

ANALYZING THE CONNECTION BETWEEN GYMNAST'S STATURE AND MEDAL PERFORMANCE ON APPARATUSES IN MEN'S ARTISTIC GYMNASTICS

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Abstract

In order to achieve success in sports, certain physical fitness characteristics are necessary. This study aims to determine whether a relationship exists between the height of male gymnasts who have won medals in the World Championships and Olympic Games in Artistic Gymnastics, and the apparatus on which they achieved those medals. Competitions in Men's Artistic Gymnastics at World Championships and Olympic Games are held in six apparatuses for individuals: floor exercise, pommel horse, rings, vault, parallel bars and horizontal bar. Each apparatus follows specific rules for evaluating gymnastics routines. Airborne acrobatics dominate on floor and vault, while support holds prominence on pommel horse and parallel bars, and hanging manoeuvres characterize rings and the high bar. While a gymnast's body height influences all forms of gymnastics, the question remains: who can rise to the top on each apparatus?

Within the scope of the research, the results between the years from 2009 to 2021 were examined. In this context, data from three Olympic Games (2012, 2016 and 2020) and nine World Championships (2009, 2010, 2011, 2013, 2014, 2015, 2017, 2018 and 2019) were used. The heights (251 sets of data) of the gymnasts who won medals in these competitions were evaluated.

While the shortest of the medal-winning gymnasts was 150cm tall (floor exercise and pommel horse) and the tallest 183cm (floor exercise and horizontal bar), the average height of the medal-winning gymnasts was 164.67cm (± 6.12). There is statistically significant difference between the heights of the gymnasts who won medals on apparatuses ($p < 0.05$).

Keywords: *gymnasts, body height, medal.*

INTRODUCTION

Scientific studies on sports show that there are certain morphological features that increase the athlete's chance of success. Furthermore, in the same sport, these

morphological features vary depending on the position of the athlete, his role, and the type of competition he specializes in (Stanula et al., 2013; Taboada-Iglesias,

Santana, & Gutierrez-Sanchez, 2017). Success in artistic gymnastics certainly depends on the morphological characteristics of the athletes, some of which are basic body height and weight (Almir Atikovic, 2020).

Gymnastics is one of the oldest sports branches. The International Gymnastics Federation (FIG) was founded in 1881. Gymnastics has been part of all Olympic Games organized since 1896 (Massidda & Calo, 2012). The first gymnastics World Championship was held in the Netherlands in 1903 (Almir Atikovic, 2020; Ivan Cuk et al., 2007). Since its inception, competition schedules have changed. However, men's gymnastics practiced in the mid-1930s is very similar to the current practices (Ivan Cuk et al., 2007).

The rules of the competition for artistic gymnastics are based on the COP. The first version of these rules dates back to 1949 (Almir Atikovic & Smajlovic, 2011). The competition rules are defined by: statutes of the FIG, FIG Technical Regulations, COP, Apparatus Norms which get changed and perfected by the FIG's commissions for each Olympic cycle (A. Atikovic, Kalinski, & Cuk, 2017; Almir Atikovic & Smajlovic, 2011).

Artistic gymnastics is a sport that includes multiple competitions, in contrast to many other sports branches. There are six apparatuses for men and four apparatuses for women, and each apparatus is performed in a series that requires branch specific skills (Prassas, Kwon, & Sands, 2006). There are four distinct competitions. The first is the qualification round, in which all gymnasts participate. The top eight teams from the qualifications advance to the team finals. Similarly, the highest-scoring 24 gymnasts in the qualifications earn a spot in the all-around final. A maximum of two

gymnasts from each country can participate in the all-around finals. Another competition is the apparatus finals. To qualify for the apparatus finals, being among the top 8 athletes from the qualification is essential. A maximum of two gymnasts from each country can compete in the apparatus finals. (Committee, 2020).

A gymnast does not necessarily have to compete on all six apparatuses. Since 2007, World Cups have been organized, allowing competition on a single apparatus. This rule change has allowed gymnasts to specialize in single or more apparatuses according to their abilities and skills, rather than training on all six apparatuses (Sibanc, Kalichova, Hedbavny, Cuk, & Pajek, 2017). Since 2008, there has been more specialization in the apparatus competitions. Since FIG now allows gymnasts to compete in a single apparatus, characteristics of gymnasts, such as body height and weight, have become a determining factor in choosing their apparatus (Marijo Možnik 2013).

Competition apparatus used in artistic gymnastics adhere to specific norms determined by the FIG (International Gymnastics Federation). These apparatuses must be utilized in any competition sanctioned by the FIG, such as the World Championships and the Olympic Games. The dimensions of the floor are 12x12m, while the pommel horse stands 105cm high from the landing mat, and the vault is 135cm high. The rings are set at 280cm, the parallel bars at 180cm, and the horizontal bar at 260cm high from the landing mats (Erkut, 2021). This raises the question of whether the standardized height of the apparatus may confer an advantage to certain gymnasts based on their body height. Developments in training methods, equipment, and changes in competition

rules also impact the criteria for athletes' body structures in the selection of sports disciplines (Stanula et al., 2013). Gymnasts have typically been of smaller stature, as it provides better balance and facilitates easier rotation during the flight phase. However, the diminutiveness of female gymnasts, in particular, has become more pronounced in recent times (Almir Atikovic, 2020).

The aim of this study was to investigate whether a relationship exists between the height of gymnasts who have won medals in the Artistic Gymnastics World Championships and the Olympic Games and the specific apparatus on which they achieved those medals.

METHODS

In this study, the results of three Olympics and nine world championships organized between 2009 and 2021 were evaluated. The heights of the athletes were obtained from FIG and national and international Olympic Committee data. In this context, 253 sets of data were evaluated. Only the heights of two gymnasts could not be obtained. MS Excel 2016 and Sigma Plot were used for statistical analysis. Kruskal-Wallis test was used for analysis of multiple groups.

Table 1

The included competitions and the number of medals obtained

	Gold	Silver	Bronze
2009 World Championships - London	7	7	7
2010 World Championships - Rotterdam	7	8	6
2011 World Championships - Tokyo	7	8	7
2012 Olympic Games - London	7	7	7
2013 World Championships - Antwerp	7	8	6
2014 World Championships - Nanning	7	7	7
2015 World Championships - Glasgow	7	7	7
2016 Olympic Games - Rio De Janeiro	7	7	7
2017 World Championships - Montreal	7	7	7
2018 World Championships - Doha	7	7	7
2019 World Championships - Stuttgart	7	7	7
2020 Olympic Games - Tokyo	7	7	7

Table 1 presents the evaluated competitions and the number of medals. In the 2010 competition, two gymnasts won silver medals on the PH. In 2011, two gymnasts achieved bronze medals on the FX, while two gymnasts won silver medals on the PH. At the 2013 World Championships, two gymnasts secured bronze medals on the PH.

RESULTS

Within the scope of our study, the Olympic Games and World Championships held between 2009 and 2021 were examined and the following data were obtained:

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Table 2

Height of gymnasts who won medals in all-around and the six apparatuses

Body Height	FX	PH	RI	VT	PB	HB	AA
150 cm - 159,9 cm	7	4	8	5	4	3	5
160 cm - 169,9 cm	24	12	27	29	22	16	26
170 cm - 179,9 cm	4	15	1	0	9	15	5
180 cm - 189,9 cm	2	5	0	1	0	2	0
Total	37	36	36	35	35	36	36
mean	163.51	169.61	161,47	162.57	164.20	167.58	163.67
max	183.00	180.00	170.00	180.00	178.00	183.00	173.00
min	150.00	150.00	158.00	154.00	156.00	158.00	157.00
sd	6.72	7.72	2.95	5.08	5,68	6.04	4.14

Table 2 provides the height ranges of the medal-winning gymnasts. The majority of gymnasts fall within the height range of 160 to 169.9cm (62.15%). However, on the pommel horse (PH), there is a distinct difference, as the majority of medal-winning gymnasts are 170cm and taller (75%), unlike on other apparatuses. The number of gymnasts on the HB apparatus is nearly equal for those above and below 170 cm (17-19). No gymnast with a height of 180 cm or taller has won a medal in the rings (RI), parallel bars (PB), or all-around events. RI and vault VT exhibit similar characteristics. In the RI, 97.2% of medal-winning gymnasts are shorter than 170 cm. Similarly, in the vault, 97.14% of medal-winning gymnasts are athletes shorter than 170 cm.

According to Table 3, there were statistically significant differences ($p < 0.05$) between FX and PH as well as HB, between PH and PB, between RI and PB as well as All-around (AA), between PB and HB, and between HB and AA. On the other hand, higher levels of statistical differences ($p < 0.01$) were found between PH and RI, VT, and AA, between RI and HB, and between VT and HB.

When examining the variations in height across Olympic cycles, a decrease in the heights of medal-winning gymnasts was observed in the 2013-2016 and 2017-2020 Olympic cycles on the FX and VT. A significant relationship was found between the heights of the gymnasts who won medals on FX and PH between 2013-2016 and 2017-2020 ($p < 0.05$).

Table 3
Heights differences in gymnasts

	PH	RI	VT	PB	HB	AA
FX	0.001*	0.099	0.506	0.642	0.008*	0.907
PH		0,000**	0.000**	0.001*	0.219	0.000**
RI			0.267	0.013*	0.000**	0.012*
VT				0.210	0.000**	0.322
PB					0.018*	0,652
HB						0.002*

* $p < 0.05$ ** $p < 0.001$

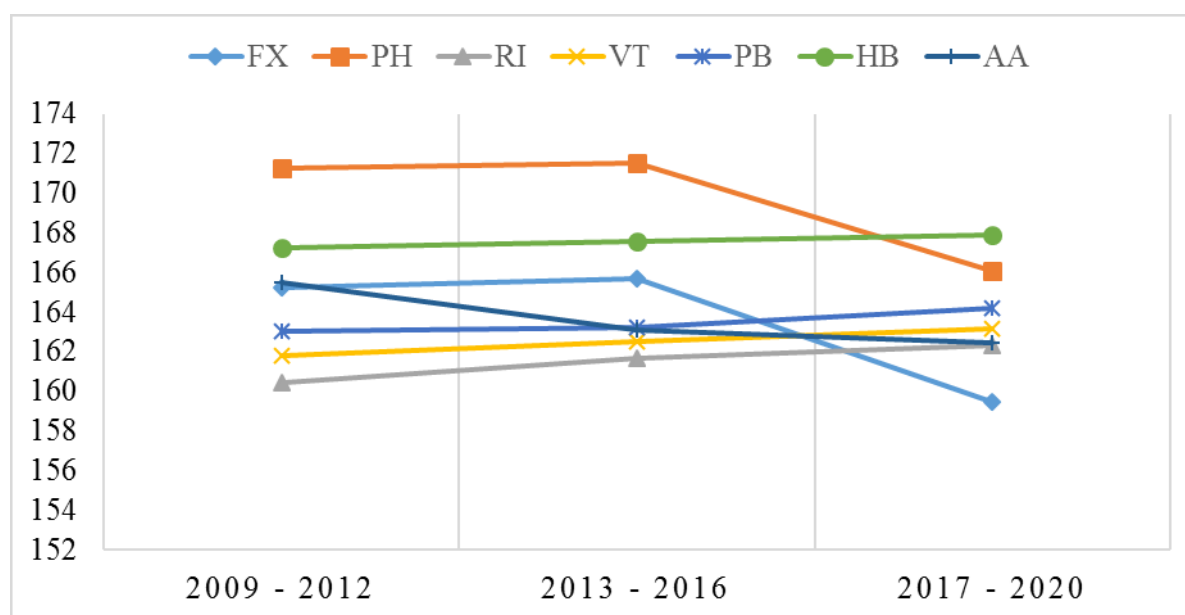


Figure 1. Average height of the gymnasts who won medals during Olympic cycles

DISCUSSION

Gymnastics has traditionally been perceived as a sport suitable primarily for shorter individuals. Height has been used as a criterion in athlete selection processes. However, when examining competition results, it becomes apparent that gymnasts of different heights excel on specific apparatuses. Particularly in team competitions, it has been observed that teams consist of gymnasts with diverse heights. These observations have prompted the need for a study on gymnasts' heights. The aim of this study was to investigate whether there is a relationship between the height of the gymnasts who won medals in the Artistic Gymnastics World Championships and the Olympic Games, and the apparatus in which they won medals. Our study revealed statistically significant differences in terms of height among gymnasts who won medals on different apparatuses. There were significant differences ($p < 0.05$) between FX and PH as well as HB; between PH and

PB; between RI and PB as well as AA; between PB and HB, and between HB and AA. Furthermore, higher levels of statistical differences ($p < 0.01$) were found between PH and RI, VT, and AA, between RI and HB, and between VT and HB.

In the 1930s, gymnastic was the most developed sports branch considering the number of competitors and quality level. This was the reason why first sports researchers, called anthropologists, became interested in gymnastics. The first major research was conducted at the Olympic Games organized in Amsterdam in 1928. The study concluded that short people could be successful in gymnastics whereas tall people could be successful in athletics (Ivan Cuk et al., 2007). Studies show that the height and weight of the gymnasts participating in the competitions between 1933-2000 did not change, but the width of the shoulders and hips did. Gymnasts today have wider shoulders and narrower hips than before. This is the result of complex movements involving horizontal and

vertical rotation (Cuk, Pajek, Jakse, Pajek, & Pecek, 2012).

The gymnasts selected for recreational and performance purposes were shorter than their average age before they started training. In both genders, families of gymnasts were also reported to be shorter than average. This situation was interpreted as an indication that gymnasts had characteristics inherited from their families (Malina et al., 2013).

In the study conducted by Rozin and Ceburaev (2007), the heights of the gymnasts participating in the Olympic Games showed an average of 167.7cm in the 1964 Olympics, 167.9cm in the 1968 Olympics, 169.1cm in the 1972 Olympics, 166.7cm in the 1976 Olympics, and 168.2cm in the 1980 Olympics. (Ivan Cuk et al., 2007). These results are in line with our study. In fact, there is a similarity between the average height of the athletes participating in these competitions and the average height of the medal-winning gymnasts.

In another study, the details of 165 gymnasts at the world championship held in Rotterdam in 1989 show that the average height was 167.0cm; the shortest gymnast was 153.2cm tall, and the tallest 183.8cm (Claessens et al., 1991).

Success in applying a technique in artistic gymnastics depends on strength, flexibility, and the individual's somatotype characteristics (Sibanc et al., 2017). In their study on the characteristics affecting the success of young gymnasts, Cuk and Novak (2007) reported that gymnasts should possess a short stature, light body weight, high-quality muscles, a strong chest, and a low body fat percentage in terms of anthropometry. Based on this information, shorter body height seems to be more advantageous on the rings, considering the

technical requirements of the apparatus. Gymnasts who have won medals on the pommel horse and horizontal bar, which do not require strength movements as much as rings, tend to be taller than those on the other apparatuses.

In our study, the height of 61.66% medallists was in the range of 160.00 - 169.99cm. 82.86 percent of vault medallists were in the 160.00-169.99cm category; showing that gymnasts in this height range have a better chance, especially on vault. In pommel horse, dominant height range was 170.00-179.99 cm, representing 41.67% of medallists.

Although artistic gymnastics is defined as a single sport branch, it requires different physical features to be at the forefront in each of the six different competition apparatuses (Morucci et al., 2014). This situation shows that gymnasts should be selected on the basis of apparatus. Our study indicates that relatively short people have better chance of winning medals, especially on rings and vault.

Gymnasts must possess distinct physical attributes tailored to each apparatus in which they compete. Success on the floor requires strong muscles in the lower part of the body, while strength in the upper body is crucial for the rings. Conversely, excelling in the all-around (AA) category demands above-average strength development across all body parts (Kalinski, Jelaska, & Knezevic, 2017). These and similar considerations lead to speculation that gymnasts with varying physical characteristics might enjoy advantages depending on the apparatus they compete in.

Another study found that the average height of the gymnasts who competed in the AA and ranked in the top 10 between 2007 and 2011 was 165.5 cm (Marijo Možnik

2013). In our study, it was observed that the gymnasts who won medals in AA, had a limited range of body height. In the apparatuses, the heights of the medal-winning gymnasts were in a wider range.

The study compared the physical characteristics of male gymnasts participating in the Artistic Gymnastics World Championships held in 2000 and 2015. Measurements were taken from competitors on a voluntary basis to observe changes in physical attributes over the past fifteen years. As a result of these measurements, the shortest gymnast who took part in the 2000 competitions stood at 157.4 cm in height, whereas in 2015, the heights of the two shortest gymnasts were recorded at 150 cm. In both years, the tallest gymnasts competed on the horizontal bar, with a height of 185.5 cm. The difference between the tallest and shortest gymnast's height was 28.1 cm in 2000, while this disparity increased to 33 cm in 2015 (Sibanc et al., 2017). Notably, allowing gymnasts to specialize in specific apparatuses has contributed to a rise in the number of taller gymnasts.

In a separate study, researchers examined the morphological characteristics of gymnasts participating in a World Cup competition and found that the average height of gymnasts was 168 cm, with an average body weight of 66 kg (Cuk et al., 2012).

Studies on the physical characteristics of gymnasts have not been conducted only in artistic gymnastics. Taboada et al. (2017) found a statistically significant difference between the heights of gymnasts competing in the mix pair category in their study on the morphological characteristics of acrobatic gymnasts (Taboada-Iglesias et al., 2017). In a study carried out by Carvalho et al. (2012) on an elite group of rhythmic gymnasts, it

was found that being tall in rhythmic gymnastics had a positive effect on performance. Compared to the past, rhythmic gymnasts are taller today (Lurdes Avila-Carvalho, 2012).

CONCLUSIONS

While there is a prevailing notion that gymnasts should possess a short stature, various factors such as the technical attributes of the apparatus, specialized movement techniques, and competition regulations can introduce advantages or disadvantages based on the gymnast's height. The outcomes of our study demonstrate the height of medal-winning gymnasts can differ according to the apparatus they compete on, challenging the conventional belief that success is confined to individuals of shorter stature. This revelation contradicts the notion that artistic gymnastics exclusively favors those with reduced height. It is crucial to acknowledge that this study's scope is limited to male artistic gymnasts who partook in world and Olympic championships from 2009 to 2021.

In our study in which we evaluated the Olympic Games and World Championships between 2009 and 2021, the following conclusions emerged:

- While a gymnast with a height of 183cm on the floor and horizontal bar could win a medal, a gymnast taller than 170cm on the rings apparatus could not win a medal.
- While gymnasts taller than 170cm were able to win medals on other apparatuses, excluding rings, the tallest gymnast who won a medal in AA was 173cm tall.
- When the length differences are evaluated, the widest gap is on the floor (19.49cm), and the narrowest gap is on the rings (8.53cm).
- Considering the Olympic cycles, there was a 6.17cm decrease in the average height of

gymnasts on the floor in 2017-2020 compared to 2013-2016. A similar differentiation was observed on the pommel horse with 5.32cm.

Gymnasts who attain or approach a particular height threshold can be guided towards apparatuses where their potential for success aligns with their height. When contemplating modifications to apparatus norms, the FIG and relevant committees should factor in gymnasts' heights, ensuring a thorough assessment of these changes. In prospective studies, enhancing research methodologies to encompass measurements not only of height but also of the lengths of gymnasts' upper and lower extremities could offer further comprehensive insights into comprehending the influence of gymnastics apparatuses on physical structure. This avenue of research can also extend to encompass female gymnasts.

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