OLYMPIC GAMES (BEIJING) ANALYSIS: THE PERFORMANCE KEY

[1]Sunčica Delaš Kalinski, [1,2]Johnny Padulo, [3]Almir Atiković, [1]Mirjana Milić and [1]Igor Jelaska

[1]Faculty of kinesiology, University of Split, Croatia
[2]University eCampus, Novedrate (CO), Italy
[3]University of Tuzla, Faculty of Physical Education and Sports, Bosnia and Herzegovina

Original scientific paper

Abstract
Despite the fact that they predominantly qualified as All-Around competitors for the Olympic Games in Beijing (OG2012), only about 61% of gymnasts competed All-Around in the Qualifying competition (C-I), while others competed on some or only on one apparatus. The smallest percentage of gymnasts competed the vault (70%); the apparatus on which the lowest value of Difficulty Score (DS=5.35), the highest value of the Execution Score (ES=8.43) and finally the highest Final Score (FS=14.03) were determined, as compared to other apparatuses. Approximately 82% competitors competed in Uneven Bars, Balance Beam and Floor. Although these were the world's best gymnasts, significant differences were determined in almost all DS, ES and FS (of all apparatuses) between differently ranked All-Around competitors of the C-I competition at the OG2012. These results are probably the consequence of tactics, but also the objectives of different gymnasts related to the results at the Olympic Games. The selection of appropriate tactics is the key in extending relatively short career of elite female gymnasts.

Key words: *number of competitors, apparatuses, ANOVA*

Introduction

The Olympic Games (OG) are probably every athlete's dream. It takes at least 10 years to reach Olympic quality in artistic gymnastics (Arkaev & Suchilin, 2009). However, "Olympic quality" is usually not enough to qualify for the OG. It is merely an implied precondition given that all Olympic gymnasts (top gymnasts of each national federation) go through a set (quite eliminating) qualification system to be able to participate at the OG. The maximum of 98 gymnasts can have the right to participate in the OG: 1) 96 gymnasts who achieved their participation right as a) a part of one of the 12 qualified teams; b) based on an individual All-Around result; c) as medal winners (from the World Championship that took place a year before the Olympic Games). To this it is added: a) 1 gymnast who did not qualify for the Olympic Games in the qualifying competitions based on her individual or team result, but she comes from a country where gymnastics is not developed as a sport; b) 1 (the best) gymnast from the country that is organizing the games and which did not ensure hers participation through the qualification system. Regardless of the Qualifications, which are almost solely based on the All-Around result, the competitors are not obligated to perform on all apparatuses of women's All-Around event at the Olympic Games. This rule is mostly used by those competitors who believe their All-Around result, as opposed to their result on a single apparatus, is not good enough for final competition. The result in artistic gymnastics is derived from the judges' scores assigned according to the Code of Points (CoP; Fédération Internationale de Gymnastique (FIG)). CoP is a rulebook that defines the scoring system in gymnastics. With the aim of improving the quality and objectivity of judging, the CoP goes through certain changes in every Olympic cycle. According to the 2009 CoP, which was in effect at the 2012 Olympics, the rule was that the *Final Score* (*FS*) on each apparatus is obtained by summing up the *Difficulty Score* (*DS*; the sum of 8 most difficult elements, special requirements and bonifications) and *Execution Score* (*ES*; average values of judges' deductions subtracted from the score 10.00). The *All-Around Score (AA)* is the sum of the *FS's* obtained from all 4 (or as much as competitor competed) apparatuses in Women's Artistic Gymnastics (WAG). Formation of these scores, i.e. expert judges' scoring of gymnastic performances according to the "new way of judging" (implemented in artistic gymnastics since 2006) was the subject of numerous previous investigations both in women's (Bučar Pajek et al., 2011; Bučar, Čuk, Pajek, Karácsony, & Leskošek, 2012; Bučar Pajek et al., 2013; Atiković et al., 2014) and in men's artistic gymnastics (Čuk, & Atiković, 2009; Čuk, & Forbes, 2010; Leskošek et al., 2010; Dallas, & Kirialanis, 2010; Čuk, Fink, & Leskošek, 2012; Leskošek et al., 2012; Leskošek, Čuk, & Bučar Pajek, 2013). General conclusion of all these investigations was that reliability and objectivity of judging at major competitions was generally satisfactory. However, regardless of the results of previous studies, and due to the problem of systematic bias and inconsistency of judges which partly occur because of the constant (smaller or bigger) changes of the CoP in each "new Olympic cycle", it is necessary to continuously analyse the quality of judging at gymnastic competitions.

The importance of continuous monitoring of judging quality is additionally emphasized when implementing some "new" rules or new technologies (Bučar Pajek et al., 2011). An example of such new rule (implemented in WAG CoP 2009 and elaborated in WAG CoP 2013) is the scoring of artistry on the balance beam and on the floor.

In general, artistry is defined as mastery of execution and should be moved away from the personal taste of beauty (WAG CoP FIG, 2009); it is not only "what" the gymnast performs, but also "how" she performs her routine (WAG CoP FIG, 2013).

According to the 2013 WAG CoP, artistry on the beam is viewed through: a) artistic performance; b) composition and choreograph; c) rhythm & tempo; and on the floor through: a) artistic performance; b) composition and choreograph; c) expression; d) music; e) musicality. Given the structural complexity of this sport, and in parallel the aspiration to achieve their maximum in a relatively short career in women's gymnastics (Arkaev & Suchilin, 2009), the issue of tactics in practice, but also in the way of competing at certain competitions becomes extremely important.

One of the important components in tactics, especially of teams, is also the competitors' age. Since 1994 the CoP prescribes that only senior competitors (gymnasts older than 16) can participate in World Championships, whereas gymnasts who turn 16 in the current year can participate in the Olympic Games, but only as members of national teams.

Age restrictions have primarily been designed in order to protect child athletes from injury. This prolongs their competitive career, but also encourages older gymnasts to remain in the sport. Before adopting this rule, the average age of international women competitors was 16.49 years, whereas after the rule had been adopted, more precisely in 2005, the average age of competitors was 18.10 years (Léglise, 1997).

The second reason for changing the rule of age restriction lies in the objective differences in anthropological characteristics between chronologically older and biologically more mature women gymnasts in relation to the younger and biologically immature ones. Younger gymnasts, particularly those who have not yet gone through puberty, tend to be lighter and smaller (Claessens, Lefevre et al. 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 centre 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). All of the aforementioned leads to two conclusions. First, younger gymnasts, in comparison to the chronologically and biologically more mature ones, perform more complex skills more easily. Second, younger and older gymnasts simply do not compete "under the same conditions". However, the impact of body size and biological age does not always have a negative connotation, especially when women gymnasts reach maturity. At that point the increased anthropometric measures enable them to produce greater force and perform more difficult elements, which give them advantage compared to the younger gymnasts (Erceg, Delaš Kalinski & Milić, 2014). In accordance with the aforementioned, the aims of this study were: a) to determine the number of gymnasts who did not compete the whole All-Around event ("non All-Around") at the Qualifying Competition (C-I) at the 2012 Olympics, b) to determine the characteristics of performance of All-Around gymnasts on individual apparatuses of women's All-Around event; c) to determine the differences between the groups of All-Around gymnasts based on their All-Around ranking.

Methods

Total sample consisted of 97 participants of the qualifying (All-Around) competition at the Olympic Games in Beijing (2012). Of the total sample, 59 gymnasts who participated in all four apparatuses of women's All-Around event (vault, uneven bars, balance beam, and floor) represented the subject sample for further analyses. Based on their competitive efficiency, they were divided into three subgroups: 1^{st} group, N_1=20 (gymnasts ranked from 1^{st} to 20^{th} place); 2^{nd} group, N_2=20 (gymnasts ranked from 21^{st} to 40^{th} place); 3^{rd} group, N_3=19 (gymnasts ranked from 41^{st} to 59^{th} place). *Difficulty scores* (*DS*), *Execution Scores* (*ES*) and *Final Scores* (*FS*) achieved on each apparatus represented the variable sample. Results were taken from http://gymnasticsresults.com/. By descriptive analysis on the applied variables the following was determined: mean±SD (Mean±standard deviation), minimum and maximum result (Min and Max), coefficient of variation (CV) and values of Skewness (Skew) and Kurtosis (Kurt) of result distribution. Detailed insight into those variables, at the same competitions, have been determined in some previous studies (Massida, & Calo, 2012; Atiković, Delaš Kalinski, Kremnicky et al., 2014; Erceg, Delaš Kalinski, & Milić, 2014). By using the one-way ANOVA and Tukey *post hoc* analysis difference between the defined groups in *DS*, *ES* and *FS* determined on all apparatuses of the gymnastics All-Around was analysed. (Partial) eta squared (η^2) was used for effect size assessment. All calculations were done by Statistica 12.0 (Statsoft, Tulsa, OK, USA).

Results

The number of competitors on certain number of apparatuses of the qualifying All-Around competition (C-I) and combination of apparatuses on which the competitors who did not compete All-

Around performed at the 2012 Olympic Games are presented in Graph 1.

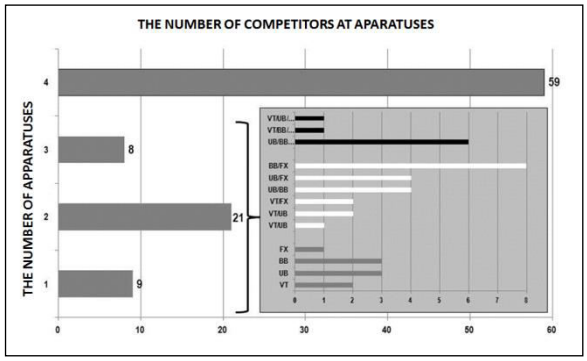

Figure 1. The number of competitors on a certain number of apparatuses and combinations of apparatuses of "non All-Around" gymnasts at the qualifying All-Around competition at the 2012 Olympic Games. Legend: VT – vault, UB – uneven bars, BB – balance beam, FX – floor

Out of the 97 competitors, only 59 of them (60.83%) competed on all apparatuses of women's All-Around, 8 gymnasts (8.25%) decided to compete on three apparatuses, 21 gymnasts (21.65%) competed on 2 apparatuses, and 9 gymnasts (9.27%) only on one apparatus. The results of descriptive statistics of the *Difficulty Score (DS), Execution Score (ES)* and *Final Score (FS)* variable on each of the 4 apparatuses of the women's All-Around (vault, uneven bars, balance beam, floor), and total All-Around result (*AA*), determined on a sample of 59 women gymnasts – competitors of the qualifying All-Around competition at the Olympic Games (Beijing, 2012) are presented in Table 1. Average values of the same variables, recorded at major competitions in the period from 2006 to 2011 and analysed by Atiković et al. (2014) are also presented in the table.

Table 1. Descriptive statistics of the *DS, ES* and *FS* variable on 4 All-Around apparatuses (*vault, uneven bars, balance beam, floor*) and total *All-Around* result (*AA*) of competitors at the 2012 Olympic Games and competitors at all major competitions in the period from 2006 to 2011

	OG 2012 N=59						Atiković et al. (2014) Results from major competition from 2006 to 2011 N= 5795
	Mean±SD	Min	Max	CV	Skew	Kurt	Mean±SD
VTDS	5.35±.57	4.60	6.30	10.71	.78	-.21	4.96±.50
VTES	8.43±.58	7.63	9.40	6.91	-.05	.20	8.48±.41
VTFS	14.03±.86	12.23	15.90	6.12	.27	-.22	13.44±.75
UBDS	5.63±.70	3.60	7.00	12.45	-.40	.66	5.06±1.05
UBES	7.87±.70	5.46	8.97	8.85	-1.32	2.39	7.40±.98
UBFS	13.50±1.19	10.46	15.83	8.80	-.26	.19	12.47±1.74
BBDS	5.55±.53	4.40	6.50	9.63	-.30	-.58	5.22±.69
BBES	7.57±.95	4.40	8.90	12.50	-.85	.85	7.52±.95
BBFS	13.11±1.28	9.70	15.27	9.78	-.23	-.39	12.88±1.45
FXDS	5.37±.45	4.30	6.50	8.45	-.05	.03	4.99±.57
FXES	8.05±.50	6.50	8.83	6.23	-1.04	1.49	7.95±.63
FXFS	13.36±.86	11.37	15.33	6.46	-.03	-.45	12.93±1.10
AA	54.01±3.37	47.02	60.63	6.23	.14	-.67	39.78±14.33

Legend: Mean±SD - Mean± standard deviation, Min – minimum result, Max – maximum result, CV – coefficient of variation, Skew – coefficient of skewness, Kurt – coefficient of kurtosis

Descriptive indicators of all the analysed variables determined at the OG2012 and mean values of the results from major competitions in the period from 2006 to 2011 (according to Atiković et al., 2014) are presented in Table 1. The highest mean values of the *DS* score were recorded on uneven bars (*UBDS=5.63*), whereas the lowest were recorded on the vault (*VTDS=5.35*). The highest mean values of *ES* were recorded on the vault (*VTES=8.43*), and the lowest ones on the balance beam (*BBES=7.57*). The highest mean values of *FS* were recorded on the vault (*VTFS=14.03*), and the lowest ones on the balance beam (*BBFS=13.11*). At the OG2012 mild negative asymmetry and increased coefficient of kurtosis of result distribution were determined for the *UBES* and *FXES* variables. All the other variables showed good sensitivity. The comparison of the results from the OG2012 and the results obtained by Atiković et al. (2014) showed higher mean values of all variables determined at the OG2012 in relation to the mean values of variables calculated for the period from 2006 to 2011 (according to Atiković et al., 2014). Due to numerous factors which differentiate this investigation from that of Atiković et al. (2014; different "qualities" of scores from which mean values of all scores were determined, application of different CoP at the analysed competitions, different levels and qualities of competitors at the analysed competitions), analyses of differences between the results of these two studies were not performed. Results of *one-way* ANOVA with *post hoc* Tukey HDS test of the applied variables between the predefined groups classified according to competitive efficiency are presented in Table 2.

Table 2. Analysis of differences between competitors of C-I competition with different ranking

Variable	Effect size	Most efficient N=20	Average N=20	Least efficient N=19	ANOVA	
		rank 1-20	rank 21-40	rank 41-59		
	η^2	$Mean_1 \pm SD_1$	$Mean_2 \pm SD_2$	$Mean_3 \pm SD_3$	F	p
VTDS	.275	6.10*,#±.10	5.53*,±.68	5.03#±.31	5.63	.03
VTES	.218	9.40*,#±.11	8.59*±.18	8.07#±.50	12.67	.00
VTFS	.427	14.84*,#±.63	13.83*,$±.61	13.31#,$±.50	32.65	.00
UBDS	.251	6.17*,#±.48	5.61*,$±.38	5.03#,$±.73	20.50	.00
UBES	.254	8.23#±.47	7.95$±.52	7.36#,$±.82	9.78	.00
UBFS	.393	14.40*,#±.88	13.56*,$±.76	12.39#,$±1.01	24.07	.00
BBDS	.339	5.97*,#±.37	5.60*,$±.36	5.00#,$±.37	32.26	.00
BBES	.279	8.36*,#±.52	7.37*,$±.75	6.88#,$±.90	19.90	.00
BBFS	.469	14.33*,#±.75	12.96*±.79	11.86#±.90	43.29	.00
FXDS	.401	5.75*,#±.32	5.40*,$±.31	4.91#,$±.30	33.48	.00
FXES	.298	8.42*,#±.28	8.02*,$±.48	7.65#,$±.41	17.33	.00
FXFS	.486	14.11*,#±.54	13.35*,$±.63	12.48#,$±.48	39.10	.00
AA	.857	57.68*,#±1.74	53.71*,$±.89	50.03#,$±1.18	153.86	.00

Legend: Mean±SD - mean±standard deviation, F – ANOVA F value, p – level of significance, η^2 **–** effect size. ***** - statistical significance of post hoc analysis of Tukey HDS test between means of the first and the second group, **#** - statistical significance of post hoc analysis of Tukey HDS test between means of the first and the third group, $ - statistical significance of post hoc analysis of Tukey HDS test between means of the second and the third group

By examining Table 2, significant difference can be seen in all the observed variables between the predefined groups according to the criterion of competitive efficiency. By further *post hoc* analysis by Tukey HDS test it was determined that the first group of gymnasts (ranked from the 1st to the 20th place), which had numerically higher values of almost all scores in comparison to the second group of gymnasts (ranked from the 21st to the 40th place) and numerically higher values of all scores in comparison to the third group of gymnasts (ranked from the 40th to the 59th place), differed significantly from the other two defined groups. Very large effect sizes have been found for all observed variables. The exception, i.e. significant non-difference between the first and the second group of gymnasts was determined in the value of *ES* on uneven bars (*UBES*). Moreover, there was no significant difference between the second and the third group of gymnasts in the *DS* and *ES* variables of vault (*VTDS* and *VTES*), and between final scores on the balance beam (*BBFS*).

Discussion

Even though they earned their right to participate at the OG based on their All-Around result from the World Championship or the qualifications Olympic tournament, not all competitors performed the All-Around at the qualifications competition (C-I) at the 2012 Olympic Games in Beijing. By analysing the combinations of apparatuses on which "non All-Around" gymnasts performed, it can be concluded that, in general, least gymnasts competed the vault. Of the 8 gymnasts who competed on three apparatuses, only two competed the vault, and of the 21 gymnasts who competed on two apparatuses, only 5 competed the vault. It can be said that the other apparatuses were used almost equally in "combinations of apparatuses". The reason for the smallest number of competitors on the vault probably derives from the highly demanding nature of the apparatus, regardless of the fact that, in relation to other apparatuses, the vault includes only one element (vault) which must be performed in the All-Around part of the competition (Delaš Kalinski, 2015; CoP, 2009).

The basis for discussion about the descriptive results determined at this competition, with the aim of detecting certain characteristics, trend of development of results and the way of exercising in artistic gymnastics, we build primarily on the presented and previously calculated results from the study carried out by Atiković et al. (2014). These authors analysed the results from major competitions (World Championships, Olympic Games and European competitions) in the WAG period from 2006 to 2011. By comparing the results it can be seen that the gymnasts at the OG2012 had a few tenths of score (from 0.33 to 0.38) higher mean values of *DS* on all apparatuses in relation to previous competitions. This confirms the progress in quality of exercise, i.e. the existence of a higher number of exercises with elements from greater difficulty groups of gymnastic elements (WAG CoP, 2013).

On the other hand, there were almost no numerical differences in the values of *ES*. Taking into account the results obtained, but also the fact that *DS* is actually the value that defines the rank of competitors (Bučar et al., 2012), the numerical difference between *FS* at certain apparatuses of the compared competitions is a logical result. However, it is important to mention that the previous discussion (the comparison between the results of OG2012 and those obtained by Atiković et al. (2014)) should be taken into consideration with certain detachment, for several reasons: 1) the OG2012 investigation dealt with the results of exclusively all-around competitors (who competed on all four apparatuses on C-I at OG2012), whereas Atiković et al. (2014) took all results from the C-I competition (regardless of the number of apparatuses on which the gymnasts competed); 2) the right to participate on World Championships and Olympic Games (in general) is not nearly the same (World Championships are the qualifications for the Olympic Games), so neither the quality of competitors nor the values of average results should be the same; 3) one part of the results from the investigation carried out by Atiković et al. (2014) are the consequence of application of the 2005 CoP, whereas the other part of the results are the consequence of application of the 2009 CoP. Given that in the mentioned two CoP's there was a change in *DS* calculation (first, difficulty values of 10 most difficult elements were summed up, and later 8 most difficult elements), considering the calculated average values (for the results in the period from 2006 to 2011), the conclusion arises that these are probably not an ideal indicator of actual, and probably not even average quality of exercise in that period. However, considering the fact that there is a high correlation between the scores of different CoP's from 1964 to 2009 (correlations between CoP's (FIG) are: 1) 1971-1964: r^2=0.95; 2) 1978-1971: r^2=0.89; 3) 1985-1978: r^2=0.76; 4) 1989-1985: r^2=0.76; 5) 1997-1993: r^2=0.79; 6) 2001-1997: r^2=0.87; 7) 2006-2001: r^2=0.98; 8) 2009-2006: r^2=1; Atiković and Smajlović, 2011), the aforementioned conclusion is not acceptable. On the contrary, it is possible and even desirable, especially with the aim of detecting development of the sport, to compare the results from different Olympic cycles. Taking this into consideration, the conclusion should be that in the last decade all competitors, regardless of the unpredictability of the sport, showed equally good performances of exercises at major competitions, both in technical and aesthetical sense. By examining the results of descriptive statistics (Table 1) it can be concluded that *DS* is not the sole value that determines *FS* on a certain apparatus (Bučar et al., 2012). Namely, the lowest mean value of *DS* ($Mean_{VTDS}$=*5.35*), but also the highest value of mean *ES* ($Mean_{VTES}$=*8.43*) were recorded on the vault, in comparison to other apparatuses. The sums of *DS* and *ES* on the vault, in comparison to other apparatuses, ultimately produced: the highest mean value of *FS* ($Mean_{VTFS}$=*14.03*); b) the highest minimum result of FS (Min_{VTFS}=*12.23*) and the highest maximum result of FS

($Max_{VTFS}=15.90$); c) the smallest variations between the competitors' scores ($CV_{VTFS}=6.12$). The obtained results are completely congruent with the results of previous investigations (Atiković et al., 2011; Atiković et al., 2014; Bučar Pajek et al., 2012; Leskošek et al., 2013) and justify the suggestion made by the authors of previous studies about the revision of the CoP (FIG 2013) in terms of the starting D marks for vaults. Contrary to the vault, uneven bars are the apparatus on which the highest mean values of *DS* ($Mean_{UBDS}=5.63$) were recorded, as well as the highest maximum result of *DS* ($Max_{UBDS}=7.00$) and the highest mean values related to *ES*. Regardless of these results, the uneven bars were not determined the apparatus with the highest *FS*. Such result is probably mostly contributed by almost the highest value of the coefficient of variability precisely of *DS* ($CV_{UBDS}=12.45$), in comparison to other apparatuses. The problem of exercising on uneven bars has been investigated by Ferreirinha, Carvalho, Corte-Real and Silva (2011). According to these authors, uneven bars are an apparatus on which a significant evolution of difficulty parts of exercise occurs from junior to senior category. Considering the fact that a certain number of gymnasts competed at the OG2012 who, according to their chronological age, belonged to the junior category, the result recorded on the uneven bars is justified. The probability that "younger competitors" caused high variability of *DS* on uneven bars can also be partly interpreted through the results recorded for the vault. Namely, from the values of *DS* determined on the vault it can be seen that all-around competitors (in general) performed vaults of lower difficulty values. The reason for this probably derives from the fact that increased anthropometric measures are necessary to perform vaults of higher difficulty values (Erceg, Delaš Kalinski, and Milić, 2014; Delaš Kalinski, 2015), and gymnasts achieve these at older chronological age (Claessens, Lefevre et al. 2006). The balance beam, in comparison to other apparatuses, was characterised by average values of different parameters of *DS*, the lowest values of different parameters of *ES* and the highest values of coefficient of variability of *ES* ($CV_{BBES}=12.50$) and *FS* ($CV_{BBFS}=9.78$). The lowest mean value of *FS* ($Mean_{BBFS}=13.11$), the lowest minimum result of *FS* ($Min_{BBFS}=10.46$) and the lowest maximum result of total *FS* ($Max_{BBFS}=15.27$) were also recorded on this apparatus. The obtained results speak in favour of the unpredictability of this apparatus and confirm the results of two recent investigations related to the exercise on the balance beam. Aleksić-Veljković et al. (2015) analysed specific dynamic balance in women gymnasts aged 8 and 13 years and determined that it significantly correlates with success on the balance beam, but also with the total result at a competition. Balance as an ability is determined by numerous factors: genetic, state of the vestibular apparatus, age, supporting surface, the height of the body's center of gravity, the number of motor habits, strength, coordination, flexibility, emotional state (Kayapnar, 2011), muscle fatigue (Cetin et al., 2008).

During the exercise on the balance beam balance is extremely important in executing complex acrobatic elements (Panjan & Sarabon, 2010), as well as dance elements (Delaš Kalinski, Božanić & Atiković, 2011). On the other hand, considering anthropometric and other changes that occur in the phase of growth and development, to which surely a part of the competitors belong, as previously determined, balance is certainly not a "stabilised ability". Congruently, high variability of *ES*, and consequently the lowest values determined in other parameters, are a expected result. Except for variability in exercising that arises from the "instability" of balance, it is probable that the deduction for artistry of execution of the balance beam exercise also affected the obtained results. As mentioned in the introduction, in theory, artistry is defined as mastery of execution. Generally, components of artistry are following: inappropriate gesture and mimic, insufficient artistry of presentation, sureness of performance and insufficient variation in rhythm. The final artistry deduction is included in the final E score; the magnitude of deduction is from 0.1 or 0.3 points and the sum of all artistry deductions may rise up to 0.8 points (WAG CoP, FIG, 2013). Accordingly, this deduction may significantly impact the final result on those apparatuses and consequently on All-Around Score. Bučar Pajek (2015) conducted a study of artistry deduction on balance beam at 2011 World Championship. The study determined poor inter-rater reliability and validity of judging artistry and the author proposed repeated examination of judging deduction in the present Olympic Cycle (2012-2016). On the floor, in comparison to other apparatuses, the values of different parameters of all scores (*FXDS, FXES, FXFS*) were mostly average. However, the CV_{FXES} value, in relation to the value of the same parameter on other apparatuses, was the lowest. Such a result, if observed from the viewpoint of the demanding nature of the apparatus and artistry deduction, is surprising. Namely, if we consider that this is the most energy demanding apparatus of women's all-around (Rodriguez et al., 1999; Jemni et al., 2011), which is certainly contributed by artistry of performance, and if we know that judge's subjective evaluation/perception of a competitor is the highest at this apparatus (Bučar Pajek et al., 2013), the obtained result (the lowest variability of *ES* determined) is completely opposite to previous research. Congruently, the importance of examination and determination of reliability and validity of artistry deduction on the floor in present Olympic Cycle is emphasized. Even though the present study investigated the best women gymnasts in the world and the most important and only Olympic competition in their career, it was determined that among the groups of participants of the C-I competition at the OG 2012, defined based on competitors' ranking, there were significant differences in almost all scores. The differentiation between the first and the second group of gymnasts was not found in the *UBES* value. This was probably due to the proficiency of these two groups of competitors, regardless of

significant differences found between their *DS* values.There were no differences between the second and the third group of competitors in *VTDS* and *VTES*. Such result confirms the results and conclusions of previous studies:

1) *DS* of the vault has not been unified with determining *DS* on other apparatuses of women's All-Around (Čuk & Atiković, 2009; Čuk & Forbes, 2010; Atiković et al., 2011; Atiković et al., 2014; Bučar Pajek et al., 2012; Leskošek et al., 2013); 2) the vault is the apparatus on which small-scale deduction by the E referee committee in comparison with other apparatus was determined (Atiković et al., 2014). Taking this into consideration, the obtained result is a expected consequence. Non-differentiation between the second and the third group of competitors in *BBFS* probably arose from the highest values of coefficients of variability of *DS* and *FS* on this apparatus (CV_{BBDS}=*9.63*; CV_{BBES}=*12.50*), in comparison to other apparatuses. As there were no significant differences between the first and the second group of competitors, it is probable that the high values of coefficient of variability arise from variations in scores between the second and the third group of competitors. Congruently, it is assumed that within the second and the third group of competitors there were those who's final score on the balance beam (*BBFS*) was the sum of high *DS* and low *ES* and those who's final score was the sum of low *DS* and high *ES*.

It remains to be determined in future investigations if the determined differences were the consequence of competitors' different biological age, or the consequence of biological immaturity/maturity on competitors' exercise, or they are the consequence of belonging to national teams from different continents (Delaš Kalinski, 2015).

However, regardless of the cause of differentiation between the groups of competitors with different ranking, the obtained results of ANOVA are fully congruent with the conclusions of Massidda and Caló (2011) who state that: "…the primary determinant of success is the ability to perform a high difficulty exercise, with a high *Execution Score*".

Conclusion

By summing up the abovementioned results and discussion it can be inferred that:

1) almost exclusively all-around way of qualifying for the Olympic Games is not a reliable predictor of the number of All-Around competitors at the Olympic Games;

2) the vault is a women's All-Around apparatus which generally least competitors compete (70%); it is most difficult to achieve high *DS* on the vault, but due to relatively fewer mistakes (which lead to high *ES*), generally the highest final scores (*FS*) are achieved on it

3) compared to the vault, at the qualifying competition at the Olympic Games, more gymnasts (≥82%) competed uneven bars, balance beam and floor, which can be interpreted in two ways:
a) a higher number of gymnasts believe in the possibility of qualifying for final competitions on these apparatuses, as opposed to the vault; b) these apparatuses are probably somewhat easier for gymnasts to perform (as opposed to the vault) if their goal is only to qualify and not to achieve result at the OG;

4) at the qualifying competition at the 2012 Olympic Games in Beijing there was a significant difference in quality of top world gymnasts with different ranking. According to the results, primarily only those gymnasts who have the highest values of both *DS* and *FS* on all apparatuses have the possibility to qualify for the *All-Around Final Competition*. However, if in addition to this CoP (that says that 24 best competitors qualify for this competition; 2 from the same country at the most) is examined and the results of the qualifying and the final *All-Around competition* are observed, it can be concluded that, regardless of their significant differences in almost all scores, a large number of gymnasts from the second group also participated in the *All-Around finals* (32nd ranked gymnast of the qualifying competition participated in the final *All-Around competition*). This, however, cannot be concluded for the third group of competitors.

Hypothetically, according to the determined results, it is possible that besides the best ranked *All-Around* gymnasts, a few gymnasts with a lower *All-Around* ranking (especially those ranked from the 21st to the 40th place) qualify for the final competitions on apparatuses, especially on the vault, since it was determined that there were gymnasts in this group with vault *FS* similar to the best ranked *All-Around gymnasts*.

Nevertheless, by examining "the original data", the fact that two vaults should be executed to enter the finale for vault in the C-I competition and that out of the 8 final places there are two at the most for competitors from the same national team, such a competitor was not found at the OG2012. In the vault finals (C-III competition at the OG2012) there was only one competitor who competed in All-Around in the C-I competition, whereas the remaining competitors of the vault finals competed only on this apparatus at the OG2012. The obtained results suggest the difficulty of performing two vaults, i.e. qualifying for the vault finals according to the CoP (2009) rules.

On other apparatuses (uneven bars, balance beam and floor), 5 All-Around competitors and 3 "*non All-Around*" *competitors* for each apparatus qualified for final competitions. It is recommended that the determined characteristics of exercise among top women gymnasts and their tactics are viewed as guidelines in training processes of future Olympic gymnasts.

References

Aleksić-Veljković, A., Madić, D., Herodek, K., Živčić Marković, K., & Đokić, D. (2015). Dynamic balance of young female gymnasts. In Mitija Samardžić Pavletič and M. Bučar Pajek, (Eds.). Book of abstracts and proceedings of 2nd International Scientific Congress Organized by the Slovenian Gymnastics Federation, Portorož (pp. 102-108). Ljubljana: Slovenian Gymnastics Federation.

Arkaiev, L.I., & Suchilin, N.G. (2009). *Gymnastics: How to create champions* (2nd ed.). Oxford: Meyer & Meyer Sport Ltd.

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., Delaš Kalinski, S., Kremnicky, J. Tabaković, M., & Samardžija Pavletič, M. (2014). Characteristics and trend of judging scores in the European, World Championships and Olympic games in the female's artistic gymnastics from 2006 to 2010 year. In M. Bučar Pajek, N. Jarc & M. Samardžić Pavletič (Eds.). Book of abstracts and proceedings of 1st International Scientific Congress Organized by the Slovenian Gymnastics Federation, Portorož (pp. 65-73). Ljubljana: Slovenian Gymnastics Federation.

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., Karacsony, I., & Leskošek, B. (2012). Reliability and validity of judging in women's artistic gymnastics at the University Games 2009*. European J 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*? J of Human Kinetics, 37*(1), 173-181. Bučar Pajek, M. (2015). Judging Artistry on Balance Beam. In M. Bučar Pajek, N. Jarc & M. Samardžić Pavletič (Eds.). Book of abstracts and proceedings of 1st International Scientific Congress Organized by the Slovenian Gymnastics Federation, Portorož (pp. 65-73). Ljubljana: Slovenian Gymnastics Federation.

Claessens, A.L., Lefevre, J., Beunen, G.P. & Malina, R.M. (2006). "Maturity-associated variation in the body size and proportions of elite female gymnasts 14-17 years of age." *European journal of paediatrics***,** *165*(3): 186-192. 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., 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.

Dallas, G., & Kirialanis, P. (2010). Judges` evaluation of routines in men`s artistic gymnastics. *Science of Gymnastics Journal, 2*, 49-58.

Delaš Kalinski, S. (2015). Intracontinental and intercontinental characteristics and differences between junior and senior gymnasts. In Mitija Samardžić Pavletič and M. Bučar Pajek, (Eds.). Book of abstracts and proceedings of 2nd International Scientific Congress Organized by the Slovenian Gymnastics Federation, Portorož (pp. 66-78). Ljubljana: Slovenian Gymnastics Federation.

Delaš Kalinski, S., Božanić, A., & Atiković, A. (2011). Influence of dance elements on balance beam results. *Science of Gymnastics Journal*. *3*(2), 39-45.

Erceg, T., Delaš Kalinski S., & Milić, M. (2014). The score differences between elite European junior and senior female gymnasts. *Kinesiology, 46*(Suppl 1), 88-94.

Fédération Internationale de Gymnastique. (2006). Code of points for Women's Artistic Gymnastics. Moutier: Fédération Internationale de Gymnastique.

FIG (2009). Code of points for women artistic gymnastics competitions. Retrieved October 1, 2009,

From http://figdocs.lx2.sportcentric.com/external/serve.php?document1205

FIG (2009a). 2009 FIG General Judges' Rules. FIG. Retrieved December 3, 2009, from http://figdocs.lx2.sportcentric.com/external/serve.php?document=658.

Federation Internationale de Gymnastique (2013). *2013-2016 Code of Points (Women's Artistic Gymnastics)*. Available at:

http://www.figgymnastics.com/publicdir/rules/files/wag/WAG%20CoP%2020132016%20(English)%20Aug%202013.pdf

Fédération Internationale de Gymnastique - FIG (2014), Code of Points for Female's Artistic Gymnastics 2013-2016. Retrieved January 5, 2014,

from http://www.fig-gymnastics.com/site/rules/disciplines/art

Ferreirinha, J., Carvalho, J., Corte-Real, C., & Silva, A. (2011). The evolution of real difficulty value of uneven bars routines from elite gymnasts in last five Olympic cycles. *Science of Gymnastics Journal, 3*(1), 15-24.

http://corporate.olympics.com.au/files/dmfile/FIG_Gymnastics_April2011.pdf.

https://en.wikipedia.org/wiki/Age_requirements_in_gymnastics

Jemni, M., Sands, W., Salmela, J., Holvoet, P. & Gateva, M. (2011). *The science of gymnastics*. London and New York: Routledge Taylor and Francis Group.

Léglise, M. (1997). Limits on Young Gymnasts' Involvement in High-Level Sport. Report presented at the International Gymnastics Federation Scientific Symposium, Oct. 22-23, Berlin. Rertrieved 01.12.2015.

from https://usagym.org/pages/home/publications/technique/1998/4/limits.pdf.

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. DOI:10.5604/20831862.988884
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.
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. DOI:10.1080/02640414.2012.710759
Panjan, A., & Sarabon, N. (2010). Review of methods for the evaluation of human balance body. *Sport Science Review*, *19*(5-6), 131-163. DOI: 10.2478/v10237-011-0036-5

ANALIZA OLIMPIJSKIH IGARA (PEKING): KLJUČ IZVEDBE

Sažetak
Unatoč činjenici da su se pretežno kvalificirali kao svestrani natjecatelji za Olimpijske igre u Pekingu (OI2012), samo oko 61% gimnastičara natjecao se svestrano u kvalifikacijskom natjecanju (C-I), dok su se ostali natjecali na nekim ili samo jednom pomagalu. Najmanji postotak gimnastičara natjecao se u preskoku (70%); pomagalu na kojem su najniža vrijednost Rezultata poteškoća (DS=5,35), najviša vrijednost Rezultata izvršenja (ES=8,43) i napokon najviši Krajnji rezultat (FS=14,03) bili utvrđeni u usporedbi sa ostalim pomagalima. Približno 82% natjecatelja natjecalo se u dvovisinskim ručama, gredi i parteru. Iako su ovo bili najbolji svjetski gimnastičari, značajne razlike su utvrđene u gotovo svim DS, ES i FS (od svih pomagala) između različito rankiranih svestranih natjecatelja C-I natjecanja na OI2012. Ovi rezultati su vjerojatno posljedice taktika, ali također i ciljeva različitih gimnastičara povezanih sa rezultatima na Olimpijskim igrama. Odabir prikladnih taktika je ključ u prolongiranju relativno kratke karijere elitnih gimnastičarki.

Ključne riječi: *broj natjecatelja, pomagala, ANOVA*

Received: February 20, 2016
Accepted: June 15, 2016
Correspondence to:
Mirjana Milić, PhD
Faculty of Kinesiology,
University of Split
Teslina 6, 21 000 Split, Croatia
Tel: 00385 (0)98 98 97 780
e-mail: mirjanam@kifst.hr