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Somatotype of Elite Italian Gymnasts

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ABSTRACT

The somatotyping method is especially helpful in sports in which the body could directly influence the biomechanics of movements and the performance's results. The purpose of this study was to determine the somatotype of elite Italian gymnasts and to compare it in terms of competition levels. The sample comprised 64 elite gymnasts (42 females (F), somatotype 1.4-4.4-3.2; and 22 males (M), somatotype 1.6-6.3-2.1) belonging to the Italian National Artistic Gymnastic Team (2007) at different competition levels: Allieve, Junior, and Senior. Mean whole somatotypes, by competition levels, were not significantly different in both sexes (Female gymnasts: Allieve, 1.3-4.6-3.3; Junior, 1.3-4.2-3.6; Senior, 1.7-4.2-2.7; Male gymnasts: Junior, 1.5-6.3-2.5; Senior, 1.7-6.3-1.6). Male Junior gymnasts exhibited greater ectomorphy than Senior athletes ($F_{1,20}$=7.75, p<0.01). Compared to other elite athletes male and female gymnasts tend to be less endomorphic and more mesomorphic. This study highlighted the peculiarities of the somatotype of Italian elite gymnasts and their strong homogeneity, evident also from the low values of somatotype attitudinal mean (SAM). The results emphasize the need for a specific somatotype to reach an elite level in sport and the need to integrate the somatotype analysis between the scientific instruments for selecting talent also in artistic gymnastics.

Key words: *anthropometry, artistic gymnastics, somatotype, elite athletes*

Introduction

Understanding and describing the characteristics of elite human performance in sport involve the analysis of the various factors which influence the performance at different levels. Several authors[8,22,25] have shown that elite athletes have distinct characteristics, including anthropometric dimensions, somatotype and body composition.

The somatotyping method is especially helpful in the »aesthetic« sports, such as artistic gymnastics, where the body is the primary element in obtaining high performance scores[16]. In fact, the gymnasts' body could influence the judges' evaluation[5] and the biomechanics of the technical movements[2]. Generally, somatotypes of athletes are quite different from each other[19] and several trends characterizing competitive gymnasts from reference samples are obvious[6]. Most evidence is that, whilst ratings in each of the somatotype components may vary from one sample to another, the relative dominance of components does not[7,12,18]. In female gymnasts the mesomorphy is, usually, the dominant component and ectomorphy is greater than endomorphy[12]. This somatotype is identified as an ectomorphic mesomorph and it differs from those of sedentary female who, typically, tends to be more endomorphic and less mesomorphic[7].

As far as male gymnasts is concerned, they have a balanced mesomorphs somatotype with greater mesomorphy values than those observed in female gymnasts[12].

There are few recent studies selectively focused on somatotype of top-level gymnasts and none has been conducted on elite Italian gymnasts.

The aim of this study was to describe somatotypes of Italian elite male and female artistic gymnasts in the XXI century in relation to competition levels.

Material and Methods

This study investigated the somatotypes of Italian elite male and female gymnasts, who were members of Italian National Artistic Gymnastic Team (2007) in different categories: Allieve (A) (n.23), Junior (J) (Females, n.10; Males, n.13) and Senior (S) (Females, n.9; Males,

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n.9) according to the gymnasts' age and the Italian Gymnastics Federation' rules. The examined samples were representative of the entire groups in terms of competition levels (that included only National, European, World and Olympic medal winners). All athletes included in this study provided informed consent, and the study was approved by the President and the ethics committee of the Italian Gymnastic Federation (F.G.I.). All participants were subjected to anthropometric measurements. The rules and techniques for measuring recommended by the International Working Group of Kinanthropometry, outlined by Ross and Marfell-Jones[27] and adopted by the International Society for the Advancement of Kinanthropometry (ISAK) were followed for each assessment.

The sample comprised 64 elite male and female gymnasts (Females = n.42, mean age 13.4 ± 2.5; and Males = n.22, mean age 18.6 ± 5.0) from Italian origin. Females had been practicing gymnastics for 6.4 years, on average, and their training consisted of 28.2 ± 6.8 hours per week (range 15–42 hours). Males had been practicing gymnastics for 11.0 years, on average, and their training consisted of 26.2 ± 6.2 hours per week (range 15–36 hours).

The following variables were assessed for each subject: stature, weight, humerus and femur widths, arm (flexed) and calf girths and the biceps, triceps, subscapular, supraspinale, and medial calf skinfolds. Skinfolds were taken by means of the Lange caliper. A portable stadiometer (Freestanding Magnimeter, Raven Equipment Ltd, UK) was used to measure height. All measurements were performed twice, and the results were averaged. Technical errors of measurement met the required target levels for within and between measurers: ≤ 5% for skinfolds and ≤ 1% for other measures[1]. All participants were measured by the same trained anthropologist. Height Weight Ratio (HWR), as a ponderal index for calculating ectomorphic somatotype, was calculated dividing the height by cube root of weight, according to procedures used for Heath-Carter somatotype rating. The somatotype was estimated following the Heath & Carter Anthropometric protocol[12].

The special somatotype analysis of variance methods (SANOV) was used to compare the three-dimensional somatotype according to competition level and sex[9]. Comparison of separate components' means were made by univariate analyses of variance using Tukey's HSD test of significance at the $p<0.01$ level. Analysis of covariance (ANCOVA) controlling for age was calculated for each anthropometric variable by level (Allieve, Junior and Senior) and by sex (male and female). If the ANCOVA was significant, univariate F-tests were performed to determine which component contribute to the difference(s). STATISTICA (version 8.0, Statsoft) and Somatotype-Calculation and Analysis (Sweat Technologies) software were used for all statistical analysis.

Results

The descriptive statistics for age, body size and somatotype variables by sex and competition levels are presented in Table I. Overall, the gymnasts' age range was 9–22 years for females and 12–27 years for males. Female gymnasts were, on average, younger ($t=5.54$, $p<0.001$) than male gymnasts. After controlling for age with ANCOVA, females were shorter ($t=7.87$, $p<0.001$) and lighter ($t=9.79$, $p<0.001$) than male gymnasts.

Females had a higher height-weight ratio (stature/body mass$^{-0.33}$) than male gymnasts ($F=23.19$, $p<0.001$). The somatotype attitudinal means (SAM) for each sex did not differ ($t=0.85$). When the whole somatotype means of male and female gymnasts were compared using SANOV, they were significantly different (SAD=2.30, $F=48.24$, $p<0.001$). Univariate analyses revealed no differences in endomorphy ($F_{1,62}=3.99$), but there were differences in mesomorphy ($F_{1,62}=87.22$, $p<0.001$) and ectomorphy ($F_{1,62}=23.61$, $p<0.001$), which were higher in males than in females. The mean somatotype of females

TABLE 1
ANTHROPOMETRIC AND SOMATOTYPE FEATURES FOR ELITE MALE AND FEMALE GYMNASTS BY COMPETITION LEVEL (MEAN ± SD)

	Age (y)	Stature (cm)	Weight (kg)	HWR	Endo	Meso	Ecto	SAM
Female								
Allieve (n=23)	11.7±1.0	139.7±8.1[d]	33.2±5.0[d]	43.5±1.1	1.3±0.2	4.6±0.7	3.3±1.4	0.9±0.5
Junior (n=10)	14.1±0.5	148.4±6.3	38.7±5.8	44.0±1.0	1.3±0.3	4.2±0.6	3.6±0.7	0.8±0.5
Senior (n=9)	17.1±2.0[bc]	153.8±5.6[b]	46.8±5.8[bc]	42.7±0.9	1.7±0.5	4.2±0.8	2.7±0.6	1.0±0.5
All (n=42)	13.4±2.4[a]	144.8±9.2[a]	37.4±7.5[a]	43.5±1.1[a]	1.4±0.3	4.4±0.7[a]	3.2±0.8[a]	1.0±0.5
Male								
Junior (n=13)	15.1±1.7	161.4±11.1	55.7±12.3	42.5±1.1	1.5±0.2	6.3±0.8	2.5±0.8	1.1±0.5
Senior (n=9)	22.4±4.8[e]	169.0±5.7	69.3±4.2[e]	41.1±1.1[e]	1.7±0.2	6.3±0.9	1.6±0.6[e]	0.9±0.6
All (n=22)	18.1±4.9	164.5±9.8	61.3±11.8	41.9±1.3	1.6±0.2	6.3±0.9	2.1±0.9	1.1±0.5

[a] $p<0.01$ for Female versus Male gymnasts; [b] $p<0.01$ for Senior versus Allieve female gymnasts; [c] $p<0.01$ for Senior versus Junior female gymnasts; [d] $p<0.01$ for Allieve versus Junior female gymnasts; [e] $p<0.01$ for Senior versus Junior male gymnasts. HWR = Height Weight Ratio.

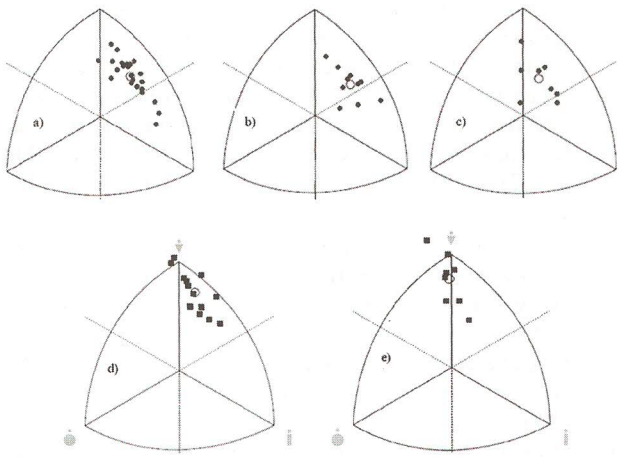

Fig. 1. Somatotype distribution of male and female gymnasts. Female: a) Allieve n=23, b) Junior n=10, c) Senior n=9; Male: d) Junior n=13, e) Senior, n=9; O = Mean somatotypes.

was ectomorphic mesomorph, while those of males fell in the balanced mesomorph category.

Senior female gymnasts were older ($F=60.41$, $p<0.001$) than Allieve and Junior. After controlling for age with ANCOVA, senior were heavier ($F=20.7$, $p<0.001$) than Allieve and Junior. Allieve were lighter and shorter ($F=13.71$, $p<0.001$) than Junior, and Senior were also taller than Allieve ($F=21.91$, $p<0.001$). The height-weight ratio did not differ from the three competition levels ($F=3.23$).

The somatoplots for the three groups are shown in Figure 1. The SAMs for each level did not differ ($F=0.42$) with a narrow range of 0.93–1.16. Therefore, the distributions of the somatoplots about their respective means were very similar in relation to competition level.

The whole somatotype means also did not differ among the three gymnasts' groups ($F=2.38$). All showed a mean somatotype which fell in the ectomorphic mesomorph category. In the three groups, the most frequent category was the ectomorphic mesomorph (Allieve 70%; Junior 50%, Senior 44%), followed by the mesomorph ectomorph (Allieve 13%, Junior 30%, Senior 22%). The 13% of Allieve and 20% of Junior were classified mesomorphic-ectomorph, while 22% of Senior fell into the balanced mesomorph category as the 4% of Allieve did.

Senior male gymnasts were older ($t=8.25$, $p<0.001$) than Junior. After controlling for age with ANCOVA, Junior were lighter ($t=3.16$, $p<0.01$) than Senior.

Height did not differ between the two competition levels ($t=1.08$), while the height-weight ratio was higher in Junior than in Senior ($t=-2.75$, $p<0.05$). The somatoplots for the two competition levels are shown in Figure 1.

The SAMs did not differ ($t=0.18$) and were very similar for each level, and the distributions of the somatoplots about their respective means were also similar. The whole somatotype means also did not differ between the two gymnasts' groups ($SAD=0.93$, $F=3.28$), but the univariate analyses of variance revealed differences in ectomorphy ($F_{1,20}=7.75$, $p<0.01$) that was higher in Junior than Senior gymnasts. The mean somatotype was ectomorphic mesomorph for Junior and balanced mesomorph for Senior.

For Junior the most frequently category was the ectomorphic-mesomorph (69%) followed by the balanced mesomorph (31%), while for Senior gymnasts the most frequent category was the balanced mesomorph, (78%) followed by endomorphic mesomorph (11%) and by ectomorphic mesomorph (11%).

Discussion and Conclusion

This investigation gave indications of interest which will be useful to expand and update the somatotype data on elite gymnasts. In females, the effect of competitive level on the investigated anthropometric characteristics is evident and it can be attributed to a difference in age among the three groups of athletes. Conversely, somatotype differences among the three groups are minima, indicating a strong homogeneity whatever the competitive levels. Therefore, the somatotype significantly characterizes the gymnasts compared to female athletes in other different sports such, for example, tennis and volleyball[23,28]. Most of the examined gymnasts were characterized by an ectomorphic mesomorph somatotype with a trend towards a balanced mesomorph somatotype, especially for senior gymnasts. Our results agree with those described in literature[14]. Female Italian gymnasts showed a greater development of mesomorphy (4.4 *vs.* 3.7) and lower values of endomorphy (1.4 *vs.* 1.8) compared to female gymnasts examined by Claessens and colleagues (13), while the ectomorphic component was similar between the two groups of athletes (3.1 *vs.* 3.2).

Generally, young successful athletes (11–17 years) tend to have a somatotype similar to those of adult athletes in their respective sports[10]. Young athletes have slightly lower values of endomorphy and mesomorphy and tend to be more ectomorphic than adult athletes[4]. The latter component reflects the role of growth in the transition between late adolescence and young adulthood. In our sample we found no significant differences among the three competition levels, though senior athletes were slightly more endomorphic and less ectomorphic than their younger colleagues.

Similar findings are evident among male junior gymnasts, who had higher ectomorphic values than senior athletes. Most of the male gymnasts (57.5%) who participated at the World Championships of 1987[13] were classified as balanced mesomorph, as was true for Italian males. Male Italian gymnasts showed a greater development of mesomorphy (6.3 vs 5.6) compared to gymnasts examined by Claessens and colleagues (13), while ectomorphic and endomorphic components were very similar in both groups (endo: Italy 1.6 vs World 1.5; ecto: Italy 2.1 vs World 2.1, respectively).

Amigo and colleagues[3] showed that in 90% of cases, the individual somatotypes of elite male Spanish gym-

nasts were classified as ectomorphic mesomorph. The Italian male gymnasts examined in the present study showed a mean somatotype similar to those of Australian (1.8-6.2-2.5)[24] and Argentinean gymnasts (1.9-6.7-1.6)[26]. As seen in our sample, the mean somatotype of Argentine and Australian gymnasts fell in the balanced mesomorph region. Italian gymnasts showed a peculiar somatotype versus other elite athletes from different sports, such as, volleyball and karate[20, 21] and, on average, male gymnasts tend to be more balanced mesomorph.

The very low values of SAMs in all gymnasts' groups of both sexes emphasize an important somatotype homogeneity regardless of competitive level.

The difference in the whole somatotype mean between male and female gymnasts could be due to the typical difference in physical structure between genders, but also to the different technical movements performed by gymnasts. In fact, although artistic gymnastics performance shares many similarities between both males and females, it also needs different athletic requirements that favor a particular optimal somatotype. The typical exercise of males consists to perform short routines characterized by a greater development of fat free mass compared to the technical movement of artistic female gymnastics that, conversely, required less development of maximal strength. Our results agree with Carter and Heath's findings[12], although it is important to highlight the greater mesomorphic value of gymnasts in the present study. Compared to gymnasts of 20 years ago[13], the whole mean somatotype of Italian gymnasts was very similar to those of elite gymnasts who participated in the 1987 World Championship, indicating a stability of somatotype as a whole during passage of time. However, when the somatotype components were separately considered, the Italian male and female gymnasts were more mesomorphic compared to gymnasts of 20 years ago, and female Italian athletes also had a lower endomorphy value.

The differences in somatotype components between Italian athletes and gymnasts of 20 years ago has arisen partly due to changes in difficulty levels of males and females prescribed by Code of Points by FIG (International Federation of Gymnastic), expecting gymnasts to generate higher muscle force in all body parts and to perform elements, including more rotation around vertical and horizontal axes which require adjustments in body structure.

Researches on artistic gymnasts somatotype are hardly available on literature, or they are based on old date[17], although is well known the evidence, underscored by Claessens[15], of changes in physical structure of the elite gymnasts from 1960 till today. For example, some data[8,10,13] on mean somatotypes of female gymnasts shows a trend of decreasing endomorphy ratings among international competitors between the Mexico Olympics in 1968 (endo: 2.7) and the World Championships in 1987 (endo: 1.8).

Generally, the biomechanical aspects of gymnastics seem to favor athletes with a linear physical structure, a relatively low endomorphy value and a high mesomorphic development. As for height and weight, differences in somatotype between the gymnasts and the reference sample are evident early and remain evident until adulthood. While it is probable that the genetic component favors some people than others in developing a good physical structure for artistic gymnastics, it is equally probable that selection by coaches, training, and diet are key factors in the development of elite performance[11].

Perhaps the „perfect physique" for every sports does not exist, because other factors are also essential, such as psychological and motivational attitudes, relationship with the coach, methods of training etc. Undoubtedly, however, subjects with a somatotype different from that identified in this research will be less likely to reach a high level in artistic gymnastics[29,30].

Our data will be added to the results of reference for the somatometrical characteristics of elite gymnasts to provide up–to-date values for future research and assessment.

The strong somatotypic homogeneity of the Italian gymnasts suggests the importance of a specific morphology to achieve high level in artistic gymnastic and, as a consequence, it can give coaches useful indication to orient training protocol.

Our results indicate that a peculiar somatotype characterizes gymnasts regardless age and level of competition, suggesting the importance to introduce the somatotype's analysis in the identification and selection process of talents.

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SOMATOTIP ELITNIH TALIJANSKIH GIMNASTIČARA

S A Ž E T A K

Određivanje somatotipa je metoda osobito korisna u sportovima u kojima tijelo izravno utječe na biomehaniku pokreta i rezultata izvedbe. Cilj je ovog istraživanja utvrditi somatotip elitnih talijanskih gimnastičara te ga usporediti u smislu razina natjecanja. Uzorak se sastojao od 64 elitnih gimnastičara (42 žena (F), somatotipa 1.4-4.4-3.2, i 22 muškarca (M), somatotipa 1.6-6.3-2.1) koji pripadaju talijanskom nacionalnom gimnastičkom timu (2007) u različitim razinama natjecanja: Allieve, Junior i Senior. Čitavi srednji somatotipovi, prema razinama natjecanja, ne razlikuju se značajno u oba spola (gimnastičarke: Allieve, 1.3-4.6-3.3, Junior, Senior, 1.3-4.2-3.6; 1.7-4.2-2.7; gimnastičari: Junior, 1,5-6,3 do 2,5; viši, 1.7-6.3-1.6). Muški Junior gimnastičari pokazuju veću ektomorfnost od starijih sportaša ($F_{1,20} = 7,75$, $p<0,01$). U usporedbi s drugim elitnim sportašima, muški i ženski gimnastičari imaju tendenciju biti manje endomorfni i više mezomorfni. Ova studija istakla je osobitosti somatotipa talijanskih elitnih gimnastičara i njihovu snažnu homogenost. Rezultati naglašavaju potrebu da određeni somatotip dostigne elitnu razinu u sportu te potrebu da se analiza somatotipa uključi među znanstvene instrumente za odabir talenata i u sportskoj gimnastici.