Morphotypology of high-level weightlifters : Anthropometry and Somatotypy.

Touami A[1]., Mimouni N[2]., Touami M.A[3]

[1;3]Laboratoire de l'Entrainement et de la Technologie, ES/STS Alger ; [2]Laboratoire des Sciences biologiques appliquées au Sport. ES/STS Alger.
[1] alitouami1964@gmail.com ; [2]amir.benak@gmail.com; [3] nmimou@live.fr

ARTICLE INFORMATION

Corresponding author:

Mimouni Nabila
 e-mail: nmimou@live.fr

Abstract

Weightlifting is a discipline where technique and anthropometric characteristics are essential to achieve the best results in competition. This study aims to describe the morphological characteristics of high-level Arab and African weightlifters. We measured anthropometric parameters, calculated physical development indices and determined somatotype using the Heath-Carter method. The aim of this method is to analyze the relationships between body composition and somatotype in high-level weightlifters.

To do this, we used anthropometric methods based on the methodology of the International Society for the Advancement of Kinanthropometry (ISAK), calculated body composition according to Mateigka and physical development indices specific to weightlifters.

Forty-four high-level weightlifters were evaluated using anthropometric methods. We calculated body composition and determined somatotypes.

The results reveal a mesomorphic dominance associated with a high muscle mass, adapted to the explosive strength requirement of the discipline.

I.   Introduction

Weightlifting is a power sport in which morphology plays a crucial role in performance. Athletes must mobilize maximum force in a very short time, which imposes particular requirements in terms of body composition, segmental morphology and biomechanical proportions. Numerous studies have shown that weightlifters are predominantly mesomorphic, with specific adaptations according to weight category (Tanner, 1964). Weightlifting differs from other bodybuilding or fitness disciplines in its unique approach to training. It is based on two main movements:
- The snatch, where the bar is lifted from the ground to overhead in a single movement.
- The clean and jerk, a two-stage movement in which the bar is first raised to the shoulders (épaulé), then propelled over the head (jeté).
Both movements involve the whole body, developing essential athletic qualities.

Carter (2010), insists on the need to observe the best athletes to determine the physical and morphological clues necessary to achieve great performances. A favorable morphology is necessary, as individuals with shorter-than-average arms are better suited to weightlifting thanks to the law of leverage. Short femurs are also advantageous, as they bring the center of gravity of the "athlete-bar" assembly as close to the ground as possible, thereby diminishing the effect of gravity on the athlete. They also enable the athlete to raise the bar more easily during the front squat phase. For a weightlifter, several anthropometric, biomechanical and physiological indices are essential to assess potential performance, monitor training progress and optimize weight categorization. As competitive weightlifting is contested in ten bodyweight categories for men and similarly for women, the anthropometric characteristics of athletes vary considerably. The body composition of weightlifters is similar to that of athletes of comparable body mass in other strength and power sports. However, the shorter body size and limb length of weightlifters offer mechanical advantages when lifting heavy loads by reducing mechanical torque and the vertical distance over which the bar must be moved. In addition, shorter body dimensions coincide with greater average skeletal muscle cross-sectional area, which is advantageous for weightlifting performance (Dafnis Vidal Pérez et al, 2021).

Weightlifting training induces a high metabolic cost. Although dietary records show that weightlifters generally achieve the required daily energy intake, weightlifting weight cannot be considered a risk factor. Body composition is of major interest.

The influence of sporting activity on an individual's body composition has been the subject of much research and has been demonstrated in several studies (Mavroeidi and Stewart 2003).

Physical activity and training programs confer on the human organism a considerable morphological adaptation, affecting bone, lean tissue and fat. Indeed, physical activity is known to influence the amount and distribution of subcutaneous fat (Nindl et al., 1996), while training for certain sporting specialties can induce specific muscle group.

The study by Fry et al. (2006) in the Journal of Strength and Conditioning Research identified body mass index, vertical jump height, relative fat percentage, and grip strength as key variables that discriminate elite American junior men weightlifters. Using discriminant analysis, the researchers found these easily administered field tests could correctly classify 84% of elite and non-elite junior male weightlifters, suggesting their utility as a screening tool. The study suggests that these variables could be used as a practical screening tool to identify talented junior male weightlifters. This approach can aid in player selection and the development of more targeted training programs for weightlifters.

The purpose of the Imran's and al. (2011) study was to compare the somatotypes of Body Builders and Weight Lifters. The data on somatotypes of the subjects were obtained by using the Carter and Heath method, developed by Carter and Heath (1990). The result of the study showed that there was a significant difference between body builders and weight lifters of their endomorph. Weightlifters are tend to have more fat percentage as compared to bodybuilders. There was not much difference found in the mesomorphy status of the bodybuilders and weightlifters but the bodybuilders showed slightly more musculature than the weightlifters and in the ectomorphy status bodybuilders tend to be more ectomorph than weightlifters.

The aim of the study of Ebada Khaled (Anthropometric measurements, somatotypes and physical abilities of junior weightlifters, 2013), is to investigate the contribution ratios of anthropometric measurements and somatotypes and physical abilities as a function to predict the selection of

talented junior weightlifters. The results showed that the anthropometric measurements and physical patterns, body composition and physical abilities contribute in the selection of talented junior weightlifters. And weightlifters talented players are characterized by two types of somatotypes, mesomorph, balanced mesomorph, and mesomorph endomorph. These results must be taken into account by the Weightlifting Federation and trainers to be used as a signal for the selection of talented junior weightlifters. Development, thereby affecting muscle mass (Spenst et al., 1993).

For Dachri and Mimouni (2011), the evolution of sport performance became now nearly impossible to push the records more than the actual biologic limit. The objective of this work is to determinate the somatotypical profile of the African weightlifters of different categories of the weight, through the morphological parameter assessment, and to situate this profile with regard to weightlifters of high level. The African weightlifters morphology define themselves according to three category of the weight (light, mean, heavy). The. Somatotype of algerian weightlifters present the nearer values of African and Arabian weightlifters.

The body composition of weightlifters varies significantly across weight categories, as the biomechanical, metabolic and tactical demands are not the same between a -55 kg athlete and one weighing +109 kg (Durguerian, A. 2017).

If we look closely at the typical differences observed according to weight categories, we find that :

1.   Lightweight categories (e.g. -55 kg, -61 kg men ; -49 kg women) feature low body fat (6-10% for men ; 12-18% for women); high muscle mass in relation to total body weight and somatotypy with dominant mesomorphism and moderate ectomorphic profile (e.g. 2.0-5.5-1.5). This requires rigorous weight control, emphasis on muscle density and excellent relative power. These athletes prioritize relative strength (strength per kg of body mass) and must maintain an optimized body composition to remain in their category.

2.   Intermediate categories (e.g. -73 kg, -89 kg men) : These athletes are characterized by moderate body fat (8-12%) and well-developed muscle mass, particularly in the trunk, shoulders and thighs. They have a pure or mixed mesomorphic somatotype (e.g. 2.5-6.5-0.9). This gives them a good balance between absolute power and mobility, without excessive

accumulation of body fat. Athletes here focus on absolute maximum strength while maintaining good joint mobility.

Somatotyping is an effective technique for studying anthropometric variations and body composition.

For a better understanding, the three components represent the following :

Component	Interpretation
Endomorphy	Low = low body fat
Mesomorphy	High = well-developed musculature
Ectomorphy	Low = compact structure (not lanky)

For Buffa R. et al. (2005), the general trend in somatotypy among weightlifters is as follows :

Category	Fat mass (%)	MMuscle mass(%)	Somatotype
Light	6–10	40–45	2–5.5–1.5
Medium	8–12	45–50	2.5–6.5–0.9
Heavy	12–20+	45–55+	4–7–0.5

Athletes show a clear mesomorphic dominance, with an increase in endomorphy in the heaviest categories.

According to Orvanova (1990), weightlifters in the lightest weight classes turn out to be ectomorphic or balanced mesomorphs, while those in the heaviest weight classes tend to be endomorphic mesomorphs. Ectomorphy decreases, while mesomorphy and endomorphy increase with weight class. When we compare three age groups of weightlifters within each weight class, we see the same pattern of age differences. The youngest weightlifters in each weight category have higher endomorphy and lower mesomorphy than older weightlifters. Ectomorphy is higher in younger weightlifters below the heavyweight class. Given that significant differences were found in all three somatotype components between different weight categories of weightlifters, it will be necessary in future studies to consider the somatotypes of weightlifters according to official weight classes.

We therefore set out to study the body composition and somatotype of Arab and African weightlifters taking part in continental jousts and considered by their performances to be the top performers in their weight categories.

Methodology :
Hypothesis
We assume that our sample has :
- An endomorph dominance in the heavy weight categories ;
- A tendency towards mesomorph in the middle weight categories ;
- An ectomorph dominance, especially among light weights and young practitioners.

- Sample :
44 international male weightlifters (aged 18-28), classified by weight category.
- Heavy category (96kg-109kg): 10 athletes
- Medium category (67kg-73kg-81kg): 17 athletes
- Light category (55kg-67kg): 17 athletes

All the male athletes take part in national and international competitions. They have been training regularly for between 4 and 20 years, with an average weekly training volume of 20 hours and between 5 and 9 training sessions per week.

Table 1: Presentation of total sample parameters.

Categories Parameter's	Heavy	Medium	Light
Age (ans)	$20,70 \pm 2,00$	$22,71 \pm 3,77$	$24,35 \pm 4,15$
Weight (kg)	$99,04 \pm 11,48$	$77,04 \pm 6,87$	$56,00 \pm 2,78$
Stature (cm)	$177,20 \pm 6,14$	$169 \pm 4,74$	$160,90 \pm 3,34$

Methods and Investigation materials :
The main instruments used were an anthropometric suitcase for all anthropometric measurements, a Secca scale for weight measurement, and Harpenden-type folding forceps for measuring skinfolds. In addition, for anthropometric measurements we selecte :

o Height, body mass ;
o Perimeters (arm, thigh, calf);
o Skin folds (triceps, subscapular, suprailiac, etc.) ;
o Bone diameters (bi-epicondylial, bi-malleolar).

To determine the somatotype using the Heath-Carter method (endomorphy, mesomorphy, ectomorphy)

Weightlifting is a discipline in which technique and anthropometric characteristics are essential to achieving the best results in competition.

1. There are several indices that give a better idea of a weightlifter's morphology :

a) Body Mass Index (BMI), also known as the Kaup Index

$$\text{Weight (kg)} / \text{Height}^2 \text{ (m}^2\text{)}$$

Used to monitor overall variations in weight.

b) Absolute surface area in m^2: the body surface area is calculated using Izakson's formula (1958). Used to determine how well athletes are developing physically.

$$S = 100 + P + \frac{(\text{Height} - 160)}{100} ; (\text{Body weight in kg, Height in cm}).$$

The body surface area of a top-level athlete is equal to or greater than 2 m^2. In addition to the absolute size of the body surface area, we often use its relative index, which is defined by the ratio of body weight to body surface area.

c) Energy coast index or relative body surface area (m²/kg): This is an index which gives us information about an athlete's degree of energy expenditure, and is a function of actual body surface area and body weight. The smaller the surface area per kg of weight, the less energy is lost.

$$SR \text{ (m}^2\text{/kg)} = S / P.$$

d) Sheldon index : the Sheldon weight index, also known as Livi's inverted index, is expressed as the height divided by the cube root of the weight :

$$\frac{T}{\sqrt[3]{P}}$$

2. Body composition parameters : We have also calculated the components of body weight and their relative values :
- Absolute muscle mass (kg) ;
- Relative muscle index : (muscle mass / total weight) % ;
- Absolute bone mass ;
Relative bone index : (bone mass/total weight) % ;
- Absolute body fat ;
- Relative fat index : f(at mass/total weight)%.

A good weightlifter has well-developed muscles in the lower limbs, trunk and shoulders. The relative fat index is ideally <10% for men (excluding the heavy category) to optimise relative
Power.

Results :

As weight alone is not considered to be a sufficiently complete indicator of physical fitness, it is mainly used in the field of sports. It is based on the chemical interpretation of body composition, which focuses on the molecular distribution of the human body to differentiate the quantity of proteins, lipids and carbohydrates. Body composition corresponds to all the elements that make up the body.

Weightlifting is much more than just a strength sport. Often associated with athletes lifting impressive loads, this Olympic discipline is in fact based on a unique combination of power, speed, coordination and mobility (Garhammer, J. 1991).
Analysis of body composition shows that weightlifters have a developed muscle mass, in keeping with the practice of their speciality.

Table 2 : Body composition of weightlifters

	Muscle mass (kg)	Fat mass (kg)	Bone mass (kg)
Heavy	47,76	20,32	13,22
Medium	38,95	11,16	12,34
Light	30,20	7,41	11,24
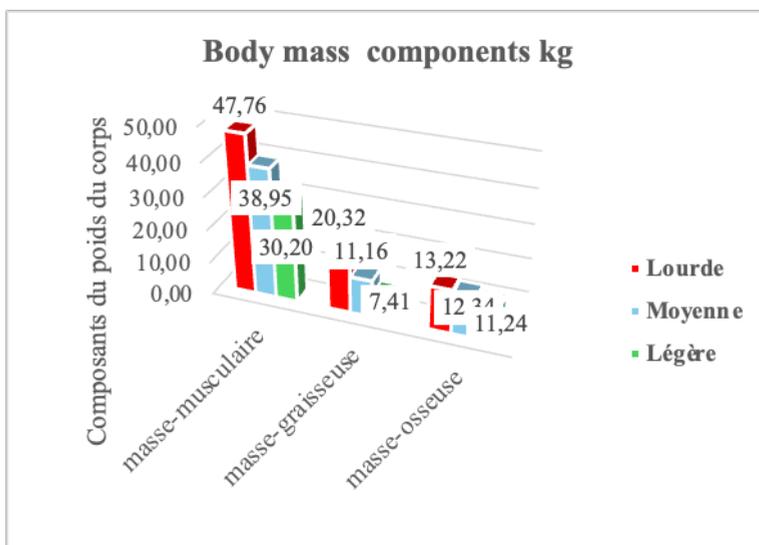
Figure 1: Body composition in kg of weightlifters
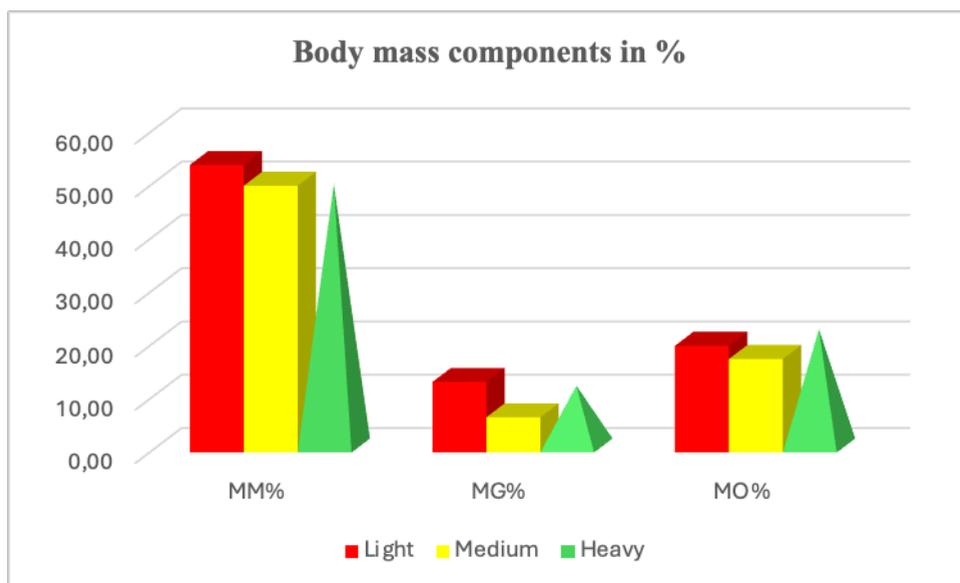
Figure 2 : Body mass in % for weightlifters

Table 3 : Body composition in percent of weightlifters

	MM%	MG%	MO%
Light	53,98	13,23	20,04
Medium	50,07	6,60	17,55
Heavy	49,1	11,2	21,8

Analysis of the various components of body weight, expressed as a percentage, shows good homogeneity for the light and medium categories and heterogeneity for the heavy category. Body fat in % indicates whether there is too much or too little body fat. As a guide, 6-12% (men), 12-18% (women). The lowest percentage of fat characterises the medium category, followed by the heavy category in accordance with the reference values. The light category is characterised by a high bone component.

Muscle mass is essential for strength. It represents 45-55% of total weight. Our weightlifters fall within this range.
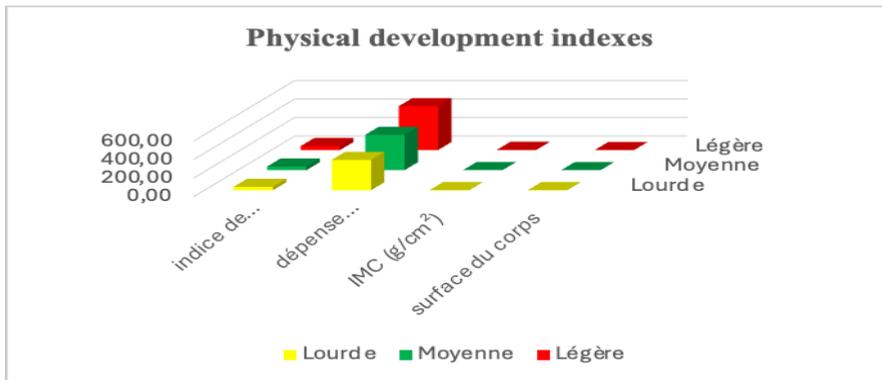

Figure 3 : Physical development indexes for weightlifters

Category	Sheldon index	Energy cost (cm²/kg)	IMC (g/cm²)	Absolute area (m²)
Heavy	38,39±1,89	328,70±40,85	32,0±0,39	2,17±0,14
CV%	4,92	12,43	12,18	6,46
Medium	40,73±1,74	382,10±41,68	28,3±0,31	1,92±0,08
CV%	4,27	10,91	10,95	4,17
Light	43,33±0,93	474,00±26,24	26,0±0,12	1,80±0,06
CV%	2,15	5,54	4,62	3,33

To better characterise the physical development of weightlifters according to weight category, we calculated certain physical development indexes.

The Sheldon index, expressing the linearity of the subject, shows that the light category presents a slight linearity. However, the three groups were fairly homogeneous.

The BMI or body mass index assesses overall corpulence. The optimum values for weightlifters are between 24-28 kg/m2.

The absolute surface area gives us information on the state of physical development. Weightlifters in the heavy category have the highest body surface area with 2.17m² ± 0.14m², the medium category has a value of 1.92m² ±0.08m² and the light category has a low value of 1.70m² ±0.07m². In this index, the values of the coefficient of variation show homogeneity in the three groups of weight categories.

From the absolute surface area we can calculate an index relative to weight: the energy coast index. The light category shows good homogeneity, but the other two categories are heterogeneous.
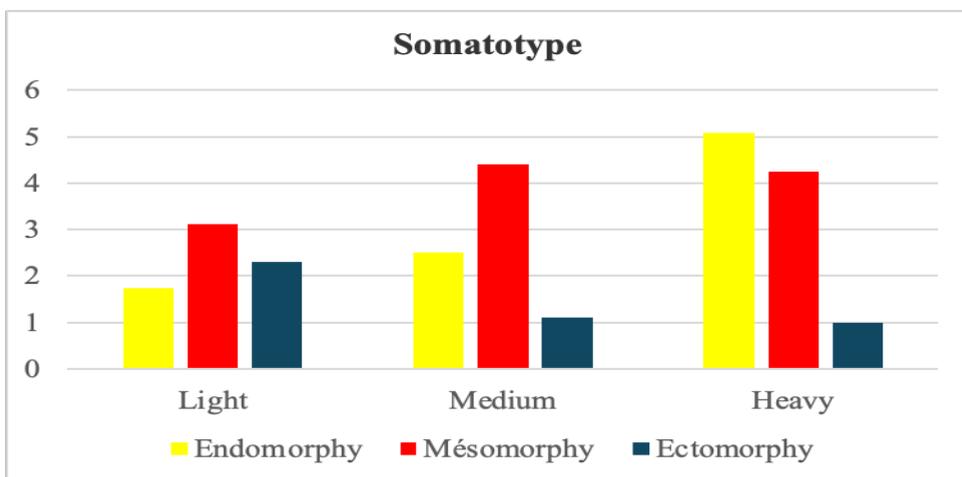
Heat-Carter somatotype (1990) :

Figure 4 : Somatotypes for weightlifters

Endomorphism characterises the roundness of the body and the development of fat.

The highest value is found in the heavy category (5.07 ±1.73), a value of 2.51 ± 0.88 for the medium category, and a small value for the light category. The values in the three weight categories are heterogeneous.

Mesomorphy indicates robustness, i.e. mesomorphs are more robust than endomorphs and ectomorphs. The highest value is for the medium category with 4.40 ± 0.82, an intermediate value for the heavy category with 4.25 ± 0.72, and the lowest value for the light category with 3.11 ± 0.71.

The ectomorph has less fat and a lower degree of robustness than the others. The result shows that the highest value is retained for the light category with 2.30 ± 0.52, the medium category has a value of 1.10 ± 0.68 and the heavy category with a very low value of 1.00 ± 0.68. Our sample is fairly homogeneous.

In conclusion of the typological analysis, we can say that :

*The light category is: low in endomorphy, medium in mesomorphy and high in ectomorphy; therefore of the ecto-mesomorphic type.

*The medium category is: low in ectomorphy - medium in endomorphy - and high in mesomorphy; therefore meso-endomorphic.

*The heavy category is: very weak in ectomorphy - average in mesomorphy - and strong in
Endomorphy ; therefore of endo-mesomorphic type.

Discussion :

The results confirm that high-level weightlifters have a morphology adapted to the expression of maximum force. High mesomorphism reflects a developed muscle mass, particularly in the lower and upper limbs. Low ectomorphy indicates a structure that is not very long, which favours stability and force transmission (Campillo, 1998).

In the heaviest athletes, an increase in endomorphy is observed, which could correspond to a strategy of mass gain to improve biomechanical leverage. Comparison with other disciplines (e.g. wrestlers, judokas) shows a similar

morphological trend but with its own functional particularities (Storey, A., & Smith, H. K. (2012).

Arab and African weightlifters in the light category are strong in mesomorphism, average in endomorphism and weak in ectomorphism, i.e. of the meso-ectomorphic type. African weightlifters in the medium category have good mesomorphism, average endomorphism and low ectomorphism. Weightlifters in the heavy category tend to have high endomorphism and low ectomorphism. Mesomorphy is moderate and they are endo-mesomorphic.

According to Orvanova (1990) weightlifters in the lightest weight classes tend to be ectomorphs or balanced mesomorphs, while those in the heaviest weight classes tend to be endomorphic mesomorphs. Ectomorphy decreases, while mesomorphy and endomorphy increase with weight class.

Conclusion :

The morphotypology of weightlifters is marked by a mesomorphic predominance, which is essential for weightlifting performance. This information is useful for orientation, training and talent detection. Further research could incorporate functional measurements (strength, power) to further correlate morphology and performance.

Recommendations :

- Monitoring athletes, especially international athletes, must necessarily involve anthropometric methods and the calculation of body composition, in particular the study of physical development indices.

-       The study and determination of the somatotypes of weightlifters, especially international ones, is very useful for selecting young weightlifters and also very interesting for monitoring high-performance weightlifters.

- We recommend that weightlifting coaches pay particular attention to and closely monitor athletes with a 'mesomorphic' dominance, as they are more likely to quickly develop strong muscle mass, often associated with the considerable strength required in this discipline.

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