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The Relationship Between Anthropometric Characteristics and Tapping Dynamic Strength, Balance, and Force Velocity in Elite Handball Players

Elit Hentbolcularda Antropometrik Özellikler ile Vurma Dinamik Kuvveti, Denge ve Kuvvet-Hız İlişkisi

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Abstract

The aim of this study was to examine the relationships between anthropometric characteristics and dynamic strength, balance, and force–velocity parameters following taping application in elite handball players. Fourteen elite male athletes competing in the Turkish Men's Handball Super League participated in the study (age: 22.85 ± 2.87 years; height: 169.71 ± 5.22 cm; body weight: 65.78 ± 6.65 kg). Anthropometric data such as height, weight, body mass index, and leg length were measured using standard methods. Dynamic strength, balance, and force–velocity tests were conducted before and after taping application. Spearman's correlation coefficient was used for data analysis. The analyses revealed significant positive correlations between height and body weight (r = .742, p < .01), height and Vmax (r = .663, p < .05), height and the Dynamic High Jump test (r = .697, p < .05), leg length and the Dynamic High Jump test (r = .797, p < .01), and BMI and Pmax (r = .693, p < .05). The findings demonstrate that anthropometric characteristics play a determining role in strength and velocity parameters in handball players. In particular, the significant associations of height, leg length, and BMI with performance outcomes highlight the importance of considering anthropometric data in player selection and training planning.

Keywords: Handball, anthropometric characteristics, strength, balance

Öz

Bu araştırmanın amacı, elit düzeyde hentbolcuların antropometrik özellikleri ile taping uygulaması sonrası dinamik kuvvet, denge ve force–velocity parametreleri arasındaki ilişkileri incelemektir. Literatürde hentbol gibi yüksek şiddetli, çok yönlü performans gerektiren branşlarda antropometrik özelliklerin performans belirleyicisi olduğu vurgulanmaktadır. Çalışmaya Türkiye Erkek Hentbol Süper Ligi'nde yer alan 14 elit erkek sporcu katılmıştır (yaş: 22,85 ± 2,87 yıl; boy: 169,71 ± 5,22 cm; vücut ağırlığı: 65,78 ± 6,65 kg). Katılımcıların boy, kilo, vücut kitle indeksi ve bacak uzunluğu gibi antropometrik verileri standart yöntemlerle ölçülmüştür (Çalışkan & Zeki, 2017). Dinamik kuvvet, denge ve force–velocity testleri taping uygulaması öncesi ve sonrası gerçekleştirilmiştir. Verilerin analizinde Spearman korelasyon katsayısı kullanılmıştır. Analizler sonucunda; boy ile vücut ağırlığı (r = ,742; p < 0,01), boy ile Vmax (r = ,663; p < 0,05) ve Dinamik Yüksek Çıkış testi (r = ,697; p < 0,05), bacak uzunluğu ile DYC (r = ,797; p < 0,01) ve VKİ ile Pmax (r = ,693; p < 0,05) arasında anlamlı pozitif ilişkiler saptanmıştır. **Sonuç:** Elde edilen bulgular, antropometrik özelliklerin hentbolcularda kuvvet ve velocity parametreleri üzerinde belirleyici rol oynadığını göstermektedir. Özellikle boy, bacak uzunluğu ve VKİ'nin performans çıktılarıyla olan anlamlı ilişkisi, oyuncu seçimi ve antrenman planlamasında antropometrik verilerin dikkate alınmasının önemini ortaya koymaktadır.

Anahtar Kelimeler; Hentbol, Antropometrik özellikler, Kuvvet, Denge

**This study was presented as an abstract at the 8th International Eurasian Conference on Sports, Education and Society*

Introduction

Athletes involved in sports must possess superior characteristics in terms of speed, strength, skill, coordination, anthropometry, and physiology. It is necessary to proceed based on scientific research to develop the skills and abilities that athletes possess. In order to achieve the goals set in sport, examining the athlete's anthropometric and physiological characteristics, applying the correct training model, and working at the right place and time will greatly contribute to the athlete reaching the desired goal (Ersöz, Özkara, & Karakaya, 1996; Duyul Albay, Zorba, & Saygın, 2008).

Considering the fast and accurate playing characteristics of handball, handball players must possess a high level of basic motor skills such as strength, speed, agility, balance, jumping ability, and coordination (Eler & Bereket, 2001). In handball, the ability to generate quick strength and maintain strength plays a significant role in the athlete's ability to score. In handball, the ability of players to jump and shoot, their hang time in the air, and their ability to block shots are almost entirely based on jumping power, which forms the foundation of these techniques (Koç & Aslan, 2010). At the same time, the high anaerobic capacity of handball players, particularly for high-intensity contact and mobility with short breaks during the game, is among the main factors affecting performance (Rannou, Ben Abderrahman, Bishop, & Chamari, 2001).

In addition to the parameters mentioned above, tactical skills and game strategies play an important role in handball players (Tsunawake, Tahara, Moji, Muraki, Minowa, & Yukawa, 2003). The athlete's ability to make quick decisions, gain time for the next move, and provide the correct movement components varies depending on the motor responses to signals from the peripheral nervous system.

As in many sports, the balance parameter holds an important place in handball. Athletes need to have good balance parameters for both the development of their sporting skills and the prevention of injuries (Haksever, Ersöz, & Bayraktar, 2023). In a sport such as handball, which involves direct contact, protection from injuries will greatly positively affect the athlete's performance. Therefore, in handball, balance is fundamental to jumps and falls. A high balance protects the athlete both against opponents and in terms of preventing injuries.

The aim of this study is to examine the effects of taping on dynamic strength, balance, and force-velocity profile in elite handball players based on their anthropometric characteristics; to reveal the relationship between these variables, and to contribute scientifically to performance-oriented evaluations. Within this scope, the relationship between the athletes' physical characteristics (height, weight, body composition, etc.) and performance parameters was evaluated, and the potential supportive or limiting effects of taping on these performance components were analysed.

METHOD

Study Group

Our research group consists of 15 athletes from the Spor Toto Handball Team competing in the Super League. Prior to the research, participants were provided with detailed information about the study and read the World Medical Association's Declaration of Helsinki. They signed a "Voluntary Consent Form" confirming their voluntary participation in the research.

Data Collection Tools

The participants' body composition, anthropometric measurements, balance, dynamic strength, force velocity, and jumping performance were assessed at the TOHM sports performance laboratory. Each athlete participating in the study was provided with detailed information about the study and the protocols of the tests performed.

Participants' body composition, anthropometric measurements, and balance measurements were taken on the morning of Day 1. On Day 2, strength and jumping performance measurements were taken. Participants underwent a 15-minute warm-up exercise protocol before the measurements.

Body Composition Measurements

Participants in the study underwent body composition measurements wearing shorts and a T-shirt, barefoot. Height, body weight, body fat percentage, and BMI scores were measured using the Tanita BC418 Segmental Body Composition Scale (TANITA BC-418, Tanita, Tokyo, Japan) (Güder, Yılmaz & Karakaya, 2022).

Anthropometric measurements

Skinfold Measurements: All measurements were taken twice on the right side of the athletes, and the average value was recorded. Triceps Skinfold Thickness: Measured vertically on the skin fold over the muscle, at the midpoint between the "acromion" of the scapula and the "olecranon" process of the ulna, on the back-midline of the upper arm (over the triceps muscle). Subscapular Skinfold Thickness: With the arm hanging down and the body relaxed, the skin fold was pinched diagonally across the body, just below the scapula and parallel to the edge of the bone. Suprailiac 2 Skin Fold Thickness: Measured by pinching the skin fold slightly diagonally (semi-horizontally) just above the ilium on the midline of the body. Calf Skinfold Thickness: The measurement was taken by grasping the skin and fat tissue on the medial side of the widest part of the right calf. (Pazarözyurt & İnce, 2009)

Balance Test Protocol

A dynamic balance device was used to measure balance ability. Postural control was assessed using the body's centre of gravity/pressure. Three different indices are formed according to the direction of deviations from the horizontal plane: total stability, anterior-posterior, and medial-lateral. These indices are calculated according to the region corresponding to the letters in the balance results. Three tasks were defined and performed sequentially in the test. These tasks were maintaining postural control on both feet, on the right foot, and on the left foot. Participants were instructed to stand as still as possible on a force platform for 10 seconds, minimising sway by maintaining the body's centre of gravity. The test was initiated by the examiner when the participant stepped onto the platform. Participants were asked to remain as stable as possible for up to 10 seconds for each test measurement position. The test was terminated when subjects could no longer maintain the test position requirements. Test measurements were performed once in each test position, with a 10-second rest period between positions. When subjects completely lost their balance (fell off the force platform or, in single-leg stance, supported themselves with their foot on the force plate or the ground for more than 1 second), the test was terminated, and the subject repeated the test. Before the test, measurements were taken, and subjects performed 1 ± 2 trials of each test position.

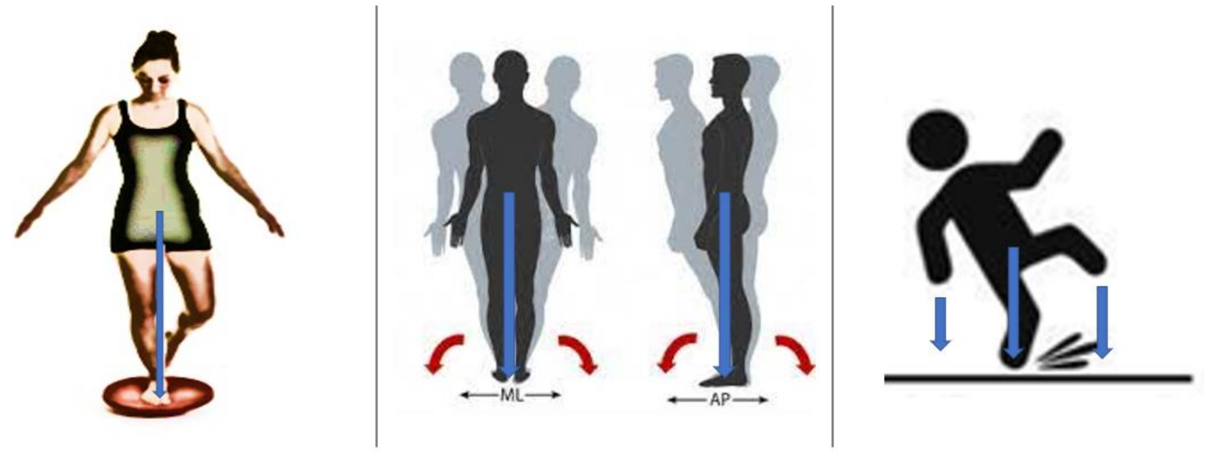

Figure 1. When postural sway increases, the body cannot maintain its centre of gravity.

SQUAT JUMP AND COUNTERMOVEMENT JUMP TEST.

The Optojump device was used in the jump test. The athletes' values were recorded in the Optojump programme.

Squat Jump: In the squat jump test, which measures the explosive strength characteristic exhibited by the leg muscles based on maximum strength, a full upward jump is performed with the knees flexed at 90 degrees in the squat position and the hands on the waist.

Active Jump: In this test, in addition to measuring the explosive strength of the leg muscles, the elastic force property that affects explosive strength in jumping also comes into play. The active jump test is performed by quickly squatting down with the knees fully extended and upright, and then performing a full upward jump.

Evaluation

- Athletes with a high squat value but a low active jump value may be interpreted as having a deficiency in "jump-specific coordination."
- Athletes with a high active jump value but a low squat value may be interpreted as having insufficient explosive strength abilities.
- However, in some athletes, if the active jump value is high but the squat is below average, this should be interpreted as a deficiency in leg strength.
- Coaches can compare athletes based on the relative strength values for each jump.

DYNAMIC STRENGTH INDEX (DSI) TEST

Data Collection Tools

Jump height, ground contact time, and flight time were recorded using the Microgate Opto Jump device. The isometric mid-thigh pull (IMTP) test was measured using the Kistler brand – MVC measurement system.

Data Collection

Prior to the test, the athlete's body weight (kg), the distance between the SIA (spina iliaca anterior superior) and the fingertips (cm), and the distance from the SIA projection to the ground while the athlete was in a 90-degree squat position were measured and recorded. The athletes were warmed up for 15 minutes. The athletes were placed on the Optojump device, and three CMJ jumps were performed and recorded, with one minute of rest in between. The athletes rested for 3 minutes. The athletes were then placed on the Kistler device, and three IMTP pulls were performed and recorded, with each pull lasting 5-10 seconds and one minute of rest in between. The data were processed using Excel software, and the results were evaluated.

DSI was calculated using formulas based on the ratio of ballistic peak force to isometric peak force. The DSI values identified in the athletes were evaluated according to Table 1.

Table 1. Percentage values used in interpreting DSI

DSI PUANI	**Proposed Training Program**	**Proposed Training Programı**
<%60	Low	Ballistic strength training
%60 - %80	Moderate	Concurrent strength training
>%80	High	Strength training

The dynamic strength index provides information about athletes' capacity to generate ballistic force using explosive power and maximal strength, as well as any deficiencies in the performance components that constitute this performance. Coaches can reorganise training programmes based on this information. It is recommended that measurements be repeated at specific times of the year to regularly monitor the performance components that athletes aim to develop.

Data Analysis and Interpretation

The statistical analysis of the data obtained within the scope of the research was performed using Microsoft Excel and SPSS 22.0 computer software. First, a missing data assessment was conducted in the research. As a result of this process, no missing data was detected. Measurements were taken once for the anthropometric characteristics taken as independent variables and the jump, taping, strength, velocity, and balance parameters taken as dependent variables from the 14 athletes participating in the study. First, the normality assumptions for the obtained data were checked with the Shapiro-Willk test, and it was determined that the data did not meet the normality assumptions. The relevant literature indicates that skewness and kurtosis values are also prominent for normality assumptions. For these values, the -1.5 +1.5 range suggested by Tabachnick and Fidell (2013) was considered, and it was determined that the values did not fall within the specified limits. Accordingly, Spearman's correlation analysis was used to determine the relationships between the parameters. The coefficients obtained from this analysis were evaluated according to Schober et al. (2018) (.00-.10: insignificant, .10-.39: weak, .40-.69: moderate, .70-.89: strong, .90-1: very strong).

FINDINGS

Table 1. Spearman Correlation Analysis Results Regarding the Relationship Between Anthropometric Characteristics and Jumping Parameters

Variables		Time in the air	Contact	Height	Power	Pace Step	Walking pointx	Walking Point gapx	Step with
Fat Mass	r	,095	,149	,108	,147	-,090	,437	,420	,433
	p	,747	,612	,714	,615	,759	,118	,135	,122
	n	14	14	14	14	14	14	14	14
Lean Mass	r	,218	,126	,204	,108	-,231	,231	,196	,437
	p	,454	,667	,483	,714	,427	,427	,503	,118
	n	14	14	14	14	14	14	14	14
Triceps	r	,040	,557*	,038	-,113	-,148	,413	,444	,470
	p	,892	**,039**	,899	,702	,614	,142	,112	,090
	n	14	14	14	14	14	14	14	14
Subscapular	r	-,044	,007	-,055	-,002	,077	,135	,183	-,051
	p	,881	,982	,851	,994	,793	,646	,531	,863
	n	14	14	14	14	14	14	14	14
Midaxillar	r	,265	,281	,270	,162	-,281	,334	,385	,369
	p	,360	,330	,351	,581	,331	,243	,174	,194
	n	14	14	14	14	14	14	14	14
Chest	r	-,177	,058	-,185	-,062	,145	,029	,084	-,154
	p	,546	,845	,527	,834	,620	,923	,776	,599
	n	14	14	14	14	14	14	14	14
Abdomen	r	,031	,063	,029	,068	-,011	,231	,209	,187
	p	,917	,830	,923	,817	,970	,427	,474	,523
	n	14	14	14	14	14	14	14	14
Subrallak	r	-,075	,003	-,059	-,031	,101	,541*	,484	,249
	p	,799	,991	,840	,917	,731	**,046**	,079	,391
	n	14	14	14	14	14	14	14	14

Thigh	r	-,013	-,032	-,040	-,097	,086	-,068	-,042	,183
	p	,964	,915	,893	,742	,770	,817	,887	,532
	n	14	14	14	14	14	14	14	14

Upon examination of Table 1, no statistically significant relationship was found between anthropometric variables such as fat mass, lean mass, triceps, subscapular, midaxillary, chest, abdomen, and thigh circumference and jump parameters. However, while no significant relationship was found between the subrallak parameter and jumping parameters, a moderately positive (r=0.541; p=0.046) significant relationship was found between walking pointx and subrallak.

Table 2. Spearman Correlation Analysis Results Regarding the Relationship Between Anthropometric Characteristics and Taping Left Foot Parameters

Variables		Time in the Air	Time on Ground	Pace StepS	Pace StepM	Stride Time Cycle
Fat Mass	r	,079	,054	-,268	-,268	,058
	p	,787	,854	,355	,354	,843
	n	14	14	14	14	14
Lean Mass	r	-,069	,115	,184	,184	,025
	p	,814	,696	,529	,528	,933
	n	14	14	14	14	14
Triceps	r	,528	,669**	-,641*	-,642*	,612*
	p	,052	**,009**	**,013**	**,013**	**,020**
	n	14	14	14	14	14
Subscapular	r	,163	,047	-,401	-,401	,099
	p	,577	,874	,155	,155	,737
	n	14	14	14	14	14
Midaxillar	r	,285	,316	-,398	-,397	,294
	p	,323	,270	,159	,160	,307
	n	14	14	14	14	14
Chest	r	-,157	-,236	-,072	-,073	-,208
	p	,593	,417	,806	,803	,476
	n	14	14	14	14	14
Abdomen	r	,312	,250	-,570*	-,570*	,280
	p	,277	,389	**,033**	**,033**	,332
	n	14	14	14	14	14
Subrallak	r	,447	,343	-,609*	-,609*	,413
	p	,109	,230	**,021**	**,021**	,143
	n	14	14	14	14	14
Thigh	r	,548*	,627*	-,473	-,472	,582*
	p	**,043**	**,016**	,088	,088	**,029**
	n	14	14	14	14	14

Table 2 shows that there is no statistically significant relationship between fat mass, lean mass, subscapular, midaxillary, and chest anthropometric variables and taping parameters for the left foot. However, while no significant relationship was found between the triceps and the airborne taping parameter included in the study, a moderate positive relationship was found between the ground contact time and the triceps parameter (p=-,669; r=,009), a moderate negative relationship between pace stepS (p=-,641; r=0.013), a moderate negative relationship was found between pace stepM (p=−0.642; r=0.013), and finally, a moderate positive relationship was found between stride time cycle (p=0.612; r=0.020). These relationships were statistically significant.

When examining the results related to the abdomen parameter, no statistically significant relationship was found between the airborne time, ground contact time, and stride time cycle parameters, while a moderately negative relationship was found between pace stepS (p=0.033; r = -0.570) and pace stepM (p = -0.570; r = 0.033), and this relationship was found to be statistically significant.

When examining the results related to the subrallak parameter, no statistically significant relationship was found between the airborne time, ground contact time, and stride time cycle parameters. However, a moderately negative relationship was found between pace steps (p=-,609; r=0.021) and pace ptepM (p=−0.609; r=0.021), and this relationship is statistically significant.

Finally, when examining the results related to the Thigh parameter, no statistically significant relationship was found between the pace stepS and pace stepM parameters. However, a moderately positive relationship was found between hang time (p=0.043; r=0.548), and a moderately positive relationship was found between stride time cycle (p=0.029; r=-0.627). r=–0.627), and stride time cycle (p=0.029; r=0.582), and that this relationship is statistically significant.

Table 3. Spearman Correlation Analysis Results Regarding the Relationship Between Anthropometric Characteristics and Taping Right Foot Parameters

Variables		Time in the Air	Ground Contact Time	Pace StepS	Pace StepM	Stride Time Cycle
Fat Mass	r	,669**	,027	-,128	-,160	,061
	p	**,009**	,927	,663	,585	,835
	n	14	14	14	14	14
Lean Mass	r	-,251	,078	,197	,206	,031
	p	,387	,792	,500	,479	,916
	n	14	14	14	14	14
Triceps	r	,355	,598*	-,695**	-,691**	,625*
	p	,213	**,024**	**,006**	**,006**	**,017**
	n	14	14	14	14	14
Subscapular	r	,514	,025	-,317	-,335	,096
	p	,060	,933	,270	,242	,744
	n	14	14	14	14	14
Midaxillar	r	,485	,258	-,306	-,314	,290
	p	,079	,374	,287	,274	,314
	n	14	14	14	14	14
Chest	r	,511	-,238	,023	-,005	-,205

	p	,062	,412	,937	,985	,483
	n	14	14	14	14	14
Abdomen	r	,423	,202	-,407	-,447	,288
	p	,131	,488	,149	,109	,318
	n	14	14	14	14	14
Subrallak	r	,534*	,331	-,416	-,456	,420
	p	**,049**	,247	,139	,102	,135
	n	14	14	14	14	14
Thigh	r	,241	,574*	-,544*	-,508	,568*
	p	,407	**,032**	**,044**	,063	**,034**
	n	14	14	14	14	14

Table 3 shows that there is no statistically significant relationship between lean mass, subscapular, midaxillary, chest, and abdominal anthropometric variables and taping right foot parameters. However, while no significant relationship was found between the triceps and the parameters of time spent in the study area, pace steps, pace step M, and stride time cycle, a moderate positive relationship (p=0.009; r=0.669) was observed between time spent in the air and the fat mass parameter, and this relationship was found to be statistically significant.

When examining the results related to the triceps parameter, no statistically significant relationship was found between the hang time parameters. However, a moderately positive relationship was found between hang time and time spent on the ground (p=0.024; r=0.598), a moderately negative relationship between pace stepS and hang time (p=0.006; r=-,695) a moderate negative relationship, between pace stepM (p=.006; r=-,691) a moderate negative relationship, and between stride time cycle (p=.017; r=.625) a moderate positive relationship, and that this relationship is statistically significant.

When examining the results related to the subrallak parameter, no significant relationship was found between ground contact time, pace steps, pace step M, and stride time cycle parameters. However, a moderately positive relationship was observed between airborne time and the subrallak parameter (p=0.049; r=0.534), and this relationship was statistically significant.

Finally, when examining the results related to the Thigh parameter, no statistically significant relationship was found between the airborne time and pace stepM parameters, while a moderately positive relationship was found between ground contact time (p=0.032; r=0.574), a moderately positive relationship between pace stepS (p=0.044; r = −0.544), and stride time cycle (p = 0.034; r = 0.568), and this relationship is statistically significant.

Table 4. Spearman Correlation Analysis Results Regarding the Relationship Between Anthropometric Characteristics and Dynamic Force Parameters

Variables		Force JH	Force JF	Force IMTP PeakKG	Force IMTP PeakfN	Force DSI
Fat Mass	r	-,315	,530	,306	,306	,433
	p	,273	,051	,287	,287	,122
	n	14	14	14	14	14
Lean Mass	r	,548*	,013	-,084	-,084	,114
	p	**,042**	,964	,776	,776	,697
	n	14	14	14	14	14
Triceps	r	-,104	,013	-,272	-,272	,239
	p	,724	,964	,347	,347	,411
	n	14	14	14	14	14
Subscapular	r	-,460	,517	,414	,414	,362
	p	,098	,058	,141	,141	,203
	n	14	14	14	14	14
Midaxillar	r	-,118	,334	,134	,134	,315
	p	,689	,243	,648	,648	,273
	n	14	14	14	14	14
Chest	r	-,308	,600*	,317	,317	,368
	p	,284	,023	,270	,270	,195
	n	14	14	14	14	14
Abdomen	r	-,247	,552*	,604*	,604*	,323
	p	,395	**,041**	**,022**	**,022**	,259
	n	14	14	14	14	14
Subrallak	r	-,390	,291	,168	,168	,412
	p	,168	,313	,567	,567	,143
	n	14	14	14	14	14
Thigh	r	-,050	-,280	-,073	-,073	-,126
	p	,866	,332	,805	,805	,669
	n	14	14	14	14	14

Table 4 shows that there is no statistically significant relationship between fat mass, triceps subscapular, midaxillary, chest, subrallak, and thigh anthropometric variables and dynamic force parameters. However, while no significant relationship was found between lean mass and the force JF, force ımtp peakKG, force ımtp peakfN, and force DSI parameters included in the study, a moderate positive relationship was found between force JH and the lean mass parameter (p=.042; r=0.548), and this relationship was found to be statistically significant.

When examining the results related to the abdominal parameter, no statistically significant relationship was found between the force JH and force DSI parameters, while a moderately positive relationship was found between force JF (p=.041; r=.552) and force ımtp peakKG (p=.022; r=0.604), and strength ımtp peakfN (p=0.022; r=0.604), and that this relationship is statistically significant.

Table 5. Spearman Correlation Analysis Results Regarding the Relationship Between Anthropometric Characteristics and Balance Parameters

Variables		Balance Density	Balance Amplitude
Fat Mass	r	-,327	,424
	p	,253	,131
	n	14	14
Lean Mass	r	-,626*	,468
	p	**,017**	,091
	n	14	14
Triceps	r	-,536*	,594*
	p	**,048**	**,025**
	n	14	14
Subscapular	r	,095	,086
	p	,747	,770
	n	14	14
Midaxillar	r	-,378	,524
	p	,182	,054
	n	14	14
Chest	r	,073	,075
	p	,805	,799
	n	14	14
Abdomen	r	,015	,112
	p	,958	,703
	n	14	14
Subrallak	r	-,070	,200
	p	,811	,493
	n	14	14
Thigh	r	-,458	,421
	p	,099	,134
	n	14	14

Table 5 shows that there is no statistically significant relationship between fat mass, subscapular, midaxillary, chest, abdomen, subrallak, and thigh anthropometric variables and balance parameters. However, while no significant relationship was found between lean mass and the balance amplitude parameter included in the study, a moderate negative relationship (p=.017; r=-.626) was observed between balance intensity and lean mass parameter, and this relationship was found to be statistically significant.

When examining the results related to the abdomen parameter, a moderately negative relationship was found between balance density and triceps (p=.048; r=-.536), and a moderately positive relationship was found between balance amplitude (p=.025; r=.594), and this relationship was found to be statistically significant.

Table 6. Spearman Correlation Analysis Results Regarding the Relationship Between Anthropometric Characteristics and Velocity Parameters

Variables		Velocity FOKG	Velocity VOm	Velocitp Max
Fat Mass	r	-,101	-,128	-,274
	p	,731	,664	,343
	n	14	14	14
Lean Mass	r	-,053	,431	,234
	p	,858	,124	,420
	n	14	14	14
Triceps	r	-,075	,102	-,191
	p	,798	,729	,513
	n	14	14	14
Subscapular	r	-,049	-,325	-,315
	p	,869	,257	,272
	n	14	14	14
Midaxillar	r	-,128	-,024	-,133
	p	,662	,934	,649
	n	14	14	14
Chest	r	,021	-,247	-,103
	p	,943	,395	,726
	n	14	14	14
Abdomen	r	-,156	-,101	-,183
	p	,594	,731	,530
	n	14	14	14
Subrallak	r	-,370	,116	-,478
	p	,193	,694	,084
	n	14	14	14
Thigh	r	,141	-,221	-,172
	p	,630	,449	,557
	n	14	14	14

Table 6 shows that there is no statistically significant relationship between fat mass, subscapular, midaxillary, chest, abdomen, subrallak, and thigh anthropometric variables and balance parameters.

DISCUSSION

This study examined the effects of various anthropometric characteristics on strength, balance, and taping performance in elite handball players. The findings indicate that body composition variables, particularly muscle circumference and lean mass, are decisive in performance tests.

Firstly, the positive correlation found between lean mass and circumference measurements and isometric strength tests (IMTP) supports previous studies. Maughan, Watson, and Weir (1983) noted a strong relationship between muscle mass and maximal force production. Similarly, Abe, Kearns, and Fukunaga (2000) emphasised that upper and lower extremity circumferences can be used to predict strength capacity. The relationship between abdominal circumference and IMTP in the current study supports the view that core muscles play a fundamental role in force production (Kibler, Press & Sciascia, 2006).

The fact that variables such as stride time cycle, ground contact time, and step frequency in the taping test show significant relationships with triceps and thigh circumference reveals that lower extremity muscle mass is particularly effective on agility and mobility. This parallels findings reported by Reilly, Williams, Nevill, and Franks (2000), indicating that lower body strength influences agility and change-of-direction performance. Furthermore, Gabbett, Kelly, and Sheppard (2008) confirmed the direct relationship between strength development and agility, particularly in contact team sports.

The observed relationships between balance parameters and triceps circumference and lean mass point to indirect effects of the upper extremity on postural control. Winter (1995) noted that the interaction between the central nervous system, proprioceptive feedback, and muscle mass is important for postural balance. The findings of the present study are consistent with previous studies on the effect of muscle mass on balance strategies (Gribble, Hertel & Plisky, 2004; Paillard, Noé, Rivière, Marion & Montoya, 2006). Particularly in sports such as handball, which heavily utilise the upper extremities, the effect of the shoulder girdle and upper arm muscle structure on stability may be even more pronounced.

The study found no significant relationship between jump tests and anthropometric variables. This result supports studies suggesting that jump performance is determined not only by muscle mass but also by neuromuscular factors such as motor unit activation, tendon stiffness, and movement technique (Cormie, McGuigan & Newton, 2011; Markovic & Mikulic, 2010). In this context, better motor coordination and muscle-fascia chain interaction may play a role in individuals who can demonstrate high jumping performance (Bobbert & van Ingen Schenau, 1988).

Furthermore, some studies conducted on handball players in the literature have also indicated that anthropometric characteristics differ according to position and that their effect on performance varies (Bayios, Anastasopoulou, Sioudris & Boudolos, 2006). It has been shown that elite handball players have different body compositions according to their positions and that these differences have significant effects on performance. Therefore, evaluating the current findings with position-based differences in mind may provide a more comprehensive interpretation.

In conclusion, this study demonstrates that anthropometric characteristics are related to performance components such as strength, balance, and taping in a sport like handball, which requires versatile physical capacity. These findings should be taken into account in individualised performance assessments and the structuring of training programmes for athletes. Future studies could enhance the generalisability of these findings by conducting longitudinal analyses, gender-based comparisons, and position-based evaluations.

CONCLUSION

This study was conducted to examine the relationship between anthropometric characteristics and taping, dynamic strength, balance, and strength-velocity relationships in elite handball players. The findings revealed that certain anthropometric measurements are significantly related to performance parameters, particularly strength and balance.

In general, variables such as lean mass, triceps, and thigh circumference were observed to play a decisive role in taping, strength, and balance performance. In particular, the fact that triceps circumference and thigh circumference were significantly related to stride time, cycle, ground contact time, and step parameters in taping tests suggests that lower limb anthropometry has important effects on athletic mobility and balance. The presence of positive, significant relationships between dynamic strength parameters and lean mass and abdominal circumference supports the interaction between strength development and body composition.

In terms of balance parameters, the relationship between triceps and lean mass density and amplitude variables suggests that muscle mass distribution may affect postural control. However, the absence of a significant relationship between jumping performance and anthropometric variables indicates that this ability may be more dependent on neuromuscular coordination and technical factors.

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