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The Effects of Bioimpedance Analysis Results and Upper Extremity Anthropometric Measurements on Grip Strength in Young Adults

Genç Erişkinlerde Biyoempedans Analiz Sonuçlarının ve Üst Ekstremite Antropometrik Ölçümlerinin Kavrama Kuvvetine Etkisi

Burcu KAMAŞAK[1]
0000-0001-5340-1260
Esra BAYRAMOĞLU DEMİRDÖĞEN[2]
0000-0001-9950-1873
Tufan ULCAY[1]
0000-0003-2203-3850
Özkan GÖRGÜLÜ[3]
0000-0002-6802-4450
Beyza Nur DEMİR[1]
0000-0001-6329-565X
Şeyma KARAOSMANOĞLU[1]
0000-0002-9932-7673
Emre UĞUZ[1]
0000-0001-7813-3290
Ahmet UZUN[4]
0000-0003-4147-3798
Kenan AYCAN[1]
0000-0002-3275-0573

[1]Department of Anatomy, Kırşehir Ahi Evran University Faculty of Medicine, Kırşehir, Türkiye

[2]Department of Physiotherapy and Rehabilitation, Kırşehir Ahi Evran University Health Sciences Institute, Kırşehir, Türkiye

[3]Department of Biostatistics, Kırşehir Ahi Evran University Faculty of Medicine, Kırşehir, Türkiye

[4]Department of Anatomy, Ondokuz Mayıs University Faculty of Medicine, Samsun, Türkiye

Corresponding Author
Sorumlu Yazar
Burcu KAMAŞAK
brc1608@hotmail.com

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ABSTRACT

Aim: Among the hand functions, grasping is an important function for the continuity of daily living activities. The assessment of grip strength is crucial for identifying athletic prowess, neuromuscular illnesses, assessing potential side effects following hand surgery, and treatment plans. It was aimed to examine whether bioimpedance analysis (BIA) and upper extremity anthropometric measurements are effected grip strength in young adults.
Material and Methods: The study was conducted on 110 young adults, 55 males and 55 females, aged 18-25 years. Individuals with a history of trauma, musculoskeletal problems, and cardiac, respiratory, metabolic, or systemic diseases were not included in the study. Non-flexible tape measure, Harpenden anthropometric set, digital caliper, hand dynamometer, and skinfold caliper were used for anthropometric measurements. Body fat percentage and lean body mass, muscle mass, basal metabolic rate, and total body fluid parameters were investigated by bioelectrical impedance measurement. Three measurements were taken to reduce the error rate, and the average of these measurements was considered.
Results: Excluding arm circumference, forearm length, and wrist circumference from anthropometric measurements, and mineral from BIA parameters; anthropometric measurements and BIA results were found to be statistically significantly correlated with grip strength.
Conclusion: Upper extremity anthropometric measurements and BIA were associated with grip strength and varied according to gender. Significant correlations were found between grip strength with most of the anthropometric parameters and BIA.
Keywords: Anthropometry; bioimpedance analysis; grip strength; upper extremity; young adults.

ÖZ

Amaç: El fonksiyonları arasında kavrama, günlük yaşam aktivitelerinin devamlılığı için önemli bir fonksiyondur. Kavrama gücünün değerlendirilmesi, atletik beceriyi belirlemek, nöromüsküler hastalıklar, el cerrahisini takiben olası yan etkileri değerlendirmek ve tedavi planları için çok önemlidir. Genç erişkinlerde biyoempedans analizi (BIA) ve üst ekstremite antropometrik ölçümlerinin kavrama gücünü etkileyip etkilemediğinin incelenmesi amaçlandı.
Gereç ve Yöntemler: Çalışma, yaşları 18-25 yıl arasında olan 55 erkek ve 55 kadın olmak üzere 110 genç yetişkin üzerinde gerçekleştirildi. Travma öyküsü, kas-iskelet sistemi sorunu ve kalp, solunum, metabolik veya sistemik hastalığı olan kişiler çalışmaya alınmadı. Antropometrik ölçümler için esnek olmayan mezura, Harpenden antropometrik seti, dijital kumpas, el dinamometresi ve deri kıvrım kalınlığı ölçüm cihazı kullanıldı. Biyoelektrik empedans ölçümü ile vücut yağ yüzdesi ve yağsız vücut kütlesi, kas kütlesi, bazal metabolizma hızı ve toplam vücut sıvısı parametreleri araştırıldı. Hata oranını düşürmek için 3 kez ölçüm alındı ve bu ölçümlerin ortalaması dikkate alındı.
Bulgular: Antropometrik ölçümlerden kol çevresi, ön kol uzunluğu ve bilek çevresi, BIA parametrelerinden ise mineral hariç olmak üzere; antropometrik ölçümler ve BIA sonuçlarının kavrama gücü ile istatistiksel olarak anlamlı bir şekilde ilişkili olduğu bulundu.
Sonuç: Üst ekstremite antropometrik ölçümleri ve BIA kavrama kuvveti ile ilişkilidir ve cinsiyete göre farklılık göstermektedir. Kavrama kuvveti ile antropometrik parametrelerin çoğu arasında ve BIA ile anlamlı bir ilişki bulunmuştur.
Anahtar kelimeler: Antropometri; biyoempedans analizi; kavrama kuvveti; üst ekstremite; genç erişkinler.

INTRODUCTION

Various body composition analysis methods have been developed in clinical and athletic fields to determine optimal body composition and to identify and classify diseases. Bioimpedance analysis (BIA) is a common approach used in body composition measurement and health assessment systems. BIA is a very easy-to-use and non-invasive method (1). Varied methods are used to interpret the data obtained by bioimpedance measurements. There are a wide variety of bioimpedance applications in healthcare, such as disease prognosis and monitoring of body vitality (2).

Anthropometry is a systematic technique-based science that measures the physical characteristics of the human body using measurement principles. Anthropometric measurements are made dynamically and statically. Measurements such as height, length, circumference, and skin thickness are static measurements. Dynamic data is obtained by measuring the limits of bending, elongation, and spinning/turning movements (3). Anthropometry is a widely used, portable, cheap, simple, and useable technique consisting of various body measurements (4).

Grip strength is an indicator of disability, morbidity, mortality, increased dependence on activities of daily living, and cognitive decline in adults (5). It is important for the auxiliary diagnosis of diseases in many clinical branches such as internal medicine, orthopedics, and physiotherapy. Studies on this subject have shown that grip strength is not only related to general body muscle strength but also to upper extremity muscle strength (6). Low grip strength is also correlated with hypertension, coronary artery disease, peripheral artery disease, heart failure, stroke, or chronic obstructive pulmonary disease. Furthermore, grip strength is negatively associated with physical frailty even after accounting for the effects of body mass index (BMI) and arm muscle circumference (7). Evaluation of grip strength helps to identify the risk of micro-trauma as well as to determine both the rehabilitation process of overuse injury and the performance level of athletes (8,9).

We aimed to benefit these various clinical and social areas to examine whether upper extremity anthropometric measurements and BIA results are effected grip strength in young adults. The present study's results contribute to determining the risk of future disease, with grip strength in the young population with less health problems. The correlation between grip strength and BIA and anthropometric measurements is effective in determining health problems such as obesity and metabolic syndrome.

MATERIAL AND METHODS

This study was approved by the Non-Invasive Clinical Research Ethics Committee of Kırşehir Ahi Evran University Faculty of Medicine (Date: 10.05.2022, Ethical number: 2022-09/99). Volunteers were informed about the measurements and signed an informed consent form. The sample size of the study was determined by a priori power analysis. When the correlation was taken as ρ H_1=0.3, Power (1-ß)=0.85, the minimum sample size to be studied was 110. The study was conducted on a total of 110 young adults (55 male and 55 female) between the ages of 18-25 years, collected cross-sectionally from Kırşehir Ahi Evran University Faculty of Medicine. Individuals without any history of trauma, musculoskeletal problems, or cardiac, respiratory, metabolic, or systemic diseases were included in the study. For anthropometric measurements, an inflexible tape measure, Harpenden anthropometric set, digital caliper, stadiometer, hand dynamometer, pinch meter, and skinfold caliper were used. To reduce the error rate, the measurements were made by the researcher, three times, and the average was taken. TANITA MC-780 is used for BIA. Height was measured with bare feet by a stadiometer in an anatomical position. Weight was measured with an electronic scale while the participants were hungry. BMI was calculated using the weight kg/m^2 method.

Triceps skinfold thickness, biceps skinfold thickness, arm circumference, forearm circumference, wrist circumference, upper extremity length, arm length, forearm length, hand length, palm length, third finger length, hand width, wrist medio-lateral diameter, wrist dorso-volar diameter, grip strength, tip pinch, key pinch, palmar pinch, weight (kg), height (cm) were measured. As the BIA measurements were taken such as BMI (kg/m^2), lean mass (%), muscle (%), fat mass (%), total body fluid (lt), intracellular fluid (kg), extracellular fluid (kg), protein (%), mineral (%), basal metabolic rate (kcal), obesity degree (%), waist/hip ratio, waist/height ratio, phase angle (provides information about cellular health and integrity).

Triceps and biceps skinfold thickness were measured by skinfold caliper from the dominant upper extremities of individuals (Figure 1A and Figure 1B). Grip strength was measured by hand dynamometer (Figure 1C).

Figure 1. A) Triceps skinfold thickness, **B)** Biceps skinfold thickness, **C)** Grip strength

Arm circumference (the criterion point is taken as the medial epicondyle of the humerus and is made by taking 10-15 cm above this point or the most swollen part of the muscle), forearm circumference (the distance between the olecranon and styloid proccess of radius) and wrist circumference were measured by inflexible tape measure.
Upper extremity length (distance between the acromion and the most distal part of the third finger), arm length, and forearm length were measured by the Harpenden anthropometric set (Figure 2).
Hand length, palm length and third finger length, hand width, wrist medio-lateral diameter (wrist line level, from the medial and lateral points), and wrist dorso-volar diameter (anterior-posterior thickness was measured at the wrist crease line level) were measured by a digital caliper (Figure 3).
Tip pinch, key pinch, and palmar pinch were measured by pinch meter (Figure 4).
Weight, lean mass, muscle mass, fat mass, total body fluid, intracellular fluid, extracellular fluid, protein, mineral, basal metabolic rate, obesity degree, waist/hip ratio, waist/height ratio, and phase angle were measured by BIA device. Participants were asked to stand barefoot on the electrode panel and hold the electrodes in their anatomical position by contacting the fingers and palms of both hands.

Statistical Analysis

The conformity of the data to the normal distribution was evaluated with the Kolmogorov-Smirnov and Shapiro-Wilk tests. Independent t-test and Mann-Whitney U tests were used for univariate analyzes according to the availability of assumptions. The correlation between variables was calculated by Pearson correlation analysis. Data analysis was performed using Statistical Package for Social Sciences for windows (IBM SPSS version 28.0, Armonk, NY, USA). The significance level was accepted as $p<0.05$.

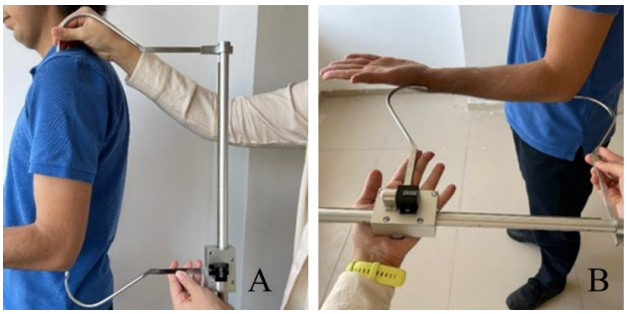

Figure 2. A) Arm length, **B)** Forearm length

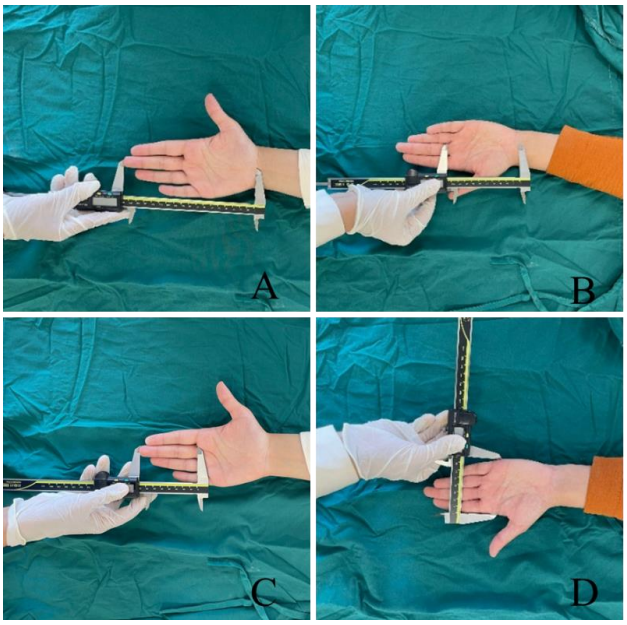

Figure 3. A) Hand length, **B)** Palm length, **C)** Third finger length, **D)** Hand width

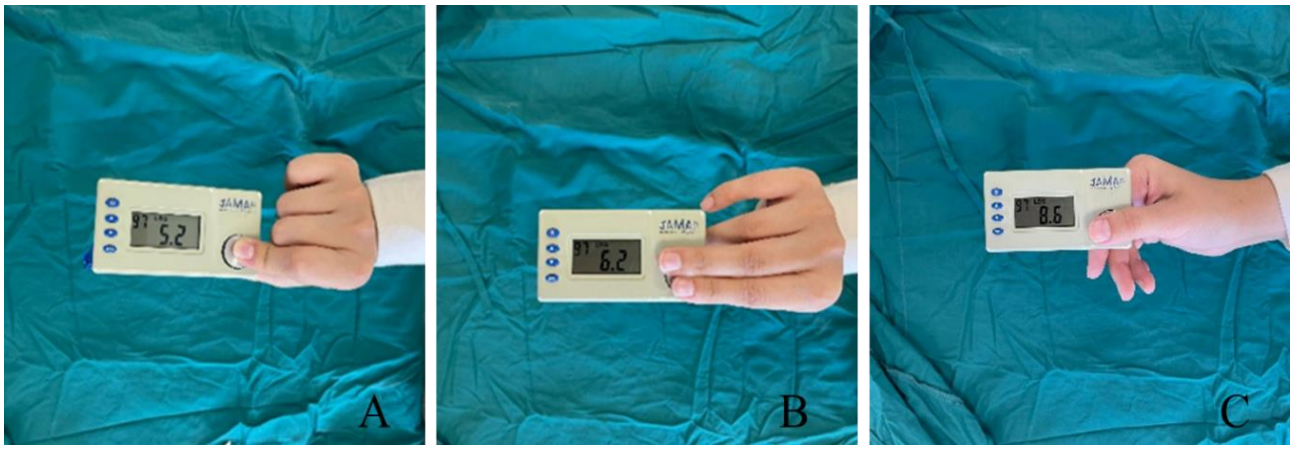

Figure 4. A) Tip pinch, **B)** Key pinch, **C)** Palmar pinch

RESULTS

Descriptive statistics and group comparisons of the variables that are the subject of the study were given in Table 1. The mean age of individuals was calculated as 19.07±1.16 years. Height and weight were calculated to be higher in males than in females. A statistically significant difference was found between the genders in terms of all variables ($p<0.001$) except arm circumference and forearm length. Arm circumference, forearm circumference, wrist circumference, upper extremity length, arm length, forearm length, hand length, third finger length, palm length, hand width, wrist medio-lateral diameter, wrist dorso-volar diameter, tip pinch, key pinch, palmar pinch,

weight, height, BMI, lean mass, muscle mass, total body fluid, intracellular fluid, extracellular fluid, basal metabolic rate, protein, mineral, obesity degree, waist/height ratio, waist/hip ratio, phase angle, grip strength of males was higher than females. Even though arm circumference and forearm length are higher in males, these were found to be statistically insignificant (p=0.070, and p=0.501, respectively). Triceps skinfold thickness, biceps skinfold thickness, and fat mass (%) were found higher in females (p<0.001).

Arm length, hand length, palm length, hand width, wrist medio-lateral diameter, wrist dorso-volar diameter, BMI, lean mass, muscle mass, total body fluid, basal metabolic rate, waist/hip ratio, forearm circumference, upper extremity length, third finger length, tip pinch, key pinch, palmar pinch, weight, height, intracellular fluid, extracellular fluid, protein, obesity degree, waist/height ratio were found to be statistically significantly positively correlated with grip strength. There is a negative significant correlation with biceps skinfold thickness. Triceps skinfold thickness, fat mass, and phase angle were found to be statistically significantly negatively correlated with grip strength (Table 2). It was determined that the correlation between grip strength and arm circumference, forearm length, and wrist circumference with mineral was not statistically significant.

DISCUSSION

Grip strength is very important for performing many activities of daily living. Studies in the literature have reported the effects of factors such as anthropometric parameters (forearm length, forearm circumference measurement), gender, hand dominance, height, BMI, and age on hand grip and finger grip strength (10-12). In a study by Stegink et al. (12), hand grip strength and finger grip strength, and anthropometric measurements were found to be positively related to the arm-forearm circumference measurements.

According to the study of Anakwe et al. (13), a significant correlation was found between forearm circumference and grip strength. Our study showed that there is a significant correlation between grip strength with upper extremity

Table 1. Anthropometric measurement and bioimpedance analysis results of young adults

	Male (n=55)	Female (n=55)	p
Triceps Skinfold Thickness (mm)	7.44±2.97	12.84±6.15	<**0.001**
Biceps Skinfold Thickness (mm)	4.5 (3.5-7.5)	8.1 (5.0-12.0)	<**0.001**
Arm Circumference (mm)	183.07±132.44	140.68±109.04	0.070
Forearm Circumference (mm)	28.00 (26.90-29.00)	23.00 (22.00-24.00)	<**0.001**
Wrist Circumference (mm)	18.00 (17.50-19.00)	15.90 (15.00-16.00)	<**0.001**
Upper Extremity Length (mm)	759.10±38.88	714.51±33.84	<**0.001**
Arm Length (mm)	361.00 (354.50-376.50)	337.00 (324.00-349.00)	<**0.001**
Forearm Length (mm)	278.71±36.65	273.98±36.82	0.501
Hand Length (mm)	182.00 (176.50-188.24)	166.00 (159.00-172.28)	<**0.001**
Third Finger Length (mm)	77.03 (73.68-82.17)	73.59 (70.27-76.69)	<**0.001**
Palm Length (mm)	108.57±14.28	97.05±8.52	<**0.001**
Hand Width (mm)	87.62±11.14	76.17±4.01	<**0.001**
Wrist Medio-lateral Diameter (mm)	60.51±4.60	53.00±5.34	<**0.001**
Wrist Dorso-volar Diameter (mm)	40.47 (37.31-43.70)	32.70 (29.02-34.41)	<**0.001**
Tip Pinch (kg)	5.03 (3.81-5.99)	3.36 (2.86-3.90)	<**0.001**
Key Pinch (kg)	8.85 (7.44-10.16)	5.13 (3.99-5.81)	<**0.001**
Palmar Pinch (kg)	6.34±1.67	4.93±1.32	<**0.001**
Weight (kg)	74.40 (65.90-83.90)	54.60 (51.20-63.50)	<**0.001**
Height (cm)	178.00 (173.00-181.00)	167.00 (162.00-170.00)	<**0.001**
Body Mass Index (kg/m^2)	23.93±3.87	20.83±4.03	<**0.001**
Lean Mass (%)	83.59 (77.59-88.24)	78.64 (72.68-80.68)	<**0.001**
Muscle Mass (%)	79.46 (73.72-83.79)	74.67 (68.96-76.54)	<**0.001**
Fat Mass (%)	16.41 (11.44-22.42)	21.36 (19.33-27.33)	<**0.001**
Total Body Fluid (lt)	60.91 (55.73-64.56)	56.71 (52.60-58.78)	<**0.001**
Intracellular Fluid (kg)	26.90 (24.80-28.70)	18.20 (17.20-19.90)	<**0.001**
Extracellular Fluid (kg)	18.00 (16.60-19.00)	12.70 (12.00-14.10)	<**0.001**
Basal Metabolic Rate (kcal)	1855.38±199.04	1362.64±138.78	<**0.001**
Protein (%)	16.66 (16.06-17.56)	15.94 (14.56-16.62)	<**0.001**
Mineral (%)	6.09 (5.60-6.48)	5.64 (5.18-5.89)	<**0.001**
Obesity Degree (%)	9.01 (-3.26-22.74)	-5.24 (-14.87-7.93)	<**0.001**
Waist/Height ratio	0.48 (0.44-0.53)	0.42 (0.39-0.47)	<**0.001**
Waist/Hip ratio	0.88±0.05	0.76±0.06	<**0.001**
Phase Angle	6.38±0.52	5.30±0.77	<**0.001**
Grip Strength (kg)	41.62±8.67	25.31±5.67	<**0.001**

Table 2. Correlation results between grip strength and anthropometric measurements with BIA of young adults

	r	p
Triceps Skinfold Thickness	-0.323	**0.001**
Biceps Skinfold Thickness	-0.194	**0.042**
Arm Circumference	0.096	0.317
Forearm Circumference	0.680	**<0.001**
Wrist Circumference	0.016	0.870
Upper Extremity Length	0.349	**<0.001**
Arm Length	0.416	**<0.001**
Forearm Length	0.095	0.322
Hand Length	0.460	**<0.001**
Third Finger Length	0.235	**0.013**
Palm Length	0.415	**<0.001**
Hand Width	0.452	**<0.001**
Wrist Medio-lateral Diameter	0.487	**<0.001**
Wrist Dorso-volar Diameter	0.438	**<0.001**
Tip Pinch	0.579	**<0.001**
Key Pinch	0.728	**<0.001**
Palmar pinch	0.604	**<0.001**
Weight	0.520	**<0.001**
Height	0.225	**0.018**
Body Mass Index	0.327	**<0.001**
Lean Mass	0.348	**<0.001**
Muscle Mass	0.346	**<0.001**
Fat Mass	- 0.351	**<0.001**
Total Body Fluid	0.357	**<0.001**
Intracellular Fluid	0.733	**<0.001**
Extracellular Fluid	0.675	**<0.001**
Basal Metabolic Rate	0.687	**<0.001**
Protein	0.197	**0.039**
Mineral	0.039	0.686
Obesity Degree	0.345	**<0.001**
Waist/Height ratio	0.283	**0.003**
Waist/Hip ratio	0.535	**<0.001**
Phase Angle	-0.555	**<0.001**

anthropometric measurements and BIA. Also, we found a significant correlation between muscle mass and grip strength, which was higher in males (r=0.346).

As a result of the study by Seethamma et al. (14), it was found that grip strength was directly related to the anthropometric measurement of hand length and forearm circumference, and therefore grip strength was associated with hand length and forearm circumference regardless of age and gender. While we obtained similar results to Seethamma et al. (14), contrary to the results of our study, Nefesoğlu et al. (15) reported that grip strength was associated with forearm length, arm circumference, and wrist circumference.

Contrary to our results, Narin et al. (6) reported that grip and finger grip strength were higher in individuals with longer forearms and more circumference measurements. In our research, a significant result was found between the palm length and grip strength, as in Narin et al. (6). In the analysis performed by Öktem et al. (11), no significant correlation was found between the arm length measured in both arms and the grip strength. However, a highly significant correlation was found in our study (r=0.416).

The study of Fallahi et al. (16) on grip strength, found that individuals for all age groups with larger hand circumference or longer palm length had stronger grip strength. In our research, a significant result was found the palm length and hand width with grip strength, as in this study. Our study is the first, conducted to examine the dorso-volar and medio-lateral diameter of the wrist and its effect on grip strength in both genders among sedentary young adults (0.438, and 0.487, respectively).

In another study on young adults, forearm circumference, third finger length, and height showed a significant positive correlation with grip strength (17). Similarly, we found that forearm circumference, height, third finger, and palm length are positively correlated with grip strength. In numerous studies, the effect of many anthropometric parameters on grip strength was investigated, but none of them searched the effect of pinches strength. Tip, key and palmar pinches are positively correlated with grip strength in our study (r=0.579, r=0.728, and r=0.604, respectively).

In the current study, there is a significant and positive correlation between waist/hip ratio with grip strength, contrary to Hutasuhut et al.'s (18) study. Also, a significant and negative correlation was found between waist-height ratio and BMI with grip strength (19). Contrary to this study, we found a positive correlation between BMI and waist/height ratio with grip strength.

In a study conducted in prepubertal children, triceps and biceps skinfold thickness was found to be significantly higher in females (20). Our triceps and biceps skinfold thickness outcomes are also similar to results in the literature (r=-0.323, and r=-0.194, respectively).

Stenholm et al. (21) reported that long-term exposure to obesity was associated with poor grip strength in adulthood. In the group we studied in this study, a negative significant correlation was found between BMI and obesity degree with grip strength.

In another study, lean body mass was associated with stronger grip strength in both genders, but mainly in males, while the fat mass index was associated with weaker grip strength as in our study (22).

In a study by Bittencourt et al. (23) examining the correlation between phase angle and functionality in the elderly female population, a significant correlation was found between phase angle and grip strength (r=0.177). We obtained a more significant correlation (r=-0.555) in our study than in Bittencourt et al. (23).

According to our results, adipose parameters such as skinfold thickness and fat mass were found to be higher in females. This may be due to hormonal reasons and a sedentary lifestyle or less physical activity. Obesity is becoming a global problem in young adults as well as adults. In order to prevent this, routine examinations including grip strength can be developed in the early control of obesity based on the highly significant values in our study. Nutritional content may be one of the reasons for the positive and significant association between grip strength with protein and mineral ratio in our study. The total body fluid, intracellular and extracellular fluid had a positive and significant correlation with grip strength in the current study. These fluid parameters can contribute to the treatment of edema.

CONCLUSION

In conclusion, we believe that the data we collect as a result of the current study will be beneficial in many areas, especially in the early diagnosis and treatment of diseases. Furthermore, this study can be helpful for rehabilitation and sports branches. The assessment of grip strength is crucial for identifying artistic and athletic prowess, monitoring neuromuscular illnesses, assessing potential side effects following hand surgery, and formulating treatment plans.

Ethics Committee Approval: The study was approved by the Clinical Research Ethics Committee of Kırşehir Ahi Evran University (10.05.2022, 2022-09/99).

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