RESEARCH ARTICLE

INTERNATIONAL JOURNAL OF KINANTHROPOMETRY

DOI: 10.34256/ijk2118

Somatotype and its association with body mass index, body fat, and muscle mass among adult male elite weightlifters of Merida, Mexico

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DOI: https://doi.org/10.34256/ijk2118
Received: 17 -11-2021, Revised: 24-12-2021; Accepted: 25-12-2021; Published: 31-12-2021

Abstract

Aim: To evaluate somatotype and its association with body mass index (BMI), body fat (%), and muscle mass (%) among adult male elite weightlifters in Merida, Mexico. **Methods:** Eight elite male weightlifters, age ranged from 20-29 year were studied at Yucatan State Sports Institute of Mexico. Height, weight, skinfolds (biceps, triceps, subscapular, iliac crest, supraspinale, thigh, and calf), girths (mid-upper arm relaxed and flexed, mid-thigh, and calf) and breadths (humerus, femur) were recorded. BMI, body fat (%), muscle mass (%), and somatotype were estimated. Phantom Z-score values (Zp scores) were calculated to estimate similarity of body size and proportionality. **Results:** Average age of the participants was 25.80±1.6 years. Average endomorphic mesomorph somatotype (3.8-7.1-0.5) was observed in the present study. Endomorphy showed significant ($p<0.05$) correlation with BMI ($r= 0.80$), percent body fat ($r= 0.98$), and percent muscle mass ($r= -0.91$). Mesomorphy was significantly correlated with percent muscle mass ($r= 0.65$, $p<0.05$). BMI had correlation with percent body fat ($r= 0.70$, $p<0.05$) and percent muscle mass ($r= -0.55$, $p>0.05$). Simultaneous increase of body fat and muscle mass with the rise of body weight of the weightlifters were evident. Body weight, breadths and circumferences had positive Zp scores whereas skinfolds had negative Zp scores. Conclusions: Somatotype of elite weightlifters showed higher relative muscularity and lower body fatness. Somatotype was observed to be a reliable indicator to distinguish between body fatness and leanness.

Keywords: Cerebral Palsy (CP), Glutamine, Triceps Skin Fold (TSF), Middle Upper Arm Circumference (MUAC), Body Mass (Weight).

Resumen

Objetivo: Evaluar el somatotipo y su asociación con el índice de masa corporal (IMC), grasa corporal (%) y masa muscular (%) en halterofilistas de élite masculinos adultos en Mérida, México. **Métodos:** Se llevó a cabo un estudio transversal con ocho halterofilistas masculinos de élite, entre los 20 y 29 años en el Instituto de Deportes del Estado de Yucatán en México. Se midieron la estatura, el peso, los pliegues cutáneos (bíceps, tríceps, subescapular, cresta ilíaca, supraespinal, muslo y pierna) y circunferencias (brazo relajado y flexionado, muslo medio y pierna) y anchos (húmero, fémur). Se estimaron el IMC, la grasa corporal (%), la masa muscular (%) y el somatotipo. Los valores de la puntuación Z de Phantom (puntuaciones Zp) fueron calculados para evaluar la similitud del tamaño corporal y la proporcionalidad. **Resultados:** La edad promedio de los participantes fue 25.80 ± 1.6 años. En el presente estudio se observó un somatotipo mesomorfo endomórfico (promedio 3.8-7.1-0.5) de los halterofilistas. El componente endomorfia mostró una correlación significativa ($p <0.05$) con el IMC ($r = 0.80$), el porcentaje de grasa corporal ($r = 0.98$) y el porcentaje de masa muscular ($r = -0.91$). Así mismo, el componente mesomorfia se correlacionó significativamente con el porcentaje de masa muscular ($r = 0.65$, $p <0.05$). El IMC tuvo correlación con el porcentaje de grasa corporal ($r = 0.70$, $p <0.05$) y el porcentaje de masa muscular ($r = -0.55$, $p> 0.05$). El aumento simultáneo de la grasa corporal y la masa muscular con el aumento del peso corporal fue evidente. El peso corporal, la amplitud y las circunferencias tuvieron puntuaciones Zp positivas, mientras que los

pliegues cutáneos tuvieron puntuaciones Zp negativas. **Conclusiones:** El somatotipo de los halterofilistas de élite mostró mayor musculatura relativa y menor grasa corporal. Se observó que el somatotipo es un indicador confiable para distinguir entre la masa grasa y la masa libre de grasa.

Palabras Clave: IMC, Valor de Phantom, Endomorfia, Mesomorfia, Ectomorfia.

Introducción

Anthropometric evaluation of nutritional status, characteristics of body proportion and composition (body fat and lean body mass) in sports are important to develop and maintain physique, health, and wellness of the athletes. Body mass index (BMI) is an important indicator of nutritional status (undernutrition, overweight, and obesity). However, BMI is reported to be positively correlated with body fat and muscle mass (Chumlea et al. 2002). Therefore, BMI cannot distinguish between fat mass and lean body mass (Bogin and Varela-Silva 2012). Somatotype is used to estimate overall physique, based on body shape: endomorphy (relative fatness), mesomorphy (musculoskeletal development relative to height), and ectomorphy (relative linearity) (Carter and Heath 1990). Body type (somatotype) of athletes may be changed as per demand of sport through optimum training, exercise, and nutritional intervention that help athletes to enhance sport skills and performance. Anthropometric evaluation of body proportion, composition, and body type are also important for talent identification.

Weightlifting is a popular sport in Mexico, and it demands muscular strength to create force to lift the weight against gravity. A blend of muscle mass, relatively lower body fat, relative short limb lengths, more muscle mass in the arm and endomorphic mesomorph somatotype may help the weightlifters for better sport performance (Fry et al. 2006, Vidal Pérez et al. 2021). Short stature, relatively short subischial leg length, and high body fat characterize the physique of the Maya ethnic group of Yucatan Peninsula in Mexico and Guatemala (Bogin and Varela-Silva 2010, 2012). Paucity of reports on morphological characteristics of weightlifters from Yucatan raised our interest to document the information of elite weightlifters from the state. The aim of the present study was to evaluate somatotype and its association with BMI, body fat (%), and muscle mass (%) among adult male elite weightlifters in Merida, Mexico.

Materials and Methods

Participants

A cross-sectional study was carried out among 30 adult male weightlifters aged 20 to 29 years in the month of February-March 2019 at Yucatan State Sports Institute (IDEY in Spanish acronym) (*Centro Deportivo Kukulcán*) in Merida, Mexico. Among them, elite weightlifters (n = 8) were selected for the present study who had participated in the championships at national and international levels. The convenience sample was not representative. The research project was evaluated by the appropriate institutional committee (see Acknowledgements).

Anthropometric parameters

Recording of anthropometric measurements followed the guideline of International Society for the Advancement of Kinanthropometry (ISAK) (Esparza-Ros et al. 2019). Height, weight, girths (relaxed and flexed mid-upper arm, thigh, and calf), skinfolds (biceps, triceps, subscapular, iliac crest, supraspinale, mid-thigh, and calf), and breadths (humerus, femur) of the weightlifters were measured by an ISAK level 3 criterion anthropometrist (SDB). Data were recorded in the morning, before any physical exercises and heavy breakfast.

Body weight was measured to the nearest 0.05 kg using an electronic weighing scale (Seca ®, model 881, Hamburg, Germany), and height to the nearest 0.1 cm using a standard anthropometer (Seca ®, Germany). Percutaneous measurements were recorded on the right side of the body; breadths were recorded using a standard sliding caliper (CESCORF ®, Brazil); circumferences using standard tape (Lufkin)- both to the nearest 0.1 cm, and skinfold thickness nearest 0.1 mm using a Harpenden skinfold caliper. Intra-observer technical error of measurement was within acceptable limits; anthropometric measurement had intraclass correlation coefficient >0.85 (Altman 1999).

Body mass index (BMI) was estimated using the formula [BMI= weight (kg)/height^2 (m)] (WHO 1995). Height-to-weight ratio was calculated. Body fat (%) was estimated using standard equation = (4.95/density – 4.50) x 100 (Siri 1956). Density was calculated using standard formulas by age of the participants (Durnin and Womersley 1974). A pre-validated formula was used to estimate skeletal muscle mass (kg and %) (Lee et al. 2000)

that showed agreement with the results obtained using dual-energy X-ray absorptiometry (González-Mendoza et al. 2019). Somatotype rating was done using standard formulas (Carter and Heath 1990).

Distribution of anthropometric data in different body weight categories as per guideline of the International Weightlifting Federation for Olympic Games (IWF 2015) was done to observe differences in morphological characteristics of the weightlifters in the groups. Phantom Z-score values (Zp scores) were used to estimate relative body size and proportionality of the participant weightlifters (Ross and Marfell-Jones 1991, Ross and Wilson 1974).

Microsoft Excel ® and SPSS software (Statistical Package for Social Sciences) (Version 15.00, Chicago IL, USA) were used for data analysis, somatotype rating and calculation of Phantom Z-scores. Anthropometric data were found to be within acceptable limits of normal distributions (Shapiro-Wilk test, $p<0.05$). Descriptive statistics of mean and standard deviation values were calculated. One-way Analysis of Variance was done to find significant differences between the mean values of independent variables; correlation coefficients were used to find association between variables. Statistical significance was set a priori at $p<0.05$.

Results

Mean value of age of young male weightlifters was 25.80 years, ranging between 20 and 29 years. Body weight of the weightlifters also had a wider range (74 to 101 kg) with a mean value 88.46 kg. Similarly, stature showed a mean value of 170.3 cm, ranged between 158 and 179 cm. Mean value of BMI was 30.59 kg/m^2 where majority of the weightlifters were overweight and obese (only one individual had normal BMI of 24.02 kg/m^2). Body fat (%) of the athletes was relatively low (16.86%) with higher muscle mass (39.62 kg, 44.84%) (Table 1).

Table 1 Descriptive statistics of age and anthropometrics characteristics of young adult male elite weightlifting athletes (n=8).

Variables	Minimum	Maximum	Mean (SD)
Age (year)	20.31	29.86	25.80 (1.62)
Body weight (kg)	73.80	100.80	88.46 (9.36)
Height (cm)	158.00	179.20	170.30 (6.34)
MUAC (cm) (relaxed)	30.00	40.90	35.91 (3.35)
MUAC (cm) (flexed)	31.50	41.10	37.34 (3.09)
Thigh circumference (cm) maximum	53.90	70.80	64.58 (5.97)
Mid-thigh circumference (cm)	53.20	65.80	61.09 (4.58)
Calf circumference (cm)	37.60	41.80	39.13 (1.54)
Biceps skinfold (mm)	3.50	7.00	5.48 (1.18)
Triceps skinfold (mm)	6.50	14.00	10.98 (2.33)
Subscapular skinfold (mm)	8.00	17.00	12.29 (2.96)
Iliac crest skinfold (mm)	8.50	22.10	16.23 (4.99)
Supraspinale skinfold (mm)	6.50	19.00	14.30 (4.80)
Thigh skinfold (mm)	6.40	27.80	12.29 (6.66)
Calf skinfold (mm)	6.00	13.00	9.24 (2.37)
Humerus breadth (cm)	6.20	8.00	7.26 (0.54)
Femur breadth (cm)	7.30	11.00	9.95 (1.19)
Body mass index (kg/m^2)	24.02	33.68	30.59 (3.68)
Height-to-weight ratio	36.10	41.80	38.31 (1.93)
Body fat (%)	13.34	19.70	16.86 (2.36)
MM (kg) (Lee et al., 2000)	33.75	43.94	39.62 (3.78)

MM (%) (Lee et al., 2000)	43.59	47.46	44.84 (1.30)

SD: Standard deviation; MUAC: Mid-upper arm circumference; MM: Muscle mass

Weightlifters in the present study had endomorphic mesomorph somatotype (3.8-7.1-0.5) in average with a wide range of mesomorphy component (5.2 to 8.5) (Table 2). When plotted on the somatochart, the weightlifters were observed in the mesomorph endomorph and endomorphic mesomorph zones (Figure 1).

Table 2 Somatotype of young adult male elite weightlifting athletes (n=8).

Somatotype	Minimum	Maximum	Mean (SD)
Endomorphy	2.7	4.6	3.8 (0.7)
Mesomorphy	5.1	8.5	7.10(1.2)
Ectomorphy	0.1	2.0	0.5 (0.7)

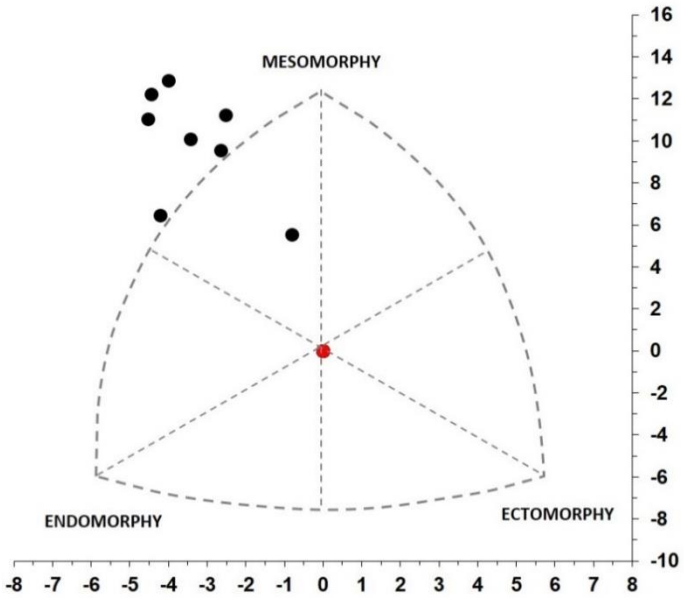

Figure 1 Somatotype of young adult male elite weightlifting athletes (n=8).

Distribution of anthropometric characteristics and somatotype of the weightlifters according to the body weight categories was presented in Table 3. Consistent increase of mean values of BMI, body fat (%), muscle mass (%), endomorphy, and mesomorphy components with the higher weight categories were observed. However, differences of mean values were not significant ($p>0.05$). BMI showed significant positive correlation ($p<0.05$) with body fat (%) ($r = 0.70$), endomorphy component ($r = 0.80$) and negative correlation with muscle mass ($r = -0.55$, $p = 0.15$) and ectomorphy component ($r = -0.92$, $p<0.0001$). Body fat (%) also showed significant ($p<0.0001$) negative correlation with muscle mass (%) ($r = -0.90$) and positive correlation with endomorphy component ($r = 0.98$). Muscle mass showed significant correlation with the three components: endomorphy ($r = -0.91$), mesomorphy ($r = 0.65$), and ectomorphy ($r = -0.74$) (Table 4).

Table 3 Distribution of anthropometric characteristics of weightlifting athletes (n = 8) in different body weight categories.

Variables	<81 kg (n= 2) Mean (SD)	<89 kg (n=2) Mean (SD)	<96 kg (n=3) Mean (SD)	<102 kg (n=1) Mean (SD)	F*
Body mass index (kg/m^2)	25.58 (2.21)	31.78 (2.59)	32.12 (2.62)	33.68	3.67
Body fat (%)	14.61 (0.45)	15.23 (2.67)	18.51 (0.25)	19.70	5.65
Muscle mass (%) (Lee et al., 2000)	43.59 (2.55)	44.25 (0.45)	45.55 (0.26)	45.66	0.95

Endomorphy	3.1 (0.4)	3.4 (0.9)	4.3 (0.2)	4.6	3.15
Mesomorphy	6.0 (1.2)	7.1 (1.53)	7.8 (1.0)	7.9	0.77
Ectomorphy	1.4 (0.9)	0.2 (0.10)	0.3 (0.2)	0.1	2.60

SD: Standard deviation; F: One-way Analysis of Variance; *p>0.05

Table 4 Correlation among BMI, body fat (%) and somatotype of young adult male elite weightlifting athletes (n=8).

Variables	BMI (kg/m^2)		Body fat (%)		MM (%)	
	r	p-value	r	p-value	r	p-value
Body fat (%)	0.70	**0.05**	1	1	-0.90	**<0.0001**
MM (%)	-0.55	0.15	-0.90	**<0.0001**	1	1
Endomorphy	0.80	**0.02**	0.98	**<0.0001**	-0.91	**<0.0001**
Mesomorphy	0.58	0.14	0.42	0.30	0.65	**0.05**
Ectomorphy	-0.92	**<0.0001**	-0.52	0.19	**-0.7**	**0.04**

Body mass index (kg/m^2); MM: Muscle mass (Lee et al., 2000); r = Pearson correlation coefficient

Body size and proportionality of the weightlifters, estimated by Phantom Z-scores showed body weight, humerus and femur breadths, mid-upper arm circumference (relaxed and flexed), and calf circumference had higher Zp values (positive). Z-scores of skinfolds had lower values (negative) (Figure 2).

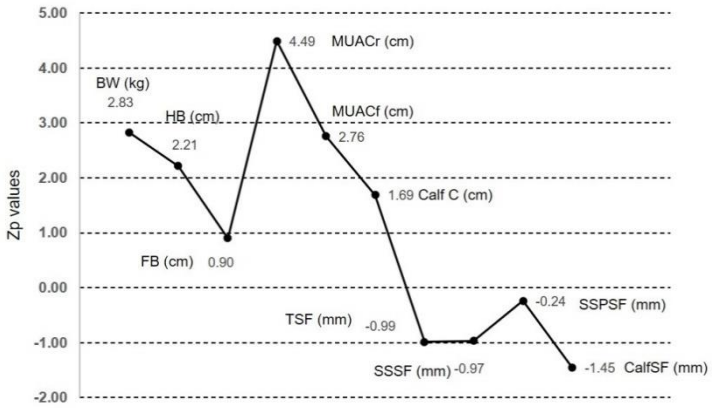

Figure 2 Relative body size of young adult male elite weightlifting athletes (n=8) with reference to Phantom z-score. (BW: Body weight; Calf C: Calf circumference; CalfSF: Calf skinfold**;** FB: Femur breadth; HB: humerus breadth; MUACf: Mid-upper arm circumference (flexed); MUACr: Mid-upper arm circumference (relaxed); SSPSF: Supraspinale skinfold; SSSF: Subscapular skinfold; TSF: Triceps skinfold)

Discussion

The purpose of the study was to estimate body type (somatotype) of adult male elite weightlifters and evaluate its interrelationships with BMI, body fat (%), and muscle mass (%). The weightlifters had endomorphic mesomorph somatotype, in average; relative fatness (endomorphy) showed significant positive correlation with BMI and body fat (%). The weightlifters had notable musculoskeletal development relative to height (mesomorphy). BMI had significant positive correlation with body fat (%) and negative correlation with percentage muscle mass and relative linearity (ectomorphy). Body fat (%) showed negative interrelationship with muscle mass (%). Therefore, it was evident that BMI was not a reliable indicator to distinguish between body fat and lean body mass (positive correlation with percentage body fat, endomorphy, and mesomorphy components). On the other hand, somatotype could clearly distinguish between relative fatness, musculoskeletal development relative to height, and relative linearity and had corresponding interrelationships with percentage body fat and muscle mass.

Body proportion and composition are important aspects for the development of athletic skill and performance. Therefore, anthropometric evaluation of the parameters can document physical and physiological aspects of athletes representing a country and can be used to compare with the profiles of athletes from other

countries, along with their levels of competence. Average body weight of the weightlifters in the present study was 88.46 kg, which value was higher than the average body weight (75.2 kg) of elite Spanish male weightlifters (Canda 2012). Yucatec weightlifters were relatively short (average 170.3 cm, ranged between 158 and 179 cm) in comparison with that of Spanish weightlifters (179.5 cm). However, variation of body size and proportions across the populations in the world was reported (Bogin and Varela-Silva 2010). Short height was reported to be advantageous for the weightlifters (Canda 2012) but another studiys showed that taller weightlifters with higher body weight also had remarkable advantages (Huebner and Perperoglou 2020). The weightlifters with short height, short arms, low body fat, and high muscularity had higher relative strength and power than others (Carter 1982, Ford et al. 1985, Fry et al. 2006, Mayhew et al. 1993). Body fat (%) of the participant weightlifters in the present study (16.86%) was higher than the recommended values for men (5-12%) (Wilmore and Costill 2007) and also that of Spanish weightlifters (10%) (Vidal Pérez et al. 2021). However, relative fatness was lower than relative muscularity of the weightlifters in the present study. Muscle mass (%) estimated among the participant weightlifters (44.84%) was lower than that value reported earlier (51.6%) (Vidal Pérez et al. 2021) though the guidelines for evaluation were different in these studies.

It was reported that adult male weightlifters in weight categories had different body types (Stone et al. 2006). Somatotype of weightlifters ≤85 kg body weight category was ectomorph or mesomorph with 5–10% body fat (Orvanová 1990), and heavy-weight weightlifters were endomorphic mesomorphs (Stone et al. 2006). Sample size of the present study was relatively small (n = 8). However, results obtained in the present study at different body weight categories (<81 kg, <89 kg, < 96 kg, and < 102 kg) were concordant with those reported earlier (Fry et al. 2006, Orvanová 1990 Stone et al. 2006). Yucatec weightlifters of higher body weight categories had higher BMI, body fat (%), muscle mass, endomorphy and mesomorphy components in comparison with peers in the lower body weight categories.

The young adult male elite weightlifters in the present study had endomorphic mesomorph somatotype (3.8-7.1-0.5) in average that exhibited a blend of high muscularity with relatively low body fatness. Somatotype of high-performance weightlifters from Colombia was endomorphic mesomorph (3.1-4.2-1.7) (Barajas Ramon and Santana Lobo 2010), which was very similar to the results obtained in the present study. However, mesomorph component of the weightlifters from Merida was higher than that of Colombian weightlifters. The Colombian weightlifters had lower BMI (25 kg/m^2) and body fat (10%) in comparison with the characteristics of weightlifters of Merida, Mexico (30.59 kg/m^2, 16.86%, respectively). Quelal López (2013) reported lower body fat (12%), and endomorphic mesomorph somatotype (2.9-7.8-1.0) of the weightlifters (69 to 80 kg body weight category) from Ecuador with age range of 15-20 year. Somatotype of weightlifters from Latin American countries were similar, independent of other morphological characteristics. Adult weightlifters (above 20 years of age) from Spain also had similar somatotype (2.2-7.2-0.9), showing relatively higher muscularity (Lopez and Aragones 1989). Kutseryb and colleagues (2017) reported endomorphic mesomorph somatotype (2.9-5.7-2.3) in average for Ukrainian weightlifters with a notable ectomorphy component.

Limitations

Limitations of the study include first the type of sample (convenience) that was relatively smaller and drawn from a single sports complex (IDEY). Bigger sample size and data from other regions of Mexico could have comparative estimates of physical characteristics of the weightlifters. In addition, comparative statement of the characteristics of body proportion and composition of the Yucatec weightlifters with that of weightlifters of Olympic Games could enrich the study. Data on barbell velocity in squat Snatch and Clean & Jerk and their association with morphological characteristics of the weightlifters could show more precise results that will be considered in future studies. Non-availability of data of female weightlifting athletes was another limitation.

Conclusion

The present study contributes important information of physical characteristics of elite male weightlifters from Merida, Mexico. In agreement with the previous studies among weightlifters reported from Latin American and other countries, the present study showed endomorphic mesomorph somatotype with relatively high muscularity, and low body fat of the weightlifters despite smaller sample size. Simultaneous increase of body fat and muscle mass with the rise of body weight of the weightlifters was evident. The information will offer an understanding of morphological characteristics of Yucatec weightlifters that will help athletes, coaches, trainers, nutritionists, health, and other sport professionals to improve sports performance.

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Acknowledgements

The Authors are thankful to the participant weightlifters, authorities of Cinvestav-IPN and IDEY for their valuable support.

Institutional Review Board Statement

The study was conducted according to the guidelines of the Declaration of Helsinki. Appropriate institutional committee evaluated the protocol that was primarily developed for the research work of doctoral thesis of one of the co-authors (AMCV). Permission of the authority of the Yucatan State Sports Institute (IDEY) in Merida was taken before the commencement of the study.

Informed Consent Statement

The participants gave consent before recording of anthropometric measurements.

Contributions by the authors: Co-authors had equal contributions to develop the manuscript. AMCV developed the research project and helped in the preparation of manuscript. SDB conceptualized the idea of the present study, recorded, and analyzed data and prepared the first draft of manuscript. AAG and CXSC reviewed the manuscript and gave valuable suggestions to finalize the report.

Conflict of interest

The Authors do not have any conflicts of interest to declare.

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