CHRONOLOGICAL AGE AMONG OLYMPIC WOMEN'S ARTISTIC GYMNASTICS. DOES IT REALLY MATTER?

Igor Jelaska, Sunčica Delaš Kalinski and Tina Crnjak

Faculty of Kinesiology, University of Split, Split, Croatia

Abstract

Chronological age and its contribution to the performance quality of female gymnasts have been the subject of discussion for years. The aim of the study was to determine did the chronological age had an impact on the success of female gymnasts at the Olympic Games, in the period from 1964 to 2016. Results determined how the average age of all female Olympians was significantly higher than the minimum age prescribed by International Gymnastics Federation. The youngest gymnasts were mostly All-Around qualifiers, while the competitors in the Apparatus Finals had a slightly higher average age. Significant differences were found between the age of All-Around qualifiers and participants of the vault finals. There were no significant differences in the average age of the medal winners and non-medal winners among the participants of the different Apparatus Finals. Since predominantly older gymnasts reached the highest levels of competition, it was assumed that cognitive maturity and a greater amount of deliberate practice, which predominantly characterize older gymnast, is likely to have a greater impact on the maximum score at the Olympic Games compared to better anthropometric characteristics, mainly attributed to younger gymnasts.

Key words: *female gymnast, chronological age, historical review, ANOVA.*

Introduction

Artistic women's gymnastics has long been viewed as a sport dominated not by women, as the name suggests, but instead by girls (Eagleman, Rodenberg & Lee, 2014). The reason arises from the fact that through the past female gymnasts were younger than other female athletes, and their age continue to decrease from the mid-1960s through the 1980s (at the Olympic Games (OG) 1964 the average age (AA) was 22.2 years ± 2.8 years; at the OG1976 the AA was 18.3 ± 5.5 years (Arkaev & Suchilin, 2004); at the World Championship (WC) 1995 the AA was 16.57 years while at the WC1997 the AA of female competitors was 17.43 years (Léglise, 1998)). The ability of young female gymnast to compete on a high level comes from the biological characteristics of females gymnasts who, already as a child, have enough estrogen and possibility to develop muscles why their intensive training begin earlier (compared to male gymnasts training).

Accordingly, from the beginning their training is characterized by high-quality practice (deliberate practice; Ericsson (2007, 2008)) in order to acquire, improve and attain expertise of all required skills. In puberty, once hormones kick in, female body changes and potentially affect a gymnast: 1) the growth of breasts and hips, interfere with the gymnasts performance (Ryan, 1995); performance of even basic gymnastic elements becomes very difficult; 2) body increasements do not match with the Women Artistic Gymnastics (WAG) ideal body (femininity, youthfulness, cuteness and superhuman power performed through tiny 'pixie-like' bodies and feminine (Barker-Ruchti, 2009; Weber, 2012; Cohen, 2013)). As stated before, female gymnasts during childhood and early adolescence go through the deliberate practice because it is a fundamental factor to succeed in WAG (Côté & Fraser-Thomas, 2008). Deliberate practice is challenging, effortful, and requires repetition and feedback; it largely explains performance differences among people and may not be inherently enjoyable or immediately rewarding (Ericsson, 2007, 2008). The time invested in deliberate practice differs between sports (Côté, Lidor & Hackfort, 2009). Different studies quote somewhat different time of deliberate practice which is needed in order to reach top female artistic gymnastics quality. Arkaev and Suchilin (2004) and Martindale, Collins, and Abraham (2007) stated that it takes 8-10 years to reach top artistic gymnastics quality in girls.

Accordingly, female gymnast usually commencing around the age of 6 and are included in professional training of the elite level by the time they turn 10, in order to reach peak strength, and peak performance, usually at the age of 16 (Tofler, Stryer, Micheli & Herman, 1996; Arkaev & Suchilin, 2004). Malina et al. (2013), in their review article, analyzed previous studies information's about gymnasts training and found the following: 1) in gymnastics schools of the former Soviet Union initial training of 5–6 years old children lasted 8 h/week while elite training of 16-18 years old gymnasts lasted 32–36 h/week (Hartley, 1988); 2) English female gymnasts exceeded the coach-recommended thresholds from TOYA study (Training of Young Athletes 1987–1990; Rowey, 1993) at 8 (61 %) and 10 (90 %) years of age, but were below thresholds at 12–16 years (Baxter-Jones, & Helms, 1996); 3) the "optimal plan" for training elite US female gymnasts (junior pre-elite

age 11–14, junior elite age 11–15 years and senior elite age 16 years) suggests two daily sessions (morning 2–3 h, afternoon 3–4 h), 6 days per week what in total means from 30 to 42 hours per week plus 1 hour of dance training at least twice per week by a dance professional familiar with needs of artistic gymnastics (USA Gymnastics). However, gymnastics training is more complex than hours per week. "Gymnastics schools" differ in specific training activities (warm-up, stretching, strength training, instruction and repetition of specific skills and routines, rest between repetitions, dance and choreography and others). Time spent in specific activities change with the age and level in gymnastics; vary between "gymnastics schools", during the season, and among coaches and limit comparisons and bringing a precise conclusion of the necessary amount of deliberate practice for attaining superior levels of performance in artistic gymnastics (Malina et al., 2013).

Also, to "create" female gymnasts who can meet the growing demands that the Code of Points (CoP; book of rules and regiments in artistic gymnastics) puts in front of them every four years, but also those gymnasts that will highlight and impose as the best ones, the training of female gymnasts evolve over time so that information reported in the previous studies may not be representative for elite female gymnasts today. Generally, early amounts of deliberate practice are critical for success in gymnastics. However, many previous studies argued about the „negative" impact of the earlier attainment of deliberate practice and competition, among female gymnasts, on their maturity.

Common conclusions were: 1) the early deliberate practice negatively influenced on adulthood; on decrease of the mean ages, heights, and weights of world class female artistic gymnasts declined from the mid-1960s through the 1980s (Malina, 1994; Ryan, 1995; Malina, Bouchard & Bar-Or , 2004; Claessens, Lefevre, Beunen & Malina, 2006; Kerr et al., 2006; Martindale, Collins, & Abraham, 2007; Barker-Ruchti, 2009; 2) females intensive training at a young age was causing a range of physical problems like stunted growth, bone deformity and a delayed onset of menarche (Caine, Lewis, O'Connor, Howe & Bass, 2001; Cassas & Cassettari-Wayhs, 2006; Daly, Bass, & Finch, 2001; Dresler, 1997; Lindholm, Hagenfeldt, & Hagman, 1995; Tofler et al., 1996), 3) early deliberate practice of female gymnasts caused some psychological problems like distorted body-image, self-confidence, and dietary habits (Lindholm et al., 1995; Martinsen, Bratland-Sanda, Eriksson & Sundgot-Borgen, 2010).

All the above-mentioned negative aspects of early deliberate practice, as well as a lack of enjoyment, perceptions of competence, social pressures, competing priorities and physical factors as maturation and injuries (Crane & Temple, 2015) are the reason for the dropout from organized sport among children and adolescents, including female artistic gymnastics. Pion, Lenoir, Vandorpe &

Segers (2015) determined how a dropout rate is unusually high in artistic gymnastics. They used Kaplan-Meier analysis and determined that only 18% of the female gymnasts that passed the baseline talent identification test survived at the highest competition level 5 years later. The Cox Proportional Hazards Model indicated that gymnasts with a score in the best quartile for a specific characteristic significantly increased chances of survival by 45-129%. These characteristics being: basic motor skills (129%), shoulder strength (96%), leg strength (53%) and 3 gross motor coordination items (45-73%; Pion, Lenoir, Vandorpe & Segers, 2015). The decision to end a career might be the outcome of severe physical and mental exhaustion in older gymnasts (18–22 years), resulting from heavy training at an early age (Koukouris, 2005). Five of the six studies in artistic gymnastics reported that injuries were the second most frequently reported reason for dropout in sports gymnastics (Crane and Temple, 2015).

In order to protect the musculoskeletal development of young competitors, to lengthen their careers, to prevent burnout, to help reduce injuries, and to redirect the image of the sport positively for the public, spectators, and media (Eagleman, Rodenberg & Lee, 2014), the International Gymnastics Federation (FIG) during the last three decades gradually increased its minimum age requirements for both genders in artistic gymnastics, although the problem of minimum age it is far more contentious in WAG. The minimum age requirement for gymnasts represents the chronological age needed for participation in senior competitions sanctioned by the FIG. Prior to 1981, the minimum required age was 14 years (gymnasts had to turn 14 by the start of the OG to be eligible). In 1981, the minimum required age was increased to 15 years of age (gymnasts had to turn 15 in the calendar year in order to compete in senior-level events).

From 1997 both genders older than 16 could participate in World Championships. However, female gymnasts who turned 16 and male gymnasts who turned 18 in the current year could participate in the OG but only as members of national teams. Based on all previous facts, the chronological age of female gymnasts who "survived" and overcome all problems that appeared on their path towards participation at different competition levels at the OG present a problem of the paper.

Accordingly, the following aims of the study have been posted: 1) to determine average age among female gymnasts who participated at all Olympic Games held from 1964 to 2016; 2) to determine the differences in average age among female gymnasts who participated in All-Around competitions and Apparatus Finalists at all Olympic Games held from 1964 to 2016; 3) to determine the influence of average age on winning or not-winning medals in Apparatus Finals at all OG held from 1964 to 2016.

Methods

Subjects

The sample included all elite female senior gymnasts who participated in Competition 1 – Qualifications (C-I) and in all Apparatus Finals (C-III) at all OG held from 1964 to 2016 (N = 1178). Names and birthdates of gymnasts were collected from open-access Internet websites; mostly from the official OG web site: olympic.org/gymnastics-artistic. There were no ethical issues involved in the analysis and interpretation of the used data, as these data were obtained in secondary form and were not obtained by experimentation. Gymnasts, participants in the analyzed OGs, have been divided and analyzed as five subgroups according to their participation on certain levels of Olympic gymnastics competition: one group included gymnasts who participated only in All-Around Qualifications (n = 1033) and four groups included different Apparatus Finalists (n_{VAULT} =99; $n_{UNEVEN BARS}$ = 98; $n_{BALANCE BEAM}$ = 97; n_{FLOOR} = 95). Data about gymnasts' participation at the certain level of competition at the Olympic Games have been retrieved from the specialized web site for gymnastics results (www.gymnasticsresults.com, accessed from the 5th of June to the 20th of July 2017.).

Variables

The variable sample is represented by a set of: 1) gymnast's date of birth; 2) dates of C-I and C-III competitions at the OG; 3) affiliation of the gymnasts to a group of All-Around competitors or to a group of different Apparatus Finalists; 4) affiliation of the gymnasts to a group of medalists or non-medalists in a different Apparatus Finals; for the all Olympic Games held from 1964 to 2016.

Methods

Conversion of a date of birth into chronological age was done using MS Excel function *YEAR*. Parameters for this function were competitor's date of birth and date of specific competition that was analyzed. Due to the identification of significance of variable's deviation from normal distribution Kolmogorov- Smirnov test was applied. A single data has been identified as an outlier if was out of Mean±2SD and none was found. One-way ANOVA for independent samples with 14 levels within categorical predictor was applied to identify the impact of factor *OG Year* (1964, 1968, 1972, 1976, 1980, 1984, 1988, 1992, 1996, 2000, 2004, 2008, 2012, 2016) on the age of competitors of different competition levels (All-Around qualifiers or different apparatus finalists: VT- vault finalists, UB – uneven bars finalists, BB- balance beam finalists, FX- floor finalists). Independent samples factorial 2×14 ANOVA was applied to identify the impact of the factor *Success* (medalists vs. non-medalists) and factor *OG Year* (1964, 1968, 1972, 1976, 1980, 1984, 1988, 1992, 1996, 2000, 2004, 2008, 2012, 2016) on the sample of VT, UB, BB and FX. Independent samples ANOVA was used to identify differences between the whole sample of medalists and non-medalists on particular apparatus.

Bonferroni post hoc correction was applied for identification of particular differences between levels of the factor. Single sample t-test was used three times for examination of statistical significance between differences of average Olympian's age from a certain period and minimum age requirement that was valid for the same period. For all applied statistical analyses, the effect size was estimated by using (partial) eta squared coefficient (η^2). Type one error was set at α=5%. All data were calculated using data analysis software system Statistica 12 (StatSoft, Tulsa, Oklahoma, USA).

Results

The average age of female gymnasts who participated only in All-Around Qualifications, and haven't qualified for any apparatus finals, at the Olympic Games held in the period from 1964 to 2016, is shown in Figure 1. Gymnasts who participated in different Apparatus Finals were excluded from this sample.
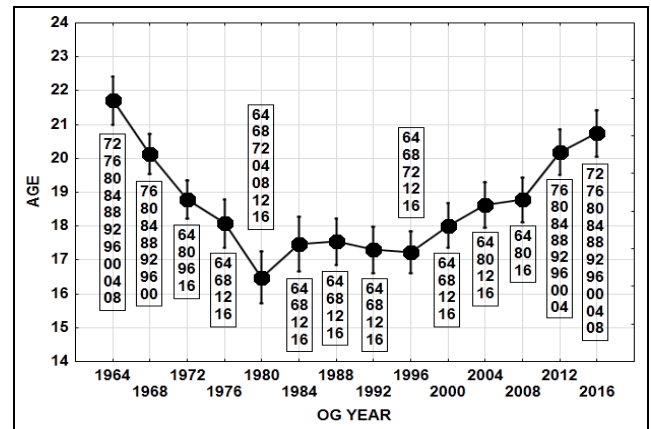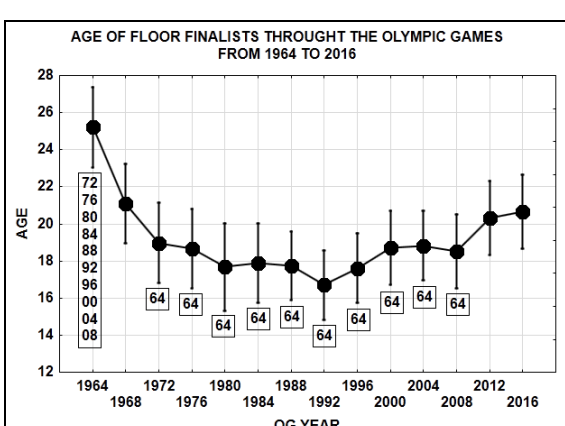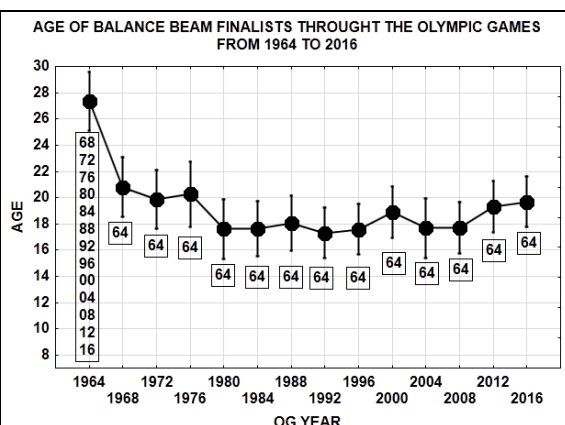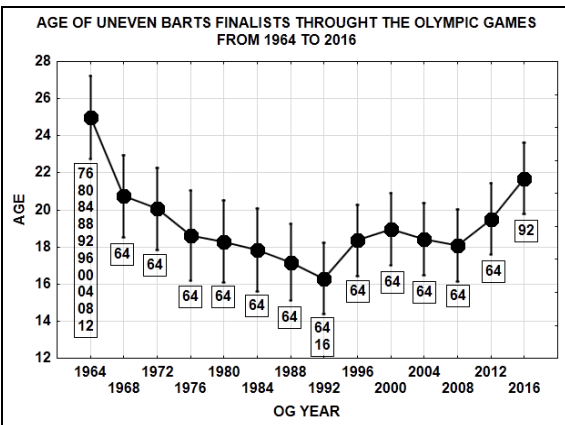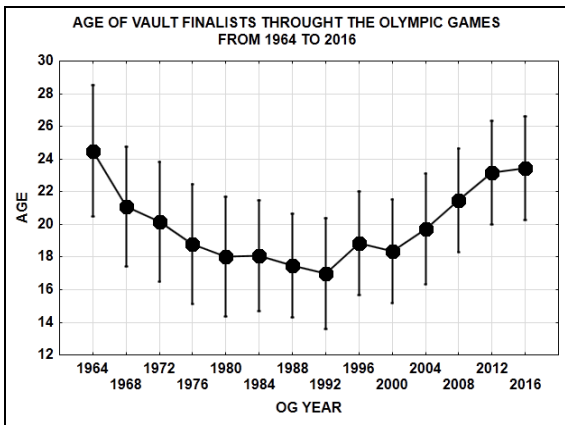

Figure 1 Average age trend of female gymnasts participants of All-Around Qualifications at the OG held from 1964 to 2016.

Legend: Data are presented as Mean±Standard Deviation, AGE- age of female gymnasts participants of All-Around qualifications or of different Apparatus Finals in the Olympic Games held from 1964 to 2016, 64 / 68 / 72 / 76 / 80 / 84 / 88 / 92 / 96 / 00 / 04 / 08 / 12 / 16 - significant difference from the age determined at OG1964/OG1968/OG1972/OG1976/OG1980/OG1984/OG1988/OG1992/OG1996/OG2000/OG2004/OG2008/OG2012/OG2016; Significance of differences was examined by using Bonferroni correction.

In the OG held from 1964 to 2016, the average age of participants who participated only in C-I competition (All-Around competitors) ranged from 16.49 (OG1980) to 21.70 (OG1964); minimum values of average age ranged from 13.23 (OG1976) to 15.72 (OG2000); maximum values of average age ranged from 22.50 (OG1992) to 33.11 (OG1964). Obtained results, expected, confirmed results of previous studies (Barker-Ruchti, 2009; Claessens, Lefevre, Beunen, & Malina, 2006; Kerr et al., 2006; Malina, 1994; Ryan, 1995), and showed precise trend of the All-Around Qualifiers AA on the analysed OG: from OG1964 to OG1980.

AGE OF VAULT FINALISTS THROUGHT THE OLYMPIC GAMES FROM 1964 TO 2016

AGE OF UNEVEN BARTS FINALISTS THROUGHT THE OLYMPIC GAMES FROM 1964 TO 2016

AGE OF BALANCE BEAM FINALISTS THROUGHT THE OLYMPIC GAMES FROM 1964 TO 2016

AGE OF FLOOR FINALISTS THROUGHT THE OLYMPIC GAMES FROM 1964 TO 2016

Figures 2 – 5 Average age trend of female gymnasts participants of Vault, Uneven Bars, Balance Beam and Floor finals at the OG held from 1964 to 2016.

Legend: Data are presented as Mean±Standard Deviation, AGE- age of female gymnasts participants of All-Around qualifications or of different Apparatus Finals in the Olympic Games held from 1964 to 2016, 64/68/72/76/80/84/88/92/96/00/04/08/12/16 - significant difference from the age determined at OG1964/OG1968/OG1972/OG1976/OG1980/OG1984/OG1988/OG1992/OG1996/OG2000/OG2004/OG2008/OG2012/OG2016; Significance of differences was examined by using Bonferroni correction.

AA of those female gymnasts was continuously decreasing; compared to OG1980, from the OG1984 AA was generally increasing. Differences between All-Around qualifiers chronological age through the observed OG years were determined as significant ($F_{13,1009} = 18.71$; $p < 0.001$; $\eta^2 = 0.19$). Bonferroni correction revealed significant differences between AA of different OG; the same is presented in Figure 1. AA of different Apparatus Finalists, from the OGs held in the period from 1964 to 2016, independently from the year of the OG year, is shown in the Figures 2-5.

For the competitors of VT mean values ranged from 17.00 (OG1992) to 24.50 (OG1964); minimum values ranged from 13.89 (OG1992) to 19.58 (OG1964); maximum values ranged from 20.26 (OG1980) to 41.16 (OG2016). For the UB competitors mean values ranged from 16.30 (OG1992) to 25.00 (OG1964); minimum values ranged from 14.69 (OG1976) to 19.40 (OG1964); maximum values ranged from 17.44 (OG1992) to 30.56 (OG2016). For the BB competitors mean values ranged from 17.32 (OG1992) to 27.36 (OG1964); minimum values ranged from 14.35 (OG1996) to 22.33 (OG1964); maximum values ranged from 19.47 (OG1992) to 30.81 (OG196).

For the FX competitors mean values ranged from 16.70 (OG1992) to 25.22 (OG1964); minimum values ranged from 14.49 (OG1980) to 19.58 (OG1964); maximum values ranged from 18.65 (OG1992) to 29.81 (OG196). Minimum age determined at the VT, which was lower than minimum age requirements for the OG1992, according to find data, belongs to Gina Gogean, although her team reported that she was a year older. Regarding the chronological age, effect of the factor *Year* was found to be significant for all Apparatus finalists: 1) VT ($F_{13,84} = 1.90$; $p = 0.04$; $\eta^2 = 0.23$); 2) UB ($F_{13,84} = 4.15$; $p < 0.001$; $\eta^2 = 0.39$): 3) BB ($F_{13,83} = 5.46$; $p < 0.001$; $\eta^2 = 0.46$); 4) FX ($F_{13,81} = 4.15$; $p < 0.001$; $\eta^2 = 0.40$).

Bonferroni post hoc correction revealed significant differences between certain years; data are presented in Figures 2-5. Generally, differences between UB, BB and FX are very similar to differences determined between All-Around qualifiers, confirming the uniqueness of the sample on a particular OG, regardless of ultimate success of some gymnasts. When data from OG1964 was removed (because those data significantly differ from the age of most other analyzed OGs) in any subsample no significant differences were determined within the age of any subsample (All-

Around qualifiers or different Apparatus Finalists). Accordingly, competitors of any subsample can be presented as a unique sample (Figure 6).
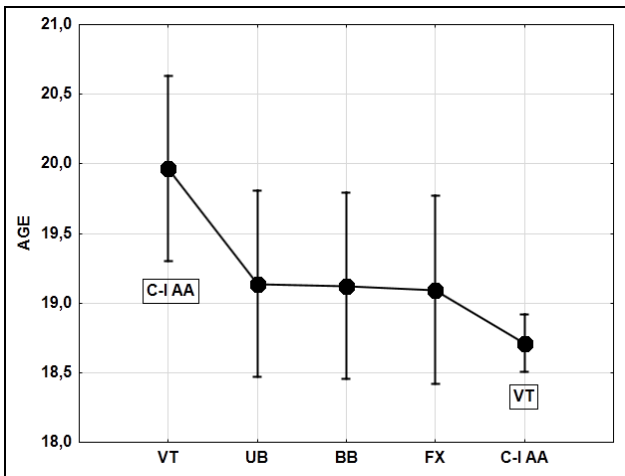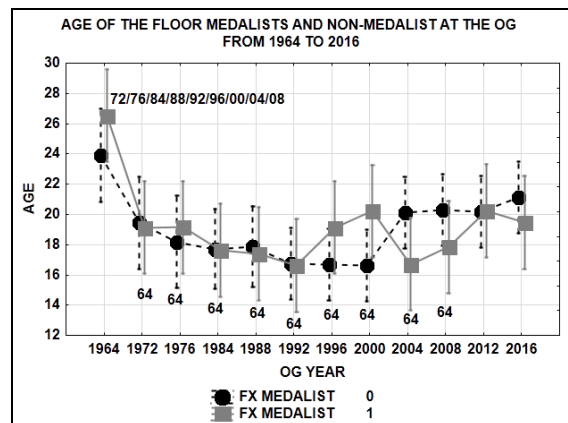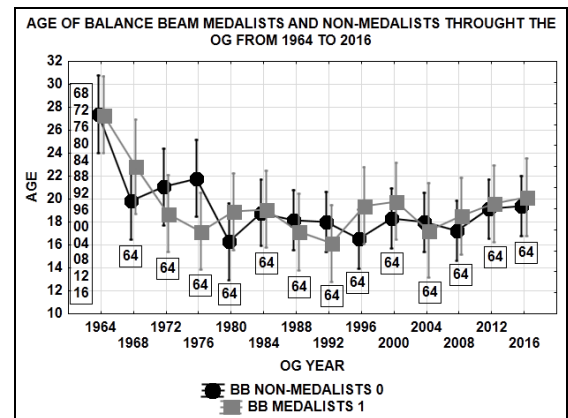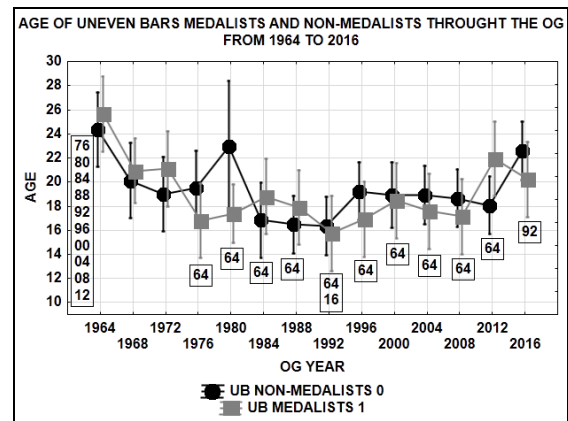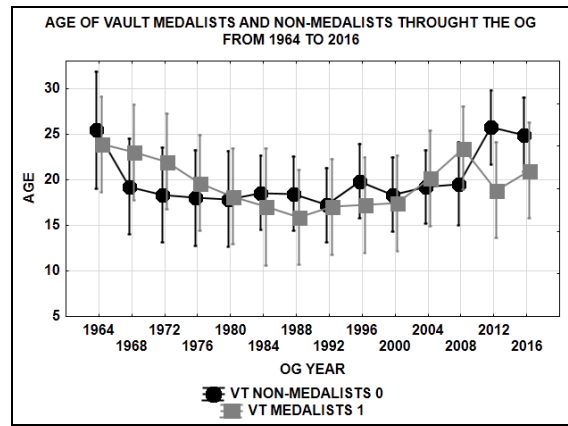

Figure 6. Differences in average age between female gymnasts participants at different levels of the competitions in the OG held from 1964 to 2016.

Legend: Data are presented as Mean±Standard Deviation, AGE- age of female gymnasts participants of different finals in the Olympic Games held from 1964 to 2016, C-I AA- average age of All-Around Qualifiers, VT– average age of participants of Vault Finals, UB – average age of participants of Uneven Bars Finals, BB – average age of participants of Balance Beam Finals, FX – average age of participants of Floor Finals.

For the competitors of different C-III competition (Apparatus Finals competitors) mean values of the average age ranged from 16.33 (determined on the uneven bars in the OG1992) to 27.36 (determined on the balance beam in the OG1964); minimum values of average age ranged from 13.89 (determined on the vault in the OG1992) to 22.33 (determined on the balance beam in the OG1964); maximum values of average age ranged from 17.44 (determined on the uneven bars in the OG1992) to 41.16 (determined on the vault in the OG2016). Differences in contestant's chronological age, according to their participation at the certain level of OG competition, independently from the OG year were found to be significant ($F_{4,1406} = 3.56$; p = 0.00; $\eta^2 = 0.01$).

Bonferroni correction revealed significant differences only between VT and All-Around gymnasts (p < 0.001). Furthermore, when Oksana Chusovitina (6 times Olympian) was removed from the sample, differences were also found to be significant ($F_{4,1220} = 2.67$; p = 0.031; $\eta^2 = 0.008$) but Bonferroni correction did not reveal significant differences between particular groups (p > 0.05). AA of medal winners and non –medal winners at different Apparatus Finals, from the OGs held in the period from 1980 to 2016, independently from the year of the OG year, is shown in the Figures 7-10. Age of All-Around medalist hasn't been analyzed because of a large difference in the size of subsamples (3 All-Around medal winners compared to approximately 95 non-medal winners).

Figures 7-10. Age of medalist and non-medalists of Vault, Uneven Bars, Balance Beam and Floor finals at the OG held from 1964 to 2016.

Legend: Data are presented as Mean±Standard Deviation, AGE- age of female gymnasts participants of All-Around qualifications or of different Apparatus Finals in the Olympic Games held from 1964 to 2016, 64/72/76/84/88/ 92/96/00/04/08/12/16 - significant difference from the age determined at OG1964/OG1972/OG1976/OG1984/ OG1988/OG1992/OG1996/OG2000/OG2004/OG2008/OG2012/OG2016; Significance of differences was examined by using Bonferroni correction.

Regarding VT, 2 way factorial ANOVA revealed that impact of factor *Success* on contestant's age was not significant ($F_{1,72}= 0.20$; $p = 0.65$; $\eta^2 = 0.00$) as well as the impact of factor *OG Year* ($F_{13,72} = 1.72$; $p = 0.78$; $\eta^2 = 0.24$) and interaction *Success×OG Year* ($F_{13,72} = 0.83$; $p = 0.63$; $\eta^2 = 0.13$). Regarding UB, that impact of factor *Success* on contestant's age was not determined as significant ($F_{1,72} = 0.49$; $p = 0.49$; $\eta^2 = 0.01$), the impact of factor *OG Year* was determined as significant ($F_{13,72} =4.38$; $p < 0.001$; $\eta^2 = 0.44$) while interaction of factors *Success×OG Year* was not determined as significant ($F_{13,72} = 1.20$; $p = 0.30$; $\eta^2 = 0.18$).

Similarly, regarding BB, the impact of factor *Success* on contestant's age was not determined as significant ($F_{1,71} = 0.06$; $p = 0.80$; $\eta^2 = 0.00$), the impact of factor *OG Year* was determined as significant ($F_{13,71} = 4.84$; $p < 0.001$; $\eta^2 = 0.47$) while the interaction of factors *Success×OG Year* was not determined as significant ($F_{13,71} = 0.86$; $p = 0.60$; $\eta^2 = 0.14$). Finally, regarding FX, it was shown that impact of factor *Success* on contestant's age was not significant ($F_{1,673} = 0.42$; $p = 0.52$; $\eta^2 = 0.01$), the impact of factor *OG Year* was significant ($F_{13,73} = 3.99$; $p < 0.001$; $\eta^2 = 0.42$) while interaction of factors *Success×OG Year* was not determined as significant ($F_{13,73} = 1.02$; $p = 0.44$; $\eta^2 = 0.15$). When results form OG1964 are removed, there are no significant differences between medalist and non-medalists. Accordingly, competitors of the certain apparatus finals can be seen as a unique sample. The average age of different apparatus finalists and differences between them are shown in Figure 11.
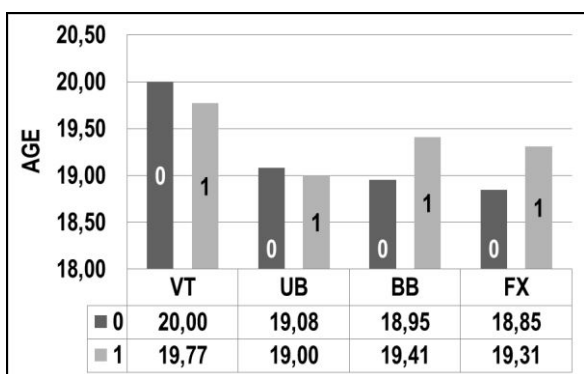

Figure 11. Differences in average age between female gymnasts participants of different Apparatus Finals held in the OG from 1964 to 2016.

Legend: 0- non-medal winners, 1 – medal winners, VT – vault finalists, UB – uneven bars finalists, BB – balance beam finalists, FX – floor finalists.

Regarding differences between medalists and non-medalists at different apparatuses finals (VT, UB, BB, FX), independently fom the OG year, independent samples ANOVA revealed the following results: for VT ($F_{1,98} = 0.06$; $p = 0.81$; $\eta^2 = 0.00$), for UB ($F_{1,98} = 0.02$; $p = 0.90$; $\eta^2 = 0.00$), for BB ($F_{1,97} = 0.38$; $p = 0.34$; $\eta^2 = 0.00$) and for FX ($F_{1,99} = 0.52$; $p = 0.47$; $\eta^2 = 0.01$). Accordingly, no significant differences have been determined between age of medalists and non-medalists in any apparatus finals.

Discussion

Decrease in AA and increasing number of the youngest female gymnasts in the period from 1964 to 1980 (at the OG1964 no 14 age gymnasts have been determined; at the OG1972 the six female gymnasts was 14 years old, at the OG1976 was 10 and at the OG1980 even 19 female gymnasts was 14 years old) didn't have influence on not-determining a significant difference between the AA of all gymnasts Olympians and the normative age ($AA_{OG1964-OG1980}=19.11\pm3.80$; $t(305)=23.53$; $p<0.001$). Compared to OG1980, in the period from OG1984 to OG1988 a certain increase in AA has been determined, and in OG1992 and in OG1996 a certain decrease in AA. However, at all those OGs AA was also significantly higher than the normative age of 15 ($AA_{OG1984-OG1996} = 17.48\pm2.05$); $t(322) = 21.41$; $p < 0.001$). Original results reveal how at the OG1984 four gymnast were under the 15 years, while 16 of them were only 15 years old.

At the OG1988 there were no gymnasts under 15 and 21 gymnasts were 15 years old. If those results are seen through the minimum age from 1997 (gymnasts who turn 16 in the calendar year can compete at the OG but only as a team members) than the number of gymnasts younger than 16, in the period from 1972 to 1984, was 15.68% (OG1972), 22.85% (OG1976), 47.69% (OG1980) and 32.25% (OG1984) of the overall number of gymnasts at those OGs. Objectively, such a high percentage of the youngest gymnasts justified declaring of a WAG as a sport for girls (Eagleman, Rodenberg & Lee, 2014), which from that time has been preserved even today.

This assertion is additionally strengthened with the results about female gymnast's maturation. Namely, female gymnasts maturation is late (compared to non-gymnastics population; Malina, 2014), and the age of 15 is considered to be a boundary between prepubescent and post-pubescent athletes gymnasts (Baxter-Jones et al., 1994). Despite the great degree of the youngest gymnast, in the period from 1972 to 1988, results show how the age of the most female Olympians didn't fit in the range from 15 to 17 years – the period that is typically considered to be their peak (Law et al., 2007). Because of this finding a question about a property of intense deliberate practice from very young age, in order to achieve elite performance standards, arises. AA that is significantly higher from the minimum age,

together with the positive trend of the AA results supports the conclusion that female gymnasts have prolonged careers and skills development after the age of 16, and that it is possible to have top-level achievements after the age of 20 (Zurc, 2017). From OG1997 up to OG2016 AA was continuously increasing partly probably as a consequence of the increased minimum age requirements from 1997 ($AA_{OG1997-OG2016}$ = 19.41±3.56). In this period values of the AA were also significantly higher that normative age ($t(484)$ = 21.07; $p < 0.001$). However, did increased minimum age requirements had the influence on the musculoskeletal development of young competitors, on injury reduction, and on positive changing the image of the sport for the public, fans, and media (Eagleman et al., 2014), remains to be explored in further studies. Competitors with the lowest permissible age also have been determined in apparatus finals.

However, due to a low number of those competitors, we assume that their age didn't have an influence on the AA of the whole sample, of certain apparatus, finalists. The lowest AA, determined for All-Around qualifiers, lead to presumption how the most of the youngest gymnasts participate only at the first level of Olympic Competitions (All-Around qualifications). The highest levels of Olympic Competition (Apparatus Finals) were probably „reserved" for something older, probably more experienced gymnasts that performed more difficult elements. This conclusion confirm findings of Baker, Janning, Wong, Cobley and Schorer (2014) and hypothesis of the Hancock, Starkes and Ste-Marie (2015) that at the highest competitive standards (where increased deliberate practice is required), relatively older gymnasts would be advantaged due to their greater cognitive maturity that may be needed for exercising under such training conditions.

Cognitive maturity occurs in the mid-twenties and includes: mature judgment, seeing into the future, seeing how behavior can affect future, associating cause and effect, moral intelligence, abstract thinking, seeing what is not obvious, planning and decision-making, rational behavior and decision-making, rules of social conduct, understanding rules of social conduct. Obtained results are in opposition to findings of the positive influence of immature anthropological characteristics on female gymnasts performance. Namely, because WAG has a basis in flexibility and being able to flip and twist (and flexibility is better when you are younger, and the flipping and twisting is easier when you are a smaller and lighter; Monsma & Malina, 2005), according to findings correlated with immaturity, older female gymnasts who, due to biological maturity mostly don't possess those anthropological characteristics, would be disadvantaged. Although a significant difference between VT and C-I All-Around competitors is mostly predictable to attribute to a participation of Oksana Chusovitina (6 times Olympian; 3 times vault finalist – OG2008/OG2012/OG2016) in a sample of VT, results show how after removing her from the VT

subsample a significant difference between VT and C-I All-Around competitors remained. Accordingly, Chusovitina didn't have such a huge impact on AA of VT; they are generally older than All-Around competitors. Since, after eliminating data from OG1964, generally there were no significant differences within finalists of a different apparatus, it can be assumed that, regardless of the period and/or the Olympics on which the finalists participated, the time to achieve the highest scores on certain apparatuses was always the same. Because the difficulty of performed skills visibly differs between each OG, it is clear that all the factors, which play a huge role in acquiring more difficult skills and achieving the highest competition levels in the equal time, are more and more planned and controlled.

Atiković, Delaš Kalinski and Čuk (2017) analyzed the trend of the chronological age of all female gymnasts medal winners at the OG in the period between 1928 and 2016 (n = 655). They determined how the oldest medal winners were on the balance beam ($AA_{1928-2016}$ = 20.88±4.93) and the youngest at the floor ($AA_{1928-2016}$ = 20.24±4.14). Obtained result on the floor confirm findings from Monsma and Malina (2005) about easier and, according to better scores, higher quality flipping and twisting (mostly represented in the floor exercise) by a younger female gymnast. Although exercising on the balance beam also mostly consist from flipping and twisting on a narrowed surface, results from this study show how performance of the same, with the constant maintenance of balance, probably requires more time (in order to acquire stability, experience, and safety) because of what medal winners on this apparatus were older than the other female gymnasts Olympic medal winners. Determination of the factor *OG Year* as significant for the AA of non-medalists and medalists at the UB, BB, and FX implies that through the years AA was changed independently from the fact are the finalist from those apparatuses medalist or non-medalists.

AA of medalist and non-medalists is probably changed due to the changes that influenced the whole sample of female Olympians (changes in minimum age requirements, changes in a difficulty of performed skills that lead to a need for a longer period of learning, understanding the benefits of exercising at an older age, planning and programming participation at more than one Olympic Games etc.). Factor *OG Year* wasn't determined to be significant for the VT. Because AA for the VT was determined as the highest one, it is to assume how since always the complexity of the most difficult vaults, ones needed to qualify for the vault finals, needed more time to acquire (compared to the time needed to acquire skills on other apparatuses). When were analyzed as a unique subsample of one Apparatus Finals (independent from the OG year), ANOVA doubtlessly haven't determined any significant differences in AA between medal winners and non-medal winners.

Since there were no significant differences between different apparatus competitors, obtained results are logical and emphasize that age probably isn't the key factor which determines the rank in the highest level of gymnastics competitions - Apparatus Finals; the quality and the difficulty of the performed skills is (Delaš Kalinski, Jelaska, & Atiković, 2017).

Conclusion

AA of the elite female gymnasts has been significantly different from the minimum age requirements valid for the period from 1964 to 1980, from 1981 to 1996, and from 1997 up to 2016. However, because of the relatively big percent of the youngest gymnasts at the competitions, it is logical that public perceives female artistic gymnastics as a sport of girls rather than of women. Results revealed significant differences only between the lowest AA of All-Around qualifiers and the highest AA of vault finalists. Different apparatus finalists had similar AA what lead to a conclusion that, independently from

the complexity of the certain apparatus, female gymnasts generally qualify for the highest levels of Olympic competition in the same age. Between medalist and non-medalists (of any apparatus) no significant differences in AA have been determined. Winning or not winning medals obviously relies on the difficulty and the quality of the female gymnast's performance; not on the age of gymnasts. The best, most famous example is Nadia Comaneci who, in the lowest permissible age, due to the originality, difficulty, and quality of own performances was a part of all apparatus finals at the OG1976. However, Comaneci example isn't very often. The obtained results confirmed that generally the highest competitive levels and the results are achieved by somewhat older female gymnasts. Cognitive maturity and a greater amount of deliberate practice (likely to be found in older female gymnasts) probably have more impact on the female gymnasts quality than anthropometric characteristics (which are considered to enable easier performance of the most demanding gymnastic elements; which are attributable to somewhat younger female gymnasts).

References

Arkaev, L., & Suchilin, N.G. (2004). *Gymnastics: how to create champions*. Oxford: Meyer & Meyer Verlag.

Atiković, A., Delaš Kalinski, S., & Čuk, I. (2017). Change the gymnastics minimum age requirements and the changes that have occurred in major competitions in women's artistic gymnastics. *Acta Kinesiologica, 11*(1), 80-88.

Baker, J., Janning, C., Wong, H., Cobley, S., & Schorer, J. (2014). Variations in relative age effects in individual sports: skiing, figure skating and gymnastics. *European J of Sport Science, 14*(*1*), 183-190.

Barker-Ruchti, N. (2009). Ballerinas and pixies: A genealogy of the changing female gymnastics body. *The International Journal of the History of Sport, 26*(1), 45-62.

Baxter-Jones, A.D.G., &Helms, P. (1996). Effects of training at a young age: a review of the Training of Young Athletes (TOYA) study. *Pediatric Exercise Science*, 8, 310-327.

Baxter-Jones, A.D.G., Helms, P., Maffulli, N., Baines-Preece, J.C., & Preece, M. (1994). Growth and development of male gymnasts, swimmers, soccer and tennis players: a longitudinal study. *Annals of Human Biology, 22*(5), 381-394.

Caine, D., Lewis, R., O'Connor, P., Howe, W., & Bass, S. (2001). Does gymnastics training inhibit growth of females? *Clinical Journal of Sport Medicine, 11*(4), 260-270.

Cassas, K.J., & Cassettari-Wayhs, A. (2006). Childhood and adolescent sports-related overuse injuries. *American Family Physician, 73*(6), 1014-1022.

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 Pediatrics, 165*(3), 186-192.

Cohen, R.L. (2013). Femininity, Childhood and the Non-Making of a Sporting Celebrity: The Beth Tweddle Case. *Sociological Research Online, 18*(3).

Côté, I., Lidor, R., & Hackfort, D. (2009). To sample or to specialize? Seven postulates about youth sports activities that lead to continued participation and elite performance. *International Journal of Sport and Exercise Psychology, 7*(1), 7-17.

Daly, R.M., Bass, S.L., & Finch, C.F. (2001). Balancing the risk of injury to gymnasts: how effective are the counter measures? *British Journal of Sports Medicine, 35*(1), 8-19.

Delaš Kalinski, S., Jelaska, G., & Atiković, A. (2017). Elite female vault finals from 2008-2016. *Acta Kinesiologica*, *11*(1), 62-66.

Dresler, C.M. (1997). Physical and emotional problems of elite female gymnasts. *New England Journal of Medicine, 336*(2), 140-140.

Eagleman, A.N., Rodenberg, R.M., & Lee, S. (2014). From 'hollow-eyed pixies' to 'team of adults': Media portrayals of Olympic women's gymnastics before and after an increased minimum age policy. *Qualitative Research in Sport, Exercise and Health, 6*(3), 401-421.

Ericsson, K.A. (2007). Deliberate practice and the modifiability of body and mind: toward a science of the structure and acquisition of expert and elite performance. *International Journal of Sport Psychology, 38*(1), 4-34.

Ericsson, K.A. (2008). Deliberate Practice and Acquisition of Expert Performance: A General Overview. *Academic Emergency Medicine, 15*(11), 988-994.

Fraser-Thomas, J., Côté, J., & Deakin, J. (2008). Examining adolescent sport dropout and prolonged engagement from a developmental perspective. *Journal of applied sport psychology*, *20*(3), 318-333.

Hancock, D.J., Starkes, J.L., & Ste-Marie, D.M. (2015). The relative age effect in female gymnastics: a flip-flop phenomenon. *International Journal of Sport Psychology*, *11*(1). 714-725.

Hartley, G.L. (1988). A comparative view of talent selection for sport in two socialist states-the USSR and the DDR-with particular reference to gymnastics. In: *The growing child in competitive sport:* THE BANC International Proceedings*;* National Coaching Foundation, Leeds, UK:50–56.

Kerr, G., Berman, E., & De Souza, M.J. (2006). Disordered eating in women's gymnastics: Perspectives of athletes, coaches, parents, and judges. *Journal of Applied Sport Psychology, 18*(1), 28-43.

Law, M.P., Côté, J., & Ericsson, K.A. (2007). Characteristics of expert development in rhythmic gymnastics: A retrospective study. *International Journal of Sport and Exercise Psychology, 5*(1), 82-103.

Léglise, M. (1998). Limits on young gymnast's involvement in high-level sport. *Technique, 18*(4), 8-14.

Lindholm, C., Hagenfeldt, K., & Hagman, U. (1995). A Nutrition Study in Juvenile Elite Gymnasts. *Acta Paediatrica, 84*(3), 273-277.

Malina, R.M. (1994). Longitudinal Observations on Physical Growth and Tw2 Skeletal Maturation of Girls in Tokyo-Radiographic Atlas of Hand and Wris-Eto, M, Ashizawa, K. *American J of Human Biology, 6*(3),

Malina, R.M. (2014). Top 10 Research Questions Related to Growth and Maturation of Relevance to Physical Activity, Performance, and Fitness. *Research Quarterly for Exercise and Sport, 85*(2), 157-173.

Malina, R.M., Baxter-Jones, A.D.G., Armstrong, N., Beunen, G.P., Caine, D., Daly, R. M., & Russell, K. (2013). Role of Intensive Training in the Growth and Maturation of Artistic Gymnasts. *Sports Medicine,*

Malina, R.M., Bouchard, C., & Bar-Or, O. (2004). *Growth, maturation, and physical activity*. NY: Human Kinetics.

Martindale, R.J.J., Collins, D., & Abraham, A. (2007). Effective Talent Development: The Elite Coach Perspective in UK Sport. *Journal of Applied Sport Psychology, 19*(2), 187-206.

Martinsen, M., Bratland-Sanda, S., Eriksson, A.K., & Sundgot-Borgen, J. (2010). Dieting to win or to be thin? A study of dieting and disordered eating among adolescent elite athletes and non-athlete controls. *British Journal of Sports Medicine, 44*(1), 70-76.

Monsma, E.V. & Malina, R.M. (2005). Anthropometric characteristics and somatotype in competitive female figure skaters: Variation across competitive level and skating discipline. *Journal of Sports Medicine and Physical Fitness, 45*(4)*,* 491-500.

Rowley, S. (1993). *Training of Young Athletes study: TOYA and intensive training*. London: The Sports Council.

Ryan, J. (1995). *Pretty girls in little boxes: The making and breaking of elite gymnasts and figure skaters*. New York: Doubleday.

Tofler, I.R., Stryer, B.K., Micheli, L.J., & Herman, L.R. (1996). Physical and emotional problems of elite female gymnasts. *New England Journal of Medicine, 335*(4), 281-283.

Weber, J., & Barker-Ruchti, N. (2012). Bending, flirting, floating, flying: A critical analysis of female figures in 1970s gymnastics photographs. *Sociology of sport journal, 29*(1), 22-41.

Zurc, J. (2017). It was worth it– i would do it again!: phenomenological perspectives on life in the elite women's artistic gymnastics. *Science of Gymnastics Journal, 9*(1), 41-59.

*** (2016). /Gymnastics Artistics/ https://www.olympic.org/gymnastics-artistic

*** (2017). /OnTheirLevel/ Maturation of the teen brain. http://ontheirlevel.org/whats-happening/maturation-of-the-teen-brain

*** (2017). /USA Gymnastics/ Coaching elite athletes. http://www.usa-gymnastics.org/pages/women/pages/coaching_elite_athletes.html

*** www.gymnasticsresults.com

VAŽNOST KRONOLOŠKE DOB KOD GIMNASTIČARKI OLIMPIJKI

Sažetak

Kronološka dob i njen utjecaj na kvalitetu izvedbi gimnastičarki godinama je predmet rasprave. Cilj istraživanja bio je utvrditi da li je kronološka doba imala utjecaja na uspjeh gimnastičarki sudionica Olimpijskih igara u razdoblju od 1964. do 2016. godine. Rezultati su odredili kako je prosječna starost svih gimnastičarki bila značajno viša od minimalne propisane dobi (propisane od strane Međunarodne gimnastičke federacije). Najmlađe gimnastičarke uglavnom su bile sudionice višebojskog kvalifikacijskog natjecanja, dok su natjecateljice finala po spravama imale numerički nešto višu prosječnu dob. Značajne razlike utvrđene su između dobi višebojskih natjecateljica i sudionica finalnog natjecanja na preskoku. Nije bilo značajnih razlika u dobi osvajačica medalja i ne-osvajačica medalja u pojedinim finalnim natjecanjima po spravama. Budući da su pretežno starije gimnastičarke dosegnule finalna natjecanja, pretpostavljeno je da su kognitivna zrelost i veća trenažna opterećenja, koja uglavnom karakteriziraju starije gimnastičarke, vjerojatno imale veći utjecaj na dosizanje najviših razina natjecanja na Olimpijskim igrama u usporedbi s boljim antropometrijskim karakteristikama, koje se uglavnom pripisuju mlađim gimnastičarkama.

Ključne riječi: *gimnastičarke, kronološka dob, povijesni pregled, ANOVA.*