GYMNASTIC PERFORMANCE
AS RELATED TO ANTHROPOMETRIC
AND SOMATOTYPE CHARACTERISTICS
IN MALE GYMNASTS

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Abstract: *The purpose of this study was to investigate the relation between body type characteristics and performance in male gymnasts of outstanding level. During the 24th World Championships Artistic Gymnastics, held at Rotterdam 1987, 165 male gymnasts were investigated. In total 19 body dimensions were measured and somatotype was anthropometrically determined according to the Heath-Carter technique. To investigate the relationship between physique and performance, the gymnasts were divided into three level categories (n varied between 20 and 22 for each group) on the basis of the final ranking scores obtained during the competition: lowest level (performance scores varied from 98.25 to 106.0); middle level (performance scores varied from 111.20 to 113.00) and highest level (performance scores varied from 115.05 to 117.00). Differencees between groups were analysed by means of an analysis of variance and Duncan's a posteriori tests. Results indicated that significant differences between group means were found for height, sitting height, leg lenght, forearm length, humerus and femur widths, biceps, triceps and calf skinfolds, weight, and the endomorphy component. The lowest level category obtained in general higher mean values on these variables in comparison with the middle and the highest level categories. It was also demonstrated that the gymnasts of the lowest level group were significantly younger than the gymnasts of the other two level groups with mean chronological ages of 20.46, 21.80 and 22.13 years, respectively. It can thus be stated that, even on the highest level of gymnastic competition, a significant differentiation in body build between placers and non-placers can be observed, indicating that physical characteristics are to some degree selective parameters for top level artistic gymnastics.*

Key words: *Anthropometry; Somatotype; Gymnastic performance; Males*

Introduction

It is a well-known fact that top sportsmen and women have a different physical build to the average population, and also that there are physical differences between athletes practising different sports and/or different events within a particular sport (Carter 1984). Studies of Olympic gymnasts (Carter et al. 1982) and other world-class gymnasts (Claessens et al. 1991) show that compared to the average population, these athletes have a smaller lenght development and a thinner build, with less subcutaneous fat. Although they have smaller circumference measurements in absolute terms, leading gymnasts tend to have developed relatively large muscles. It is clear that there are a variety of reasons for this differentiation, including selection and training. However only sporadic research has been carried out concerning the question whether there is still a relation between body constitution and highly skilled gymnastic performance within the outstanding male gymnasts and so far, only a limited number of variables such as age, height and weight (Carter et al. 1971, Gajdos 1984; Lopez et al. 1979) and somatotype (Carter et al. 1971, Lopez et al. 1979) have been examined. These studies show that, generally speaking, top-ranking gymnasts have a smaller stature and weight less than middle-ranking ones, and are more likely to be mesomorphic and less likely to have an endomorphic and ectomorphic somatotype. The purpose of this study was to explore the relationship between physical build and artistic gymnastic performance in top international gymnasts.

Material and Methods

A total of 165 gymnasts were examined during the 24th World Championships Artistic Gymnastics, held in Rotterdam, the Netherlands, from 18 to 25 October 1987. The subjects came from a total of 35 different countries. Most of them were Caucasian (n = 126); the others were Asiatic (n = 27); Negroid (n = 4) or mixed-race (n = 7). Their average age was 21.9 ± 2.4 years, varying from 16.0 to 28.6 years. A total of 19 body measurements were taken (see *Table 1*). Subject's somatotypes were also determined using Heath-Carter's anthropometric technique (Carter & Heath 1990). The somatotype ponderal index (= height/weight**1/3) and the total of three skinfolds (Triceps + subscapular + suprailiac) were also calculated. For a detailed description of these measurements and the procedures used for this project, reference is given to Claessens et al. (1991). In order to examine the relationship between performance and physical characteristics, three separate groups were set up based on the total points the gymnasts achieved in the free and compulsory events (max. points = 120) during the World Championships: (1) a lowest level group (n = 20) with a points total between 98.25 and 106.00; (2) a middle level group (n = 20) with a points total between 111.20 and 113.00; and a highest level group (n = 22) with a points total between 115.05 and 117.10. The differences in body dimensions and somatotype between the three groups were examined using an analysis of variance and Duncan's a posteriori tests.

Results

The results of the analysis of variance for the physical characteristics and the somatotype components for the three groups are shown in *Table 1*. This shows that gymnasts belonging to the lower level showed significantly greater figures for all lenght measurements than those in the middle and highest level groups. Between these two latter groups, however, there was no significant difference in lenght development. In terms of height, for example, the lower-ranking gymnasts were on average 6.5 cm taller than the higher-ranking. In terms of width measurements, only significant differences were found for the humerus width (p < 0.05) and the femur width (p < 0.01), with the lowest level group showing the highest average values of 7.2 cm and 9.5 cm, respectively. Although this group also had broader shoulders and hips, these measurements did not differ significantly from those of the two other grooups. All skinfold measurements were on average higher for group 1 than those of groups 2 and 3. The biceps skinfold and the sum of skinfolds were significantly (p < 0.05) higher in the lowest level group compared with the highest level group, but neither differed significantly from the average of the middle level group. The lower-ranking gymnasts also showed significantly higher skinfold measurements for the triceps (p < 0.05) and calf (p < 0.01) than the middle-ranking and higher-ranking groups. These differences in skinfold values can also been seen in the significantly (p < 0.05) higher average endomorphic component in group 1 than in group 3, with mean values of 1.7 and 1.5, respectively. Although there were no significant differences in circumference measurements, the lowest level group had smaller upper limb girths (except for the forearm circumference), but larger lower limb circumferences. Finally, the higher-ranking and middle-ranking groups were significantly older (p < 0.05) than the lower-ranking group, with average ages of 21.8, 22.1 and 20.5 years, respectively.

Table 1. **Analysis of differences in anthropometric and somatotype characteristics among three level groups of highly skilled male gymnasts (Data Rotterdam 1987)**

Characteristics	F-value	DUNCAN'S a posteriori test		
Age (years)	3.85*	22.1 (2)	21.8 (3)	20.5 (1)
Weight (kg)	5.21**	66.3 (1)	62.8 (2)	60.5 (3)
Height (cm)	7.11**	170.6 (1)	165.3 (2)	164.1 (3)
Sitting height (cm)	7.27**	90.5 (1)	88.6 (2)	87.1 (3)
Leg lenght (cm)	4.07*	80.1 (1)	77.0 (3)	76.7 (2)
Forearm lenght (cm)	5.94**	25.4 (1)	24.5 (2)	24.0 (3)
Biacr. diam. (cm)	2.07	39.2 (1)	38.3 (3)	38.2 (2)
Biiliac diam. (cm)	0.30	26.4 (1)	26.3 (2)	26.1 (3)
Humerus width (cm)	4.54*	7.2 (1)	7.0 (2)	6.9 (3)
Femur width (cm)	5.30**	9.5 (1)	9.2 (2)	9.0 (3)
Biceps girth (cm)	0.81	34.8 (2)	34.2 (3)	34.2 (1)
Upperarm girth (cm)	1.32	31.7 (2)	30.9 (3)	30.9 (1)
Forearm girth (cm)	0.79	27.7 (1)	27.5 (2)	27.2 (3)
Thigh girth (cm)	1.45	51.5 (1)	51.0 (2)	49.9 (3)
Calf girth (cm)	0.45	34.9 (1)	34.5 (3)	34.5 (2)
Biceps skinfold (mm)	3.29*	3.5 (1)	3.3 (2)	3.1 (3)
Triceps skinfold (mm)	7.22*	6.2 (1)	5.1 (2)	5.1 (3)
Subscap. skinfold (mm)	0.89	7.7 (1)	7.4 (2)	7.3 (3)
Suprailiac skinfold (mm)	0.79	4.1 (1)	4.0 (2)	3.9 (3)
Calf skinfold (mm)	10.84**	5.3 (1)	4.4 (2)	4.3 (3)
Sum skinfolds (mm)	3.28*	18.1 (1)	16.5 (2)	16.2 (3)
Endomorphy	3.24*	1.7 (1)	1.5 (2)	1.5 (3)
Mesomorphy	2.27	5.8 (2)	5.7 (3)	5.4 (1)
Ectomorphy	1.93	2.3 (1)	2.1 (3)	1.9 (2)
Somatotype Pond. Index	1.93	42.2 (1)	41.9 (3)	41.6 (2)

* = $p < 0.05$ / ** = $p < 0.01$
--- = the underlined mean values do not differ significantly
(1) = lowest classified group (N = 20)
(2) = middle classified group (N = 20)
(3) = highest classified group (N = 22)

Discussion

The results of this study show that there is a difference in physical characteristics between the highest and the lowest level world-class gymnasts. The best performers are characterised by a shorter lenght development as seen by a smaller height, sitting height, forearm lenght and lower leg lenght; have narrower limbs, and less subcutaneous fat, with smaller skinfold measurements and a lower endomorphic component. These results largely support the findings of Carter et al. (1971), Gajdos (1984), and Lopez et al. (1979). It is clear that this differentiation is affected by a number of factors, including selection and training. Since intense physical activity should not have any effect on body lenght development (Broekhoff 1986), we believe that the smaller lenght measurements of better gymnasts are due mainly to a process of selection. The relatively thicker layer of subcutaneous fat in less outstanding gymnasts is probably due largely to the fact that they train less frequently and less intensively. The training figures given by the subjects of this study show that the higher-ranking train for significantly ($p < 0.05$) more hours per week than the lower-ranking ones, at 25.4 hours and 19.8 hours, respectively. The training figures also show that the highest level gymnasts began gymnastics an average of one year earlier than the lowest level performers, with mean starting age values of 8.6 and 9.6 years, respectively. If we also take into account the fact that the best gymnasts are also chronological older than the less successful ones (21.8 and 20.5 years, respectively), there is an average difference of 2.3 years in the total time spent involved in gymnastics between the two groups. Another important factor may be the difference in ethnic background between the gymnasts in the different groups. A study by Le Veau et al. (1974) of the differences between world-class Japanese and American gymnasts shows that those of Asian origin are distinctly smaller, with shorter extremities but the same weight, indicating a more highly-developed musculature. But closer analysis of our figures, taking account of the gymnasts' ethnic background, shows that this is not a factor for the observed differences in this study. In fact there was no significant difference in somatic characteristics or somatotype between the 15 Causasian and 6 Asiatic gymnasts in the highest level group (in this group there only was one gymnast of Negroid ethnicity). The results of this study therefore indicate there is still a difference in body build between more successful and less successful gymnasts competing on the highest level, and it is likely that the selection factor plays an important part in this difference.

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