.07% (WC2014)). The obtained results don't confirm conclusions from previous studies which state that the *DS* generally determines the *VTFS/VTTS1/VTTS2* (Čuk & Atiković, 2009; Čuk & Forbes, 2010; Bučar Pajek, Forbes, Pajek, & Leskošek, 2011; Bučar, Čuk, Pajek, Karácsony, & Leskošek, 2012; Bučar Pajek, Čuk, Pajek, Kovač, & Leskošek, 2013; Massida & Calo, 2012). According to those results, the *ES* is the main score in determining *FS/TS*.

The present study aims at underlining the fact that the vault *DS* is the parameter that affects the difference between *VT1TS* of Vault Qualifiers and *VTFS* of All-Around Competitors. However, according to research Čuk, Fink & Leskošek (2012), there is a possibility of neglecting the above-mentioned fact. Namely, the authors show that the proportion between the *DS* and the *ES*, according to different formulas, can range from 17% to 67% .With the different proportions in the *FS* calculations, the number of changes in the rankings is high: 81% in C-I and C-II 61% and 35% and C-III.

Trend in the *DS* results in C-I competitions, in both groups of competitors, showed a sinusoidal trend of results between the two analysed Olympic Games. After the OG2008 and the OG2012 (where generally the highest values of all the analysed variables were determined) there has been some numerical decrease in *DV's* of the performed vaults. However, this statement is not entirely accurate due to the changes that occurred in the CoP at the beginning of each new Olympic cycle and duration of the career of most women All-Around Competitors.

Establishing high frequencies of certain vaults at major competitions often results in a reduction of the *DV* in one of the following CoP. This might lead to weak differentiation between competitors, such as in Men's Artistic Gymnastics (Čuk & Atiković, 2009; Čuk & Forbes, 2010; Bučar Pajek, Forbes, Pajek, & Leskošek, 2011; Bučar, Čuk, Pajek, Karácsony, & Leskošek, 2012; Bučar Pajek, Čuk, Pajek, Kovač, & Leskošek, 2013; Massida & Calo, 2012). The same situation occurred in every CoP after 2005, to some vaults that had high or the highest *DV*. If the aforementioned is related to some extent to findings in this study, we may claim that it is likely that a large number of competitors performed precisely those vaults whose *DV* (after certain OG) has been reduced. Also, it is possible that there was no decline in the difficulty of the performed vaults, i.e., determined numerical reduction is the result of the CoP *DV* decrease. Yet, further research on the issue should be done in the future.

Participation in the Olympic Games is usually the main goal in every gymnast's career. After participating at the OG a large number of competitors, in particular All-Around Competitors, very often end their careers. This was probably the case with the OG2008 and the OG2012 after which 'new' competitors entered the game. If it is known that female gymnasts' biological maturation comes later compared to the average population (Malina, 1994; Malina, 1998; Bass et al., 2000; Courtei, Jaffre, Obert, & Benhamou, 2001; Baxter-Jones, Thompson, & Malina, 2002; Bass, Daly, & Cane, 2002; Caine, Bass, & Daly, 2003; Baxter-Jones, Maffulli, & Mirwald, 2003; Daly, Caine, Bass, Pieter, & Broekhoff, 2005; Erlandson, Sherar, Mirwald, Maffulli, & Baxter-Jones, 2008), and, accordingly, their biological maturity characterized by the stability of the motor programs (Arkaiev & Suchilin, 2009), it is possible that a number of 'new' female seniors was not biologically mature. Younger gymnasts, particularly those who have not yet gone through puberty, tend to be lighter and smaller (Claessens et al., 1991, 2006), more pliable and flexible, have better strength-to-weight ratio than older gymnasts. When a female gymnast hits puberty, growth spurts and weight gain may affect her center of gravity, causing mental and physical stress as she must adjust, and in some cases relearn, her moves to compensate (https://en.wikipedia.org/wiki/Age_requirements_in_gymnastics). And while such characteristics are desirable for other apparatuses, the authors believe that they do not contribute to better performance of the vault. Furthermore, the opinion of the author relies on the Arkaev and Suchilin (2009) statement that somewhat higher and heavier female gymnasts will probably perform vaults better. How many competitors with such anthropometric characteristics there were, and how are these important for the better performance of the vault remains to be examined in future research.

The importance of morphological characteristics in vault performance in men's artistic gymnasts was found in the study conducted by Možnik et al. (2013). The authors found that the best ranked gymnasts on the vault have lower body height and weight compared to the best gymnasts on parallel bars and high bar.

Accordingly, due to anthropometric characteristics (Erceg, Delaš Kalinski, & Milić, 2014), and, according to practical point of view, due to different factors of limitation in motor learning processes (Schmidt & Wrisberg, 2008), those gymnasts were likely not able to perform, in their first year of competition in senior category, vaults that had *DV's* similar to those determined in the previous Olympic Games.

However, through their biological maturation and automatization of their performances (Schmidt & Wrisberg, 2008), by the end of the Olympic cycle, they achieved equal *DV's* to those determined at the previous Olympic Games. Achieving the same and/or even higher results than the ones from the previous Olympic Games, with reduced *DV's* of vaults compared to the *DV's* of the same vaults at the previous

Olympic Games, simply confirms the thesis about progress in the quality and complexity of vaults in WAG. Taking into account the trend of the results after the OG2012, especially the ones determined at the WC2015, it is to assume that at the OG2016 the results of All-Around Competitors would be similar to the ones from the OG2012. For the Vault Qualifiers at the OG2016, we can expect numerically slightly higher results from the ones determined at the OG2012.

Trend of the *ES* results also shows that Vault Qualifiers, in almost all the analysed competitions, had numerically higher values than All-Around Competitors. In contrast to the sinusoidal trend of the *DS* results, we can say that the results of the *ES* showed significant decrease only after the OG2008. It was probably due to the introduction of the rules of landing within the 'CORIDOR'. Numerically higher values of All-Around Competitors, compared to Vault Qualifiers, in the *ES* determined at the QOG2012, emphasize the quality of the performance, i.e., readiness of All-Around Competitors for this competition: their "last train for Olympics 2012". After the OG2012 and after certain changes in the rules of landing, steady progress of the *ES*, both for All-Around Competitor and Vault Qualifiers was determined. Since the introduction of the 'new method of judging' (FIG, 2006) had the intention of improving competitors performance, based on these results, we may conclude that the competition on vault definitely does go in that direction. It is obvious that for all competitors the performance of vaults becomes '... more important and making vault seem more like a full routine instead of two separate skills in which if you mess up on those, you can make up for it on the other' (https://betweentheolympics.wordpress.com /2012/04/02/vault-in-the-proposed-2013-2016-code-of-points/).

As mentioned above, it has been determined that the development of the *FS/TS1* is similar to the trend of the *DS* results: after the OG2008 and the OG2012 value of the *FS/TS1* decreased, while the values of the *FS/TS1* between those competitions increased. Slightly different from the trend in the *DS*, significant difference between All-Around Competitors and Vault Qualifiers in the *FS/TS1* was determined only in two competitions (WC2014 and WC2015). Since the *FS/TS1* is a composite of the *DS* and the *ES*, the obtained results confirm previously established progress in performance of All-Around Competitors.

Review of results in Figures 5-8 (values of different variables of the only vault of All-Around Competitors and of the 2nd jump of Vault Qualifiers) generally present similarity between those vaults. Similarity is also confirmed by not determining significant differences in any variables between those two vaults. The result should be viewed through the abovementioned rules for competing in Vault Qualifications: according to the CoP 2009 it was necessary to perform two vaults that are different in the 1st and the 2nd phase of the flight; according to the CoP 2013 it was necessary to perform two vaults in different groups and with different second flight phase. This leads to the conclusion that female Vault Qualifiers generally cannot perform equally good vaults that are structurally different. The authors believe that there are several reasons for this: 1) shorter time that gymnasts dedicate to vault training compared to the time invested in training of other apparatuses, (Čuk & Karácsony, 2004); 2) complexity of those motor skills (vaults); 3) anthropometric characteristics of gymnasts (Erceg, Delaš Kalinski, & Milić, 2014; Delaš Kalinski, 2015).

Moreover, the authors claim that the contained results raise the question (for further research) of the real equality of the *DV's* of vaults that classified in different vault groups in the WAG CoP.

CONCLUSION

The percentage of female competitors, who participated in Vault Qualifications with the aim to qualify for Vault Finals at the analysed competitions (from 2008 to

2015), depended on the format of the competition. At the competitions which were not Team Finals Competition (C-IV), the percentage of Vault Qualifiers was 81.03% (WC2009) and 90.90% (WC2013). At the other analysed competitions, only 20% of competitors were Vault Qualifiers.

Although all the analysed competitions were of the highest level, we conclude that some factors from anthropological status, motor learning process and competitors' tactics caused numerical differences and in some competitions even significant differences (in the *DS* between the only vault of All-Around Competitors and the 1st vault of Vault Qualifiers). Consequently, in some competitions the differences were determined between *VTFS* of All-Around Competitors and *VT1TS* of Vault Qualifiers. Significant differences were not determined between variables of the 2nd vault of Vault Qualifiers and variables of the only vault of All-Around Competitors.

Based on the determined results, we claim that the structural complexity of two different vaults (regardless of the fact that those are the only two skills, which is significantly less when compared to the number of elements performed during an exercise on other apparatuses) is such that most female gymnasts cannot perform them equally well.

Regardless of the *DV's* of vaults that they performed, significant differences between All-Around Competitors and Vault Qualifiers were not determined in the *ES*. This leads to the conclusion that both female competitor groups performed their vaults equal in technical and aesthetical sense.

Since the vault is an apparatus that constantly develops in the direction of more and more difficult vaults, the results of this study should be taken into account when planning and programming training sessions for competitors who aspire toward the Vault Finals.

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