Historical Trends in the Size of US Olympic Female Artistic Gymnasts

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The lay press, scientists, and physicians appear to believe that gymnasts are continually getting smaller and that their “smallness” is a health risk. **Purpose:** To assess the historical changes in the size and age of the US women’s Olympic gymnastics teams from 1956 to 2008. **Methods:** The official records from the US Olympic Committee and USA Gymnastics of Olympic team members were assessed at 2 levels: individual height, mass, age, and body-mass index (BMI) and the team performance scores and rankings. Fourteen Olympic teams with a total of 106 team members, including the alternates, were included. Trend analyses were conducted using linear and polynomial models. **Results:** Simple linear correlations indicated that since 1956, height, mass, age, BMI, and team Olympic rank have been declining. However, second-order polynomial curve fits indicated that in the last 4 Olympic Games the members of the US women’s gymnastics teams have been getting larger. **Conclusion:** Women Olympic gymnasts were getting smaller through approximately 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 athlete size changes along with a shift from the near dominance of the former communist Eastern Bloc.

**Keywords:** anthropometry, gymnastics, body size

Olympic female artistic gymnasts—henceforth, for brevity, the term gymnasts shall be used for artistic gymnasts—are young, short, and light compared with the rest of the Olympic athletic population. An extensive study of the 1996 Rotterdam World Championships showed again that gymnasts, male and female, are small, lean, and muscular. The demands of Olympic gymnastics have continued to escalate, and currently, a light, powerful, and, usually, petite athlete is optimal. Largely because of these types of observations, the Fédération Internationale de Gymnastique, in 1980, right before the Olympic Games, decided to raise the minimum age from 14 to 15 years for international-level female gymnasts. This rule change was followed later, in 1997, by another modification that increased the international competitive age to 16 years. In both cases, the assumption was that the new rules would enhance the maturity of international-level female gymnasts and, concomitantly, reduce the stress and potential injury risk to the gymnasts, as well as add an emphasis on elegance and acrobatics. The effects of these minimum-age rule changes, along with an escalation of skill difficulty, had a largely unanticipated outcome. The gymnasts were (and are) being forced to increase their skill difficulty, at the expense of elegance, to compete successfully, all being counter to the desired goal. Moreover, the issue of age falsification—selecting younger gymnasts but reporting them as age eligible—has arisen along with more media attention and scrutiny.

Most recently, the Chinese were found to have falsified the age of Dong Fangxiao, actually 14 years old but falsified as 16 years, during the 2000 Sydney Olympic Games, forcing the Chinese to forfeit the bronze team medal to the US team.

Although numerous questions have been posed concerning the small size of female competitive gymnasts and the reasons for this, the overarching idea of trying to reduce stress on children and adolescents and to ensure their optimal development is laudable. However, there appears to be an impression in both the scientific/medical and lay communities that female gymnasts are abnormally small, and a constellation of factors surrounding smallness is viewed as unhealthy. As such, it is important for women’s gymnastics to remain under scrutiny to ensure that the trend of the sport is not moving in an unhealthy direction.

Nattiv and Mandelbaum described a decline in both the height and the weight of female gymnasts up to the time of their article in 1993 and questioned whether the quest for diminutive size among gymnasts posed a health risk. During the 2008 Olympic Games the American Col-
lege of Sports Medicine incorporated a Web page that highlighted some assumptions about Olympic women’s gymnastics. The ACSM Web site’s Olympic Games expert commentary offered the following statement:

It is clear that over time gymnasts are getting smaller but it is not clear whether this is a result of selection or participation in gymnastics. Researchers have found that elite level gymnasts may experience diminished growth during their years of training and competition and then catch-up growth during time off or after stopping the sport. No one is sure whether the catch-up is complete however.12

The female athlete triad also has been invoked to describe a litany of symptoms that plague young gymnasts.13 The implications of these early studies and concerns seem to proceed from an assumption that taller is healthier. However, this view is not supported by life-span data.14 Given the divergence of opinions and the apparent assumptions that still mark public commentary about women’s Olympic gymnastics, it is important that American women gymnasts be characterized, with regard to size and age, such that one can pursue further research from an informed position about the nature of the change in size of female gymnasts. Whom better to learn from than the members of the US Olympic teams?

The purpose of this investigation was to examine the trends in the size and age of female members of the US Olympic team. Official US Olympic Committee (USOC) records of the Olympic women’s gymnastics teams from the 1956 Olympic Games through to the 2008 Olympic Games were examined to determine the historical trends of these variables. Analyses proceeded on 2 levels: assessment of the trends of individual athlete team members and assessment of the performances of each team such that each team was considered the datum for further analyses.

Methods

Subjects

A total of 14 women’s Olympic gymnastics team records were examined. The data set included both the competing team members and alternates (N = 106). Team rosters ranged from 7 to 10 members, depending on the selection policies for each team. Seven team members were most commonly selected, with 6 who actually competed 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 was secondary to the international competition format as set by the Fédération Internationale de Gymnastique. Additional alternates have been named, and thus an Olympic team “squad” was created that was later evaluated at a pre-Olympic training camp in order to determine the rankings and the actual Olympic team. The entire Olympic squad traveled to the Olympic Games, while only the actual team participated in official trainings and competitions. Thirteen athletes competed in more than 1 Olympic Games, with 8 competing in 2 and 5 competing in 3. Repeating athletes were included in the relevant analyses to maintain the intact teams as the units of analyses. Moreover, given that the Olympic Games were conducted at 4-year intervals, the size of the gymnast should have reflected the passage of time (ie, growth, development, and maturation), resulting in the athlete’s body changing and reflecting the time interval between Olympiads.

The Olympic Games for women’s gymnastics were not continuous through this period, with a notable boycott in 1980 by many Western countries, as well as a boycott in 1984 by numerous communist-bloc countries. Fortunately, a US team was selected in 1980, but no final team rank was available. Moreover, the minimum-age rules changed in 1980 and 1997. The minimum age before 1981 was 14 years, and in the interim to 1997 it was 15 years. Current rules demand that senior, international-level gymnasts be 16 years in the calendar year of the particular international contest (eg, Olympic Games, World Championships).

Design

We conducted a historical trend analysis from the official records of the USOC and USA Gymnastics regarding the height, mass (ie, weight), age, and calculated body-mass index (BMI) for the women’s artistic gymnastics Olympic teams.

Methodology

Official USOC and USA Gymnastics records were surveyed, and the age, birth date, height, and mass for each Olympic-team athlete were recorded from paper forms to a computer file for analysis. Final team rankings for each respective Olympic Games were recorded. No contact with individual athletes was required. All data were obtained following the requirements of the USOC on the study of human subjects and athletes. Moreover, these data are publicly available from the official records maintained by the USOC in the library of the Olympic Training Center in Colorado Springs, CO. BMI also was calculated for trend comparisons.

Statistical Analysis

Descriptive statistics are presented for individual athletes on each team in Figures 1–3. Group means for each team are presented in Table 1. Linear regression and other curve-fitting regression methods were used to determine the best fit to 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 $R^2$ values using Microsoft Excel 2003 (Redmond, WA, Version 11.8220.8221). The best model fit to the historical data was determined by the highest $R^2$ value. Linear and second-order polynomial equations are presented in Table 2.
Results

Table 1 shows descriptive information regarding the Olympic Games, the number of US athletes considered on each team and variable, and the final team rank. Table 2 presents equations for the least-squares best fits of linear- and polynomial-regression equations. Figures 1 through 3 show the time series of the means and individual athlete raw data for each variable and the final US team ranks for each Olympic Games. Figures 1 through 3 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. In addition, note that the overall curve of body size trends is reflected to a degree in the Olympic teams’ final placement ranks.

Discussion

The answer to the question of whether US female Olympic gymnasts are getting smaller appears to be, “It depends.” The answer depends on the period of the historical record examined and the result of the particular curve fitting. American gymnasts were getting smaller through approximately the 1980s to the early 1990s. However, the most recent trend is increasing height, mass, age, and BMI. The Pearson correlations and polynomial analyses between the Games and height, mass, age, and BMI indicated that as the US gymnasts became smaller, their Olympic Games final team ranking improved (Tables 1 and 2, Figures 1–3). As described in the introduction, female Olympic gymnasts need to be small and light to perform their skills with the greatest efficiency and effectiveness. For example, Claessens et al 15 showed that higher endomorphy scores were negatively related to performance scores at the 1987 Rotterdam World Championships. However, the trend toward smallness cannot continue indefinitely, and as can be seen by the historical trends regarding size (Figures 1 and 2), US gymnasts are not getting smaller in the most recent Olympic Games, covering 16 years (1992–2008); they actually are getting larger.

The change in the size of American female gymnasts at the Olympic level may reflect a number of things that have evolved in the US women’s national-team program. First, there are no team weigh-ins; they were abolished in the mid 1990s. Second, any emphasis on weight reduction is no longer apparent in national-team activities. Third, identification and direction of gymnasts’ development are largely determined at an earlier age and monitored more carefully through a migration of the most talented athletes to the most productive and knowledgeable coaches. 16 Of course, there are occasional exceptions, gymnasts who may have an overzealous coach or parent, developed self-destructive attitudes or self-imposed weight-control strategies, and misinterpreted comments by national coaches and staff that do not reflect sound training and health practices.
Figure 2 — US women’s Olympic gymnastics teams’ reported height, mass, and body-mass index (BMI) with second-order polynomial regression curve, 1956–2008. Gymnasts competing in more than 1 Olympiad are linked via lines.
Table 1 Descriptive Information for All US Women’s Olympic Gymnastics Teams From 1956 to 2008 (Mean ± SD)

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

Abbreviations: BMI, body-mass index; NA, nonparticipation.

* Originally 4th place but raised to 3rd place after the discovery of Chinese age cheating.

Table 2 Linear and Second-Order Polynomial-Regression Equations for Individual Athlete Data on Each Variable With the Olympic Games Year

<table>
<thead>
<tr>
<th>Variable</th>
<th>Linear equation</th>
<th>$r^2$</th>
<th>Second-order polynomial equation</th>
<th>$r^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>$y = -0.0167x + 51.271$</td>
<td>.01</td>
<td>$y = 0.0029x^2 - 11.622x + 11552$</td>
<td>.08</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>$y = -0.1843x + 519.86$</td>
<td>.19</td>
<td>$y = 0.0061x^2 - 24.233x + 24357$</td>
<td>.58</td>
</tr>
<tr>
<td>Mass (kg)</td>
<td>$y = -0.1613x + 366.08$</td>
<td>.18</td>
<td>$y = 0.0125x^2 - 49.796x + 49548$</td>
<td>.64</td>
</tr>
<tr>
<td>Body-mass index</td>
<td>$y = -0.0194x + 57.684$</td>
<td>.04</td>
<td>$y = 0.0039x^2 - 15.448x + 15346$</td>
<td>.60</td>
</tr>
<tr>
<td>Rank</td>
<td>$y = -0.1440x + 290.04$</td>
<td>.76</td>
<td>$y = 0.0034x^2 - 13.486x + 13511$</td>
<td>.84</td>
</tr>
</tbody>
</table>
There are few examples of scientists who have questioned the assumptions or conclusions that smallness is an indication of ill health among female gymnasts. Although malnutrition certainly should be avoided, the popular notion that taller people are healthier is not supported in terms of life span. Moreover, Mansfield and Emans questioned the idea that smallness was detrimental, commenting that gymnasts were more satisfied with their body image than swimmers and that perhaps the goal of counseling and surveying young athletes should be more about a positive body image than simply maximizing adult height. Moreover, in an accompanying paper, Theintz et al. noted that in attaching a judgment to a gymnast’s height, one should also know the parents’ pattern of growth through adolescence. 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. For example, Malina noted that records of height in early childhood have shown that young girls destined for gymnastics are small and light long before they are selected for training.

The need to optimize mechanical performance by being strong, light, and small is well understood by gymnasts, coaches, and some scientists. Anthropometric information has shown repeatedly that gymnasts are smaller and lighter than age mates, with little variation in somatotype with age. Earlier work on cross-sectional and longitudinal testing of the US national women’s gymnastics teams showed that strength and explosiveness did not keep pace with the growing size of these gymnasts as they passed through adolescence. However, most gymnasts are able to use skill and experience to counter a decreased strength-to-weight ratio. Moreover, a more recent and increased emphasis on conditioning by the national coaching staff may be reversing this trend.

Practical Application

From a practical standpoint, the results of our study indicate that contrary to the widely held belief that gymnasts are getting smaller up until the mid- to late 1980s. Moreover, the larger gymnasts generally were more successful in the Olympic Games in spite of their larger sizes. Specifically for coaches, small size should not be used as a major determining factor for Olympic team selection.

Conclusion

Finally, the size of gymnasts appears to be an optimization problem rather than a minimization problem. The best US Olympic team finishes were accomplished when the teams were not the smallest, lightest, or leanest but greater than the lowest recorded values. Moreover, as the rules of the sport changed to emphasize more explosiveness and acrobatics, a more mesomorphic somatotype may have an advantage. The typical somatotype of female gymnasts is a balanced ectomorph–mesomorph.

References

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