

Anthropometric Linear Measurements of Female Athletes in the Italian National Athletic Teams

Medidas Antropométricas Lineares de los Atletas Nacionales Femeninos Italianos

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SUMMARY: Anthropometry is essential to understand the predisposition of an athlete to practice a specific sporting activity, to assess their fitness, and in association with functional parameters, to identify any correlations between their anthropometric profile and their sport performance. Here, we present the anthropometric profiles of athletes of the Italian national teams, who represented Italy in the 2019-2020 competitive season in the following sports: artistic (n=4) and rhythmic (n=12) gymnastics; distance swimming (speciality: 100 m freestyle) (n=14); synchronized swimming (n=10); and basketball (n=6). We also consider a group of sedentary women (n=22) for comparisons. The following anthropometric measurements were taken for each woman: stature; anterior trunk height (i.e., suprasternal-symphysis distance); chest circumference passing through the mesosternal point; biacromial diameter (i.e., akromion-akromion distance); wrist circumference; abdominal circumference passing through the omphalion and the lumbale; hip circumference; height of lower limb (i.e., epitrochanter-planta distance). Height was a selective factor in both basketball, which requires tall athletes, and artistic gymnastics, where in contrast, well-muscled athletes of small stature are required. In aquatic sports, the constitutional habitus is characterized by good development of the upper body compared to the lower limbs. The selection of elite athletes takes place primarily through anthropometric analyses, although other functional and psychological factors also influence their sports performance.

KEY WORDS: Anthropometry; Elite athlete; Sport; Talent.

INTRODUCTION

Professional sport involves the selection of athletes with anthropometric, physiological, and psychological characteristics that are appropriate to the various sports disciplines and/or the role covered within a team. Indeed, the optimal sporting performance for an elite athlete is the result of the combination of various factors: anthropometric, physiological, and motivational (Ripari *et al.*, 2008; D'Anastasio *et al.*, 2019; Ripari *et al.*, 2020). In particular, the anthropometric profile constitutes the basis on which, in general, trainers select the potential future 'sports talents' (Dodd & Newans, 2018; Mitchell *et al.*, 2018; Murr *et al.*, 2018), although anthropometric composition alone is not a determining factor. Indeed, even 'resilience', for example, has its relevance in sporting success (Sarkar & Fletcher, 2014).

This study pursued the following objectives:

1. to make available to the scientific community the anthropometric characteristics of elite female athletes of the following Italian national teams: artistic and rhythmic gymnastics; distance (100 m freestyle) and synchronized swimming; basketball.
2. to compare the anthropometric characteristics to identify those that potentially represent selective traits for identification of promising athletes.

MATERIAL AND METHOD

We examined 46 female Italian athletes from the following national teams and a comparison sample of 22 sedentary subjects (Table I): 4 athletes of the National Artistic

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Gymnastics Team; 12 athletes of the National Rhythmic Gymnastics Team; 14 athletes of the National (distance) Swimming Team; 10 athletes of the National Synchronized Swimming Team; and 6 athletes of the National Basketball Team.

Table I. The female Italian national athletics teams (2019-2020).

National team	Specialty	Athletes	
		(n)	Age range (years)
Gymnastics	Artistic	4	17-19
	Rhythmic	12	17-22
Swimming	Distance	14	17-21
	Synchronized	10	17-22
Basketball		6	20-24

The measurements were carried out during the 2019-2020 competitive season at the headquarters of the sports Federations to which the athletes belonged and at the sports centers where the athletes trained daily. The linear anthropometric characteristics recorded were the following: stature (ST); anterior trunk height (i.e., suprasternal-symphysion distance; sst-sy); chest circumference passing through the mesosternal point (CC); biacromial diameter (i.e., akromion-akromion distance; ak-ak); wrist circumference (WC); abdominal circumference passing through the omphalion and the lumbale (AC); hip circumference (HC); and height of the lower limb (epitrochanter-planta distance; ep-pl). The anthropometric measurements were carried out following the indications of Martin & Saller (1957). ST was measured using a portable stadiometer; diameters were measured with Holtain calipers, to the nearest 1 mm, and a Harpenden (Holtain) anthropometer; circumferences were measured with a Cescorf anthropometric tape, to the nearest 1 mm. Three measurements for the anthropometric variables were performed, with the mean values obtained recorded, and considering at all times a technical measurement error <2% for the measurements.

The reduced number of measurements carried out was imposed by: (a) the reduced availability of the athletes who, coming from various Italian cities, gathered together only a few times a year and only for a few days, and also due to the commitments they had with their sports clubs; and (b) despite the need to carry out non-invasive measurements that required little time, the COVID-19 pandemic interrupted contacts with the athletes starting from the first months of 2020. Considering the small number of athletes belonging to each National Team (each National Team is made up of only a few selected athletes), no comparative statistical analyses were carried out, and the data are summarized using descriptive statistics.

RESULTS

The results of the anthropometric measurements are reported in Table II. In general, these athletes were taller than the sedentary women, with the exception of the artistic gymnasts. Biacromial diameter (ak-ak) and WC were higher in the swimmers and basketball players. The CC was >96 cm in all of the athletes, with the exception of the rhythmic gymnasts, whose mean CC was also lower than that measured for the sedentary women. The distance and synchronized swimmers had greater anterior height of the trunk (sst-sy), while this was smaller in the artistic gymnasts. The mean AC of the sedentary women was higher than the means recorded for all of the athletes. The artistic gymnasts had the highest mean HC, while the rhythmic gymnasts had the lowest. For the mean total height of the lower limb (i.e., epitrochanter-planta distance; ep-pl), the distance swimmers, synchronized swimmers, basketball players and rhythmic gymnasts had values >102 cm, which were lower for the artistic gymnasts and sedentary women (<83 cm).

Table II. Anthropometric measurements of the female Italian national teams and women with a sedentary lifestyle.

Measure	Anthropometric measurement					
	Gymnastics		Swimming		Basketball	Sedentary lifestyle
	Artistic	Rhythmic	Distance	Synchronized		
Number of athletes (n)	4	12	14	10	6	22
Age (years)	18.0±1.2	19.5±1.8	19.2±1.7	19.4±1.9	22.5 ±1.9	20.05±2.3
Height (cm)	150.5±4.5	170.9±1.6	175.1±5.5	170.1±1.6	182.9 ±4.4	161.8±4.1
Suprasternal-symphysion distance (cm)	45.90±2.0	55.7±0.9	67.2±1.7	62.6±0.7	51.9 ±2.2	51.8±1.9
Chest circumference (cm)	99.9±2.8	79.9±0.5	97.7±2.9	97.8±0.9	96.9±4.4	82.4±1.9
Biacromial diameter (cm)	50.5±1.9	46.5±1.1	52.3±1.6	49.4±0.4	57.0 ±2.3	44.7±1.1
Wrist circumference (cm)	14.4±1.6	15.3±0.5	17.2±0.5	14.6±0.4	17.2 ±0.4	14.6±1.2
Abdominal circumference (cm)	85.2±2.1	69.6±0.9	73.9±2.1	70.9±1.1	70.9 ±1.1	97.2±2.6
Hip circumference (cm)	83.2±1.9	65.8±1.3	77.3±1.2	75.1±1.5	75.9 ±3.3	70.4±1.6
Epitrochanter-planta distance (cm)	81.6±1.9	104.2 ±1.0	102.4±2.7	103.2±2.2	107.0 ±4.5	82.4±1.9

Data are means ±standard deviation

DISCUSSION

The anthropometric profile of an athlete is related to sports performance (Norton *et al.*, 1996), and in the youth categories, it can help recruiters/coaches in directing an athlete towards one sport rather than another, or in a team sport, it can help in choosing the right role (Pizzigalli *et al.*, 2017; Sterkowicz-Przybycien' *et al.*, 2019; Bernal-Orozco *et al.*, 2020). According to Cagnazzo & Cagnazzo (2009), athletes with high stature (184–194 cm) are directed towards sports in which height takes on a selective value for sports performance (e.g., basketball, volleyball). Athletes with intermediate stature (181–183 cm) are generally directed towards sports in which height is selective, but not decisive (e.g., swimming, high jump, water polo, pole vault). Athletes with shorter stature (166–176 cm) may have anthropometric characteristics that make them suitable for other sports (e.g., artistic gymnastics). The ST measured in this sample of athletes of the Italian national teams reflects this trend: the basketball players had the greatest ST, the swimmers showed an intermediate ST, and the gymnasts had the lowest ST.

Measurements of WC are used for determination of body size; i.e., an individual's skeletal structure. Among individuals with the same body mass index, WC allows to distinguish those who have a greater corpulence linked to skeletal strength (Cagnazzo & Cagnazzo, 2009). In these national teams, the swimmers and basketball players were the athletes with the greatest skeletal strength. However, if we compare the means of the WC/ST ratio, the differences among the athletes of the different sports disciplines were considerably reduced (from 0.09–0.10). The differences among the WCs, therefore, might partly reflect the differences among the general somatic dimensions of these athletes.

The biacromial diameter (ak-ak) is useful for defining body size and somatotype (Cagnazzo & Cagnazzo, 2009). The highest ak-ak were recorded for the Italian swimmers and basketball players. The data indicate that these sports require athletes with high muscular strength and power. The ratio between ak-ak and height (i.e., shoulder width index = $ak-ak/ST \times 100$) (Facchini, 1988) was highest for the artistic gymnasts (33.5), followed by the basketball players (31.2), the swimmers (distance, 29.8; synchronized, 28.9), and the rhythmic gymnasts (27.3). The sedentary women had a ratio between ak-ak and ST that was only comparable to that of the rhythmic gymnasts (27.6).

In adult individuals, CC is used to assess body size. The CC/ST ($\times 100$) ratio (i.e., the Brugsch and Goldstein Index; IBG) allows classification of athletes as narrow-

chested (IBG >51), medium-chested ($51 < IBG < 55.9$) and broad-chested (IBG >56) (Cagnazzo & Cagnazzo, 2009). The artistic gymnasts and synchronized swimmers had a broad chest; the athletes of the remaining disciplines showed a medium chest. Although in swimmers ak-ak is directly correlated to a greater passive resistance in the water, this same anthropometric parameter combined with medium chest indicates a body trunk that tends to assume an 'egg-shaped' morphology, which improves the gliding through the water (Chatard *et al.*, 1990; Cortesi *et al.*, 2020).

The anterior height of the trunk (sst-sy), like the seated height, is an anthropometric value of primary importance for evaluation of the aptitudes for various sports disciplines (Cagnazzo & Cagnazzo, 2009). A shorter trunk is observed in athletes who practice 'antigravity' sports (i.e., artistic and rhythmic gymnastics, basketball), while it is more elongated in athletes who practice aquatic sports (i.e., distance and synchronized swimming). In these Italian athletes, the sst-sy/ST ($\times 100$) ratio showed the highest values for the aquatic sports (distance swimming, 38.4; synchronized swimming, 36.8), compared to those in the athletes of the other sports here (i.e., artistic gymnastics, 30.5; rhythmic gymnastics, 32.6; basketball, 28.4), which demonstrated that in the athletes involved in water sports had a more developed upper body than lower limbs. On the other hand, in swimming, the torso and shoulders are particularly stressed as the maximum propulsion is provided by the upper limbs; vice versa, in basketball, the athletes tend to be brachicormic; i.e., long limbed.

The height of the lower limb (ep-pl) was similar among the distance and synchronized swimmers and the rhythmic gymnasts, while it was low in the artistic gymnasts, and high in the basketball players. This distribution can be attributed to the different biomechanical and performance needs required during these sporting activities: a high length of the lower limbs would not allow artistic gymnasts to produce rotations and cartwheels with the same speed, as a longer lever can compromise the exercise; while in basketball, long lineal athletes prevail, who are generally characterized by relatively long lower limbs in relation to ST (Cagnazzo & Cagnazzo, 2009).

The gymnasts (both artistic and rhythmic) showed AC that was somewhat greater than HC, while for the athletes in the other sports, HC was greater than AC. In gymnasts, the AC can be a consequence of the functional overload to which the core muscles are subjected (Esteban-García *et al.*, 2021).

Among the anthropometric measures examined, ST appears to be a selective parameter both for basketball, which

requires tall and basically long-limbed athletes, and in artistic gymnasts, who, on the contrary, include athletes of reduced ST who are well-muscled. In aquatic sports (especially in distance/sprint swimming) the constitutional habitus was characterized by good development of the upper body compared to the lower limbs.

The anthropometric measures and indices of these athletes of the Italian national teams tended to differ from those found in sedentary women. With the exception of the artistic gymnasts, the athletes were taller than the sedentary women, and showed longer somatic segment lengths and circumferences (i.e., sst-sy [i.e., anterior trunk height], ak-ak [i.e., biacromial diameter], ep-pl [i.e., height of lower limb], CC), which are generally indicative of good muscle trophism of the shoulders and of the muscles of the core. The differences might be linked to the selection of the athletes carried out on the basis of anthropometric traits by the coaches in the first years of the athletes' sporting activities, to then be accentuated by their more focused athletic training over the years.

In Italy, about 11,198,000 people practice sports within sports clubs of the Italian National Olympic Committee (CONI), which are divided into national sports federations and sports promotion institutions. Considering only the national federations, the number of registered athletes is 4,532,322 (data from CONI; 23 February, 2017, based on "the numbers in sporting practices in Italy"; <https://it.scribd.com/document/361630504/CONI-2017>).

About 200 athletes belonging to the Italian national teams participate in the Olympic Games, and these therefore represent only 0.0045 % of all of the registered athletes who reach this elite level. The anthropometric data of these elite athletes of the female Italian national teams recorded during the COVID-19 pandemic thus refer to <0.0045 % of the sporting population. The anthropometric data analyzed showed that the coaches select the athletes on the basis of their anthropometric profiles and their physical and mental constitutions. Sports performance is not determined only by the anthropometric characteristics of an athlete, but certainly, the anthropometric profile contributes to sports success.

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RESUMEN: La evaluación antropométrica de un atleta es fundamental para conocer su predisposición en la práctica de un determinado deporte, evaluar su estado de forma y, junto a los parámetros funcionales, identificar posibles relaciones entre el perfil antropométrico y el rendimiento. A continuación, presentamos el perfil antropométrico de las atletas de los Equipos Nacionales que representaron a Italia en la temporada 2019-2020 en las siguientes disciplinas deportivas: gimnasia rítmica (n=12), gimnasia artística (n=4), nado sincronizado (n=10), natación (especialidad: 100 m estilo libre) (n=14), baloncesto (n=6). A cada atleta le fueron efectuadas las siguientes mediciones: altura, altura anterior del torso (distancia supraesternal-symphysion), circunferencia torácica en el punto mesosternal, diámetro biacromial (distancia acromion-acromion), circunferencia de la muñeca, circunferencia abdominal a nivel umbilical, circunferencia pélvica, altura del miembro inferior (distancia epitrocantérea-planta). La altura es el factor selectivo en el baloncesto, que exige atletas altas, así como en la gimnasia artística que, al contrario, requiere atletas no muy altas y con una buena musculatura. En los deportes acuáticos, el rasgo característico es un buen desarrollo de la parte superior del cuerpo respecto a la parte inferior. La selección de los atletas de elite se realiza en primer lugar a través de estudios antropométricos, aunque el rendimiento depende también de otros factores funcionales y psicológicos.

PALABRAS CLAVE: Antropometría; Atletas de élite; Deporte; Talento.

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