Nutrition 87–88 (2021) 111199

Contents lists available at ScienceDirect

Nutrition

journal homepage: www.nutritionjrnl.com

Applied nutritional investigation

A proposal for reference values of hand grip strength in women with different body mass indexes

Delia Morlino, Maurizio Marra Ph.D. *, Iolanda Cioffi, Rosa Sammarco, Enza Speranza, Olivia Di Vincenzo, Carmela De Caprio, Emilia De Filippo, Fabrizio Pasanisi

Internal Medicine and Clinical Nutrition Unit, Department of Clinical Medicine and Surgery, Federico II University Hospital, Naples, Italy

A R T I C L E   I N F O

Article History:
Received 5 October 2020
Received in revised form 9 December 2020
Accepted 3 February 2021

Keywords:
Handgrip strength
Bioimpedance analysis
Phase angle
Women
BMI

A B S T R A C T

Objective: Hand grip strength (HGS) is frequently used in clinical practice, resulting in a potential marker of nutritional status. This study aimed to develop reference values of HGS in Italian women with different categories of body mass index (BMI). Additionally, the main predictors of HGS were identified.

Methods: A cross-sectional study was conducted in Italian women between ages 16 and 55 y with different categories of BMI at the Department of Clinical Medicine and Surgery, Federico II University Hospital, Naples Italy. The whole sample was divided into tertiles according to BMI: 15 to 17.29 kg/m^2 (T1), 17.3 to 19.9 kg/m^2 (T2), and 20 to 25 kg/m^2 (T3). Anthropometry, bioimpedance analysis, and muscle strength by an HGS test were evaluated. The cut-off values for HGS were developed for all participants and stratified by age group. Finally, a multivariate linear regression analysis was performed to assess the main predictors of HGS.

Results: A total of 529 women with a mean age of 23.2 ± 7.0 y and an average BMI of 18.9 ± 2.5 kg/m^2 were analyzed. HGS was higher for the dominant hand than for the non-dominant hand in all BMI tertiles. On both sides, according to age groups, HGS increased with increasing age in T1 and T3, whereas it increased in the women between ages 20 and 30 y in T2 only. Multivariate linear regression analysis showed that predictors of HGS varied according to tertiles. Specifically, we found that body weight (R^2 = 0.252) was the main predictor in T1, whereas phase angle (PhA) was the main determinant in both T2 (R^2 = 0.240) and T3 (R^2 = 0.216).

Conclusion: This study defined the normal reference values of HGS in Italian women with different BMI ranges, stratifying the sample group by age. Additionally, the main predictors of HGS were assessed for each BMI tertile. In primary malnutrition (T1), the main predictor of HGS was body weight, whereas in the other two tertiles (T2, T3), the PhA was the main predictor of HGS.

Introduction

Hand grip strength (HGS) is used in clinical practice as a repeatable and inexpensive measurement. HGS is considered a useful functional capacity test for evaluating muscle strength and represents a dynamic indicator of muscle mass [1]. In recent years, HGS has also become a popular marker of nutritional status and represents a useful variable in nutritional intervention studies to evaluate early malnutrition risk [2].

It has been studied in the clinical environment and as a diagnostic tool for assessing malnutrition, overall nutritional risk, and mortality [3,4]. Additionally, HGS is a method used in clinical settings because it has been shown to be an indicator of coronary heart disease risk even in youth. High levels of HGS are associated with improved muscle quality and a reduction in both cardiometabolic risk and mortality [5]. Therefore, the important relationship has been demonstrated between future health risk and changes in body composition parameters (Fat Free Mass) and phase angle [PhA]) and HGS values [6].

Recently, the European Working Group on Sarcopenia in Older People (EWGSOP2) used low muscle strength as the primary parameter of sarcopenia since sarcopenia is probable when low muscle strength is identified [7]. As a result, a low HGS is a predictor of poor patient outcomes, such as prolonged hospital stays [8], increased functional limitations [9], enhanced health care costs [10], and poor health-related quality of life [11].

M.M. and F.P. designed the research; R.S., O.D.V., E.S., I.C., E.D.F, and C.D.C. conducted the research; M.M. and D.M. analyzed and discussed all data; D.M. and M.M. wrote the paper; M.M. and F.P. had primary responsibility for final content. All authors read and approved the final manuscript.

*Corresponding author: Tel.: +390817462333; Fax: +390817462376.
E-mail address: marra@unina.it (M. Marra).

https://doi.org/10.1016/j.nut.2021.111199
0899-9007/

Considering the increasing use of this measurement, several studies have been published about the normative values for HGS in different age groups of elderly individuals [12,13]. The studied populations included different ethnic groups from Greece [14], China [15], Brazil [16], Japan, Korea, and Australia, but there are few data about Italians. Recently, Wang, et al. [17] presented normative reference values of HGS based on data obtained from a US population, stratified by sex and age within the last 10 y. Additionally, a previous study measured HGS in a Spanish population and reported baseline values by sex and age [18].

Therefore, providing cut-offs of upper limb strength for Italian people could be clinically useful for monitoring changes in muscle strength in patients with different clinical conditions and comparing these patients to subjects of different ethnicities.

The present study was conducted on Italian women according to body mass index (BMI) tertiles and stratifying the sample by age. The first objective of the study was to provide HGS reference values for Italian women since these values are potentially useful in both clinical and research fields. The second objective was to identify the possible predictors of HGS among anthropometric (age, weight, height) and bioimpedance (bioimpedance index [BI-index], PhA) variables.

Methods

Subjects

A cross-sectional study assessing HGS values was performed in Italian women with different classes of BMIs. Data from outpatients for eating disorders, characterized by primary malnutrition, as well as from healthy controls were collected at the Department of Clinical Medicine and Surgery, Federico II University Hospital, Naples, Italy, from January 2015 to October 2019. The study population had the following characteristics: an age range between 16 and 55 y, a body weight range of 35 to 76 kg, and a BMI range between 15 and 25 kg/m^2.

Informed consent was obtained from all subjects before participation. The study protocol was approved by the Ethical Committee of the Federico II University Hospital (Prot. n. 37/17).

Anthropometric assessment

Body weight and height were measured according to standardized methods. Body weight was measured at the nearest 0.1 kg using a platform beam scale and height to the nearest 0.5 cm using a stadiometer (Seca 709; Seca, Hamburg, Germany). Body weight and height were used to calculate BMI (weight in kilograms divided by height in meters squared).

Bioimpedance analysis

Bioimpedance analysis (BIA) was performed using Human IM Plus II (DS Medica, Milan, Italy) at a room temperature of 22°C to 25°C in a fasting state for 12 h after voiding the bladder and cleaning the surface of the skin to adhere the electrodes. Participants were asked to remain in the supine position for at least 10 to 15 min before starting the measurement, with lower limbs and upper limbs slightly abducted at 45° and 30°, respectively, to avoid any contact between the extremities and the trunk. Resistance (R) and reactance (Xc) were measured at 50 kHz, and the PhA and BI-index were calculated as follows: PhA (degrees) = arctan (Xc/R) • (180/P), and BI-index (cm^2/Ω)= height^2(cm)/R [19]. Body composition assessment, fat free mass, and fat mass, were estimated using the Marra equation [20] for women with BMI of <18.5 kg/m^2 and the Sun BIA equation [21] for women of normal weight.

Hand grip strength test

Muscle strength was assessed by HGS. HGS was measured in both dominant and non-dominant hands with a Jamar dynamometer (JAMAR, Rolyan, UK). Patients performed the test standing with their upper limbs by their sides, and they were instructed to squeeze a dynamometer at maximal voluntary isometric contraction. The measurement was repeated three times alternately on both sides (dominant and non-dominant arm) with 1 min between repetitions to avoid fatigue. The dominant hand was determined by asking subjects if they were right- or left-handed. The mean value was recorded in kilograms [22].

Statistical analysis

Statistical analyses were performed using IBM SPSS (version 24.0, IBM Corp, Armonk, NY, USA). The Kolmogorov-Smirnov test was used to perform the normality of all numerical continuous variables. The test showed a normal distribution; therefore, a parametric analysis was performed. Data are presented as the mean ± SD, and statistical significance was defined as $P < 0.05$. For the comparison between means of groups, one-way Analysis Of Variance (Tukey's test) was used. Pearson's correlation was applied to evaluate associations between variables. Multivariate linear regression analysis was performed to assess the main predictors of HGS in the following variables: age, weight, height, and raw BIA variables (BI-index and PhA). The coefficient of determination (R2) and the standardized regression coefficients (β) were considered.

Results

A total of 529 participants with a mean age of 23.2 ± 7.0 y, a mean body weight of 49.1 ± 7.6 kg, and an average BMI of 18.9 ± 2.5 kg/m^2 were recruited. Subsequently, the whole sample was divided into tertiles according to BMI: the first tertile (T1), 15 to 17.29 kg/m^2; the second tertile (T2), 17.3 to 9.9 kg/m^2; and the third tertile (T3), 20 to 25 kg/m^2. Specifically, participants with eating disorders were included in the first two tertiles, showing the following characteristics: T1 (100% anorexic restrictive) and T2 (55.7% anorexic restrictive and 44.3% unspecified eating disorders), while all controls were included in the last tertile (T3).

Both anthropometric characteristics and body composition of the entire sample according to tertiles are presented in Table 1. All considered variables significantly differed among the three groups, except for age and height.

Cut-offs of HGS

The cut-offs for HGS values for all participants are reported in Table 2, whereas data according to age group (age = <20 y, 20–30 y, and >30 y) are described in Table 3. Overall, data were expressed as the mean, SD, and respective 10th, 25th, 50th, 75th, and 90th percentiles for HGS values.

Our findings showed that muscle strength was higher for the dominant hand than for the non-dominant hand in all BMI tertiles. Specifically, on both sides, we found that HGS values were higher for women in T3 than in the other tertiles (**Table 2**).

The cut-offs of HGS and their percentiles stratified by age are presented in **Table 3**. Overall, on both sides, we found that HGS values increased with increasing age for both T1 and T3 but not in T2 owing to increased values observed only in the age group between 20 and 30 y. In addition, the mean values according to age group and for both sides are shown in **Figure 1.** On the

Table 1
Anthropometric characteristics, body composition, and hand grip strength measurements

	T1 (n = 177)	T2 (n = 176)	T3 (n = 176)
Age (y)	21.9 ± 6.5	23.6 ± 7.4	23.9 ± 6.9
Weight (kg)	42.0 ± 3.4*	48.1 ± 4.0	57.3 ± 5.2
Height (cm)	161 ± 5	161 ± 6	161 ± 5
BMI (kg/m^2)	16.2 ± 0.6*	18.5 ± 0.7	21.9 ± 1.3
BI-index (cm^2/Ω)	37.7 ± 4.7*	40.6 ± 5.9	44.5 ± 5.8
FFM (kg)	37.4 ± 2.6*	39.9 ± 3.2	41.7 ± 3.6
FM (kg)	4.6 ± 1.4*	8.2 ± 3.1	15.5 ± 3.5
FM (%)	10.7 ± 2.9*	16.7 ± 5.6	26.9 ± 4.6
PhA (degrees)	5.68 ± 0.75*	6.05 ± 0.89	6.26 ± 0.75
HGS (kg)	20.0 ± 3.5*	21.3 ± 5.3	22.6 ± 5.4

BI-index, bio impedance index; BMI, body mass index; FFM, fat free mass; FM, fat mass; HGS, hand grip strength; PhA, phase angle
Data are expressed as mean ± SD
T1 = BMI 15–17.29 kg/m^2; T2 = BMI 17.3–19.9 kg/m^2; T3 = BMI 20–25 kg/m^2
*$P < 0.005$ between groups.

Table 2
Cut-off HGS measurements (in kg) by side in all participants according to tertiles

		Dominant hand (kg)						Non-dominant hand (kg)					
			Percentiles						Percentiles				
	n	Mean (SD)	10	25	50	75	90	Mean (SD)	10	25	50	75	90
T1	177	21.3 (3.7)	16.0	18.6	21.3	24.0	26.3	18.7 (3.7)	14.0	16.0	19.0	21.3	24.0
T2	176	22.3 (5.5)	15.3	18.6	22.1	26.0	29.7	20.2 (5.4)	13.3	16.6	20.0	24.0	28.0
T3	176	23.9 (5.5)	16.0	20.3	24.0	28.0	30.7	21.4 (5.4)	14.0	18.0	22.0	25.2	28.6

HGS, hand grip strength; SD, standard deviation
T1 = BMI 15–17.29 kg/m^2; T2 = BMI 17.3–19.9 kg/m^2; T3 = BMI 20–25 kg/m^2

Table 3
Cut-offs of HGS measurements (in kg) by side and age groups

		T1							T2							T3						
		Mean (SD)		percentiles					Mean (SD)		percentiles					Mean (SD)		percentiles				
		n	kg	10	25	50	75	90	n	kg	10	25	50	75	90	n	kg	10	25	50	75	90
<20 y	**D**	87	21.0 (3.6)	16.0	18.3	20.6	24.0	26.0	73	21.9 (4.9)	15.8	18.5	22.0	25.5	28.5	59	22.8 (5.4)	15.3	19.3	22.6	24.5	26.0
20–30 y	**D**	74	21.4 (3.9)	17.3	18.6	21.3	24.1	27.0	72	23.2 (5.4)	15.3	19.3	23.3	27.6	30.6	89	24.4 (7.6)	16.0	20.3	24.6	29.3	31.3
>30 y	**D**	16	22.0 (3.8)	14.9	20.2	22.0	24.5	27.2	31	21.4 (6.8)	14.0	17.3	20.3	26.0	31.6	28	25.3 (5.1)	16.6	22.1	26.0	29.5	32.1
<20 y	**n-D**	87	18.4 (3.7)	14.0	16.0	18.0	21.3	23.3	73	19.6 (5.0)	12.6	16.0	20.0	22.8	26.2	59	20.1 (5.1)	13.3	17.3	20.0	23.3	27.3
20–30 y	**n-D**	74	18.8 (3.7)	13.6	16.0	19.3	21.3	24.0	72	21.2 (5.1)	14.4	17.4	21.0	24.6	28.9	89	21.6 (5.7)	14.3	18.0	22.0	26.0	29.3
>30 y	**n-D**	16	20.1 (3.9)	13.3	17.2	20.3	23.8	25.0	31	19.6 (6.7)	12.0	16.0	18.0	24.6	29.1	28	23.6 (4.9)	14.9	20.8	22.3	28.0	30.0

HGS, hand grip strength; SD, standard deviation
D = dominant; n-D = non-dominant; T1 = BMI 15–17.29 kg/m^2; T2 = BMI 17.3–19.9 kg/m^2; T3 = BMI 20–25 kg/m^2

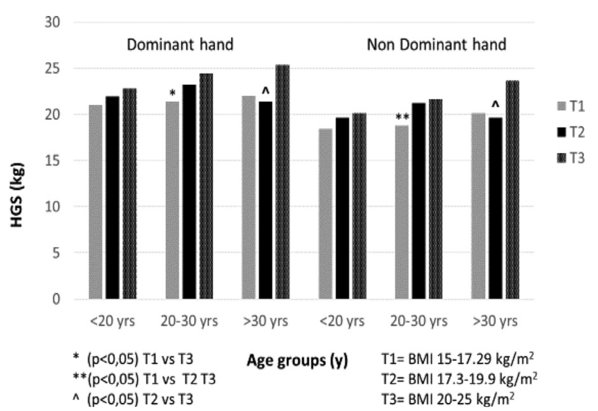

Fig. 1. HGS measurements by age groups according to BMI tertiles. BMI, body mass index. HGS, hand grip strength

dominant side, we found no difference among tertiles in subjects younger than 20 y. In the 20 to 30 y age group, the data were lower for T1 than for T3, and among women older than 30 y, HGS values were significantly reduced for subjects in T2 compared with those in T3. Similar results for HGS values were found on the non-dominant side in the youngest subjects. However, we observed significant differences in the group with ages 20 to 30 y, which had the lowest HGS values for women in T1, and in the group of participants older than 30 y, which had reduced HGS values for T2 compared to T3.

Predictors of HGS

Pearson's correlation coefficients between HGS and both anthropometric and bioimpedance variables were calculated. Body weight (r = 0.408), PhA (r = 0.331), and height (r = 0.289) gave the best correlation with HGS at T1, T2, and T3, respectively.

Finally, a multiple linear regression analysis was carried out to identify the main predictors for upper limb strength (**Table 4**). Multivariate linear regression analysis showed that the main predictor of HGS at T1 was weight (R^2 = 0.252), while PhA was the main determinant at both T2 (R^2 = 0.240) and T3 (R^2 = 0.216).

Discussion

This study first aimed to propose reference values for HGS in Italian women affected by primary malnutrition as well as from controls according to BMI tertiles and by stratifying the whole sample by age. Our results showed that muscle strength was higher for the dominant hand than for the non-dominant hand in all BMI tertiles and, according to age groups, HGS increased with increasing age in T1 and T3 but not in T2 since HGS values increased in the women aged between 20 and 30 y.

Table 4
Multivariate linear regression analysis

T1				T2				T3			
Main predictor	β	*P*	R^2	Main predictor	β	*P*	R^2	Main predictor	β	*P*	R^2
Weight	0.365	0.000	0.252	PhA	0.389	0.000	0.240	PhA	0.342	0.000	0.216
PhA	0.266	0.000		Height	0.236	0.003		Height	0.280	0.001	
BI-index	0.200	0.013		BI-index	0.180	0.024		BI-index	0.162	0.037	

BI-index, bio impedance index; PhA, phase angle
T1 = BMI 15–17.29 kg/m^2; T2 = BMI 17.3–19.9 kg/m^2; T3 = BMI 20–25 kg/m^2

According to our findings, Wang, et al. [17] proposed reference values for a population residing in the United States, but they found that the mean dominant HGS for underweight and normal-weight patients was 25 kg and 27 kg, respectively. These reference values were lower than those observed in the present study (21.3 kg and 23.9 kg for underweight and normal-weight women). Another study, conducted in a Colombian university student, suggested reference values of HGS. They studied men and women of normal weight and found that HGS increased with increasing age in both sexes. These results are similar to our HGS values found in T3 that included normal-weight women [23].

Nevertheless, Schlüssel, et al. [16] presented both right and left HGS mean values according to sex and age in healthy Brazilian adults. HGS increased slowly with age (20–39 y category) on both sides and significantly decreased after 50 y of age. In addition, they found that in men, there was a clear tendency of higher HGS on the right side, with increasing BMI at each age category, but this tendency was not evident in women.

Also, Ramírez-Vélez, et al. [24] have observed a decrease in HGS cut-off with increasing age in older adults of ≥60 y.

Despite the large difference in BMI, we observed that the muscle strength of the upper limbs did not differ much between tertiles. There is a difference of approximately 5 kg between underweight and normal weight on both sides. On the dominant side, the lowest mean value of HGS was 21 kg (T1), and the maximum value was 25.3 kg (T3), while on the non-dominant side, the lowest mean value of HGS was 18.4 kg (T1), and the maximum value was 23.6 kg (T3).

The second aim of this study was to identify the possible predictors of HGS between both anthropometric variables (age, weight, height) and some row BIA parameters (BI-index, PhA).

The main predictor in T2 and T3 was PhA, except in T1, where the greatest predictor was body weight. However, it is likely that in patients with primary malnutrition, body weight was the parameter most correlated with nutritional status among anthropometric variables.

Therefore, variations in PhA associated with decreased HGS could be useful in clinical practice for monitoring patients because both PhA and HGS are qualitative indexes of the nutritional state [6,25–28].

However, some limitations need to be considered. First, regarding HGS methods, subject cooperation was required, and sometimes, women with primary malnutrition had to be very encouraged for maximum force to be applied. Second, although the sample was relatively large, perhaps the tertiles were rather small to justify age stratification. Therefore, this study is the first to establish specific cut-offs of HGS for both underweight and normal-weight women.

In conclusion, normative data for both women with primary malnutrition and normal weight provided in this study may be useful in both clinical and research fields as early screening. Reference cut-offs and possible PhA variations could be used in a clinical setting to monitor nutritional status changes in individuals with similar ages and BMIs.

References

[1] Norman K, Stobäus N, Gonzalez MC, Schulzke JD, Pirlich M. Hand grip strength: outcome predictor and marker of nutritional status. Clin Nutr 2011;30:135–42.
[2] Flood A, Chung A, Parker H, Kearns V, O'Sullivan TA. The use of hand grip strength as a predictor of nutrition status in hospital patients. Clin Nutr 2014;33:106–14.
[3] Reber E, Gomes F, Vasiloglou MF, Schuetz P, Stanga Z. Nutritional risk screening and assessment. J Clin Med 2019;8:1065.
[4] Sorensen J, Kondrup J, Prokopowicz J, Schiesser M, Krähenbühl L, Meier R, et al. EuroOOPS: an international, multicentre study to implement nutritional risk screening and evaluate clinical outcome. Clin Nutr 2008;27:340–9.
[5] García-Hermoso A, Cavero-Redondo I, Ramírez-Vélez R, Ruiz JR, Ortega FB, Lee DC, et al. Muscular strength as a predictor of all-cause mortality in an apparently healthy population: a systematic review and meta-analysis of data from approximately 2 million men and women. Arch Phys Med Rehabil 2018;99. 2100–13.e5.
[6] Rodríguez-Rodríguez F, Cristi-Montero C, González-Ruíz K, Correa-Bautista JE, Ramírez-Vélez R. Bioelectrical impedance vector analysis and muscular fitness in healthy men. Nutrients 2016;8:407.
[7] Cruz-Jentoft AJ, Bahat G, Bauer J, Boirie Y, Bruyère O, Cederholm T, et al. Sarcopenia: revised European consensus on definition and diagnosis. Age Ageing 2019;48:16–31.
[8] Cawthon PM, Fox KM, Gandra SR, Delmonico MJ, Chiou CF, Anthony MS, et al. Do muscle mass, muscle density, strength, and physical function similarly influence risk of hospitalization in older adults? J Am Geriatr Soc 2009;57:1411–9.
[9] Ibrahim K, May C, Patel HP, Baxter M, Sayer AA, Roberts H. A feasibility study of implementing grip strength measurement into routine hospital practice: study protocol. Pilot Feasibility Stud 2016;2:27.
[10] Guerra RS, Amaral TF, Sousa AS, Pichel F, Restivo MT, Ferreira S, et al. Handgrip strength measurement as a predictor of hospitalization costs. Eur J Clin Nutr 2015;69:187–92.
[11] Leong DP, Teo KK, Rangarajan S, Lopez-Jaramillo P, Avezum A Jr, Orlandini A, et al. Prognostic value of grip strength: findings from the prospective urban rural epidemiology study. Lancet 2015;386:266–73.
[12] Alqahtani B, Alenazi A, Alshehri M, Alqahtani M, Elnaggar R. Reference values and associated factors of hand grip strength in elderly Saudi population: a cross-sectional study. BMC Geriatr 2019;19:271.
[13] Desrosiers J, Bravo G, Hébert R, Dutil E. Normative data for grip strength of elderly men and women. Am J Occup Ther 1995;49:637–44.
[14] Mitsionis G, Pakos EE, Stafilas KS, Paschos N, Papakostas T, Beris AE. Normative data on hand grip strength in a Greek adult population. Int Orthop 2009;33:713–7.
[15] Zeng P, Han Y, Pang J, Wu S, Gong H, Zhu J, et al. Sarcopenia-related features and factors associated with lower muscle strength and physical performance in older Chinese: a cross sectional study. BMC Geriatr 2016;16:45.
[16] Schlüssel MM, dos Anjos LA, de Vasconcellos MT, Kac G. Reference values of handgrip dynamometry of healthy adults: a population-based study. Clin Nutr 2008;27:601–7.
[17] Wang YC, Bohannon RW, Li X, Sindhu B, Kapellusch J. Hand-grip strength: normative reference values and equations for individuals 18 to 85 years of age residing in the United States. J Orthop Sports Phys Ther 2018;48:685–93.
[18] Luna-Heredia E, Martín-Peña G, Ruiz-Galiana J. Handgrip dynamometry in healthy adults. Clin Nutr 2005;24:250–8.
[19] Scalfi L, Bedogni G, Marra M, Di Biase G, Caldara A, Severi S, et al. The prediction of total body water from bioelectrical impedance in patients with anorexia nervosa. Br J Nutr 1997;78:357–65.
[20] Marra M, Sammarco R, De Filippo E, Caldara A, Speranza E, Scalfi L, et al. Prediction of body composition in anorexia nervosa: results from a retrospective study. Clin Nutr 2018;37:1670–4.
[21] Sun G, French CR, Martin GR, Younghusband B, Green RC, Xie YG, et al. Comparison of multifrequency bioelectrical impedance analysis with dual-energy X-ray absorptiometry for assessment of percentage body fat in a large, healthy population. Am J Clin Nutr 2005;81:74–8.
[22] Vaz M, Thangam S, Prabhu A, Shetty PS. Maximal voluntary contraction as a functional indicator of adult chronic undernutrition. Br J Nutr 1996;76:9–15.
[23] Vivas-Díaz JA, Ramírez-Vélez R, Correa-Bautista JE, Izquierdo M. Valores de fuerza prensil por dinamometría manual en universitarios de Colombia. Nutr Hosp 2016;33:113.
[24] Ramírez-Vélez R, Correa-Bautista JE, García-Hermoso A, Cano CA, Izquierdo M. Reference values for handgrip strength and their association with intrinsic capacity domains among older adults. J Cachexia Sarcopenia Muscle 2019;10:278–86.
[25] Marra M, De Filippo E, Signorini A, Silvestri E, Pasanisi F, Contaldo F, et al. Phase angle is a predictor of basal metabolic rate in female patients with anorexia nervosa. Physiol Meas 2005;26:S145–52.
[26] Marra M, Caldara A, Montagnese C, De Filippo E, Pasanisi F, Contaldo F, et al. Bioelectrical impedance phase angle in constitutionally lean females, ballet dancers and patients with anorexia nervosa. Eur J Clin Nutr 2009;63:905–8.
[27] De Filippo E, Marra M, Alfinito F, Di Guglielmo ML, Majorano P, Cerciello G, et al. Hematological complications in anorexia nervosa. Eur J Clin Nutr 2016;70:1305–8.
[28] Marra M, Sammarco R, De Filippo E, De Caprio C, Speranza E, Contaldo F, et al. Resting energy expenditure, body composition and phase angle in anorectic, ballet dancers and constitutionally lean males. Nutrients 2019;11:502.