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Morphological Characteristics in Artistic Gymnasts: A Review

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Abstract:
Background*: The aim of this systematical review study is to provide importance guidelines to enhance performance by selecting events and elements, and this will guide gymnasts to change or buildup their physique according to their desired and suitable events.*
Materials and Methods*: A systematic search was conducted online using few different databases. Nineteen out of thirty-seven relevant papers were identified all criteria in the systematic review. Ten articles were recognized in the subject of anthropometric measurements, five articles for body compositions, and four articles represent body types were included in this systematic review.*
Results*: The majority of studies found similar morphologies based on the anthropometric measures, body composition, and body type with age. Although, there was not enough evidence on whether these characteristics predicted competition performance or even distinguished between gymnasts at various competitive levels.*
Conclusion*: Based on the outcomes of this study, it is believed that the requirements for gymnasts' success are significantly influenced by their morphological characteristics. Although gymnasts' morphological characteristics are widely defined, but less known about the correlation between the characteristics and performance enhancing in artistic gymnastics.*
Key Word*: BMI, Skinfold thickness, Fat mass, Mesomorph.*

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I. Introduction

Gymnastics is a conventional, poly-structural sport focused on complicated movements executed in accordance with aesthetic criteria and stringent restrictions. Gymnastics, being one of the fundamental sports, has a major influence on an individual's psychosomatic status transition. It is distinguished by the exceptional variety and complexity of its elements, which are grouped in structural groupings within the competitive disciplines.

Artistic Gymnastics is one type of the six major types of Gymnastics. Artistic Gymnastics usually divided into Men's Artistic Gymnastics (MAG) and Women's Artistic Gymnastics (WAG). Men compete on six apparatus and women compete on four apparatus. Vault (VT) and Floor Exercises (FX) are common for both MAG and WAG. Except these two events, MAG includes Pommel Horse (PH), Rings (SR), Parallel Bars (PB) and Horizontal Bar (HB). In addition, WAG includes Uneven Bars (UB) and Balance Beam (BB).

Artistic Gymnastics is continuously evolving and changing because to changes in the International Federation of Gymnastics regulations. Gymnastics research is required to increase in the field of gymnastic training and gymnastics apparatus [1]. Gymnastics competitions are controlled by technical regulations that outline the criteria for routine creation. Gymnasts are frequently unable to fulfill all of these standards. Failure to satisfy the standard results in lower scores [2].

Previous research of [1] recognized in recent years, artistic gymnastics has grown in popularity, which may be ascribed in part to the starting of training at an early age. Gymnastics, like other competitive sports, places a high value on strategies for recognizing potential and obtaining top outcomes. These approaches involve the use of different physical, functional, and psychological measuring tools to measure gymnasts' abilities and characteristics.

Morphological features are particularly essential in gymnastics because that body is constantly moving from one position to another during the execution of the composition. Different training approaches and a lot of repetition of the elements improve one's capacity to control one's own body during workouts and gymnastics. Identification of the morphological characteristics very importance in artistic gymnastics, because it is the way can develop the performance and maximize the results for attack to the best players in the world context such in the Olympic games [3].

The anthropometric effect of each Apparatus on values is positive. Each ideal form of gymnast number Apparatus has a 19% to 68% effect on the appearance presented by the value. Anthropometrics at the appliances, on the other hand, is not a reliable predictor of value [4]. Individual competition male gymnasts' body weight and height did not differ much. Gymnasts who specialized in FX and VT had low and comparable body fat, which was also suggested by the value of endomorph, as well as low ectomorph. The ectomorph of the PH experts was the highest. The mesomorph somatotype component was found in gymnasts who chose PH and was significantly lower than other all events [5]. Also top-ranked gymnasts have a smaller stature less than middle-ranked gymnasts, and they are more likely to be mesomorph, with less probability of having an endomorphic or ectomorph somatotype [6].

Prior article of [7] has shown height, mass, age, and Body Mass Index (BMI) have already increased in recent Olympic Games. It is also worth noting that the overall trend of body size trends is reflected to some level in the Olympic team final placement ranks. The proportion of gymnast body size that is desirable for apparatus number experts vary, although basic anthropometric percentages may be characterized [4].

The purpose of this systematic review study is to deliver valuable guidelines for improving performance by deciding events and elements, which will guide gymnasts to transform or build up their musculature based on their intended and appropriate events.

II. Material And Methods

The approach for this systematic review was developed based on previously reported suggestions and results. The all original data that included in this review, collected through online search from published articles in Google Scholar, Scientific Research, PubMed and Research Gate. The articles found under the journals of Apunts Med Esport, Arch Med Deporte, Collegium Antropologicum, Journal of Sports Sciences, PLoS ONE, Science of Gymnastics Journal, The Journal of sports medicine and physical fitness, Sports Medicine, International Journal of Sport and Health Science, Food and Nutrition Sciences, International Journal of Morphology, and International Journal of Hispanic Psychology. Also, the conference proceedings of 5th International Conference on Physical Education, Sport and Health (ACPES 2019) and 6th International Scientific Conference of Contemporary Kinesiology. The published articles search was done by using the topics of Morphology, Physique, Body compositions, Somatotypes, Anthropometric measurements and profiles in artistic gymnastics.

Procedure methodology

False journals and papers that did not satisfy the standards were eliminated from the collection of articles. After a thorough assessment of the abstract, introduction, results and discussions, the suitable articles were chosen. References were used to identify additional articles in order to obtain more details and results. According to the morphological characteristics by using basic of anthropometric measurements and somatotypes were categorized after analyze the articles. The morphological characteristics were then divided into subtopics based on their relevance in artistic gymnastics.

III. Result

Beginning, thirty-seven articles were reviewed to see if they fulfilled the data demand or not. Twenty articles were chosen from those collections, the remaining articles did not fulfill the requirement. Eleven of the nineteen articles were in the subject of anthropometrics, five in the field of body compositions, and the rest four were in the topic of somatotypes. Outcomes from the twenty papers covered during the various morphological characteristics in artistic gymnastics. These morphological characteristics systematically discussed in this review under subtopics.

IV. Discussion

4.1 Anthropometric measurements

Previous study [4] showed there is a positive relationship between percentage variables of anthropometric length in men world gymnasts with final score. Anthropometric factors have an 11.6% effect. The percentage of body parts with height is seen to be 96% connected to the effect, but the association with the value is only seen to be 11.6% of its effect to be seen and can be predicted.

Table 01 shows the revised equations and related r^2 values for least squares best fits of linear and polynomial regression equations. The overall trend does not appear to be a straightforward linear connection across time. Age, height, mass and BMI have all risen since the most recent Olympic Games. Also, the general curve of body size trends may be seen in the Olympic team final placement ranks to some extent [7].

Table 01 : Updated linear and second-order polynomial regression equations for individual gymnast data on each variable with Olympic Games year. [7]

Variables	Linear equation	r^2	Second-order polynomial equation	r^2
Age (yr.)	y = -0.059x + 18.58	0.06	y = 0.029x2 – 0.558x + 20.077	0.30
Height (cm)	y = -0.5078x + 158.96	0.29	y = 0.1048x2 – 2.8886x + 164.31	0.50
Mass (kg)	y = -0.3363x + 49.407	0.13	y = 0.1804x2 – 3.0428x + 58.606	0.74
BMI	y = -0.3363x + 49.407	0.00	y = 0.0504x2 – 0.8584x + 22.207	0.81
Rank	y = -0.5231x + 8.5654	0.78	y = 0.0428x2 – 1.2467x + 10.66	0.86

In additionally leg anthropometric parameters such as joint diameters, circumferences, and skinfold thickness did not differ substantially by body side, but found some significant variations in arm features [8]. It is possible to maximum 1.2 cm difference anthropometric measurements in relation to their chronological age, because sub-elite gymnasts were somewhat older chronologically than non-elite gymnasts were. In contrast, in the other age groups and competitive levels values were very similar [9].

4.1.1 Body height

The proportion of the length of the worldwide gymnast's parts of the body to height changes with each apparatus in the artistic gymnastics. This demonstrates that the proportion of gymnasts in each apparatus varies. According to certain morphological experts, gymnasts have similarities and variances that impact their motions [4]. Female and male artistic gymnasts' mature height is not compromised by intense gymnastics training at young age [10].

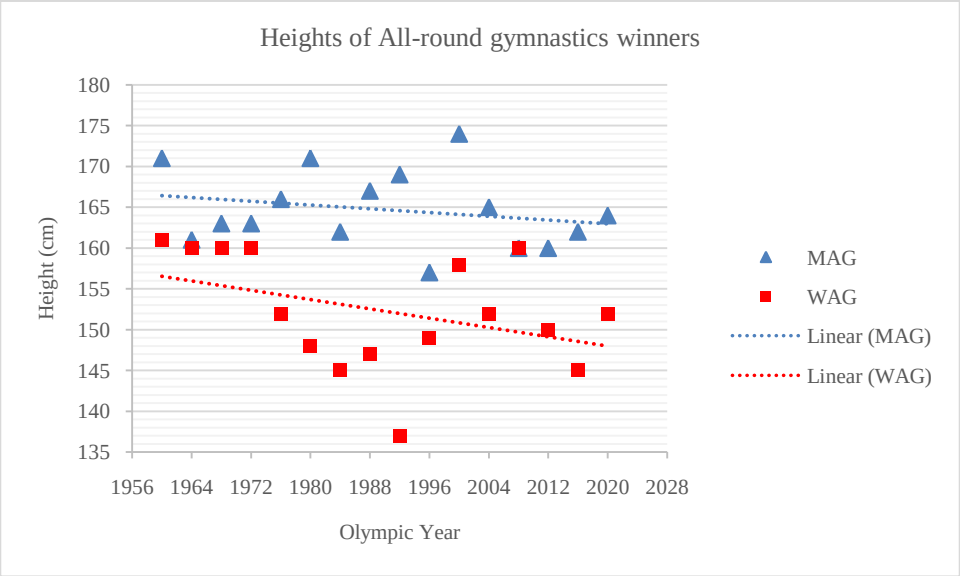


Figure 01: Height of all rounding MAG and WAG champions. [11]

According to Figure 01, Olympic MAG all rounding gymnastic champions have greater height than WAG all rounding gymnastic champions. There is a decrement in weight when it compares to year from1960 to 2020, but the WAG's reduction speed of the height is higher than MAG.

More researchers and coaches said shortest gymnasts have high chance to win in artistic gymnastic competitions. Because of body, awareness is more important to perform in gymnastics routine. Body awareness highly affect to performance in the apparatus with covering all composition requirements and connection values. It corrects with the sports biomechanics. Nevertheless, in 2020 Tokyo, tallest Belgium women artistic gymnast who has 1.70m height, broken that theory by wining gold medal in uneven bar event.

Although physical characteristics differ amongst excellent gymnasts at the highest and lowest levels. The best performers have a shorter length development as seen by a smaller height [6]. Brazilian female gymnasts from the sub-elite level were smaller than those from the non-elite level [9]. Prior article [12] recognized the growth speed of height recorded in consecutive controls and the percentage that reflects the height achieved in relation to the final adult size.

Table 02: Descriptive statistics of body height differences of the gymnasts, between the years of 2000 & 2015. [13]

Event	FX		PH		SR		PB		HB	
Year	2000	2015	2000	2015	2000	2015	2000	2015	2000	2015
Mean	166.85	170.16	168.94	171.65	163.03	167.37	165.85	168.68	170.79	171.65
SD	5.01	7.08	5.45	7.91	4.16	6.34	4.69	5.82	5.91	6.78
N	19	20	17	22	9	18	13	20	16	21
p(t-test)	0.102		0.234		0.076		0.154		0.693	

Previous research of [13] recognized According to the averages for each event and overall, there was no significant difference in height [p(t-test) > 0.05] (Table 02). Gymnasts are taller in 2015 than they were in 2000, and the variability is greater in 2015. The proportion between the tallest and shortest gymnasts is the most significant. The shortest gymnast in 2000 was 157.4 cm tall in 2015, there were two gymnasts who were barely 150 cm tall. Gymnasts on the high bar have been the tallest in both years, with 185.5 cm in 2000 and 183 cm in 2015. In 2000, the height gap between the tallest and shortest gymnast was 28.1 cm and in 2015, it was 33 cm.

Gymnasts are always shorter and lighter than the general population, with the exception of those who specialize in VT and FX, where the lower limbs are very essential. Gymnasts' peak height velocity increases in subsequent years, although being slower than that of the reference individuals before peak height velocity [14]. Previous study [15] has shown different Olympic Games do not affect the height of the body over time, certain differences among female gymnasts are noticeable.

4.1.2 Body weight

In generally gymnasts were a little taller and heavier. Because, some of the variables show significant changes, with gymnasts in the year 2000 having a lower knee diameter, skinfold thickness of the triceps brachial, a larger circumference of the thigh, and a relaxed upper arm. The gymnast's body is probably optimal by size presently, although there are some clearly visible variations in mass proportion [8].

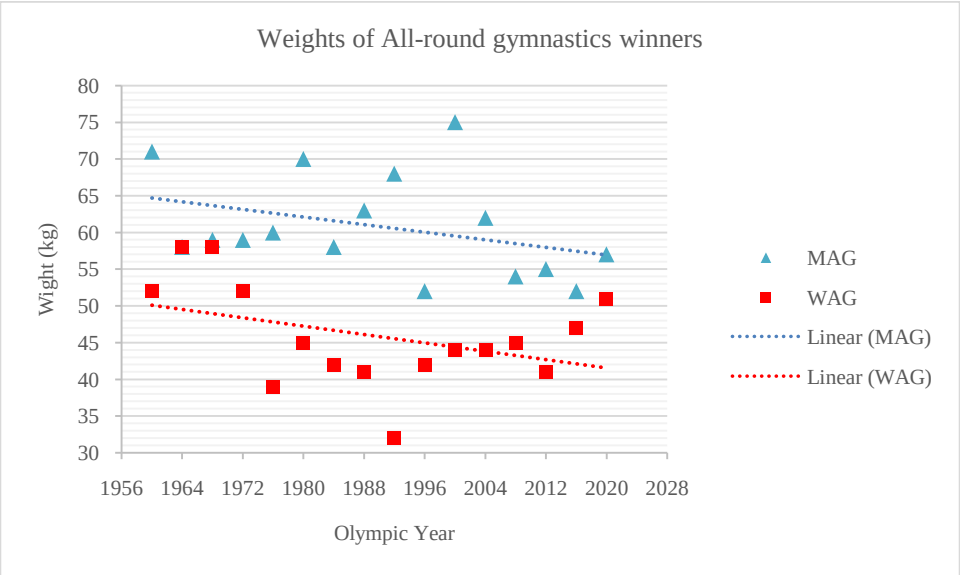


Figure 02: Weight of all rounding MAG and WAG champions. [11]

According to Figure 02, Olympic MAG all rounding gymnastic champions have higher weight than WAG all rounding gymnastic champions. There is a decrement in weight when it compares to year from1960 to 2020.

With the gap in time, there are noticeable changes in the average body weight of female gymnasts. Though, over a previous twenty year period and also, there is no significant change in average body weight in male gymnasts [15].

Although, Female gymnasts' real body weight was lower than the ideal body weight [16]. Previous article of [9] showed Brazilian female sub-elite gymnasts weight less than non-elite gymnasts. Same as the top-ranked gymnasts have a smaller stature and weight less than middle-ranked gymnasts [6].

Table 03: Relationship between height and weight MAG and WAG. [3]

Variables	MAG Body height-weight	WAG Body height-weight
Person correlation	0.712	0.755
Sig. (2-tailed)	0.000	0.000
N	94	97

Prior research of [3]shown the correlation coefficient (Table 03) among body height and body weight for MAG is r =0.712 and for WAG is r =0.755 is statistically significant at the p<0.01 level (2-tailed), indicating a linear positive correlation (Figure 03).

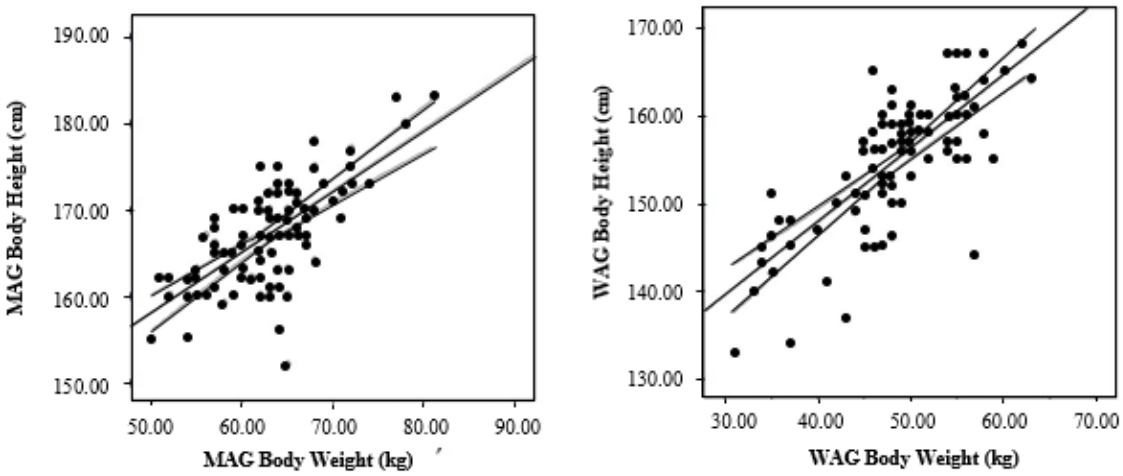


Figure 03: Linear correlation in scatter plot body height and weight MAG and WAG. [3]

4.1.3 Body Mass Index (BMI)

Gymnastics is an artistic activity that needs grace and elegance of gymnasts with a low proportion of fat tissue. Therefore, gymnasts have a lower BMI than the general population [1]. Although, the existing researches has many problems in gymnast's BMI may be higher than general population, because of the high muscle mass, bone density and the less body height of gymnasts than general population.

BMI calculate using height and weight. The height is not much varied between general population and gymnasts, but body mass has a significant difference between general population and gymnasts. Because of general population has a general fat free mass and high fat mass. Although gymnast has high fat free mass and less fat mass. Therefore, gymnast's body mass greater than general population. As the difference of body composition between general population and gymnasts, BMI value good for measure the general population's healthy level, but we cannot use it to measure gymnast's healthy level.

Through the 1980s and early 1990s, American gymnasts were growing smaller. The most recent trend is an increase in height, mass, age, and BMI. In line with the notion that smaller gymnasts had an advantage, Pearson correlations and polynomial regression studies between the games and height, mass, age, and BMI revealed that as U.S. gymnasts got smaller, their performance improved [7].

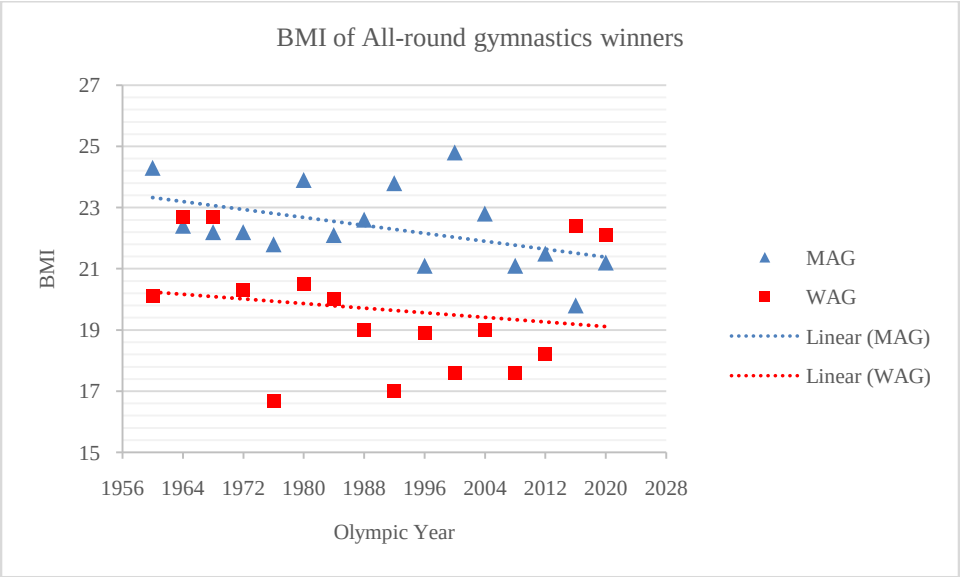


Figure 04: Variation of BMI between MAG and WAG all rounding champions. [11]

Above graph (Figure 04), shown Olympic MAG all rounding gymnastic champions have greater BMI value than WAG all rounding gymnastic champions. Also the BMI value lover with the period from 1960 to 2020.

4.1.4 Skinfold thickness

Physical characteristics differ amongst excellent gymnasts at the highest and lowest levels. The best performers have a shorter length development as seen by a less subcutaneous fat with smaller skinfold measurements [6]. Prior research [12] suggested as the skinfolds of the lower limbs, anterior thigh, and medial leg are reduced, whereas the subscapular skinfold increases. Though, the biceps and supra spinal skinfolds are the most stable. This pattern is seen among male gymnasts aged 14 to 22.

Nevertheless, previous article of [8] shown male gymnasts overload their dominant arm, which results in a larger elbow diameter, more circumference of forearm muscles, and a larger skinfold, but no changes in any of the leg characteristics between the left and right sides.

Table 04: Descriptive statistics and t-test of the skinfold thicknesses. [8]

Variables	Left side		Right side		p(t-test)	Sig.
	Mean	SD	Mean	SD		
Skinfold thickness of Biceps brachii (mm)	3.26	0.51	3.10	0.45	2.050	0.047*
Skinfold thickness of Triceps brachii (mm)	4.63	1.03	4.94	1.19	-3.407	0.002*
Skinfold thickness of Forearm - volar (mm)	3.40	0.72	3.43	0.69	-0.483	0.632
Skinfold thickness of Thigh - ventral (mm)	7.22	2.04	7.03	1.74	1.143	0.260
Skinfold thickness of Calf (mm)	5.01	1.31	4.88	1.27	1.261	0.215
Wrist diameter (cm)	6.04	0.36	6.08	0.37	-1.706	0.096
Elbow diameter (cm)	6.79	0.41	6.86	0.43	-2.808	0.008*
Knee diameter (cm)	8.79	0.54	8.78	0.54	0.333	0.741
Ankle diameter (cm)	6.94	0.59	6.90	0.65	1.397	0.170
Circumference of forearm (cm)	27.78	1.49	28.09	1.53	-3.069	0.004*
Circumference of relaxed upper arm (cm)	33.15	2.12	33.26	2.16	-0.896	0.376
Circumference of thigh (cm)	54.07	2.84	54.02	2.85	-0.640	0.526
Circumference of calf (cm)	35.50	1.87	35.55	1.88	-0.339	0.736

According to Table 04, there is a significance difference between left and right side in skinfold thickness of triceps brachial and biceps brachial, elbow diameter and circumference of forearm [8].

4.1.5 Circumferences, Segment Length and Ratios

Previous research [1] has recognized the shoulder width of gymnasts is much greater than the width of the hips. To young gymnasts, the androgenic index, or the ratio of hip width to shoulder width, is 1.23. Gymnastics participants had larger anthropometric measurements than the general population of the same age.

In terms of growth and development patterns, shoulder and hip width increase during childhood, but the ratio of acromial to crystalline distance remains constant, with a little increase from 6 - 11 years of age.

Using patterns of experience, mesomorph, lower limb index, pelvic-acromial index, and relative HGSmax, the optimized PNN model classified the ten top all-around gymnasts and the remainder of the group similarly. The predicted best ten all-around group has a low odds ratio compared to the rest of the group [5]. The proportionality profile also shows higher development of the scapular belt and the ribcage, but less development of the pelvic band [12].

Previous research of [4] shown the proportion of the length of the international gymnast's body segments to their height changes according on the MAG event. This indicates that each Apparatus has a varied proportion of gymnasts (Table 05). According to popular belief, gymnasts with comparable morphology have similarities and variances that affect their movements.

Table 05: Description of percentage of the body segments to world gymnasts' body height each apparatus. [4]

Variables	FX	PH	PB	HB	SR	VT
Height(cm)	166.0	168.0	166.85	168.92	164.69	162.12
Head (%)	14.67	14.23	13.28	11.95	12.34	13.62
Neck (%)	4.32	4.69	5.05	5.50	4.71	4.26
Body (%)	54.36	55.36	55.33	57.25	55.48	52.80
Upper arm (%)	17.31	14.67	16.34	15.66	12.29	16.99
Forearm (%)	15.00	14.23	15.03	14.85	15.17	15.19
Thigh (%)	29.60	29.77	29.25	30.33	29.60	28.10
Leg (%)	26.53	26.00	26.33	26.60	25.95	26.31
N	32	26	27	26	23	16

Although reduced growth of gymnasts' upper and lower body segment lengths has been defined, the data cannot be linked to training. Individual differences in technique and teenage maturation complicate observations in short-term longitudinal studies. Sitting height/standing height ratios in numerous samples of elite artistic gymnasts intersect with youth reference values, indicating no variations leg length [10]. Previous study [6] showed physical characteristics differ amongst excellent gymnasts at the highest and lowest levels. The best performers have a shorter length development as seen by a having narrow limbs as smaller forearm length and lower leg length.

4.2 Body composition

Gymnastsize looks to be more of an optimization challenge than a minimization problem. The best results for the United States Olympic Team were achieved when the teams were not the smallest, lightest, or leanest, but were higher than the lowest recorded numbers. Female Olympic gymnasts have traditionally been tiny, although they have recently grown in size [7]. Previous article [17] has shown significant variations in muscle mass and body fat percentages, with infantile gymnasts showing less body fat and higher muscular mass, putting them at an energy and biomechanical disadvantage. Body fat percentage was adequate for exercise and muscle mass was high.

Table 06: Comparison of the body composition of MAG and WAG. [18]

Variables	MAG		WAG	
	Mean	SD	Mean	SD
Muscle mass(kg)	33.08	3.53	21.07	3.38
Fat mass(kg)	7.44	1.57	7.55	2.73
Fat-free mass(kg)	57.74	5.78	38.12	5.77
Fat %	11.39	2.08	15.84	3.79

Previous research of [18] shown in Table 06, male gymnasts have higher muscle mass and fat-free mass than female gymnasts, but also female gymnasts have higher fat mass and fat percentage than male gymnasts. A mesoectomorphic qualitatively detecting moderate muscle-skeletal development, relative moderate linearity, less volume per height unit, and low relative adiposity with low subcutaneous fat [17].

Prior article of [13] showed, gymnasts who compete on the FX presently have a greater proportion of muscle mass, whereas gymnasts who compete on other apparatus have a lower percentage of muscle mass and tend to be taller, with a lower percentage of body fat and muscular mass. Although, Gymnasts who have a lower proportion of body fat, a lower percentage of muscle mass, and a sustained body weight have a greater percentage of bone mass and a higher percentage of inner organ mass. The large volume of specific physical activity contained in their training affects gymnasts' body composition characteristics. Gymnasts have lower

body fat percentage and visceral fat levels that are below average to extremely below average, and higher skeletal muscle mass percentage values that are above average or really above average [19].

4.3 Somatotypes

There is still a body build difference between more successful and less successful gymnasts performing at the top level, and it is likely that the selection factor plays a major role in this difference [6]. The mesomorph somatotype was found to be the most common in female gymnasts [16].

The somatotype was 2-3.4-2.9, categorized as mesoectomorphic, which corresponds to study, with low endomorph, mesomorph, and ectomorph somatotypes [17]. Physical characteristics differ amongst excellent gymnasts at the highest and lowest levels. Previous research [6] has shown the best performers have a shorter length development as seen by a lower endomorphic component. Mesomorph was the most important somatotype component among all age groups. Although, elderly non-elite gymnasts preferred endomorph, or relative fatness. Gymnasts' general body proportionality characteristics were equivalent across all age groups and competitive levels [9].

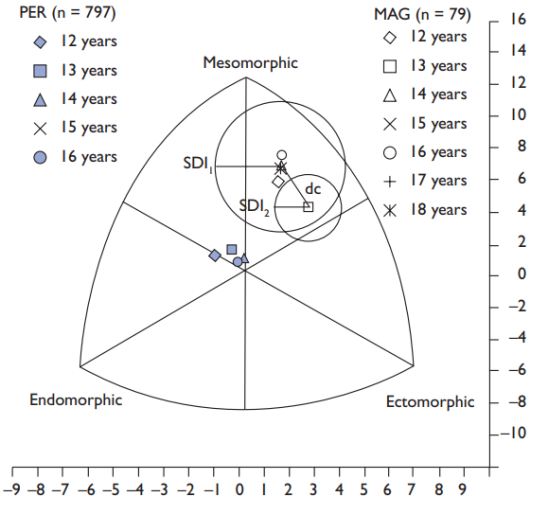
Table 07: The somatotype of Female Artistic Gymnasts. [18]

Variables	Ectomorph	Mesomorph	Endomorph
Mean	2.52	5.20	1.84
SD	1.04	0.63	0.67
Minimum	0.86	3.92	0.96
Maximum	4.44	6.12	3.09

Prior article [18] recognized the predominant somatotype among Brazilian male gymnasts is the balanced mesomorph (Table 07). The balanced mesomorph was found in 48% of the gymnasts analyzed, Endomorphic mesomorph in 33%, and Ectomorphic mesomorph in 19%. It is worth mentioning that mesomorphism was dominant in 33% of gymnasts categorized as Endomorphic mesomorph, yet endomorphism was larger than ectomorphism. In addition, Ectomorphic mesomorph made up 56% of the female Brazilian gymnasts analyzed, Endomorphic mesomorph made up 25%, Mesomorphic ectomorph made up 13%, and Ectomorphic mesomorph made up 6%.

Despite the fact that the somatochart shows that gymnasts' mean somatotype at age 13.2 0.4 is ectomorphic (Figure 05), no significant differences were identified between any of the ages studied ($p>0.05$). The lack of major variations ($p\leq0.05$) between the endomorphic, mesomorphic, and ectomorphic components shows that the gymnast's somatotype is relatively stable over time. [14].

Therefore, gymnasts' somatotype and body composition remain consistent over the whole age range studied. The variations between the reference sample and the gymnasts are evident immediately [14]. The significant somatotype homogeneity of Italian gymnasts shows the need of a certain morphology to attain high levels in artistic gymnastics, and as a result, it might provide trainers with important information to direct training protocols. Gymnasts, regardless of age or level of competition, have a unique somatotype, highlighting



the necessity of introducing somatotype analysis [20].

Figure 05: Distribution of the mean somatotype of Spanish gymnasts (MAG) and the reference sample (RSP) in the somatochart. [14]

Data origin included in this systematic review: Author, Sample size, Age, Morphological characteristics, and Results.

Author & Year	Sample size (n)	Age (years)	Morphological characteristics	Results
A. L. Claessens and R. Malina 2000	n = 165 Caucasian (n=126), Asiatic (n=27), Negroid (n=4), mixed race (n=7)	Mean age of 21.9 ± 2.4	Somatotypes Ponderal index, Skinfolds	There was no significant difference in somatotypes between Asiatic and Caucasian gymnasts. Although, there was a difference of body build between more and less successful in sport.
A. I. Amigó, A. B. Faciabén, M. M. Evrard, P. a. G. Ballarini, and M. C. Marginet 2009		7 - 25	Height, Weight, Somatotypes, Body composition	Growth pattern of gymnasts were general, but gymnasts are lighter and shorter than Spanish general population in early age.
I. Cuk, M. B. Pajek, B. Jakse, J. Pajek, and M. Pecek 2012	n = 40	Mean age of 23	Joint diameters, Circumference, Skinfold thickness	According to the body side, there was not a different in lower limbs, but there was a slight difference in upper limbs with case of single arm overload.
M. Massidda, S. Toselli, P. Brasili, and C. M. Caló 2013	n = 64 elite gymnasts Male (n = 22) Female (n = 42)	Males 18.6 ± 5.0 Females 13.4 ± 2.5	Height Weight Somatotypes	Females' height and weight were less than males, but no difference in somatotypes between male and female Italian gymnasts.
A. Poblano-Alcalá and D. Braun-Zawosnik 2014	n = 24 female gymnasts	7 - 12	Height, Weight, BMI, Skinfold thickness, Somatotypes, Body compositions	The female gymnasts' real body weight less than their ideal body weight according to their low amount of carbohydrate and calorie intake. Identify significant difference in energy availability and body composition among different somatotypes.
J. A. Ferreira and F. J. Fernandes 2015	n = 46 male (n = 21) female (n = 25)	Male 20.3± 3.41 Female 17 ± 4.66	Somatotypes, Body composition	Ectomorphic mesomorph characterized somatotype profile of the gymnasts. Mesomorph was dominant somatotype and ectomorph was greater than endomorph in gymnasts.
A. S. Canda 2016	n = 2 male gymnasts	Infant 14, Senior 22	Weight, Height, Sitting height, Arm span, Nine breadths, Eleven girths, Eight skinfolds	Body mass gain with the incensement of lean tissue mass in relation to height and skinfold thickness changed with decreasing upper body and increasing lower body subcutaneous fat. Nevertheless, height did not change with training.
K. Šibanc, M. Kalichová, P. Hedbávný, I. Čuk, and M. B. Pajek 2017	n = 40 male	17 - 30 (average 23 years)	Height, Weight, Five circumferences, Eight skinfolds, Four diameters	During 15-years, there was a tendency of weight gain by increasing bone mass and other inner organs of taller one's. Also, muscle mass and fat mass have lower effect to body weight, but had a tendency to increase body height, less percentages of muscle and fat masses.
A. Aleksić-Veljković, K. Ž. Marković, L. Milčić, M. Veljković, and M. Možnik 2017	n = 47 female	8 - 12	Height, Weight, Foot diameter, Segment length	A strong relation between anthropometry and final BB score can be established using the multiple correlations coefficient.The predictor variables explain the remaining and entire variance influenced by unknown factors.
W. A. Sands, S. R. Murray, J. R. McNeal, C. Slater, and M. H. Stone 2018	n = 116 female	14.0 - 23. 3	Height, Weight, BMI	The correlations and the polynomial regression analysis between the Games and height, mass, age, and BMI revealed that as US gymnasts smaller, their Olympic Games final team position increased.
A. Pineda, J. López, C. Martínez, and M. Medina 2018	n = 13 female elite gymnasts	Mean age of 14.9	Somatotypes	Elite female gymnasts have a mesoectomorphic somatotype and differ psychological profile.
S. Bacciotti, A. Baxter-Jones, A. Gaya, and J. Maia 2018	n = 249 female gymnasts	9 - 12	Anthropometry, Somatotypes	The presence of a typical gymnast's physical prototype throughout age and competitive level, which can be helpful to coaches during team selections.
A. No 2018	n = 191 (n = 97 WAG, n = 94 MAG Olympic gymnasts)		Body height, Body weight	Correlations between body height and weight are (MAG: R=.712; p<0.01) and (WAG: R=.755; p<0.01), corresponding. Morphology of elite level gymnasts is important to selections and specialization.
R. B. A. Putra, H. Pramono, T. Nurharsono, and C.	n = 150 male		Height, Segment length	There was a positive correlation between percentage variables, anthropometric length proportion world MAG, with final score.The

Yuwono 2019				influence of anthropometric variables is 11.6%.
K. Sterkowicz-Przybycień, S. Sterkowicz, L. Biskup, R. Zarów, Ł. Kryst, and M. Ozimek 2019	n = 53 male gymnasts (n = 19 senior, n = 34 junior)	12 -24	Height, Weight, Skinfold thickness, Somatotypes, Body compositions	Agymnastwith adequate experience and a mesomorphic somatotype component can achieve a high skill level in all-around events at a national competitive level.
P. Kutac, S. Jurkova, and R. Farana 2019	n = 668 females (n = 16 gymnasts, n = 652 general population)	8 - 12	Height, Weight, Body composition	Gymnasts in the youngest competition category differ from the general population in basic anthropometric characteristics.
A. Atikovic 2020	Male and female the Olympic gymnasts (from 1996 to 2016 Olympics)		Body weight, Body height	Over a 20-year period, there were significant differences in body weight and height of WAG. However, could not in MAG.

V. Conclusion

Many researchers conducted scientific studies on artistic gymnastics to discover more about the science surrounding the morphology characteristics in gymnasts and the correlation of morphology and artistic gymnastics, although there are still significant limits and common problems to apply the morphological predictions to artistic gymnastics. Gymnasts' body segments are always moving from one position to another in artistic gymnastics. Different training approaches and a lot of repetition of the elements to enhance gymnast's capacity of control one's own body during routines, therefore morphology is also important to enhance performance through the approaches.

Mesoectomorphic somatotype with less fat mass, high muscle mass body compositional and less body height, high body weight, less skinfold thickness of anthropometric measurements are the common morphological characteristics in artistic gymnasts. Although, with the age, genetic, puberty, maturation, nutrition, psychology and training variations gymnasts' morphological characteristics can be changed.

A single morphological characteristic in a gymnastics discipline that has a significant influence on the overall performance and results. The identification and analyzing the performance by a scientist or an analyzer but, also coaches and gymnasts can choose suitable events and predict the performance through morphological characteristics. Few morphological characteristics may be a more effective way to modeling artistic gymnastics performance development. Then the coaches should be aware of these particular characteristics in effort to improve talent identifying and gymnast performance development.

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