THE DIFFERENCES BETWEEN TEAMS IN MEN'S AND WOMEN'S MEDALLISTS AND NON-MEDALLISTS AT THE 1996–2016 OLYMPIC GAMES ARTISTIC GYMNASTICS TOURNAMENT

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Abstract The aim of this study is to determine the differences between the medallists and non-medallists in male and female artistic gymnastics at the Olympic Games from 1996 to 2016. Basic procedures: Data concerning the athletes were obtained from the "Official documents of the International Olympic Committee" which include the athlete's date of birth and date of competing. The total number of analysed OG participants in men's artistic gymnastics amounted to n = 419 and the women's artistic gymnastics was n = 417. Main findings: With men the t test for small independent samples has determined statistically significant differences between medallists and other competitors in 2000 and 2012. Among women no significant statistical differences have been found in all the mentioned variables. Conclusions: The differences between male medallists and non-medallists are manifested through the age of the competitors: 2.57 years in 2000 and 3.57 years in 2012. Compared to other OG a higher level of homogeneity and smaller age difference is noticeable. In difference to men, women had no similar differences within a period of 20 years. In artistic gymnastics in the last couple of years there is a recurring trend of a late specialisation because with each new scoring Code of Points the conditions demanded from the competitors become harder.

Key words t-test, Olympic Games, artistic gymnastics, trend

Introduction

The Fédération Internationale de Gymnastique (FIG) is the governing body for gymnastics worldwide. It is the oldest established international sports federation (1881) and has participated in the Olympic Games (OG) since their revival in 1896. The basis of all competitions in men's and women's artistic gymnastics are all-around which include many different apparatuses routines, within a team or individually. Artistic gymnastics is a typical multidisciplinary

sport with six disciplines in men's artistic gymnastics: Floor (FX), Pommel horse (PH), Rings (RI), Vault (VT), Parallel bars (PB), High bar (HB) and four disciplines in women's artistic gymnastics: Vault (VT), Uneven bars (UB), Balance beam (BB) and Floor (FX). The competition rules are defined in: Statutes of the FIG, Technical Regulations FIG, Code of Points (CoP), Apparatus norms which are changed and perfected by the FIG's commissions for each Olympic cycle.

The Olympic Games and World Championships (WC) represent the crown of every athlete's career, so is the case with gymnasts. The OG and WC, as the most important competitions in a career of every athlete, are subjected to multiannual preparations. This is why it can be concluded with certainty that only the best competitors can take part.

Up until 1981 the minimum age for participating in senior competitions was 14 years of age. At the 58th FIG Congress held in July 1980, a short time before the OG in Moscow, the minimum age rose from 14 to 15 years of age. This rule came into force in 1981 and the gymnasts had to be at least 15 years old, within a calendar year, in order to take part in the competition as seniors. These age requirements have not changed until 1997 when the minimum age raise from 15 to 16 years of age (Anderson, 1997). Since 1997, the gymnasts had to be at least 16 years old or to be turning 16 within the calendar year in order to take part in the competition as seniors.

Practicing gymnastics on a top level in early years can be damaging and dangerous to the gymnast's health (Paul, 2010). Younger gymnasts, especially the ones who have not went through puberty yet, have a tendency to be lighter, smaller, more flexible and bendable which aids them in performing more complex elements and routines and gives them a better relation between strength and weight. When a female gymnast enters puberty her growth and weight gain can affect her center of mass gravity which causes mental and physical stress that needs adjustment and in some cases she has to learn her moves again in order to compensate for them (Paul, 2010). Besides that, older gymnasts may be more prone to injuries caused by bone and muscle overstraining. Younger gymnasts have a smaller chance of such problems or a greater possibility to work through the pain during their injury (Paul, 2010).

In the 1950s and 1960s, the senior competition was dominated by athletes in their mid-to-late twenties. At the time, the CoP centred on artistry and was largely inspired by ballet. As a result, more seasoned gymnasts found success in the sport by bringing elegance to their routines. However the age limitations were introduced to gymnastics for: physiological reasons, protecting children from harmful exposure, time training, early growth, growth of body segments, pubertal growth and maturation, sex characteristics, menarche, nutritional status, weight-for-height, gymnastics training environment, familial factors. There is also the concern that imposed training limits could lead to more injuries (Anderson, 1997; Paul, 2010).

Design

A historical analysis of the chronological age trend of all teams of men's and women's artistic gymnastics who have participate in the period between 1996 and 2016 has been made. The main problem of the research was determining the differences in the age structures between particular competitions and disciplines in male and female artistic gymnastics in last 20 years decade.

Material and methods

The sample of the examinees also included all the participants in Men's artistic gymnastics (MAG) in the following competitions: OG 1996, n = 83; OG 2000, n = 72; OG 2004, n = 72; OG 2008, n = 72; OG 2012, n = 60;

OG 2016, n = 60; and in Women's artistic gymnastics (WAG): OG 1996, n = 82; OG 2000, n = 71; OG 2004, n = 72; OG 2008, n = 72; OG 2012, n = 60; OG 2016, n = 60. The total number of analysed OG participants in MAG amounted to n = 419 and the WAG was n = 417.

The intent was to collect current data of female and male gymnasts from recent years. All data for this study was obtained from the Official Website of the Olympic Games Results 1996–2016 https://www.olympic.org/olympic-results (1.09.2016). We started collecting data from the 1996 and ended with the 2016 OG. The following variables were included: date of birth, qualification date of the OG.

Data processing in this research and the application of the statistically mathematical procedures were conducted in the programme package of Microsoft Office Excel 2013 and SPSS 23.0 (SPSS Inc., Chicago, IL, USA). For calculating the chronological age the following formulas from the Microsoft Office Excel 2013 package were used.

For the total number of days of one's age since the date of birth until the first day of the competition qualifications: *Calculation formula* = DATEDIF (A1; B1; "d").

For the total number of years of one's age since the date of birth until the first day of the competition qualifications: *Calculation formula* = DATEDIF (days × 0.0027397260273973 years).

For the total number of years, months and days since the date of birth until the first day of the competition qualifications: *Calculation formula* = DATEDIF (A1; B1; "Y") & "years", &DATEDIF (A1; B1; "YM")& " months, "&DATEDIF (A1; B1; "MD") &" days".

Descriptive statistics (mean and standard deviation) are presented for team and competition years in Tables 1–2. In order to check for any deviation from normality, a number of methods can be used. One method is to use skewness and kurtosis. Skewness assesses the extent to which a variable's distribution is symmetrical. If the distribution of responses for a variable stretches toward the right or left tail of the distribution, then the distribution is referred to as skewed. Kurtosis is a measure of whether the distribution is too peaked in a very narrow distribution with most of the responses in the centre. Normality can be a problem when the sample size is small (<50). As can been seen in Tables 1 and 2, for the purposes of conducting a t-test (i.e., Skewness <|2.0| and Kurtosis <|9.0|; Schmider, Ziegler, Danay, Beyer and Bauhner, 2010. Additionally, the assumption of homogeneity of variances was tested and satisfied via Leven's F test. An independent t test was conducted to determinate if a difference existed between the chronological age of the participants of the Olympic Games. For significance 5 percent level of ($P < 0.05$).

Second order curve-fitting regression methods were used to determine the best fit for the time series of variables addressed in this study. Several time-series analysis methods were calculated and fitted to the historical data along with the resulting regression equations and R2 values using Microsoft Excel 2013. The best model fit for the historical data was determined by the highest R2 value. Second-order polynomial equations are presented in the Table 5.

Results

In (Table 1) the central and dispersal result parameters from the OG MAG games had the highest result span in 2004 of 18.05 years and the lowest span in 1996 of 13.30 years. Analysing the parameters of the central tendency of minimum and maximum values it can be established that the lowest value was in 2004 of 16.81 years and the highest was in 2008 of 35.08 years. Inspecting the results in arithmetic environments of all variables the highest

values were recorded in 2016 of 25.11 years and the lowest in 1996 of 23.49 years. The highest value of standard deviation was in 2012 of 3.70 years and the lowest in 1996 of 2.56 years. Observing the variability of the results of the chosen variables from the aspect of differentiation, skewness parameter – curvature coefficient and kurtosis – elongation coefficient, we can determine that the symmetrical variables of the resulting frequencies (Skewness) had a somewhat equal positive (epicurticle) and negative (hypocurticle) sign. The values indicate that the result distribution is normal.

Table 1. Descriptive Statistics Men's Artistic Gymnastics

Year	N	R	Min	Max	M	SD	Skew	Kurt
1996	83	13.30	17.70	31.00	23.49	2.56	0.12	0.01
2000	72	14.72	17.99	32.71	23.74	3.09	0.45	0.23
2004	72	18.05	16.81	34.86	24.35	3.26	0.28	0.59
2008	72	16.30	18.78	35.08	24.95	3.19	0.46	0.08
2012	60	15.49	18.35	33.84	24.06	3.70	0.65	0.02
2016	60	13.83	19.49	33.32	25.11	3.46	0.22	–0.54

Abbreviations: N – the number of of participants; R – range; Min: minimum; Max – maximum; M – Mean; SD – standard deviation; Skew – Skewness; Kurt – Kurtosis.

In (Table 2) the central and dispersal result parameters from the OG MAG games had the highest result span in 2004 of 21.51 years and the lowest span in 2000 of 8.12 years. Analysing the parameters of the central tendency of minimum and maximum values it can be established that the lowest value was in 1996 of 14.35 years and the highest was in 2012 of 37.13 years. Inspecting the results in arithmetic environments of all variables the highest values were recorded in 2016 of 19.70 and the lowest in 1996 of 17.29 years. The highest value of standard deviation was in 2012 of 3.85 years and the lowest in 2000 of 1.91 years. Observing the variability of the results of the chosen variables from the aspect of differentiation, skewness parameter – curvature coefficient and kurtosis – elongation coefficient, we can determine that the symmetrical variables of the resulting frequencies (Skewness) had a somewhat equal positive (epicurticle) and negative (hypocurticle) sign. One variable has a slightly higher positive sign in 2012 (Skewness 2.14) and (Kurtosis 6.52). This shows us that the Gaus curve had a hypocurticle appearance and that the results were higher and larger in number than the arithmetical environment. All other values of the parameter point out that the variables were within the allowed limits.

Table 2. Descriptive Statistics Women's Artistic Gymnastics

Year	N	R	Min	Max	M	SD	Skew	Kurt
1996	82	9.44	14.35	23.79	17.29	1.99	1.03	1.20
2000	71	8.12	15.72	23.84	18.07	1.91	0.73	–0.14
2004	72	11.72	14.46	26.18	18.33	2.50	1.45	2.02
2008	72	17.45	15.71	33.16	18.92	3.24	1.85	4.48
2012	60	21.51	15.62	37.13	19.69	3.85	2.14	6.52
2016	60	16.32	15.61	31.93	19.70	3.30	1.25	1.87

Abbreviations: N – the number of participants; R – range; Min – minimum; Max – maximum; M – Mean; SD – standard deviation; Skew – Skewness; Kurt – Kurtosis.

The results in (Table 3) of independent t test were significant, t test (70) = –3.24, p = 0.002, d = –0.77, r = 0.36, indicating that there significant difference between OG 2000 medallist (M = 21.81, SD = 2.27, n = 18) and the scores at the OG 2000 non medallist (M = 24.38, SD = 3.08, n = 54). The effect size, r was medium. The results of independent t test were significant, t test (58) = –3.53, p = 0.001, d = –0.92, r = 0.42, indicating that there are significant differences between OG2012 medallist (M = 21.38, SD = 2.00, n = 15) and the scores at the OG 2012 non medallist (M = 24.95, SD = 3.72, n = 45). The effect size, r was medium. We can state that there are no statistically important differences in the chronological age between male athletes who have and who have not won medals in the OG except in 200 and 2012. In (Table 4) which refers to the female artistic gymnastics we have not determined statistically relevant differences between certain ages and rankings of the competitors. When it comes to girls we are talking about the same population of the examinees and there are no age differences regarding to the ranking.

Table 3. Descriptive Statistics and Independent Samples Test Men's Artistic Gymnastics

Year	Group Statistics				Levene's Test for Equality of Variances		*t*-test for Equality of Means			Calculate *d* and *r* using *t* values and *df*	
	R	N	M	SD	F	Sig.	t	df	Sig. (2-tailed)	d	r
1996	1	21	22.67	2.57	0.231	0.632	–1.706	81	0.092	–0.37	0.18
	2	62	23.77	2.52							
2000	1	18	21.81	2.27	1.884	0.174	–3.248	70	0.002*	–0.77	0.36*
	2	54	24.38	3.08							
2004	1	18	24.66	2.71	0.508	0.478	0.461	70	0.646	0.11	0.05
	2	54	24.25	3.43							
2008	1	18	24.47	3.29	0.163	0.688	–0.738	70	0.463	–0.17	0.08
	2	54	25.11	3.17							
2012	1	15	21.38	2.00	3.763	0.057	–3.531	58	0.001*	–0.92	0.42*
	2	45	24.95	3.72							
2016	1	15	24.20	2.77	2.814	0.099	–1.188	58	0.240	–0.31	0.15
	2	45	25.42	3.64							

Abbreviations: N – the number of participants; M – means; SD – Standard Deviation; Skew – Skewness; Kurt – Kurtosis; t – T Test Value; df – Degrees of Freedom; * – indicates a significant difference; d – Cohen's d Value (Standardized Mean Difference); r – Effect Size [(±0.1 = very small, Sawilowsky, 2009); (±0.20 = small, Cohen, 1988); (±0.50 = medium, Cohen, 1988); (±0.80 = large, Cohen, 1988); (±1.2 = very large, Sawilowsky, 2009); (±2.0 = huge, Sawilowsky, 2009].

Table 4. Descriptive Statistics and Independent Samples Test Women's Artistic Gymnastics

Group Statistics					Levene's Test for Equality of Variances		*t*-test for Equality of Means			Calculate *d* and *r* using *t* values and *df*	
Year	R	N	M	SD	F	Sig.	t	df	Sig. (2-tailed)	d	r
1	2	3	4	5	6	7	8	9	10	11	12
1996	1	20	17.51	1.59	1.217	0.273	0.562	80	0.576	0.12	0.06
	2	62	17.22	2.11							
2000	1	18	18.19	2.02	0.688	0.410	0.297	69	0.768	0.07	0.03
	2	53	18.03	1.89							
2004	1	18	18.28	3.05	0.033	0.856	–0.092	70	0.927	–0.02	0.01
	2	54	18.35	2.33							
2008	1	18	18.63	3.33	0.224	0.637	–0.436	70	0.664	–0.10	0.05
	2	54	19.02	3.24							

1	2	3	4	5	6	7	8	9	10	11	12
2012	1	15	18.19	1.75	4.065	0.048	–1.770	58	0.082	–0.46	0.22
	2	45	20.19	4.23							
2016	1	15	18.81	2.12	3.352	0.072	–1.194	58	0.237	–0.31	0.15
	2	45	20.00	3.63							

Abbreviations: N – the number of participants; M – means; SD – Standard Deviation; Skew – Skewness; Kurt – Kurtosis; t – T Test Value; df – Degrees of Freedom; * – indicates a significant difference; d – Cohen's d Value (Standardized Mean Difference); r – Effect Size [(±0.1 = very small, Sawilowsky, 2009); (±0.20 = small, Cohen, 1988); (±0.50 = medium, Cohen, 1988); (±0.80 = large, Cohen, 1988); (±1.2 = very large, Sawilowsky, 2009); (±2.0 = huge, Sawilowsky, 2009].

Table 5. Linear and Second-Order Polynomial-Regression Equations for Each Variable With the Olympic Games Year

Variable Age (yrs)	Linear equation	r^2	Second-order polynomial equation	r^2
MAG Team 1996–2016	y = 0.2761x + 23.323	0.629	$y = –0.0357x^2 – 0.5259x + 22.99$	0.652
WAG Team 1996–2016	y = –0.4996x + 16.923	0.962	$y = –0.0327x^2 – 0.7285x + 16.617$	0.971

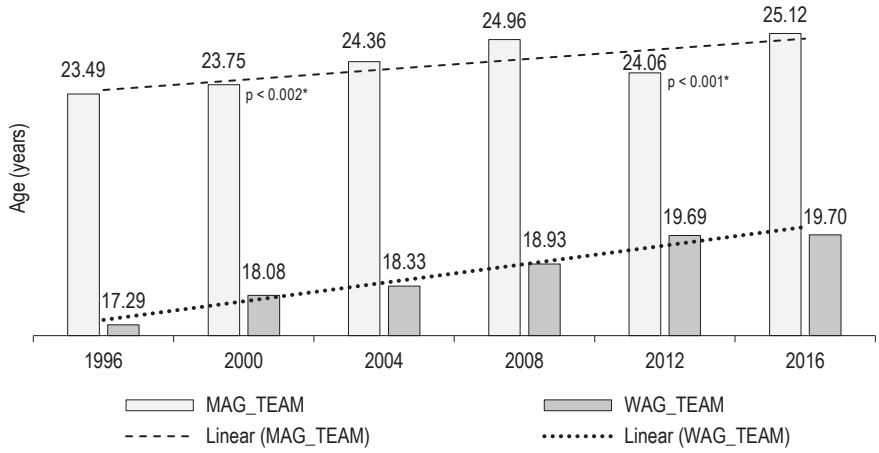

Figure 1. Olympic gymnastics teams' (men's and women's artistic gymnastics) second-order polynomial curve, 1996–2016

Discussion

Researches on age in a timeline from 1964 to 1980 were conducted by Rozin and Čeburaev (1981) and showed age of top male gymnasts at the OG [OG 1964 (M = 25.6, SD = 2.9); OG 1968 (M = 24.2, SD = 3.4); OG 1972 (M = 24.6, SD = 2.8); OG 1976 (M = 23.3, SD = 4.0); OG 1980 (M = 23.2, SD = 3.1)]. Minimum age for participants was 13.0 years at the WC 1987 and rose to 16.0 years at the 1997 WC. Mean ages have since increased: 16.5 (WC 1987), 17.4 (WC 1997), 18.0 (OG 2000), and 18.8 (OG 2008) years (Claessens, 2007; Malina et al., 2013). The demands of the Olympic gymnastics have continued to escalate, and currently, a light, powerful, and usually, petite athlete is optimal (Arkaev, Suchilin, 2004).

Some researches were aimed to find the connection between anthropometry, age and sport success in gymnastics (Caine, Lindner, 1985; Baxter-Jones, Helms, Maffulli, Baines-Preece, Preece, 1995; Damsgaard, Bencke, Matthiesen, Petersen, Muller, 2001). One of these researches had the aim of measuring the anthropometry of a gymnast at two major competitions in Ljubljana, 5th Regional Sokol Meeting in Ljubljana in 1933 and World Cup in Ljubljana 2000. In this research all the gymnasts taking part were measured. The results showed that in 1933 the average age was 21.86 years (Škerlj, 1934). The results from 2000, by authors Čuk and Karácsony showed that the gymnasts were a bit shorter and older, and the average age was 23.40 years (Čuk, Karácsony, 2002; Čuk et al., 2007). Comparing this to the acceleration process of the population's body growth and weight gain, it is evident that this process has not affected the growth of the professional gymnastics population. Unfortunately, Škerlj (1934) did not provide measures of standard age deviation in order to make calculations of statistical differences between then and now.

A similar research methodology of comparing two time periods but with a newer date was used again (Možnik, Hraski, Hraski, 2013). The first aim of that research was to determine the differences in height, weight and age of the top-level male gymnasts in relation to their classification at the WC in year 2007. The second aim was to determine whether there has been a change in height, weight and age of the elite gymnasts at the WC in year 2011, after one Olympic period. Comparing the arithmetic mean between the first seventy (thirty on vault) gymnasts in each gymnastics discipline at the WC 2007 and WC 2011 it can be concluded that there are no statistically significant differences between gymnasts in height, weight and age in any discipline.

Authors (Sands, Slater, McNeal, Murray, Stone, 2012) state in the conclusion that the US Women Olympic gymnasts were apparently getting smaller through the 1980s and early 1990s. Since then the size of these gymnasts has increased. The minimum age rule modifications may have played a role in the athlete size changes along with a shift from the near dominance of the former communist Eastern Bloc (Sands, Slater, McNeal, Murray, Stone, 2012).

According to the first FIG CoP 1964 to the present, the MAG and WAG has already gone through 14 versions or cycles CoP. Atiković (2014) emphasizes that the changes in the regulation of men's and women's artistic gymnastics occur from one cycle to another by changes in the evaluation of the difficulty value (DV) from cycle to cycle. The increased complexity of CoP in terms of the difficulty value and an increased number of deductions need a longer competitive internship to be successful. Some gymnasts and gymnasts such as Oksana Chusovitina and Yordan Yovchev succeeded at the age of 40 to be ranked high in major competitions. Oksana Chusovitina is competing at her seventh Olympics in 2016, another record, at the age of 41. Bulgaria's Yordan Yovchev, 39, became the first ever male gymnast to compete in six OG.

According to the (Balyi, Cardinal, Higgs, Norris, Way, 2005) introduced the notion of early or late specialization sports. Early specialization sports (mostly acrobatic and artistic sports such as diving, figure skating, and gymnastics) are defined as sports in which early sport-specific training (by ages 5 to 7) is necessary for future excellence. Bompa (1999) states that gymnasts achieve the best results in the WAG at the age of 14–18 and in MAG at the age of 18–25. Children and young gymnasts that start their preparation today should only reach their maximum performances after at least 9 years of training (Hofmann, 1999; Bompa, 1999, Arkaev, Suchilin, 2004). Since in artistic gymnastics each Olympic cycle becomes more demanding in terms of complexity and difficulty value of the elements, it is an expected fact that gymnasts need more time to acquire stability, experience and safety when performing such complex exercises.

We can compare our results with the McCready (2016) research "For Olympic Athletes, Is 30 the New 20?". According to McCready it's no secret that gymnasts across the board and country are getting younger, but we were not aware of the magnitude. Although they have an average age of 23.4 years, which is almost the same as the full study average, it was mainly boosted in the first half of the century. For instance, the average age of gymnasts before the 1960s was above 26 years of age, bringing the average age up significantly. But that trend was about to be busted in a big way in just a few years. During the latter half of the 1960s, we first see the downward trend starting at 23 years of age and continuing until it hits rock bottom at 18 years of age in 1992. After that low point in 1992, the average age settled in at around 21 years of age for the next 20 years. He predicts that the trend will continue into 2016, with the average gymnast being closer to 20 years of age. He looked at the 1952 Olympics and onward because women were not able to compete in Gymnastics prior to 1952. Male gymnasts have been well above the average age trend line since 1952. It almost mirrors the average age trend line in slope for the entire graph, starting with an average age of close to 27 and finally settling at the predicted age of about 22 years of age for 2016. On the other hand, the trend line for female gymnasts takes a more serious and maybe even controversial downward push. Starting at almost the exact same age as the combined trend line of 24.4 years, their trending ages drop almost nine years before finally settling on a projected average of about 16 yrs of age in 2016 (McCready, 2016).

Since the work of treating the growth trend of the age in the Olympic cycle and the changes that occur systematically from cycle to cycle. Based on the arguments presented in the text, it is evident that there has been an increase in the age of more women's artistic gymnastics than in men's artistic gymnastics.

Conclusions

According to the results presented and discussed herein, the following conclusions can be drawn:

- the differences between male medallists and non-medallists are manifested in the age of the competitors: 2.57 years in 2000 year and 3.57 years in 2012 year,
- the men from 1996 to 2016 years are on average older for 1.7 years and for women it is 2.4 years of age and the growth trend continues,
- in the upcoming period we do expect (with apparatus specialization) the age to be slightly higher,
- changes in the General Rules and Code of Points by FIG have significantly influenced the age rise compared to the previous Olympic cycles,
- male and female gymnasts ended their careers in the past earlier, while today we have some athletes in professional gymnastics who are over 35 years of age.

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