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The Relationship Between Upper Extremity Anthropometric Measurements and Bioimpedance Analysis with Grip Strength in Female Elite Handball Players

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Abstract

Handball players need to have upper extremity power and sufficient grip strength to be successful. In this context, it was aimed to determine the relationship between upper extremity anthropometric measurements and bioelectrical impedance analysis with grip strength in elite handball players. The study was conducted on 95 female elite handball players aged 18-24. Athletes with any trauma, musculoskeletal system problems, metabolic or systemic diseases that could affect the upper extremity were not included in the study. Stadiometer, electronic scale, digital caliper, inflexible tape measure, hand dynamometer, pinch meter and skinfold caliper were used for anthropometric measurements, while Tanita MC-780 was used for bioelectrical impedance analysis. Upper extremity length, arm circumference, arm span, forearm length, forearm circumference, hand length, hand width, hand span, wrist medio-lateral diameter, wrist dorso-volar diameter, wrist circumference, tip pinch, key pinch, palmar pinch were found to be statistically significantly positively correlated with grip strength. A positive significant correlation was identified between grip strength and weight, body mass index, basal metabolic rate, waist/hip ratio from bioelectrical impedance analysis. The positive correlation between grip strength and athletes' anthropometric variables demonstrated the effect of hand anthropometry on grip strength in athletes who use their hands to grip a ball or an opponent. The results of this study can be useful for optimizing training programs as well as providing practical applications for talent selection of handball players.

Keywords: Anthropometry, Bioelectrical Impedance Analysis, Grip Strength, Handball, Upper Extremity.

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Özet

Elit Kadın Hentbolcularda Üst Ekstremite Antropometrik Ölçümleri ve Biyoimpedans Analizi ile Kavrama Kuvveti Arasındaki İlişki

Hentbolcularda başarılı olmak için üst ekstremite gücüne ve yeterli kavrama gücüne sahip olmak gerekir. Bu bağlamda elit hentbolcularda üst ekstremite antropometrik ölçümleri ve biyoelektrik empedans analizi ile kavrama kuvveti arasındaki ilişkinin belirlenmesi amaçlanmıştır. Çalışma 18-24 yaş aralığında 95 kadın elit hentbolcu üzerinde gerçekleştirilmiştir. Üst ekstremiteyi etkileyebilecek herhangi bir travma, kas-iskelet sistemi problemi, metabolik veya sistemik hastalığı olan sporcular çalışmaya dahil edilmemiştir. Antropometrik ölçümler için stadiometre, elektronik terazi, dijital kumpas, esnek olmayan mezura, el dinamometresi, pinchmetre ve skinfold caliper kullanılırken, biyoelektrik empedans analizi için Tanita MC-780 kullanılmıştır. Üst ekstremite uzunluğu, kol çevresi, kol açıklığı, ön kol uzunluğu, ön kol çevresi, el uzunluğu, el genişliği, el açıklığı, bilek medio-lateral çapı, bilek dorso-volar çapı, bilek çevresi, uç sıkıştırma, anahtar sıkıştırma, palmar sıkıştırma ile kavrama kuvveti arasında istatistiksel olarak anlamlı pozitif korelasyon vardı. Biyoelektrik empedans analizinden kilo, vücut kitle indeksi, bazal metabolizma hızı, bel/kalça oranı ile kavrama kuvveti arasında pozitif anlamlı korelasyon belirlendi. Kavrama kuvveti ile sporcuların antropometrik değişkenleri arasındaki pozitif korelasyon, el antropometrisinin topu veya rakibi kavramak için ellerini kullanan sporcularda kavrama kuvveti üzerindeki etkisini gösterdi. Bu çalışmanın sonuçlarının, antrenman programlarının optimize edilmesinde ve hentbolcuların yetenek seçiminde pratik uygulamalar sağlanmasında faydalı olabileceği düşünülmektedir.

Anahtar Kelimeler: Antropometri, Biyoelektrik Empedans Analizi, Kavrama Kuvveti, Hentbol, Üst Ekstremite.

INTRODUCTION

Handball is a team sport marked by bursts of high-intensity actions like sprinting, jumping, and shooting, combined with periods of lower-intensity activities such as running, walking and standing (13). Success in handball is influenced by a combination of technical and tactical skills, as well as specific anthropometric traits and physical performance abilities (26). While the measurement of technical and tactical skills can be confused by subjectivity, the assessment of anthropometric and physical profiles provides objective data and makes it possible to identify areas on which to focus training (1).

An athlete's physical and anthropometric traits can be crucial prerequisites for excelling in a particular sport. The selection of talented athletes is primarily based on physical parameters, who has more advantages in terms of mechanics, and anthropometric measurements play an important role in the analysis of movements. Anthropometric measurements are necessary to determine the sports in which individuals should be guided, to assess the effects of training on morphological structure, and to monitor athletes' performance levels (20, 24).

Grip strength refers to the maximum force exerted during the powerful flexion of all fingers under normal biomechanical conditions. This strength is crucial for catching and throwing objects in various sports disciplines. When the fingers are longer and the hand surface variables are larger than necessary, gripping an object becomes more efficient and less tiring (8, 25). Grip measurements have been correlated with various body composition such as waist/hip ratio, body mass index, and biomarkers of aging (11, 23). The effects of various exercise protocols used by athletes can also influence grip strength (23).

It is known that athletes who perform well in certain sports tend to have a specific body type. Handball players are observed to be tall, have long arms and legs, and are able to utilize their strength most effectively relative to their body weight. Additionally, despite their body weight being above the general average, their body fat percentage is below the average (28).

Variations in anthropometric and performance characteristics among male team handball players across different playing levels are common (12, 14, 29). Studies have shown that elite male have anthropometric and performance characteristics considered more favorable for team handball compared to their lower standard counterparts (14, 29). Such data are less common in female, highlighting the need to determine the essential

characteristics required to compete in elite female handball (9, 29). In this context, it was aimed to determine the relationship between upper extremity anthropometric measurements and bioimpedance analysis and grip strength in elite female handball players.

METHOD

Participants

A total of 95 elite female handball players aged 18-24, who participated in the Turkish Female Second League Handball Tournament, with sports experience ranging from 5 to 10 years, were included in our study. An elite athlete is defined as someone who has qualified for a national team at either the junior or senior level, or who has been part of a recruitment squad for that team (22).

Athletes with any trauma, musculoskeletal problems, congenital anomalies, metabolic or systemic diseases that could affect the upper extremity were excluded from the study.

Measurements

Height was measured using a stadiometer (Seca Wall Mounted Stadiometer) and weight was measured by digital scales (Sanitas SGS 43 Digital Glass Scale) and body mass index (BMI) was calculated using the kg/m2. Upper extremity length, arm length, arm circumference, arm span, forearm length forearm circumference, hand length, hand width, hand span, wrist medio-lateral diameter, wrist dorso-volar diameter, wrist circumference, triceps skinfold thickness, biceps skinfold thickness, grip strength, tip pinch, key pinch, palmar pinch were measured. For anthropometric measurements, a digital caliper (Mitutoyo 200 mm Digital Caliper, Kanagawa, Japan), inflexible tape measure, hand dynamometer (Baseline Digital Smedley Hand Dynamometer), pinch meter (Jamar Digital Pinchmeter 50 LB), and skinfold caliper (Holtain Skinfold Caliper) were used. Anthropometric measurements were made from the participants' dominant extremities. All measurements was done by a single researcher to avoid individual bias and two measurements were taken to reduce the error rate, and the average of these measurements was considered.

The bioimpedance analysis (BIA) measurements were taken by TANITA MC-780 such as lean mass (%), muscle mass (%), fat mass (%), total body fluid (lt), basal metabolic rate (kcal), mineral (%), waist/height ratio, waist/hip ratio. Participants followed any specific preparation protocols before BIA measurements, such as fasting or hydration control, which could influence the results.

Statistical Analysis

Kolmogorov-Smirnov and Shapiro-wilk tests were used for normality assumption. Spearman correlation analysis was used for correlation between variables. Descriptive statistics of the variables were summarized as mean∓standard deviation or median (25th percentile-75th percentile) depending on the variable type and whether the assumptions were met. The sample size of the study was calculated with the G* Power 3.1.9.6 (Frans Faul, Universitat Kiel, Germany) program (effect size d=0.6; power (1-ß) =0.80). Statistical analyzes of the study were performed using Statistical Package for Social Sciences version 29.0 software for Windows (IBM SPSS Statistics,Version 29.0. Armonk, NY: IBM Corp., USA). The significance level was accepted as $p<0.05$.

Ethical approval and institutional permission

Informed consent was obtained from all participants, and the study was approved by the ethics committee of Kırşehir Ahi Evran University (Ethics Approval Number: 2022-15/132).

FINDINGS

The mean age of individuals was calculated as 19.01±1.74 years. Descriptive statistics of the variables that are the subject of the study were given in Table 1.

Table 1: Anthropometric measurement and BIA results of female elite handball players

VARIABLES	N=95
Upper Extremity Length (mm)	74.05±3.09
Arm Length (mm)	36.00 (35.00-37.25)
Arm Circumference (mm)	27.00 (25.25-29.00)
Arm Span (mm)	164.00 (160.00-167.75)
Forearm Length (mm)	21.50 (20.50-23.50)
Forearm Circumference (mm)	24.00 (23.00-24.75)
Hand Length (mm)	173.39 (169.57-177.99)
Hand Width (mm)	77.36±4.25
Hand Span (mm)	190.34 (183.57-198.14)
Wrist Dorso-volar Diameter (mm)	37.26 (35.97-38.27)
Wrist Medio-lateral Diameter (mm)	52.74±2.88
Wrist Circumference (mm)	16.00 (15.00-16.25)
Triceps Skinfold Thickness (mm)	16.30 (13.00-19.00)
Biceps Skinfold Thickness (mm)	7.00 (6.00-8.00)
Grip Strength (kg)	28.20 (25.55-31.15)
Tip Pinch (kg)	8.08±2.85
Key Pinch (kg)	15.01±3.03
Palmar pinch (kg)	13.06±2.94
Height (m)	1.65±0.06
Weight (kg)	59.88±8.81
BMI (kg/m^2)	21.82±2.56
Lean Mass (%)	78.73 (75.36-81.04)
Muscle Mass (%)	74.75 (71.57-76.90)
Fat Mass (%)	21.27 (18.96-24.64)
Total Body Fluid (lt)	58.30 (55.75-60.28)
Basal Metabolic Rate (kcal)	1500.04±122.12
Mineral (%)	4.10 (3.97-4.21)
Waist/Height ratio	0.44 (0.40-0.46)
Waist/Hip ratio	0.74±0.04

Values are expressed as mean ± 4tandard deviation and the median (25th percentile-75th percentile). BMI: Body mass index.

A statistically significant strong positive correlation was detected between grip strength and key pinch (ρ= 0.532; $p<0.001$). There was a moderately positive correlation between grip strength and upper extremity There was a moderately positive correlation between grip strength and upper extremity length, arm span, forearm circumference, hand length, hand span, wrist medio-lateral diameter, wrist dorso-volar diameter, wrist circumference, tip pinch, palmar pinch ($p<0.01$). A statistically significant weak positive correlation was found between grip strength and arm circumference, forearm length, hand width ($p<0.05$) (Table 2). No statistically significant correlation was found between grip strength with arm length, triceps skinfold thickness, biceps skinfold thickness and height.

Among the BIA parameters, weight, BMI, basal metabolic rate and waist/hip ratio were found to be statistically significantly moderately positive correlated to grip strength (Table 2). No statistically significant correlation was found between other BIA parameters and grip strength.

Table 2: Correlation results between grip strength with anthropometric measurements and BIA of female elite handball players

VARIABLES	rho (ϱ)	p
Upper Extremity Length (mm)	0.388**	**0.005**
Arm Length (mm)	0.096	0.358
Arm Circumference (mm)	0.225*	**0.030**
Arm Span (mm)	0.348**	**0.001**
Forearm Length (mm)	0.223*	**0.041**
Forearm Circumference (mm)	0.463**	**<0.001**
Hand Length (mm)	0.308**	**0.004**
Hand Width (mm)	0.252*	**0.015**
Hand Span (mm)	0.319**	**0.005**
Wrist Dorso-volar Diameter (mm)	0.311**	**0.008**
Wrist Medio-lateral Diameter (mm)	0.331**	**0.001**
Wrist Circumference (mm)	0.366**	**<0.001**
Triceps Skinfold Thickness (mm)	0.032	0.760
Biceps Skinfold Thickness (mm)	0.039	0.711
Tip Pinch (kg)	0.391**	**<0.001**
Key Pinch (kg)	0.532**	**<0.001**
Palmar pinch (kg)	0.384**	**<0.001**
Weight (kg)	0.382**	**<0.001**
Height (cm)	0.182	0.081
BMI (kg/m^2)	0.356**	**<0.001**
Lean Mass (%)	-0.030	0.779
Muscle Mass (%)	-0.031	0.769
Fat Mass (%)	0.029	0.785
Total Body Fluid (lt)	0.060	0.566
Basal Metabolic Rate (kcal)	0.360**	**<0.001**
Mineral (%)	0.025	0.809
Waist/Height ratio	0.162	0.121
Waist/Hip ratio	0.312**	**0.006**

Significant according to ** $p<0.01$ and * $p<0.05$. BMI: Body mass index.

DISCUSSION AND CONCLUSION

For ball games where the hand is used, knowledge of hand morphology and functional characteristics is important for performance (4). Grip strength is an important indicator of performance in many sports branches as well as providing effectiveness and efficiency during sports activities (27).

It was concluded that the dominant physical requirements of handball are maximum strength and muscle power in the upper extremity (6). In this context, the correlation between upper extremity anthropometric measurements and BIA parameters of elite female handball players and grip strength was examined in our study. While there was a significant relationship between grip strength and other parameters except arm length and skinfold thickness from anthropometric measurements, there was a significant correlation between grip strength and BMI, basal metabolic rate and waist/hip ratio from BIA parameters.

In a study conducted by Saki (19) on 120 female handball players, it was found that there was no significant correlation between upper extremity length and grip strength. In a study conducted by Koley et al. (10) on 101 Indian female handball players, it was reported that there was no significant correlation between upper extremity length and grip strength. In our study, unlike studies in the literature, a significant moderate positive correlation was found between upper extremity length and grip strength.

Saki (19) reported that there was no significant correlation between arm length and grip strength. In a study conducted by Adheke et al. (2) on a total of 62 athletes (38 males and 24 females), who were involved in sporting activities such as weightlifting, basketball, handball and tennis; a significant positive correlation was

found between arm length and grip strength in both genders. Koley et al. (10) found that there was significant correlation between arm length and grip strength. In a study conducted by Yıldırım et al. (28) on 65 Turkish male handball players, a significant correlation was found between arm length and grip strength. Similar to Saki (19), there was no significant correlation between arm length and grip strength in our study.

Saki (19) found that there was no significant correlation between arm circumference and grip strength. Koley et al. (10) reported that there was significant correlation between arm circumference and grip strength. In a study conducted by Pekmez (18) on 30 Turkish elite handball players aged 17-34 years and 30 Turkish youth academy handball players aged 12-18 years, it was found that there was a significant positive correlation between arm circumference and grip strength in elite and youth academy handball players. In our study, there was significant correlation between arm circumference and grip strength.

Vila et al. (26) reported that the mean arm span of handball players was found to be 171.57±9.20 cm. This value in our study was found lower than the results of Vila et al. (26). In a study conducted by Zapartidis et al. (29) on a total of 121 adolescent handball players, it was found that there was significant correlation between arm span and grip strength. Similar to studies in the literature, a significant correlation was found between arm span and grip strength in our study (rho=0.348, p=0.001).

Adheke et al. (2) found that there was a significant correlation between forearm length and grip strength in both genders. In a study conducted by Fallahi & Jadidian (8) on a total of 40 male athletes, including 14 national basketball players, 10 collegian handball players, 7 collegian volleyball players and 9 collegian wrestlers, it was found that there was significant positive correlation between forearm length and grip strength. Saki (19) reported that there was no significant correlation between forearm length and grip strength. Koley et al. (10) found that there was no significant correlation between forearm length and grip strength. In Yıldırım et al. (28)'s study, it was reported that there was no significant correlation between forearm length and grip strength. In our study, there was significant correlation between forearm length and grip strength.

In Saki (19)'s study, it was reported that there was a significant correlation between forearm circumference and grip strength (p=0.034). Yıldırım et al. (28) stated that there was a significant correlation between forearm circumference and grip strength (r=0.540, p=0.00). Pekmez (18) reported that there was significant positive correlation between forearm circumference and grip strength in elite handball players and youth academy handball players (for elite handball players r=0.617, p=0.00; for youth academy handball players r=0.56, p=0.00). Fallahi & Jadidian (8) found that there was a significant correlation between forearm circumference and grip strength (r=0.445). Similar to studies in the literature, there was significant moderate positive correlation between forearm circumference and grip strength in our study (rho=0.463, p<0.001).

Saki (19) stated that there was a significant correlation between hand length and grip strength. Koley et al. (10) found that there was significant correlation between hand length and grip strength. Fallahi & Jadidian (8) reported that there was significant correlation between hand length and grip strength. In Adheke et al. (2)'s study, it was reported that there was no significant correlation between hand length and grip strength in both genders. In our study, there was significant moderate positive correlation between hand length and grip strength.

Adheke et al. (2) reported that there was a significant correlation between hand width and grip strength in both genders. Koley et al. (10) stated that there was significant correlation between hand width and grip strength. Fallahi & Jadidian (8) found that there was significant correlation between hand width and grip strength. In our study, there was significant correlation between hand width and grip strength, the result of our study was consistent with the literature.

Fallahi & Jadidian (8) stated that there was significant correlation between hand span and grip strength. In a study conducted by Chahal & Kumar (5) on 37 male basketball players, significant correlation was found between hand span and grip strength. In our study, there was significant moderate positive correlation between hand span and grip strength.

Yıldırım et al. (28) found that there was no significant correlation between wrist medio-lateral diameter and grip strength. Contrary to Yıldırım et al. (28), there was significant moderate positive correlation between wrist medio-lateral diameter and grip strength in our study. In our study, a significant moderate positive

correlation was found between wrist dorso-volar diameter and grip strength, but no study was found in the literature which we could compare our results.

Yıldırım et al. (28) reported that there was significant correlation between wrist circumference and grip strength (r=0.300, p=0.015). In Pekmez (18)'s study, it was stated that there was significant correlation between wrist circumference and grip strength in elite handball players and youth academy handball players (for elite handball players r=0.751, p=0.00; for youth academy handball players r=0.645, p=0.00). Fallahi & Jadidian (8) found that there was significant correlation between wrist circumference and grip strength (r=0.625). In our study, the measurement result between wrist circumference and grip strength was consistent with the literature (rho=0.366, p<0.001).

In a study conducted by Mullerpatan et al. (15) on a total of 1005 healthy participants, 413 males and 592 females, the tip pinch was found to be 3.96±1.4 kg in males and 3.28±1 kg in females. In our study, the tip pinch of handball players was found to be 8.08±2.85 kg. The difference between the results of athletes and sedentary individuals is remarkable. In a study conducted by Ulcay et al. (25) on a total of 32 athletes, it was found that there was no significant correlation between tip pinch and grip strength in male athletes, while there was significant correlation between tip pinch and grip strength in female athletes. Similar to Ulcay et al. (25), there was significant moderate positive correlation between tip pinch and grip strength in our study.

In our study, the key pinch of handball players was found to be 15.01±3.03 kg. In studies conducted on healthy sedentary individuals (3, 15), this value was found to be lower than in the athletes in our study. Ulcay et al. (25) found that there was significant correlation between key pinch and grip strength in both genders. In our study, there was significant strong positive correlation between key pinch and grip strength. The results of our study are compatible with Ulcay et al. (25)'s.

In our study, the palmar pinch of handball players was found to be 13.06±2.94 kg. In study conducted by Mullerpatan et al. (15) on healthy sedentary individuals, this value was found to be lower than in the athletes in our study. The difference between the result of this variable in our study and the result of Mullerpatan et al. (15) is striking. Ulcay et al. (25) reported that there was significant correlation between palmar pinch and grip strength in both genders. In our study, there was significant moderate positive correlation between palmar pinch and grip strength.

Koley et al. (10) stated that there was significant correlation between weight and grip strength. In a study conducted by Chittibabu (7) on 144 male handball players, significant correlation was found between weight and grip strength. In our study, there was significant moderate positive correlation between weight and grip strength. The results of our study are compatible with the literature.

Koley et al. (10) stated that there was significant correlation between height and grip strength. Fallahi & Jadidian (8) found that there was significant correlation between height and grip strength. In Zapartidis et al. (29)'s study, it was reported that there was significant correlation between height and grip strength. Contrary to other studies, there was no significant correlation between height and grip strength in our study.

In a study conducted by Nikolaidis & Ingebrigtsen (16) on 96 male handball players, 57 adolescents and 39 adults, significant negative correlation was found between BMI and grip strength in adolescent handball players, while no significant correlation was found between BMI and grip strength in adult handball players. Fallahi & Jadidian (8) found that there was no significant correlation between BMI and grip strength. In our study, there was significant correlation between BMI and grip strength.

Although there are studies (16, 17, 21) that found a significant correlation between grip strength and lean mass, muscle mass, fat mass, body fluid and minerals in handball players, no significant correlation was found in our study.

In a study conducted by Sliz et al. (21) on a total of 24 female handball players (15 junior, 9 senior), the basal metabolic rate of junior handball players was found to be 1435.2±110.11 kcal and the basal metabolic rate of senior handball players was found to be 1398.56±90.15 kcal. In our study, the mean basal metabolic rate of female elite handball players was found to be 1500.04±122.12 kcal. The mean basal metabolic rate of female elite handball players in our study was higher than the mean basal metabolic rate of junior and senior handball

players in the study of Sliz et al. (21). No study has been found examining the correlation between basal metabolic rate and grip strength in athletes.

Trivedi et al. (23) on a total of 48 athletes, a significant correlation was found between waist/hip ratio and grip strength. In our study, there was significant moderate positive correlation between waist/hip ratio and grip strength, similar to Trivedi et al. (23).

A significant correlation was found between grip strength and anthropometric measurements and BIA parameters in our study. Our results in elite female handball players will provide a comparison and understanding of how grip strength is affected between genders and between handball players at different professional levels. Some anthropometric measurements can affect a player's performance in sports activities. A larger hand surface may allow for more efficient shooting and passing when there are longer and stronger extremities and fingers. Upper extremity dimensions and grip strength greatly affect offensive and defensive movements during a match. Therefore, the correlation results of this study can be useful for optimizing training programs as well as providing practical applications for talent selection of handball players. Some anthropometric variables of the arm, forearm, hand and wrist and pinch forces and body composition variables, which are good determinants of grip strength, may be useful in determining sportive abilities in other grip sports as well as handball.

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