HISTORICAL CHANGES IN HEIGHT, MASS AND AGE OF USA WOMEN'S OLYMPIC GYMNASTICS TEAM: AN UPDATE

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Original article

Abstract

Nearly every modern Olympic Games has brought astonished comments and criticism of the body sizes of female gymnasts. The comments from laypersons, scientists, journalists, and physicians too often imply that these diminutive athletes are unusually small and possibly unhealthy. Purpose: An extended and updated analysis of the sizes of U.S. female Olympic gymnasts including the 2012 and 2016 Olympic Games. Methods: Official public records from the US Olympic Committee and USA Gymnastics of Olympic team members were assessed including height, mass, age, body-mass index (BMI) and team performance rankings. Sixteen Olympic teams with a total of 123 team positions including the alternates were assessed. Trend analyses were conducted using linear and polynomial models. Results: Analyses indicated that since 1956, height, mass, age, and BMI declined at first and then increased, with the exceptions of height and rank. Best regression fits were obtained via 2nd order polynomial equations. Height and rank showed a downward trend throughout the historical period. Conclusion: Female Olympic gymnasts were getting smaller through approximately the 1980s and early 1990s. An upward trend in size variables was then observed through 2008. The addition of the 2012 and 2016 Olympic Games data showed that height shifted to a decline from a slight upward trend, and rank continued to decline throughout the historical period.

Key words: *trends, anthropometry, gymnastics, body size.*

INTRODUCTION

Women's gymnastics has risen to become a mainstream sport with all of the attention, fan interaction, ill-informed criticism, and speculation such status entails. As such, the diminutive size of these athletes continues to garner attention in the press, social media, and the scientific literature. Recent discourse on the size of 2016 champion women's gymnasts included some body shaming and sexism on Twitter that resulted in a quick retort, "They're Olympians, they didn't work out to be attractive or for our approval they did it to win Gold" (Blair, 2016). Images that show Simone Biles standing next to an Olympic volleyball player and the famed Olympic

swimmer Michael Phelps serves to demonstrate how small these athletes are (Moss, 2016). Controversy over whether gymnastics training stunts growth also continues to swirl (Malina, 1996; Malina et al., 2013; Moss, 2016). Journalists and scientists have openly questioned whether female gymnasts are unhealthy because of their size and low body weight (Finch, 2016).

Those of us who have been involved in gymnastics for many years find these discussions inane and illogical. "Female gymnasts are characterized by short stature, appropriate mass for stature, late maturation and an ectomorphic-mesomorphic somatotype." (Malina, 1999; Malina et al., 2013) p 291. Lay literature dwells on the size of gymnasts while usually also adding what incredible athletes they are (Epstein, 2016; Finch, 2016; Foster, 2016; McDonald, 2016; Mooney, 2012; Moss, 2016; Mushnick, 2016). However, serious misconceptions remain. Body size and performance characteristics were not predictors of gymnastics drop-outs after controlling for age (Claessens & Lefevre, 1998). The authors hypothesized that social and psychological factors were to blame rather than size and shape (Claessens & Lefevre, 1998). Others have indicated that the small size of gymnasts presents a significant advantage in moving their body through difficult acrobatic maneuvers, "Muscle strength is related to cross sectional area, and therefore total volume (and mass). In other words, the bigger you are the more muscle you need, and since gymnasts work by moving their bodyweight, it is an advantage to be lighter" (McDonald, 2016). A similar argument could be made for tall stature among basketball and volleyball players that extraordinary height serves these athletes. Perhaps a "just-so" story, but a sport scientist was quoted, "For the most part, female gymnasts are short because it's harder to be good at a lower level if you're tall … so the tall ones weed themselves out early and we don't see them on TV at the Olympics" (McDonald, 2016). The hormonal changes accompanying adolescence also have been considered in the natural development of the pubescent and post-pubescent female athlete. However, the hormonal milieu is generally normal relative to the skeletal age of the gymnasts (Malina, 1999; McDonald, 2016; Wulff Helge & Kanstrup, 2002).

Many opinions and writings on female gymnasts appear to be immune to scholarship and facts. Our previous study of Women's Olympic Teams from 1956 to 2008, showed that while there was a period when Olympic gymnasts were indeed getting smaller, the most recent information has contradicted this idea (Sands, Slater, McNeal, Murray, & Stone, 2012). Yes, female gymnasts are small, but is there reason to believe that U.S. Olympic gymnasts are continuing to shrink? The lay press and journalists still believe gymnasts are getting smaller (Epstein, 2016; Mushnick, 2016; Ward-Henninger, 2016).

The purpose of this continued investigation was to update the information on size, mass, age, and team rankings of U.S. Women's Olympic Teams in artistic gymnastics. This study builds on previous work examining the characteristics above with Olympic teams from 1956 to 2008. Two more Olympic Games have been held since the completion of the last study, 2012 – London, and 2016 – Rio de Janeiro.

METHODS

***Subjects*:** Sixteen women's Olympic gymnastics team records were examined. The dataset included both the competing team members and alternates (N=116). Team rosters ranged from five to 10 members, depending on the selection policies and international rules for each Olympic team. Seven team members were most commonly named, with six who actually compete, and a seventh who was the official alternate. However, team selection policies have varied depending on USA Gymnastics' rules and policies regarding team selection, which are secondary to the international competition format as set by the International Gymnastics Federation (FIG, Fédération Internationale de Gymnastique). More

recently, the International Olympic Committee has set new policies for the number of members involved with each team and sport, and the FIG has followed suit (Federation, 2015). The last two Olympic Games involved six (2012) and then five team positions (Rio de Janeiro) (Federation, 2015). The number of team athletes will be further reduced to four athletes in the 2020 Games.

The U.S. has used various methods to establish the team that actually goes to the Olympic Games. There have been official alternates who attend the Games representing the U.S. and usually receive a modified credential for access to the competition arena. The U.S. often has included additional alternates creating an Olympic team "squad" that was later evaluated at a pre-Olympic training camp in order to determine the rankings and the actual Olympic Team.

The Olympic Games for women's gymnastics were not continuous through the historical period described here, with a notable boycott in 1980 by many western countries. Fortunately, a team was selected in 1980, but no final team rank was available. Moreover, the minimum age rules changed in 1980 and again in 1997. The minimum age prior to 1981 was 14y, and in the interim to 1997, it was 15y. Current rules demand that senior, international-level gymnasts be 16y in the calendar year of the particular international contest (e.g., Olympic Games, World Championships).

Procedures: Official U.S. Olympic Committee (USOC) and USA Gymnastics (USAG) records were surveyed, and the self-reported age, birth date, height, and weight for each Olympic-team athlete were recorded from paper documents from 1956 to 2008. The 2012 and 2016 Games followed a closing of the USOC Sport Information Center Library. USA Gymnastics has not continued to maintain these types of records following 2008. Ironically, data on height, weight, and age were culled from various journalistic sources for the 2012 and 2016 Games. Height and age information was readily available for all of the athletes from the 2012 and 2016 Games. Weight information is more culturally sensitive and we were unable to find publicly available sources for two athletes' weight. All data were obtained following the requirements of the U.S. Olympic Committee on the study of human subjects/athletes. Moreover, these data were publicly available from the official records located in the USOC archives at Olympic Training Center in Colorado Springs, CO, USA. Body mass index (BMI) was also calculated for trend comparisons.

Statistical Analysis: Updated group means for each team are presented in Table 1. Descriptive statistics are presented for the athletes on each team in Figures 1-5. Linear and curvilinear regressions were used to determine the best least squares fit to the time-series of variables addressed in this study. Two time-series analysis methods were calculated and fitted to the historical data along with the resulting regression equations, 95% confidence intervals, and r^2 values using Microsoft Excel 2016 (Redmond, WA, Version 1710) and ProStat (Version 6, Pearl River, NY). The best regression model fit to the historical data was determined by the highest r^2 value.

RESULTS

Table 1 shows updated descriptive information regarding the Olympic Games, the number of U.S. athletes involved with each team or training squad, variable, and the final team rank. Table 2 presents the updated equations for the least squares best fits of linear and polynomial regression equations and associated r^2 values. Figures 1 through 5 show the time-series of the means for each team and variable with standard deviations and the final U.S.A. team ranks for each Olympic Games. Figures 1 through 5 also show the second-order polynomial fit curves. Note that the general trend over time does not appear to be a simple linear relationship (see Table 2). The more recent Olympic Games show an upward trend in height, mass, age, and BMI.

Also, note that the overall curve of body size trends is reflected to a degree in the Olympic team final placement ranks.

Table 1
Updated Descriptive Information - All Women's Olympic Gymnastics Teams 1956-2016.

Olympic Games	N	Height (cm)	Mass (kg)	Age (yr)	BMI	Team Rank
1956	7	161.8 ± 7.6	55.6 ± 3.7	19.4 ± 2.6	21.3 ± 1.9	9
1960	10	158.4 ± 4.6	51.2 ± 3.9	19.0 ± 1.9	20.4 ± 1.5	9
1964	7	156.8 ± 4.1	49.0 ± 2.2	19.9 ± 3.4	20.0 ± 0.8	9
1968	8	158.4 ± 5.1	49.6 ± 5.2	17.4 ± 1.9	19.7 ± 1.7	6
1972	7	158.6 ± 4.9	47.4 ± 2.3	18.9 ± 3.3	18.9 ± 1.0	4
1976	7	160.6 ± 2.4	48.2 ± 3.4	17.9 ± 1.2	18.7 ± 1.0	6
1980	7	149.1 ± 4.3	40.2 ± 3.9	15.7 ± 2.7	18.0 ± 1.1	NA
1984	8	152.8 ± 5.8	43.6 ± 4.0	18.1 ± 3.0	18.6 ± 0.9	2
1988	7	152.4 ± 7.2	42.6 ± 6.2	16.9 ± 2.0	18.2 ± 1.2	4
1992	7	146.2 ± 9.4	37.7 ± 4.9	16.3 ± 1.4	17.6 ± 1.0	3
1996	7	150.0 ± 6.9	41.6 ± 5.2	18.1 ± 1.7	18.4 ± 0.9	1
2000	8	154.2 ± 4.1	47.9 ± 5.1	19.1 ± 2.6	20.1 ± 1.7	4,3*
2004	8	152.1 ± 4.2	45.3 ± 3.5	19.0 ± 4.4	19.9 ± 1.2	2
2008	8	153.0 ± 7.0	47.5 ± 5.7	18.0 ± 2.0	20.2 ± 1.4	2
2012	8	158.5 ± 5.9	48.5 ± 5.3	17.0 ± 2.6	20.1 ± 1.7	1
2016	8	151.3 ± 7.6	49.0 ± 2.2	18.6 ± 2.0	20.8 ± 1.6	1

NA = Non-participation
* = Originally 4th place, raised to 3rd place after discovery of Chinese age cheating.

Table 2
Updated linear and second-order polynomial regression equations for individual athlete data on each variable with Olympic Games year.

Variable	Linear Equation	r^2	Second-Order Polynomial Equation	r^2
Age (yr)	$y = -0.059x + 18.58$	0.06	$y = 0.029x^2 – 0.558x + 20.077$	0.30
Height (cm)	$y = -0.5078x + 158.96$	0.29	$y = 0.1048x^2 – 2.8886x + 164.31$	0.50
Mass (kg)	$y = -0.3363x + 49.407$	0.13	$y = 0.1804x^2 – 3.0428x + 58.606$	0.74
BMI	$y = -0.002x + 19.458$	0.00	$y = 0.0504x^2 – 0.8584x + 22.207$	0.81
Rank	$y = -0.5231x + 8.5654$	0.78	$y = 0.0428x^2 – 1.2467x + 10.66$	0.86

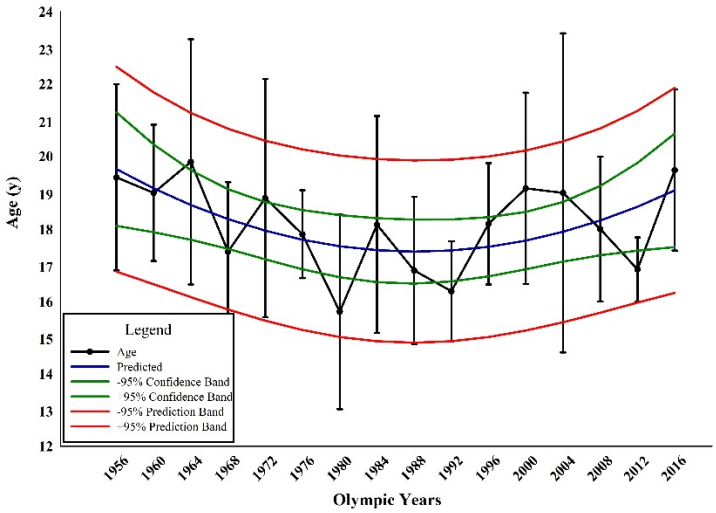

Figure 1. Updated means of age trends of the U.S. Women's Olympic Gymnastics teams from 1956 to 2016 with 2nd-order polynomial predictions and 95% confidence and prediction bands**.**

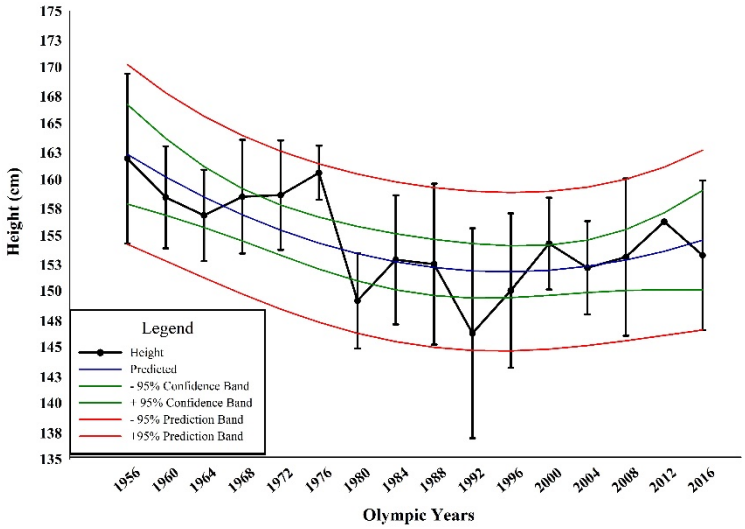

Figure 2. Updated means of standing height trends of the U.S. Women's Olympic Gymnastics teams from 1956-2016 with 2nd-order polynomial predictions and 95% Confidence Intervals. Note that the most recent Olympic team (2016) showed a decline in height from the 2012 team in spite of two members in common with both teams.

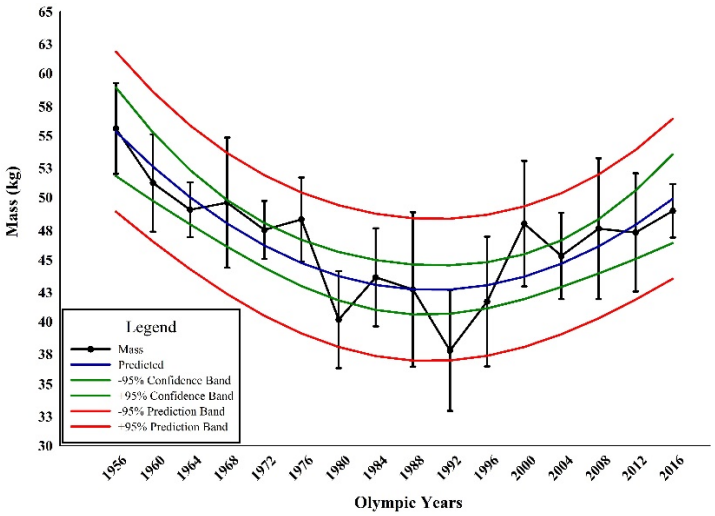

Figure 3. Updated means of body mass trends of the U.S. Women's Olympic Gymnastics teams from 1956-2016 with 2nd-order polynomial predictions and 95% confidence and prediction bands.

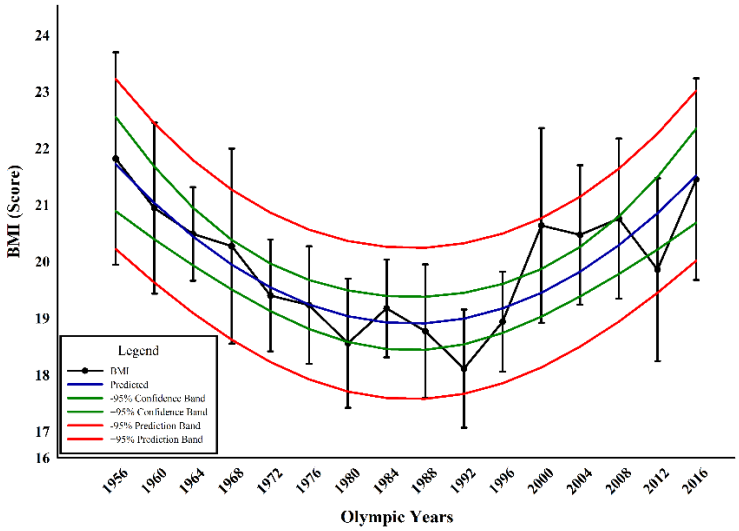

Figure 4. Updated means of body mass index trends of the U.S. Women's Olympic Gymnastics teams from 1956-2016 with 2nd-order polynomial predictions and 95% confidence and prediction bands.

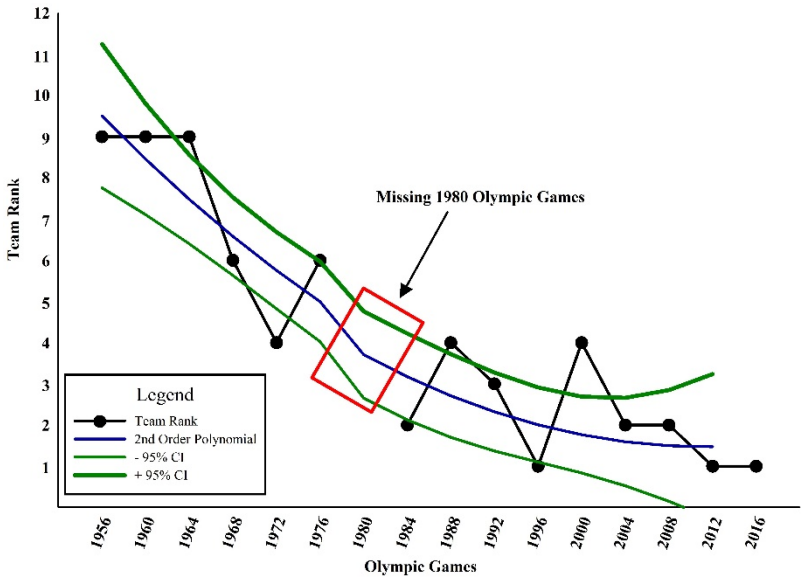

Figure 5. Updated team ranks trends of the U.S. Women's Olympic Gymnastics teams from 1956-2016 with 2nd-order polynomial predictions and 95% confidence band.

DISCUSSION

American gymnasts were getting smaller through approximately the 1980s and early 1990s. However, the most recent trend is increasing height, mass, age, and BMI. In keeping with the premise that smaller gymnasts are at an advantage, the Pearson correlations and polynomial regression analyses between the Games and height, mass, age, and BMI indicated that as the U.S. gymnasts became smaller, their Olympic Games final team ranking improved (Tables 1 and 2, Figures 1-5). A host of obvious reasons led to the conclusion that female Olympic gymnasts need to be small and light in order to perform their skills with the greatest efficiency and effectiveness (Ackland, Elliott, & Richards, 2003; Claessens, Lefevre, Beunen, & Malina, 2006; Sands, 2011; Sands et al., 2012). Evidence for a "smallness" factor in competition was provided by Claessens and colleagues showed that higher endomorphy scores were negatively related to performance scores at the 1987 Rotterdam World Championships (Claessens, Lefevre, Beunen, & Malina, 1999). However, the trend toward smallness cannot continue indefinitely, and as can be seen by the historical trends regarding size (Figures 1 and 2), U.S. gymnasts are not getting smaller in the most recent Olympic Games, covering 24 years (1992-2016), they are actually getting larger. Although as noted above, the most recent 2016 Olympic team had some very short members, even by gymnastics cultural norms (Finch, 2016; Foster, 2016; McDonald, 2016; Mooney, 2012; Moss, 2016). However, our data show that while gymnasts are small, they have not been shrinking for the past 30 years (Epstein, 2016).

CONCLUSIONS

Recent "body shaming" attacks on female Olympic gymnasts via social media have met with swift and aggressive responses indicating that the "shamers" opinions are not relevant (Blair, 2016; Kerr-Dineen, 2016). Malina has emphasized that, along with familial relationships, the selection approaches of the sport may be powerful determinants of the small size of elite, female gymnasts (Malina, 1996, 1999). For example, Malina has noted that records of height in early childhood have shown that young females destined for

gymnastics are small and light long before they are selected for training (Malina, 1996, 1999). Finally, the size of gymnasts appears to be an optimization problem rather than a minimization problem. The best U.S. Olympic Team finishes were accomplished when the teams were not the smallest, lightest, or leanest, but greater than the lowest recorded values. Female Olympic gymnasts have always been small, but most recently they have been getting larger.

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