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ORIGINAL ARTICLE

Investigation of Trapezius Muscle Strength in Elite and Sub-Elite Female Weightlifters

Elit ve Sub-Elit Kadın Halter Sporcularında Trapezius Kas Kuvvetinin Araştırılması

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ABSTRACT

Aim; Trapezius muscle strength weakness poses a risk for injuries and loss of weightlifting performance. In this study, it was aimed primarily to investigate the trapezius muscle strength in elite and sub-elite female weightlifters. In addition, it was aimed to determine the relationship between trapezius muscle strength, and weightlifting performance and anthropometric characteristics and to investigate the asymmetric development of trapezius muscle strength in current athletes.
Materials and Methods: In the study conducted on 21 elite and 21 sub-elite female weightlifters, after determining the demographic and anthropometric characters, upper, middle and lower trapezius muscle strengths were measured with a manual hand dynamometer. Statistical analysis was conducted with SPSS program. Correlations were determined by Pearson analysis. p<0.05 was accepted significantly.
Results: It was found that the right upper, middle, lower and left upper and lower trapezius muscle strength and weightlifting performance values were higher in the elite group (p<0.01, p<0.05, p<0.01, p<0.01, p<0.01, p<0.01, respectively). Moreover, a high level of correlation was found between left middle trapezius muscle strength and body mass index (BMI) and weightlifting performance in both groups (r=0.57, p<0.01; r=0.59, p<0.01; r=0.56, p<0.01, r=0.70, p<0.01, respectively). Significant asymmetry was demonstrated between right and left middle trapezius muscle strength in both groups (p<0.05, p<0.05, respectively).
Conclusion: It can be said that there is a close relationship between trapezius muscle strength, which is higher in elite female weightlifters than in sub-elite weightlifters, and BMI and weightlifting performance. Moreover, the presence of side asymmetry in trapezius muscle strength can be a reference for trainers in arranging training programs.

Keywords: Elite female weightlifter, Hand dynamometer, Trapezius muscle strength, Weightlifting performance

ÖZ

Amaç; Trapezius kas kuvveti zayıflığı yaralanmalar ve halter performansı kaybı için risk oluşturur. Bu çalışmada, elit ve sub-elit kadın halter sporcularında öncelikle trapezius kas kuvvetinin araştırılması amaçlanmıştır. Ayrıca mevcut sporcularda, trapezius kas kuvveti ile halter performansı ve antropometrik karakterler arasındaki ilişkinin belirlenmesi ve trapezius kas kuvveti asimetrik gelişiminin araştırılması amaçlanmıştır.
Gereç ve Yöntem: 21 elite ve 21 sub-elite kadın halter sporcusu üzerinde gerçekleştirilen çalışmada, demografik ve antropometrik karakterlerin belirlenmesinin ardından, manüel el dinamometresi ile üst, orta ve alt trapezius kas kuvvetleri ölçüldü.. İstatistiksel analiz SPSS programı ile yapıldı. Korelasyonlar Pearson analiziyle belirlendi. p<0,05 anlamlı olarak kabul edildi.
Bulgular: Sağ üst, orta, alt ve sol üst ve alt trapezius kas kuvveti ile halter performansı değerlerinin elit grupta daha yüksek olduğu bulundu (p<0,01, p<0,05, p<0,01, p<0,01, p<0,01, p<0,01, sırasıyla). Ayrıca, her iki grupta sol orta trapezius kas kuvveti ile vücut kütle indeksi (VKİ) ve halter performansı arasında yüksek düzeyde korelasyon bulundu (r=0.57, p<0,01; r=0.59, p<0,01; r=0.56, p<0,01, r=0.70, p<0,01, sırasıyla). Her iki grupta sağ ve sol orta trapezius kas kuvveti arasında anlamlı asimetri gösterildi (p<0,05, p<0,05, sırasıyla)
Sonuç: Elit kadın halter sporcularında sub-elitlerden daha yüksek bulunan trapezius kas kuvveti ile VKİ ve halter performansı arasında yakın ilişkili olduğu söylenebilir. Dahası, trapezius kas kuvvetinde taraf asimetrisi varlığı, antrenman programı düzenlemede antrenörlere referans olabilir.

Anahtar Kelimeler: Elit kadın halterci, El dinamometresi, Halter performansı, Trapezius kas kuvveti

Introduction

Weightlifting is a power sport in which weights are lifted with snatch and clean and jerk techniques (1-3). Successful weightlifting performance in both snatch, clean and jerk techniques requires maximum strength as well as harmonious anthropometric character (1). The influence of the trapezius muscles in the movements of the scapula, which has important functions in shoulder movements, is indisputable (4, 5). The origin of the trapezius muscle, which is located between the back muscles with its flat and triangular shape, forms the base part located along the vertebral column, and its insertion is the end point extending towards the top of the shoulder. The motor innervation of the trapezius muscle, consisting of upper, middle and lower fibers, is provided by the cranial nerve XI (nervus accessorius). The upper and lower fibers of the trapezius

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muscle work together to rotate the lateral side of the scapula upwards, enabling the upper extremity to be lifted up on the head (6).

The upper fibers of the trapezius muscle make the scapula elevate, the middle fibers adduction, and the lower fibers depression (3, 6). The trapezius muscles are mostly involved in positioning the scapula for optimum glenohumeral joint mobility, stabilizing the scapula, and transferring loads from the trunk to the upper arm in the shrug movement (7). Scapular biomechanics and glenohumeral joint dysfunction lie at the bottom of the problems arising from the complex shoulder region. The scapular position is of great importance in volleyball players (8), swimmers and tennis players (9), whose overhead movements are intense, as well as in weightlifters who require a very high level of power and maximum speed for traction and shooting movements. Scapular muscle strength is one of the most important factors that provide and maintain the scapula position (10).

On the other hand, trapezius muscle force asymmetry and disproportion, which results in the change of scapular kinematics, cause the scapular mechanics to be out of balance (9). In all athletes with overhead motion intensity, including olympic style weightlifters, deterioration of scapula biomechanics poses a serious risk in terms of sports injuries, as well as a factor that can negatively affect weightlifting performance (11).

In weightlifters, the way to provide shoulder and scapula biomechanics is to exhibit optimum power with a high level of static muscle strength activity. This will be only possible with the strong and coordinated work of the trapezius and other shoulder muscles. In weightlifters, existence of right-left asymmetry especially in shoulder and back muscle strength will cause deterioration in weightlifting performance due to its potential to cause glenohumeral joint dysfunction. From this point of view, as far as we could find, we could not find any study in the literature that specifically shows trapezius muscle strength, right-left asymmetry and their relationships with weightlifting performance in elite and sub-elite female weightlifters. In the light of current literature, we hope that knowing the upper, middle and lower trapezius muscle strength values of elite and sub-elite female weightlifters will contribute to the literature and weightlifting workers. In the current study conducted on elite and sub-elite female weightlifters, answers to the following questions were sought as hypotheses: 1) Is there a difference in trapezius muscle strength between elite and sub-elite female weightlifting groups? 2) Is there an asymmetric development of right and left trapezius muscle strength in elite and sub-elite weightlifting athletes? 3) Is there a relationships between trapezius muscle strength and anthropometric characteristics in groups? 4) Is there a relationships between trapezius muscle strength and maximum snatch and clean and jerk weightlifting performance in groups?

From this point of view, the major purpose of the present study is to investigate the trapezius muscle strength in elite and sub-elite female weightlifters in olympic style weightlifting. In addition, it was aimed to determine the relationship between trapezius muscle strength and weightlifting performance and anthropometric characteristics and to investigate the asymmetric development of trapezius muscle strength, in current athletes.

Materials and Methods

Participants

The participants of study were composed of female weightlifters who participated in the Olympic style weightlifting championships at international and national level. 5% of the elite weightlifter (EWL) group, which included 21 female athletes, were athletes who participated in the olympic games and 95% of them participated in both the World and European Weightlifting Championships. On the other hand, 65% of the sub-elite Weightlifting athletes (sub-EWL) group, consisting of 21 female athletes, was made up of athletes who participated in international weightlifting and 35% national weightlifting championships and won medals. The groups of our research consisted of the athletes of the Turkish Olympic Preparation Center in Konya and the athletes of the women's Turkish Weightlifting National Team camp opened in the same province. The EWL group was selected from the athletes who have been doing regular and active weightlifting sports (at least 6 days a week) for the last 3 years in the Turkish Weightlifting National Teams. The sub-EWL group was selected from athletes who have been doing weightlifting regularly and actively (at least 5 days a week) for 4 years. All participants were examined by a medical doctor before the measurements. It was questioned whether the athletes had any sports injury or previous surgery and whether they had physical therapy.

For all groups; being under the age of 18, doing sports for less than three years, ongoing pain in the upper extremities, musculoskeletal problem, any surgery in the upper extremities, any diagnosed systemic disease and any sports injury were determined as exclusion criteria. In addition, due to the possibility of affecting the muscle strength in the dominant extremity and thus, the trapezius muscle strength, left side dominant status was also determined as an exclusion criterion. Only right-sided dominant athletes were included in the study. In determining the dominant hand, individuals were asked about the side they used most in their daily life or sportive activities, and it was recorded. Weightlifters participating in the study were given general information about the study. A signed consent form was obtained from all athletes who agreed to participate in the study.

Data Collection Tools

Experimental Protocol

Determination of demographic characteristics and anthropometric measurements

Basic demographic data (such as age and training age) of the athletes were determined by face-to-face interview on the day the trapezius muscle strength was measured. Anthropometric characteristics (such as height and body weight) were measured on the day when the athletes did not undergo training. The body weights of the athletes were measured with the Tanita (MC 580) brand bioimpedance measurement system in the morning on an empty stomach, bare feet and wearing light clothes (12). Body mass index (BMI) was calculated by dividing the body weight by the square of the height measurement (13). The height measurements of the athletes were made with bare feet, using a Seca brand (213 portable mechanic, Germany) height meter (14). Data on the degrees achieved by the athletes in the weightlifting championships held in the World, Europe and Türkiye, the snatch, clean and jerk techniques in international tournaments, was obtained from the official websites of the World Weightlifting Federation (15), the European Weightlifting Federation (16) and the Turkish Weightlifting Federation (17).

Trapezius Muscle Strength Measurements

Upper-middle and lower trapezius muscle strength measurements were carried out in the gyms where the weightlifters train continuously, in the rooms reserved for the weightlifters, in sanitary conditions and on the days when they did not train. Measurements were made with Lafayette (Model-01165, USA) brand manual hand dynamometer. Measurements were evaluated by asking the weightlifter to apply force against the device at different angles and push the device, as reported in the literature (18-20).

In order to obtain the highest level of isometric contraction during trapezius muscle strength measurements, the middle angle of the scapula was chosen as the most suitable angle of scapula movement due to the high level of length-tension relationship. In order to determine the true and correct muscle strength during the measurement, resistance was applied to the weightlifter until the efforts of the weightlifter and the tester were equalized (21, 22). Upper-middle and lower trapezius muscle strength measurements methods were shown in figure 1. Written consent was obtained from the athlete for photographing and publishing.

Elevation action was determined as scapular movement in the upper trapezius (UT) muscle strength measurement. The dynamometer was placed on the scapula superior region of the weightlifter in the sitting position. For measurement, force was applied directly inferiorly to depress the scapula. In order to reach the precise muscle strength during the measurement, resistance was applied to the weightlifter until the efforts of the weightlifter and the tester were equalized. Since the presence of lateral flexion movement in the trunk and cervical lines invalidated the measurement, the measurement was repeated in such cases (22, 23), (Figure 1A).

Middle trapezius (MT) muscle strength was measured when the weightlifter was in the prone position, the humerus was abducted at 90°, and the glenohumeral joint was in full external rotation. The measurement was made by applying force to the wrist region, towards the lateral aspect of the distal radius of the athlete, who was asked to perform horizontal abduction with external rotation with the measuring arm in the current position. In order to obtain the true muscle strength during the measurement, resistance was applied to the weightlifter until the efforts of the weightlifter and the tester were equalized. In cases where the angle of movement of the arm in the desired directions changed, the measurement was deemed invalid and the test was repeated (24, 25), (Figure 1B).

Similar to the middle trapezius muscle strength measurement, the lower trapezius (LT) muscle strength measurement, while the weightlifter is in the prone position and the humerus is at 145° elevation, the weightlifter was asked to raise her arm, and the force was applied from the midpoint of the athlete's spina scapula in the superior and lateral directions, parallel to the long axis of the humerus. The tester performed the measurement by applying downward resistance from the outer side of the radius. In order to determine the correct muscle strength during the measurement, resistance was applied to the weightlifter until the efforts of the weightlifter and the tester were equalized. In cases where the arm elevation angle changed, the measurement was considered invalid and the test was repeated. For the LT muscle strength measurement test, adduction and depression were determined as the most appropriate scapular movement (24, 25), (Figure 1C).

A B C

Figure 1. Trapezius muscle strength measurement methods:

A-Upper trapezius muscle strength measurement method; B-Middle trapezius muscle strength measurement method; C-Lower trapezius muscle strength measurement method.

Trapezius muscle strength measurements of all weightlifters were done in upper-middle and lower order. The tester did not provide any information about the results to the weightlifters during the application. Measurements were performed in triplicate with 15-second rest periods and the average of the three measurements was recorded in kilograms. All measurements were performed by the same investigator.

Data Analysis

Before proceeding to the basic analysis, descriptive statistics of demographic variables were analyzed. To test the normality assumption, skewness-kurtosis values, histograms and Q-Q plots were examined. According to the obtained results, it was determined that all research variables showed normal distribution. A series of independent groups t-tests were conducted to examine some of the anthropometric characteristics and demographic values of EWL and sub-EWLs. Paired-sample t-test was performed to compare the anthropometric characteristics, demographic measurements and right-left trapezius muscle strength of EWL and sub-EWLs. The relationships between right-left trapezius muscle strength and other variables of the study were analyzed by Pearson Correlation analysis. The r values were considered from 0.10 to 0.29 or -0.29 to -0.10 as weak, from 0.30 to 0.49 or -0.49 to -0.30 as moderate and from 0.50 to 1.00 or -0.50 to -1.00 as high correlation. The statistical significance level was accepted as p<0.05 for all analyzes and analyzes were performed with SPSS 25 program (IBM Corp. Released 2017, IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp.).

Ethical Consent: Our research was carried out in accordance with the principles of the 2008 Helsinki Declaration, and approval was obtained from the Clinical Research Ethics Committee of Karamanoğlu Mehmetbey University Faculty of Medicine with the decision dated 29.06.2022 and numbered 06-2022/02.

Results

There was no statistically significant difference between the groups in the age, height, body weight and BMI values of the EWL and sub-EWL groups, except for age (p>0.05, Table 1).

As a result of the comparison of the training age, weightlifting performance data and trapezius muscle strength values of the elite and sub-elite female weightlifters, it was found that the performance values of the training age (p<0.001), maximum snatch (p<0.001), maximum clean and jerk (p<0.001), maximum snatch + clean and jerk (p<0.001) weightlifting performance were statistically significantly higher in EWL than in sub-EWL. In addition, right upper (p=0.001), left upper (p<0.001), right middle (p=0.045), right lower (p<0.001) and left lower trapezius (p<0.001) muscle strength values were significantly higher in EWL than in sub-EWL. On the other hand, left MT muscle strength value was marginally significantly higher in EWL than in sub-EWL (p=0.05). The athletes were doing weightlifting training at close weekly intervals. However, the present findings showed that the answer to the first question of our hypothesis was 'yes'. Moreover, it was determined that the right upper and right lower trapezius muscle strength ratio (p=0.001), and the left upper and left lower trapezius muscle strength ratio values (p=0.009) were significantly higher in sub-EWL than in EWL (Table 2).

Table1. Comparison of demographic and anthropometric values of elite and sub-elite female weightlifting groups

Parameters	Groups	n	Mean ± SEM	p
Age (year)	EWL	21	20.43 ± 0.66	0.001**
	Sub-EWL	21	18 ± 0.23	
Height (cm)	EWL	21	160.86 ± 1.69	0.591
	Sub-EWL	21	159.57 ± 1.67	
Body weight (kg)	EWL	21	66,52 ± 3,67	0.489
	Sub-EWL	21	63.31 ± 2.78	
BMI (kg/m^2)	EWL	21	25.43 ± 1,05	0.563

EWL: Elite weightlifters, sub-EWL: sub-elite weightlifters, n: Number of athletes, BMI: Body Mass Index **p<0.01, SEM: Standart Error of Mean

Table 2. Comparison of the training age, weightlifting performance data and trapezius muscle strength values of elite and sub-elite female weightlifters

Parameters	Groups	n	Mean ± SEM	p
Training age (year)	EWL	21	7.35 ± 0.6	0.000**
	Sub-EWL	21	4.43 ± 0.39	
Maximum snatch (kg)	EWL	21	85.29 ± 2.46	0.000**
	Sub-EWL	21	71.86 ± 2.23	
Maximum claen and jerk (kg)	EWL	21	110.29 ± 3.62	0.000**
	Sub-EWL	21	89.48 ± 2.65	
Maximum snatch + claen and jerk (kg)	EWL	21	195.57 ± 5.58	0.000**
	Sub-EWL	21	161.33 ± 4.82	
Right UT muscle strenght (kg)	EWL	21	32.58 ± 0.52	0.001**
	Sub-EWL	21	29.06 ± 0.78	
Left UT muscle strenght (kg)	EWL	21	34.35 ± 0.79	0.000**
	Sub-EWL	21	30,15 ± 0,73	
Right MT muscle strenght (kg)	EWL	21	6.75 ± 0.24	0.045*
	Sub-EWL	21	5.99 ± 0.28	
Left MT muscle strenght (kg)	EWL	21	7.24 ± 0.31	0.050*
	Sub-EWL	21	6.41 ± 0.27	
Right LT muscle strenght (kg)	EWL	21	6.56 ± 0.37	0.000**
	Sub-EWL	21	4.53 ± 0.25	
Left LT muscle strenght (kg)	EWL	21	6.15 ± 0.31	0.000**
	Sub-EWL	21	4.38 ± 0.25	
Right upper/lower muscle strenght ratio	EWL	21	526 ± 0.27	0.001**
	Sub-EWL	21	6.64 ± 0.25	
Left upper/lower muscle strenght ratio	EWL	21	5.89 ± 0.33	0.009**
	Sub-EWL	21	7.27 ± 0.38	

EWL: Elite weightlifters, sub-EWL: sub-elite weightlifters, n: Number of athletes, ** p<0.01, * p<0.05, SEM: Standart Error of Mean, UT: Upper Trapezius, MT: Middle Trapezius, LT: Lower Trapezius

Table 3. Comparison of the asymmetry value in the right and left trapezius muscle strength values of the elite and sub-elite female weightlifting groups

Trapezius Muscle Strength	EWL (n=21)		Sub-EWL (n=21)	
	Mean ± SEM	p	Mean ± SEM	p
Right UT muscle strenght (kg)	32.58 ± 0.52	0.024*	29.06 ± 0.78	0.207
Left UT muscle strenght (kg)	34.35 ± 0.79		30.15 ± 0.73	
Right MT muscle strenght (kg)	6.75 ± 0.24	0.039*	5.99 ± 0.28	0.038*
Left MT muscle strenght (kg)	7.24 ± 0.31		6.41 ± 0.27	
Right LT muscle strenght (kg)	6.56 ± 0.37	0.046*	4.53 ± 0.25	0.497
Left LT muscle strenght (kg)	6.15 ± 0.31		4.38 ± 0.25	
Right upper/lower muscle strenght ratio	5.26 ± 0.27	0.004**	6.64 ± 0.25	0.163
Left upper/lower muscle strenght ratio	5.89 ± 0.33		7.27 ± 0.38	

EWL: Elite weightlifters, sub-EWL: sub-elite weightlifters, n: Number of athletes, ** p<0.01, * p<0.05, SEM: Standart Error of Mean, UT: Upper Trapezius, MT: Middle Trapezius, LT: Lower Trapezius

In the t-test analysis conducted for a series of paired groups, which was performed to evaluate whether there was asymmetry in the values of the trapezius muscle strength of the elite and sub-elite female weightlifting groups. In terms of variables, it was shown that there was significant asymmetry in the strength values of the right and left upper, right and left middle and right and left lower trapezius muscles in the EWL group (p=0.024, p=0.039, p=0.046, respectively) . In addition, in the EWL group, it was observed that there was an asymmetry in favor of the left between the right upper/right lower and left upper/left lower trapezius muscle strength ratios (p=0.004). Moreover, significant asymmetry was observed only in the strength values of the right and left middle trapezius muscles in sub-EWL (p=0.038), (Table 3). Thus, right and left side asymmetry in the trapezius muscle strength of the weightlifters doing symmetric sports was demonstrated. Interestingly, these results showed that the answer to the second question of our hypothesis was 'yes'.

In the Pearson correlation analysis made to examine the relationships between the trapezius muscle strength and anthropometric and demographic characteristics and weightlifting performance in the groups, it was determined that there was a high and positive correlation between age and the training age in the EWL group (r=0,63, p<0.01). In addition, in both EWL and sub-EWL groups, it was shown that there was a high level of positive correlation between BMI and

Table 4. Correlation comparison between trapezius muscle strength values and demographic and anthropometric data of elite and sub-elite female weightlifting groups.

Parameters	Age (year)	Age (year)	BMI (kg/m²)	BMI (kg/m²)	Training age (year)	Training age (year)	Maximum snatch (kg)	Maximum snatch (kg))	Maximum claen and jerk (kg)	Maximum claen and jerk (kg)	Maximum snatch + claen and jerk (kg)	Maximum snatch + claen and jerk (kg)
	EWL n=21	Sub-EWL n=21	EWL n=21	Sub-EWL n=21	EWL n=21	Sub-EWL n=21	EWL n=21	Sub-EWL n=21	EWL n=21	Sub-EWL n=21	EWL n=21	Sub-EWL n=21
Age (year)	1.00	1.00	-0.20	0.21	0.63**	-0.11	0.02	0.05	-0.32	0.02	-0.22	0.03
BMI (kg/m²)	-0.20	0.21	1.00	1.00	0.15	-0.15	0.61**	0.55**	0.79**	0.61**	0.78**	0.59**
Training age (year)	0.63**	-0.11	0.15	-0.15	1.00	1.00	0.28	0.28	-0.04	0.28	0.10	0.28
Maximum snatch (kg)	-0.02	0.05	0.61**	0.55**	0.28	0.28	1.00	1.00	0.67**	0.95**	0.87**	0.98**
Maximum claen and jerk (kg)	-0.32	0.02	0.79**	0.61**	-0.04	0.28	0.67**	0.95**	1.00	1.00	0.94**	0.98**
Maximum snatch + claen and jerk (kg)	-0.22	0.05	0.78**	0.59**	0.09	0.28	0.87**	0.98**	0.94**	0.94**	1.00	1.00
Right UT muscle strenght (kg)	0.01	0.00	-0.02	0.16	0.24	0.02	0.12	0.21	0.07	0.29	0.09	0.26
Left UT muscle strenght (kg)	0.08	0.15	0.09	0.45*	0.36	0.12	0.42	0.61**	0.08	0.69**	0.23	0.66**
Right MT muscle strenght (kg)	0.14	-0.02	0.51*	0.55**	0.18	0.21	0.19	0.76**	0.31	0.74**	0.28	0.76**
Left MT muscle strenght (kg)	0.20	0.10	0.57**	0.59**	0.19	-0.05	0.51**	0.68**	0.52*	0.71**	0.56**	0.70**
Right LT muscle strenght (kg)	0.03	-0.02	0.22	0.57**	0.12	-0.11	0.17	0.52*	0.22	0.55**	0.21	0.54*
Left LT muscle strenght (kg)	0.03	0.55**	0.09	0.46*	-0.10	-0.39	0.10	0.35	0.13	0.32	0.12	0.33
Right upper/lower muscle strenght ratio	-0.08	0.12	-0.38	-0.55**	-0.10	0.13	-0.25	0.46	-0.34	0.45*	-0.33	0.46*
Left upper/lower muscle strenght ratio	-0.05	0.48*	-0.12	-0.19	0.14	0.37	0.01	-0.03	-0.17	0.02	-0.11	-0.00

EWL: Elite weightlifters, sub-EWL: sub-elite weightlifters, BMI: Body Mass Index, ** p<0.01, * p<0.05, n=number of athletes, SEM: Standart Error of Mean, UT: Upper Trapezius, MT: Middle Trapezius, LT: Lower Trapezius maximum snatch and clean and jerk, maximum snatch + clean and jerk weightlifting performance values (EWL group; r=0.61, p<0.01; r=0.79, p<0.01; r=0.78, p<0.01, respectively; sub- EWL group; r=0.55, p<0.01; r=0.61, p<0.01; r=0.59, p<0.01, respectively). Moreover, in both EWL and sub-EWL groups, it was reported that there was a high level of positive correlation between BMI and right and left middle trapezius muscle strength (EWL group; r=0.51, p<0.05; r=0.57, p<0.01, respectively; sub-EWL group; r=0.55 ,p<0.01; r=0.59, p<0.01, respectively), (Table 4). These findings showed that the answer to the third question of our hypothesis was 'yes'. In the EWL group, it was stated that there was a high and positive correlation between the strength of the left middle trapezius muscle and the maximum snatch, maximum clean and jerk and maximum snatch + clean and jerk weightlifting performance values (r=0,51, p<0.01; r=0,52, p<0.05; r=0.56, p<0.01, respectively). Similarly, it has been established that there is a high and positive correlation between left middle trapezius muscle strength and maximum snatch, maximum clean and jerk and maximum snatch + clean and jerk weightlifting performance values in the sub-EWL group (r=0.68, p<0.01; r=0.71, p<0.01; r=0.70, p<0.01, respectively). On the other hand, in the sub-EWL group, it was expressed that there was a high and positive correlation between the strength of the left upper, right middle and right lower trapezius muscle and maximum snatch+clean and jerk weightlifting performance (r=0.66, p<0.01; r=0.76, p<0.01; r=0.54, p<0.05, respectively). These results indicated that the answer to the fourth question of our hypothesis was 'yes'. In the sub-EWL group, a moderate and positive correlation was observed between the strength ratio of the right upper and right lower trapezius muscles and the maximum clean and jerk and maximum snatch + clean and jerk weightlifting performance (r=0.45, p<0.05; r=0.46, p<0.05, respectively). On the other hand, a moderate and positive correlation was observed between the ratio of left upper and left lower trapezius muscle strength and age in the sub-EWL group (r=0.48, p<0.05), (Table 4).

Discussion

In the current study, besides the trapezius muscle strength values in olympic style elite female weightlifting athletes, the existence of correlation between trapezius muscle strength and weightlifting performance and anthropometric values was investigated. Moreover, right and left side asymmetry of trapezius muscle strength was studied. One of the important indicators of obtaining information about the functional state of the organism is the assessment of muscle strength and muscle mass. Changes in muscle strength and muscle mass are preventable risk factors that cause performance decline (18) and injuries (26) in athletes.

As in all sports, the only goal of weightlifters and trainers is to exhibit the highest level of weightlifting performance. The way to exhibit a successful weightlifting performance is to have a balanced anthropometric structure, strength muscles and maximum power (1-3), as well as applying an adequate and appropriate training program. When the literature is reviewed for trapezius muscle strength values, which have an important role in glenohumeral joint functions and scapular stability; UT muscle strength in the dominant extremities of young handball players (26), MT muscle strength and LT muscle strength in the extremities of professional baseball players (24) are seen as 19.12 ± 4.09 kg, 6.66 ± 1.66 kg and 6.85 ± 1.90 kg, respectively. On the other hand, Cools et al. in their study on young female tennis players, found the UT muscle strength as 2.68 ± 0.64 N/kg (25). In another study conducted with young athletes who use overhead movements such as volleyball, tennis, swimming, and basketball intensively, upper, middle, and lower trapezius muscle strengths were 234.02 ± 19.15, 189.84 ± 22.65, and 197.64 ± 18.64 Newton, respectively (27). In our study, dominant extremity upper, middle and lower trapezius muscle strength values were determined as 32.58 ± 0.52 kg, 6.75 ± 0.24 kg and 6.56 ± 0.37 kg in the EWL and, 29.06 ± 0.78 kg, 5.99 ± 0.28 kg and 4.53 ± 0.25 kg in sub-EWL, respectively. The current values are largely similar to the literature data. In addition, almost all trapezius muscle fiber strengths were higher in EWLs than in sub-EWLs. We suggest that this may be due to the fact that EWLs have a longer sports history and do more weightlifting training.

Another remarkable finding of our study was that both the right (dominant side) and left upper/lower trapezius muscle strength ratios were significantly greater in favor of the upper fibers than the EWLs in the sub-EWLs. Since it is the first study to add right and left side muscle strength ratios to the trapezius isometric muscle strength measurement data by manual hand dynamometer in elite and sub-elite female weightlifters, we can discuss that our results is quite limited. The strength of both dominant and non-dominant UT muscle fibers may be higher than the lower fibers, causing scapular dyskinesia during shoulder elevation, resulting in an increased risk of injury and loss of weightlifting performance (9-11). In addition, we consider that the greater imbalance of upper and lower trapezius muscle strength in the sub-EWL may be due to the fact that the scapular stabilizers are not adequately trained in symmetrical strength training in this group of athletes (25). Interestingly, a moderate positive correlation was found between the ratio of dominant side upper and lower trapezius muscle strength and maximum snatch + clean and jerk weightlifting performance in sub-EWLs. We think that this may be due to the stronger balance of force in the upper trapezius muscle fibers that provide scapular elevation.

On the other hand, significant asymmetry was detected in favor of the non-dominant side between the upper (5.43%) and middle (7.25%) trapezius fibers in the EWLs, the middle fibers (7.41%) in the sub-EWLs, and between the right and left side muscle strengths. Weightlifting is a symmetrical branch (3).We can say that even a small amount of muscle strength asymmetry is important in terms of the risk of injury in an important sport such as weightlifting, where maximum strength and power must be exhibited in a unique harmony of balance. We evaluate that the right-left asymmetry of trapezius muscle strength may result from unbalanced and unconscious isometric strength training practice. Moreover, we think that this dangerous asymmetry may pose a risk in terms of loss of performance and significant injuries (24-26).

In our study, it was observed that the significant correlation between trapezius muscle strength, weightlifting performance and BMI in both groups of athletes largely overlapped with the literature. There are many studies in the literature that show that maximum muscle strength and power are affected by morphological characters such as muscle mass and muscle thickness (28, 29). Moreover, a profound correlation between muscle morphology and strength and power performance has been demonstrated in elite strength training athletes, including weightlifters (30).

Study Limitations: Our limitations were that the study was conducted only on elite female weightlifters and the effects of a particular training program on muscle strength could not be evaluated. The subject can be explored in future studies to cover both genders with the participation of more athletes.

Conclusion

In conclusion, the results of the current study emhasized that trapezius muscle strength was higher in elite female weightlifters than in sub-elite weightlifters. It also determined that there was significant right-left side asymmetry in trapezius muscle strength values measured by manual hand dynamometer in elite female weightlifters. Moreover, it was established that trapezius muscle strength was closely related to weightlifting performance and body mass index. The current results provide substantial answers to the questions sought to be answered in our study.

Our study has proven that weightlifting performance is significantly affected by body mass index and trapezius muscle strength and the findings obtained from elite and sub-elite female weightlifters can be a reference value for the literature. In addition, the findings can be used as reference values by athletes and sports physicians in evaluating trapezius muscle strength and by trainers in arranging a training program to increase weightlifting performance.

Ethical Consent: Ethics committee approval of the study was obtained from Karamanoğlu Mehmetbey University Faculty of Medicine Clinical Research Ethics Committee with the decision dated 29.06.2022 and numbered 06-02.

Conflict of Interest: The authors declared no conflict of interest for this study.

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Author Contributions:

Concept/Design: BI, KE; Data acquisition: BI, KE; Data analysis and interpretation: KE; BI

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