THE SCORE DIFFERENCES BETWEEN ELITE EUROPEAN JUNIOR AND SENIOR WOMEN GYMNASTS

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Abstract:

Artistic gymnastics is generally determined by the rules of the gymnastics Code of Points and long-term processes of learning gymnastics skills. Though intensive, the career of women gymnasts is relatively short, so with the goal of prolonging it the International Gymnastics Federation (FIG) prescribes junior women gymnasts should apply easier dismounts than senior gymnasts. The aim of this study was to determine the characteristics of junior routines (N=88) and their differences in relation to senior routines (N=85) by analysing the variables: *difficulty score (DS), execution score (ES), total score of each apparatus (TOTAL)* and *all-around final score (EPTOTAL)*, achieved at the 2012 European Championship (Brussels). The study established significant differences between the samples in almost all the analysed scores.

Key words: *artistic gymnastics, top level, sport statistics, t-test*

Introduction

Artistic gymnastics, as a kinesiological activity, is characterized by conventional, mostly acyclic, polystructural, extremely complex skills in terms of structure. The increase trend of structural complexity of gymnastics routines is attributed to changes of the rules, being introduced by a new Code of Points (CoP) in every Olympic cycle (Arkaev & Suchilin, 2009). To satisfy the demands of the progressing sport, extensity, intensity and quality of gymnastics training procedures have increased significantly. On the other hand, the main indicators of gymnastics performance remained the same: routine difficulty and quality of performance (Čuk, Fink, & Leskošek, 2012).

The process of learning gymnastics skills, with all respect payed to the didactic principles, usually begins around the age of five. The adoption of the most complex gymnastics' forms and variations should be completed or mostly completed by the time of reaching puberty (at the latest by the age of 14). When women gymnasts reach puberty, their longitudinal body parameters are being increased and conditioning capacity is being reduced, which usually significantly affects quality and dynamics of the processes of learning gymnastics skills. This is accompanied by the decline of sports achievements, and often by the end of the top level gymnastics career (Arkaev & Suchilin, 2009).

The skills that gymnasts learn, and consequently their competitive repertoire, are the consequence of the requirements prescribed by the gymnastics CoP.

Even though CoP has been changed more or less over time and includes a number of rules, only two rules are pointed out for the purposes of the present study: 1) the total score of each apparatus is obtained by summing the difficulty score (DS evaluates routine contents: difficulty, special requirements and bonus points) and execution score (ES evaluates routine presentation); 2) the differences between junior and senior gymnasts occur in the rules only in the form of special requirements for dismounts (FIG, 2009).

The difference in the dismount performance is primarily derived from the aim of the Fédération Internationale de Gymnastique (FIG) to protect juniors from serious injuries which most often occur when performing dismounts (Samarđija Pavletič, Atikovič, & Kolar, 2014). Making the dismount easier, from a long-term aspect, is one of the ways to prolong gymnasts' active sporting careers (which was not the trend throughout the past of women's artistic gymnastics). CoP defined that juniors can perform C difficulty dismounts (0.3P difficulty) to fulfil special requirement of 0.5P, while seniors, in order to fulfil the same requirement, need to perform D difficulty dismounts. If juniors perform more complex dismounts (from the D or higher difficulty category), they will not get any bonus. This rule does not apply for vault.

The purpose of this study was to explore the score differences (*difficulty score – DS, execution score – ES, total score of each apparatus – TOTAL,* and *all-around score – EPTOTAL*) between the elite European junior and senior gymnasts in order to

see whether junior top level gymnasts respect/
apply the dismount rule, i.e. what characterizes
and differentiates performances of the mentioned
samples.

Methods

The subject sample included 173 elite European
women gymnasts who participated in the 2012 Eu-
ropean Championship in Brussels. They competed
in two groups determined by age: the first group
consisted of junior gymnasts (N=88), and the other
group of senior gymnasts (N=85). Affiliation to a
specific group is the criterion variable.

The sample of predictor variables is represented
by a set of 13 scores: 12 derived from *difficulty
scores (DS), execution scores (ES)* and *total score
(TOTAL)* of each of the four apparatuses of women's
all-around event (*vault – VT, uneven bars – UB,
balance beam – BB* and *floor routines – FX*) and
one sum score of all four apparatuses (*all-around
final score – EPTOTAL*). The values of the mentioned
scores were taken from the FIG official web site
and the Internet (www.gymnasticsresults.com).
Metric characteristics of such scores, which are
derived from the scores of expert judges, have been
established as generally satisfactory (Bučar, Čuk,
Pajek, Karacsony, & Leskošek, 2012).

For all the 13 predictor variables the methods of
data analysis included the calculation of descriptive
statistics indicators: middle value (Median), arith-
metic mean (Mean), standard deviation (SD), mini-
mum and maximum value (Min and Max), values of
the measures of distribution asymmetry (Skewness)
and peakedness (Kurtosis), and calculating the

MaxD value for determining the normality of dis-
tribution of variables by Kolmogorov-Smirnov test
(KS).

Independent samples *t*-test was used to analyse
the differences between the two age groups of
gymnasts (*juniors* and *seniors*) in all the predictor
variables.

Results

The results of descriptive statistics of variables
difficulty score (DS), execution score (ES) and *total
score (TOTAL)* of each of the four apparatuses of
women's all-around event (*vault, uneven bars,
balance beam* and *floor*) and one sum score of all four
apparatuses (*all-around final score – EPTOTAL*)
determined on the sample of 88 European elite
junior women gymnasts are presented in Table 1.

It was established that five variables – *vault
difficulty score (VTDS), vault execution score
(VTES), vault total score (VTTOTAL), uneven bars
difficulty scor (UBDS)* and *balance beam total score
(BBTOTAL)*, significantly deviated from normal
distribution. However, given that their numerically
low (small) values of coefficients of skewness
(Skew) and kurtosis (Kurt) represent values in the
range between -3 and +3, the conditions were met
for the application and further use of parametric
analysis (Milavić, 2013). The testing of distribution
normality was performed by the Kolmogorov-
Smirnov test with the critical value of 0.15.

Middle values (Median) of the variable *dif-
ficulty scores (DS)* were the same for *uneven
bars, balance beam* and *floor* apparatus
(Median$_{UBDS, BBDS, FXDS}$=4.80), whereas for *vault*

Table 1. Descriptive statistics of the variables: difficulty score (DS), execution scores (ES) and total score (TOTAL) of four all-around apparatus (vault – VT, uneven bars – UB, balance beam – BB, floor –FX) and all-around final score (EPTOTAL) of elite European junior women gymnasts (N=88)

Variables	Median	Mean	Min	Max	SD	Skew	Kurt	MaxD
VTDS	5.00	4.99	4.20	5.80	0.35	0.16	1.81	0.31
VTES	8.47	8.41	6.63	9.27	0.53	-1.67	2.62	0.17
VTTOTAL	13.47	13.37	11.43	14.27	0.59	-1.59	2.85	0.21
UBDS	4.80	4.22	1.10	6.00	1.30	-0.84	-0.47	0.23
UBES	7.67	7.47	4.37	8.63	0.84	-1.64	2.59	0.13
UBTOTAL	12.30	11.68	6.23	14.44	1.80	-0.76	-0.13	0.15
BBDS	4.80	4.79	3.20	5.80	0.57	-0.46	-0.12	0.08
BBES	7.27	7.08	3.53	8.60	1.05	-1.03	1.46	0.08
BBTOTAL	12.02	11.87	7.87	14.30	1.38	-0.58	0.15	0.09
FXDS	4.80	4.70	3.20	5.60	0.53	-0.80	-0.04	0.16
FXES	7.47	7.38	5.14	8.77	0.80	-0.73	0.49	0.12
FXTOTAL	12.12	12.02	7.83	14.37	1.25	-0.75	0.82	0.08
EPTOTAL	49.03	47.03	10.00	56.13	8.06	2.98	11.34	0.14
								KS= 0.15

LEGEND: Median – middle value, Mean – mean, Min – minimum result, Max – maximum result, SD – standard deviation, Skew – coefficient of distribution skewness, Kurt – coefficient of distribution kurtosis, KS – Kolmogorov-Smirnov test

it was $Median_{VTDS}$=5.00. Medians of *execution scores (ES)* were in the range from 7.27 for the *balance beam* routine ($Median_{BBES}$) to 8.47 for the *vault* execution ($Median_{VTES}$). Median of the *total score* was the lowest for the *balance beam* routine ($Median_{BBTOTAL}$=12.02), and the highest for the *vault* execution ($Median_{VTTOTAL}$=13.47).

The highest mean values of all the three scores were calculated for the *vault* execution ($Mean_{VTDS}$ =4.99; $Mean_{VTES}$=8.41; $Mean_{VTTOTAL}$=13.37). The lowest mean values of *difficulty score* and *total score* were calculated for the *uneven bars* routine ($Mean_{UBDS}$=4.22; $Mean_{UBTOTAL}$=11.68), and the lowest mean value of *execution score* was calculated for the *balance beam* routine ($Mean_{BBES}$=4.07).

Numerically the lowest value ($Min_{UBTOTAL}$=6.23), but also the highest value of *total score* ($Max_{UBTOTAL}$ =14.44) were recorded for the *uneven bars* routine.

Mean value of the *all-around final score (EPTOTAL)* for the elite European junior women gymnasts was $Mean_{EPTOTAL}$=47.03, whereas the median was somewhat higher and numerically determined as $Median_{EPTOTAL}$=49.03.

Descriptive parameters of variables *difficulty score (DS), execution score (ES)* and *total score (TOTAL)* of each of the four apparatuses of women's gymnastics all-around event (*vault, uneven bars, balance beam* and *floor*) and the sum score *(all-around final score – EPTOTAL)* determined on the sample of 85 European elite senior women gymnasts are presented in Table 2.

Of the 13 variables applied, only one variable *(VTDS)* deviated significantly from normal distribution, but the values of coefficients of skewness (Skew=0.20) and kurtosis (Kurt=-0.59) were also low in this case, so the conditions for the application and further use of parametric analysis were met (Milavić, 2013). The testing of distribution normality was performed by Kolmogorov-Smirnov test with the critical value of 0.15.

Middle values (Median) of *DS* were the same for the *vault, uneven bars* and *floor* ($Median_{VTDS, UBDS, FXDS}$=5.00), whereas median for the *balance beam* was $Median_{BBDS}$=5.10. Medians of *ES* were in the range from 7.58 for the *uneven bars* routine ($Median_{UBES}$) to 8.72 for the *vault* execution ($Median_{VTES}$). Median of the *total score* was the lowest for *uneven bars* ($Median_{UBTOTAL}$=12.43) and the highest for *vault* ($Median_{VTTOTAL}$=13.75).

The highest mean values of all the three scores were calculated for *vault* ($Mean_{VTDS}$=5.20; $Mean_{VTES}$=8.68; $Mean_{VTTOTAL}$=13.83). The lowest mean values of *DS, ES* and *TOTAL* were calculated for *uneven bars* ($Mean_{UBDS}$=4.85; $Mean_{UBES}$=7.29; $Mean_{UBTOTAL}$=12.13).

The lowest value of *TOTAL* ($Min_{UBTOTAL}$=6.03) was also recorded for *uneven bars*, whereas *TOTAL* for *balance beam* ($Max_{BBTOTAL}$ =15.73) represents the highest value.

Mean value of *EPTOTAL* for the European elite senior women gymnasts was $Mean_{EPTOTAL}$=50.54, whereas the middle value was $Median_{EPTOTAL}$=50.98.

The analysis of the results of independent samples *t*-test between the European elite junior and senior women gymnasts indicated significant differences in nine out of the 13 predictor variables (Table 3).

Table 2. *Descriptive statistics of the variables: difficulty score (DS), execution scores (ES) and total score (TOTAL) of four all-around apparatuses (vault – VT, uneven bars – UB, balance beam – BB, floor –FX) and all-around final score (EPTOTAL) of elite European senior women gymnasts (N=85)*

Variables	Median	Mean	Min	Max	SD	Skew	Kurt	MaxD
VTDS	5.00	5.20	4.20	6.30	0.57	0.20	-0.59	0.20
VTES	8.72	8.68	7.80	9.30	0.39	-0.59	-0.16	0.12
VTTOTAL	13.75	13.83	12.30	15.37	0.81	-0.07	-0.52	0.09
UBDS	5.00	4.85	1.00	6.70	1.08	-1.10	1.45	0.14
UBES	7.58	7.29	3.13	8.83	1.05	-1.46	2.67	0.14
UBTOTAL	12.43	12.13	6.03	15.51	1.84	-0.68	0.29	0.09
BBDS	5.10	5.16	4.00	6.70	0.63	0.07	-0.72	0.10
BBES	7.87	7.54	4.80	9.23	1.00	-0.65	-0.32	0.13
BBTOTAL	12.73	12.69	9.13	15.73	1.49	-0.17	-0.78	0.10
FXDS	5.00	4.97	3.30	6.40	0.62	-0.30	-0.12	0.07
FXES	7.70	7.56	6.13	8.73	0.62	-0.31	-0.69	0.10
FXTOTAL	12.53	12.48	9.93	15.13	1.16	-0.06	-0.70	0.08
EPTOTAL	50.98	50.54	39.20	60.13	4.76	-0.30	-0.39	0.10
								KS= 0.15

LEGEND: Median – middle value, Mean – arithmetic mean, Min – minimum result, Max – maximum result, SD – standard deviation, Skew – coefficient of distribution skewness, Kurt – coefficient of distribution kurtosis, KS – Kolmogorov-Smirnov test

Table 3. *Analysis of differences in the predictor variables between elite European junior and senior women gymnasts obtained by independent samples t-test*

Variables	JUNIORS N=88		SENIORS N=85			
	Mean$_1$	SD$_1$	Mean$_2$	SD$_2$	T-test	p
VTDS	4.99	0.35	5.20	0.57	-1.63	0.11
VTES	8.41	0.53	8.68	0.39	-2.23	0.03
VTTOTAL	13.37	0.59	13.83	0.81	-2.37	0.02
UBDS	4.22	1.30	4.85	1.08	-3.56	0.00
UBES	7.47	0.84	7.29	1.05	1.27	0.21
UBTOTAL	11.68	1.80	12.13	1.84	-1.65	0.10
BBDS	4.79	0.57	5.16	0.63	-4.08	0.00
BBES	7.08	1.05	7.54	1.00	-2.95	0.00
BBTOTAL	11.87	1.38	12.69	1.49	-3.76	0.00
FXDS	4.70	0.53	4.97	0.62	-3.11	0.00
FXES	7.38	0.80	7.56	0.62	-1.72	0.09
FXTOTAL	12.02	1.25	12.48	1.16	-2.53	0.01
EPTOTAL	47.03	8.06	50.53	4.76	-2.55	0.01

LEGEND: Mean – arithmetic mean, SD – standard deviation, t-test – for independent samples, p – level of significance

The two groups of gymnasts differed significantly in the following variables: *uneven bars, balance beam* and *floor difficulty score (UBDS, BBDS, FXDS), vault* and *balance beam execution score (VTES, BBES), vault, balance beam* and *floor total score (VTTOTAL, BBTOTAL, FXTOTAL)* and *all-around final score (EPTOTAL)*, based on the degrees of freedom df=171 and the level of significance of p<.05.

Discussion and conclusions

The findings of the present study confirmed the hypothesis that senior women gymnasts achieve significantly higher numerical values than junior women gymnasts in almost all sub-scores that make up the score of individual apparatus routine and in the all-around final score. Significantly lower numerical values, primarily in *DS* for three of the apparatuses (*uneven bars, balance beam* and *floor*) can probably be attributed to juniors following the rules of performing easier dismounts, given that these also affect *DS* (FIG, 2009).

There were no significant differences between the samples in *vault difficulty scores (VTDS)* and these scores were the highest in both samples, when compared to *DS* for other apparatuses. The highest values of *DS* were also determined for *vault* in men artistic gymnastics (Čuk & Atiković, 2009), which confirms that it is generally easiest to achieve a high *DS* on this apparatus, regardless of the gender, and, according to the results, also regardless of women gymnasts' age. The reason for this is probably derived from the fact that in the all-around competition (the results of which have been analysed in this study) women gymnasts perform only one

vault. Compared to other apparatuses, this seems like a performance of only one element, so it could probably be brought to a high difficulty value. The *vault DS* determined in men's artistic gymnastics had the lowest correlation to the all-around score (Čuk & Atiković, 2009), and the highest *vault DS* was not determined a reliable predictor of the all-around final score in women's artistic gymnastics either. Namely, it was established that the results achieved by women gymnasts on *uneven bars* and *balance beam* had the highest impact on the final score when compared to the results achieved on other apparatuses, disregarding the quality of each competitor (Massidda & Calo, 2012).

The significant differences between juniors and seniors in *vault (VTES)* and *balance beam (BBES) execution scores (ES)*, i.e. their significant non-difference in *uneven bars (UBES)* and *floor (FXES)*, can be interpreted as a consequence of: a) the opposite influence of growth on routine execution on these apparatuses, and b) judging characteristics.

Even though process of the growth is determined primarily by genetic factors, research results have established that stress and intense gymnastics training could have strong effects on growth of women gymnasts. Some of the consequences of gymnastics training are a delay in skeletal maturation, i.e. a late acceleration of linear growth in relation to the non-gymnasts population (Claessens, et al., 1991; Georgopoulos, et al., 1999; Georgopoulos, et al., 2001; Georgopoulos, Theodoropoulou, Leglise, Vagenakis, & Markou, 2004; Malina, 1994). The increase of values of primarily anthropometric measures occurs at junior age (Arkaiev & Suchilin, 2009). It probably makes the control of balance more

difficult when executing elements on balance beam, which results in more frequent errors and, finally, in lower execution scores. In vault, increased values of anthropometric measures allow vault execution of greater difficulty, but it is probable that, due to a relatively short time in which gymnasts can do this, junior women gymnasts are not able to acquire a higher level of more difficult vaults, so they earn great deductions for their execution.

The non-existence of significant difference between junior and senior women gymnasts in the *uneven bars ES (UBES)*, and with regard to the results that had determined significantly lower numerical values of *DS (UBDS)* in juniors then in seniors, leads to the conclusion that junior routines on uneven bars, which are simpler in terms of composition and difficulty, are executed with nearly the same number of errors as those (more difficult) executed by seniors. Ferreirinha, Carvalho, Corte-Real and Silva (2011) established that uneven bars are an apparatus on which over the years and, accordingly, also by junior gymnasts growing up to be seniors, a significant evolution occurs in difficulty parts of the exercise. For the purpose of identifying all parameters influencing the changes in difficulty composition of routines, but also the changes caused by the changes in the quality of routine execution, further analyses are necessary.

The sub-samples did not differ significantly in the *floor execution score (FXES)*, whereas they differed in the *floor difficulty score (FXDS)* and *floor total score* (*FXTOTAL*), which leads to the conclusion that performance on *floor* probably depends neither on age nor on difficulty of the elements executed. The non-differentiation in the floor routine execution can probably be attributed to specific deductions – artistry deductions (lack of choreography creativity, inability to express idea of accompanying music, inappropriateness of gesture, etc.; FIG, 2009), that must be evaluated by the judges on this event. Given that these deductions are taken based on the judges' subjective assessment, they might have caused the non-differentiation in *ESs* between juniors and seniors. Bučar, Čuk, Pajek, Karacsony and Leskošek (2012) found the lowest values of inter-item correlation between judges' scores on this event in relation to other apparatuses. With the aim of determining the reasons behind the obtained results, but also of analysing the impact of artistry deductions on competitive rank (especially due to the fact that sum value of this deduction can be up to 1.1 point), the authors recommended further research (Bučar, et al., 2012; Bučar Pajek, Čuk, Pajek, Kovač, & Leskošek, 2013; Dallas & Kirialanis, 2010; Leskošek, Čuk, Karácsony, Pajek, & Bučar, 2010).

A significant difference of the subsamples in the *all-around final score (EPTOTAL)*, numerically in favour of senior women gymnasts, is a logical consequence of the results analysed earlier.

It can be concluded that "years of gymnastics practice" play a significant role in both stabilising gymnasts' performance and learning more complex variations of gymnastics skills. Given that gymnastics career is usually shorter than other athletes' careers, i.e. women gymnasts must achieve their maximum performance level usually within the period of six to nine years of practice, importance of adequately planned and programmed training becomes indisputable. Training practice should be based on current top results as well as on the information about the development trend of artistic gymnastics, considering that during one's gymnastics career usually the maximum of two changes of Code of Points would occur. Accordingly, a certain evolution in practice should follow that rule changes.

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RAZLIKE U BODOVIMA IZMEĐU JUNIORSKIH I SENIORSKIH VRHUNSKIH GIMNASTIČARKI

Sportska gimnastika je determinirana pravilima Bodovnog pravilnika FIG-a i dugotrajnim procesom učenja gimnastičkih znanja. Iako intenzivan, vijek gimnastičarki je relativno kratak pa je, radi njegova produljenja, Međunarodna gimnastička federacija (FIG) za gimnastičarke juniorke propisala jednostavnije saskoke sa sprava od onih koje izvode seniorke. Cilj ovog rada bio je, analizom *ocjena težinskih vrijednosti (DS), ocjena izvedbe (ES), konačnih ocjena na svakoj spravi (TOTAL)* i *ukupnog višebojskog rezultata (EP TOTAL)*, ostvarenih na Europskom prvenstvu 2012. godine (Bruxelles), utvrditi karakteristike juniorskog vježbanja (N=88) i njihovu različitost od karakteristika seniorskog vježbanja (N=85). Istraživanjem su utvrđene značajne razlike između uzoraka u gotovo svim analiziranim ocjenama.

Ključne riječi: *sportska gimnastika, vrhunske gimnastičarke, statistika sporta, t-test*