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# Are Scapular Muscle Strength and Endurance Associated with Performance-Related Physical Fitness in School Age Amateur Handball Players?

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## Abstract

**Purpose:** To examine the relationship between scapular muscle strength and endurance, motivation to participate in sports and performance-related physical fitness parameters in school-age amateur handball players.

**Methods:** The strength of the scapular muscles was evaluated with a digital dynamometer (Model-01165, Lafeyette Instrument®, USA), and muscular endurance was evaluated with the Scapular Muscular Endurance Test (SMET). Upper limb function and anaerobic power of athletes; Medicine Ball Throw Test (MBTT), reaction times; Nelson's Hand Reaction Test (NHRT), upper limb agility and stabilization; Davies Test (DT) and Closed Kinetic Chain Upper Extremity Stability Test (CKC UEST), arm motion speed; The Touching Discs Test (TDT) and motivation for participation in sports were evaluated using the Motivation for Participation in Sports Scale (MPSS). Spearman Correlation Analysis was applied, and the level of significance was accepted as $p < 0.05$.

**Results:** A total of 27 amateur handball players, 18 (66.7%) female and 9 (33.3%) males, with a mean age of 10.52 ± 1.55 years participated in the study. Positive and significant relationships were found between scapular muscle strength values and DT, CKC UEST and MBTT values ($p<0.05$). Also, significant positive relationships were found between scapular muscular endurance values and DT, CKC UEST and MBTT values ($p<0.05$). No significant correlation was found between the MPSS values and performance-related physical fitness tests ($p> 0.05$)

**Conclusion:** In order to increase the athletic performance and upper extremity functionality in handball players, besides exercises aimed at developing scapular muscular endurance, strengthening exercises for scapular muscles should be included in training programs to increase arm movement speed and upper extremity agility and anaerobic power. Consequently, the authors believed that physical fitness levels and sportive success of handball players can be positively affected.

**Keywords:** Endurance; Handball; Participation in Sports; Physical Fitness; Strength.

## Introduction

The period of 8-12 years of age in children is very important in terms of skill acquisition and increase in physical and motor development levels. Physical and motor development is supported by directing and participating in sports for children in this age group. Muscle strength is one of the leading motor characteristics

that develop with participation in sports. The development of muscle strength and muscular endurance in children is important in preventing injuries, increasing motor skills and sportive success [1]. With participation in sports at an early age, it is easier for the child to know and communicate with his environment, to socialize and to achieve success. Multi-faceted development of strength, endurance, mobility, speed and coordination through participation in sports at an early age is important for a successful and long handball career [2, 3]. Handball in children provides social benefits as well as physical fitness development. Physical fitness depends on a person's strength, endurance, agility, coordination, and the ability to work together [4].

In terms of physical performance, handball is a complex sport in which players jump at high speeds, run and throw the ball, requiring maximum effort in a short time [5]. In handball, the level of performance is of great importance as well as physical characteristics. In this context, it should be noted that lower and upper extremity strength is important for performance in handball-specific movements [6]. Players must have a good reaction time and upper extremity functionality in order to interfere with the opponent's movements and attacks, to pass quickly and to defend goal shots successfully [7]. Considering the playing time and the necessity of playing fast and correctly in handball, as in all team sports, the basic components of physical performance such as strength, speed, agility, endurance, mobility, skill and anaerobic power, and parameters such as technique, tactics and experience are of great importance in achieving success [8].

The reasons for participation in sports may vary from person to person and may significantly affect the continuity of sports. Participation in sports allows individuals to evaluate their self-efforts, demonstrate their skills, and assess their personal goals [9, 10]. In addition to physical performance, psychological factors such as the motivation of the person play an important role in achieving the athlete's targeted success. The expectations and performances of children with low motivation are adversely affected, and this may reduce their sportive success [11].

In sports involving overhead activity and throwing such as handball, volleyball and basketball, the strength, endurance and flexibility of the muscles, especially around the shoulders, are of great importance [12]. In handball, the upper extremity is actively used during many movements, such as catching the ball, passing, dribbling and shooting. The strength and endurance of the upper extremity are very important in shooting through defence during attack and in blocking during defense [13]. Muscular endurance insufficiency and muscular fatigue predispose to the occurrence of musculoskeletal problems. In handball sports, where unilateral extremity use is intense, scapular instability, which is seen due to weakness in scapular muscle strength, scapular muscular endurance and biomechanical disorders, poses a risk for injuries and adversely affects the performance of the upper extremity and the sportive success of the athletes [14, 15]. Determining the effect of scapular muscle strength and endurance on performance is important in terms of determining which variables are more important in developing optimal strength and conditioning programs [16].

Due to the variable dynamics of the sport of handball, both lower and upper extremity physical performances must be good in order to achieve high sports efficiency that will fulfil the expectations of the players [17]. Determining the effects of scapular muscle strength and endurance of amateur handball players on performance-related physical fitness will allow to identify strengths and weaknesses in performance-related areas and to design specific, focused training models to improve performance [18, 19]. In this context, profiling the players in terms of physical fitness before their transition to professionalism in handball can be a valuable tool in determining their abilities according to their strengths and weaknesses, optimizing strength and conditioning programs and determining game positions. The aim of this study is to examine the relationship between scapular muscular endurance, scapular muscle strength, motivation to participate in sports and performance-related physical fitness in school age (8-12 years) amateur handball players.

### Hypotheses of the study

$H0_1$: There is no relationship between scapular muscle strength and performance-related physical fitness parameters in amateur handball players.

$H0_2$: There is no relationship between scapular muscular endurance and performance-related physical fitness parameters in amateur handball players.

$H0_3$: There is no relationship between motivation to participate in sports and physical fitness parameters related to performance in amateur handball players.

## Materials and Methods

### Individuals

This study was carried out between September 2020 and March 2021 at the Eastern Mediterranean University (EMU) Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation. Ethical permission for the study was obtained from the EMU Scientific Research and Publication Ethics Committee. (Decision dated 23.03.2021 and numbered ETK00-2021-0088). Participants were informed and informed consent was obtained from their families. The amateur handball players between the ages of 8-12 in the Turkish Republic of Northern Cyprus (TRNC) Handball Federation and the Cyprus International University (CIU) Handball Team were included in the study. Athletes who participated in handball training at least 2 days a week were included in the study.

- Those who had shoulder and spine pathology in the last 6 months and those who have a history of surgery in these regions,
- Those who have any musculoskeletal problems and pain in the upper extremity,
- Those with chronic diseases,
- Girls who had entered the menarche were not included in the study.

All the evaluations used for the study were done by the

same physiotherapist. Power analysis of the study was done with G*Power 3.1.9.2. When the power analysis of the study was performed, the type I error (alpha value) was 0.05, the type II error (1-β value) was 0.8, and the effect size (Cohen's d) was 0.5, and the total number of participants to be included in the study was calculated as 26. Considering that not all participants would meet the inclusion criteria and there might be dropouts, the number of subjects evaluated for eligibility was determined as 30. The study was completed with 27 participants [Figure 1].

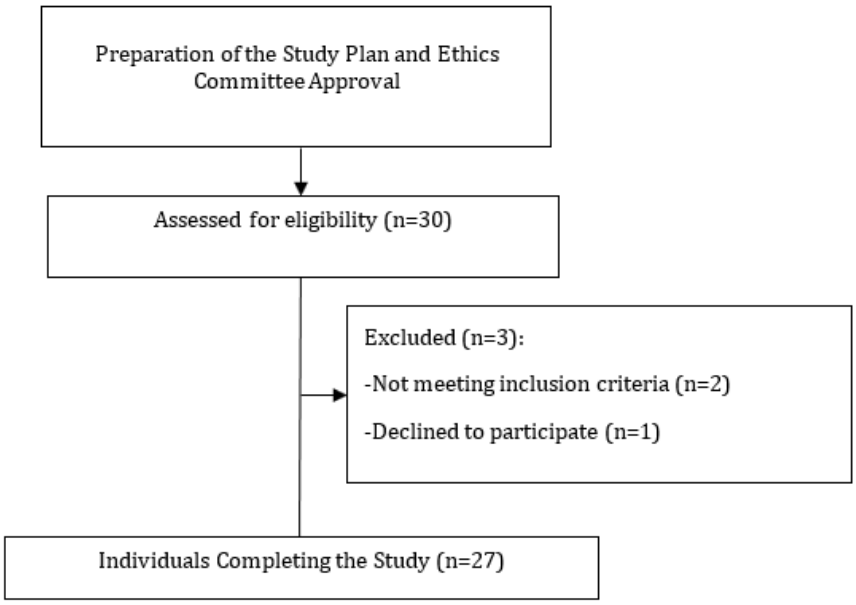


**Figure 1:** Study Plan and Schedule.

## Data Collection Tools

Demographic information of the participants (age, gender, height, body weight, body mass index (BMI) and dominant upper extremity) and sport-specific information such as weekly training time, position played, handball playing time were recorded. The dominant upper extremity was determined by observing which hand the participants wrote with.

***Scapular Muscle Strength Assessment:*** In the evaluation of scapular muscle strength, muscle strength test was performed on serratus anterior (SA), lower trapezius (LT), middle trapezius (MT) and upper trapezius (UT) muscles, which provide scapula stabilization and are the primary stabilizers of the scapulothoracic (ST) joint. Scapular muscle strength was evaluated with a digital dynamometer (Model-01165, Lafeyette Instrument®, USA). The dynamometer was calibrated before evaluation [20]. For the LT muscle test, resistance was applied with a dynamometer to the midline of the spina scapula between the acromion and the spina root while the individual was in the prone position. While the arm was in 140° elevation, the force on the scapula, which was in the abduction and depression position, was applied superiorly and laterally along the long axis of the humerus. For the MT muscle test, resistance was applied with a dynamometer to the midline of the spina scapula between the acromion and the spina root while the individual was in the prone position. While the arm was in 90° abduction, the force on the scapula in the retraction position was applied in the lateral direction parallel to the long axis of the humerus. For the UT muscle test, downward resistance was applied in the direction of scapular depression from the upper side of the scapula in the elevation position with a dynamometer while the individual was in the sitting position. For the SA muscle test, the individual was in a supine position and the shoulder was lifted up from the bed with the scapula protruding. With a dynamometer, resistance was applied downwards over the olecranon along the long axis of the humerus at the elbow joint in 90° flexion. Measurements were repeated 3 times for the dominant and nondominant side. Average values were used for analysis. In the literature, Intraclass Correlation Coefficient (ICC) values are shown between 0.89 and 0.96 for the reliability of muscle strength measurement made with this device [20].

***Scapular Muscular Endurance Assessment:*** Scapular muscular endurance was evaluated with the Scapular Muscular Endurance Test (SMET). With SMET, the endurance of the SA, LT, MT and UT muscles were evaluated, and the results were recorded in seconds. For the test, the participants were positioned in a standing position, facing the wall, with the shoulder and elbow joints in 90° flexion, and palms facing each other. The most the scapula on both sides in neutral position, the most suitable one in terms of length was placed between the elbows among five wooden sticks prepared in different lengths (30-50 cm). A dynamometer (Feta F0202 1 KG/10 N) was placed between the participant's hands while maintaining this position. In this position, individuals were asked to perform external rotation of the shoulder until a one-

kilogram load was created on the dynamometer and to maintain this force without disturbing it. The test was terminated when the participants complained that they could no longer tolerate the position, drop the wooden bar between their elbows, could not maintain 90° shoulder flexion, or cause discomfort [21].

## Physical Fitness Tests Related to Performance

***Medicine Ball Throwing Test (MBTT):*** This test is a valid and reliable test used to evaluate the open kinetic chain function of the upper extremity and to measure explosive power [22]. While the athlete was in an upright position (90 degrees knee flexion and neutral body) with his knees at the reference point on a mat, the 2 kg medicine ball was grasped with both hands and held in contact with the chest wall. The athlete was asked to throw the 2 kg medicine ball as far as possible in the direction of the lane in front of him with a chest pass. In order to minimize muscle compensations and momentum, the athlete kept his back in contact with the wall to prevent his body from moving backwards while throwing the ball. The place where the ball first touched the ground was marked [23]. The test was performed twice, and the average score was recorded.

***Nelson Hand Reaction Test (NHRT):*** The test was performed with the help of a ruler to evaluate hand reaction time. While sitting in the chair, the participants were asked to be ready with the forearm and hand on the table, with the tips of the thumb and index finger 8-10 cm outside the table, and the tops of the thumb and forefinger parallel to each other. When the ruler was released, the participant was told to catch the ruler. The value located on the upper edge of the participant's thumb, where the participant caught the ruler was recorded. Five trials were performed, and the best and worst values were discarded and the average of the remaining three measurements was taken [24].

***Davies Test (DT) and Closed Kinetic Chain Upper Extremity Stability Test (CKC UEST):*** Upper extremity agility and stabilization were evaluated with DT and CKC UEST. For the DT, in the push-up position, the hands were placed 36 inches (91 cm) apart and the athlete tried to touch their hands, respectively. Two attempts were made and the number of times he could touch for 15 seconds was recorded [25]. CKC UEST was performed in the modified push-up position in front of 2 lines drawn 30 cm apart. The athlete placed his hands on the line on his side while his elbows were in the extended position. When the time started, the hands were moved to jump from one line to the other. Two attempts were made and the number of touching the lines in 15 seconds was recorded. Care was taken not to deteriorate the push-up position and not to drag the hands while sliding the hands [26].

***Touch Test Disc Board (TTD):*** Arm movement speed was evaluated with the TTD. Two plastic discs with a diameter of 20 cm were arranged on a table of appropriate height. The distance of the two discs from the center point to each other was 80 cm (accordingly, the edges are 60 cm apart). A rectangular plate of 10 x 20 cm was placed on the table, equidistant from the two discs. Participants stood with feet apart in front of the table and the non-preferred hand was placed on the rectangular plate in the middle. The person touched the discs by moving sideways between the two discs as quickly as possible with their preferred hand over the middle hand. Along with the start command, 25 cycles were made (50 taps) that could be performed as soon as possible. The movement is terminated with the stop command. The score was counted out loud and the test was performed twice, and the mean value was used for analysis. The score is the time used to touch each disc 25 times, recorded as ten times a second (Ex. 12.5 seconds = 125 points). If the participant did not touch the disc, an extra touch was given [27].

**The Evaluation of Motivation to Participate in Sports (MPS):** Participants' motivation to participate in sports was evaluated with the 'Sport Participation Motivation Scale (SPMS)'. The SPMS consists of 30 items and 8 sub-dimensions (skill development, team membership/spirit, entertainment, friendship, competition, success/status, energy expenditure/physical fitness, and movement/activity) including the reasons for participating in sports activities. The reasons for the participation of amateur handball players in sports were evaluated on a 3-point scale as "Very Important (1)", "Least Important (2)" and "Not at All Important (3)" [28]. The SPMS was translated into Turkish by Çelebi (1993), and its validity and reliability study for Turkish students aged 9-17 was conducted by Oyar, Aşçı, Çelebi, and Mülazımoğlu (2001) [29, 30].

### Statistical Analysis

Statistical analysis of the data was performed using the SPSS package program. Continuous variables were expressed as mean ± standard deviation (X±SD), and categorical variables as numbers (n) and percentage (%). The conformity of the variables to the normal distribution was examined using the Shapiro-Wilk test. It was determined that the variables were not suitable for normal distribution. For this reason, the direction and level of the relationship between the variables were examined by Spearman Correlation Analysis. In Spearman correlation analysis results, rho value was interpreted as weak correlation up to 0.30, moderate correlation between 0.30-0.70, and strong correlation when it was greater than 0.70.

## Results

A total of 27 amateur handball players, 18 (66.7%) girls and 9 (33.3%) boys, with a mean age of 10.52±1.55 years, participated in our study. The mean height of the participants was 147.15±11.33 cm, their body weight was 41.03±9.49 kg, and their body mass index (BMI) was 18.75±2.42 kg/$m^2$. The dominant upper extremity of 77.8% of the amateur handball players participating in our study was on the right side. Participants reported that they participated in sports 17.52±11.52 months (min:6-max:42) on average. The average weekly training time was 4.81±1.77 hours. Looking at the positions they played in the team, 18.5% were goalkeepers, 18.5% were centers, 22.2% were playmakers and 40.8% were wingers.

Dominant and nondominant side scapular muscle strength values (LT, MT, UT and SA) and scapular muscular endurance values of amateur handball players participating in our study are shown in [Table 1]. There was no statistically significant difference between dominant and nondominant side muscle strengths (p>0.05).

The physical fitness test results of the amateur handball players participating in our study and the total score of the SPMS are shown in [Table 2]. The correlations between the dominant and non-dominant side scapular stabilizer muscle strength of the athletes participating in our study and the physical fitness tests related to performance are shown in [Table 3].

**Table 1:** Scapular muscle strength and scapular muscular endurance values of individuals.

| Muscle Strength (kg) | | X±SD | p |
|---|---|---|---|
| **LT** | **Dominant** | 14.41±1.55 | |
| | **Non-Dominant** | 13.79±1.55 | ,789 |
| **MT** | **Dominant** | 14.52±1.45 | |
| | **Non-Dominant** | 13.98±1.44 | ,441 |
| **UT** | **Dominant** | 15.59±1.13 | |
| | **Non-Dominant** | 14.84±1.12 | ,977 |
| **SA** | **Dominant** | 13.17±1.01 | |
| | **Non-Dominant** | 12.65±1.01 | ,589 |
| **Scapular Muscular Endurance (sec)** | | 97.26±39.79 | |

**Table 2:** Result values of individuals' performance-related physical fitness tests and SPMS.

| Tests | X±SD | p |
|---|---|---|
| **TTD (sec)** | 150.94±21.85 | |
| **NHRT (cm)** | | |
| Dominant | 15.51±2.50 | ,683 |
| Non-Dominant | 18.64±1.89 | |
| **DT (repetition / 15 sec)** | 19.37±4.23 | |
| **CKC UEST (repeat/ 15 sec)** | 12.72±4.78 | |
| **MBTT (cm)** | 339.02±86.89 | |
| **SPMS Total Score** | 36.48±4.64 | |

**Table 3:** Correlation analysis between individuals' dominant and non-dominant side scapular muscle strength and performance-related physical fitness tests.

| Spearman's | | TTD (sec) | DT (n/15 s) | CKC UEST (n/15 sec) | NHRT (cm) Dominant | NHRT (cm) non-Dominant | MBTT |
|---|---|---|---|---|---|---|---|
| **LT Dominant** | rho | -,582** | ,674** | ,532** | -,397* | -,450* | ,744** |
| | p | ,001 | ,001 | ,004 | ,048 | ,019 | ,001 |
| **LT Non-Dominant** | rho | -,559** | ,635** | ,467* | -,392* | -,366 | ,704** |
| | p | ,002 | ,001 | ,014 | ,043 | ,061 | ,001 |
| **MT Dominant** | rho | -,513** | ,665** | ,531** | -,402* | -,368 | ,725** |
| | p | ,006 | ,001 | ,004 | ,038 | ,059 | ,001 |
| **MT Non-Dominant** | rho | -,620** | ,664** | ,504** | -458* | -442* | ,751** |
| | p | ,001 | ,001 | ,007 | ,016 | ,021 | ,001 |
| **UT Dominant** | rho | -,464* | ,591** | ,431* | -,259 | -,320 | ,657** |
| | p | ,015 | ,001 | ,025 | ,192 | ,103 | ,001 |
| **UT Non-Dominant** | rho | -,501** | ,625** | ,410* | -,284 | -,287 | ,660** |
| | p | ,008 | ,001 | ,034 | ,151 | ,147 | ,001 |
| **SA Dominant** | Rho | -,711** | ,738** | ,489* | -,474* | -,515 | ,833** |
| | p | ,001 | ,001 | ,010 | ,013 | ,006 | ,001 |
| **SA Non-Dominant** | Rho | -,755** | ,759** | ,554** | -,480* | -,585** | ,827** |
| | p | ,001 | ,001 | ,003 | ,011 | ,001 | ,001 |

TTD, Touch Test Disc Board; DT, Davies Test; CKC UEST, Closed Kinetic Chain Upper Extremity Stability Test; NHRT, Nelson Hand Reaction Test; MBTT, Medicine Ball Throwing Test; rho: Spearman Correlation Analysis

Significant and moderately negative correlation between TTD results and LT, MT and UT muscle strength; there was a significant and strong negative correlation with SA muscle strength ($p<0.05$). In other words, it was concluded that as the strength of the scapular muscles increased, the time required for TTD decreased. Significant and moderately positive correlation between DT results and LT, MT and UT muscle strength; there was a significant and strong positive correlation with SA muscle strength ($p<0.05$). In other words, it was concluded that as the strength of the scapular muscles increased, the number of DT repetitions of the individuals also increased.

A significant and moderately positive correlation was found between CKC UEST results and LT, MT, UT and SA muscle strength ($p<0.05$). In other words, it was concluded that as the strength of the scapular muscles increased, the number of CKC UEST repetitions also increased. A significant and moderately negative correlation was found between dominant and nondominant NHRT results and LT, MT and SA muscle strength ($p<0.05$). On the other hand, no significant relationship was found with UT muscle strength ($p>0.05$). In other words, increasing LT, MT and SA muscle strength may decrease hand reaction time. On the other hand, UT muscle strength does not have a statistically significant effect on hand reaction time.

While there was a significant and strong positive correlation between MBTT results and LT, MT and SA muscle strength; a significant and positive moderate correlation was found between UT muscle strength ($p<0.05$). In other words, it was concluded that as the strength of the scapular muscles' increases, the distance at which individuals can throw the medicine ball increases.

Correlations between handball players' scapular muscular endurance and performance-related physical fitness tests are shown in [Table 4]. A significant and strong negative correlation was found between TTD results and scapular muscular endurance ($p<0.05$). In other words, it was concluded that as the scapular muscle endurance of the individuals increased, the time required for TTD decreased. It was found that there was a significant and strong positive correlation between DT, CKC UEST and MBTT results and scapular muscular endurance ($p<0.05$). In other words, it was concluded that as the scapular muscular endurance increased, the number of DT and CKC UEST repetitions and medicine ball distance increased.

**Table 4:** The relationship between scapular muscular endurance and physical fitness tests related to performance.

| | | TTD (sec) | DT (X/15s) | CKC UEST (X/15s) | NHRT (cm) dominant | NHRT (cm) non dominant | MBTT |
|---|---|---|---|---|---|---|---|
| **Scapular Muscular Endurance (sec)** | rho | -,734** | ,803** | ,735** | -,557** | -,641** | ,833** |
| | p | ,001 | ,001 | ,001 | ,003 | ,001 | ,001 |
| TTD, Touch Test Disc Board; DT, Davies Test; CKC UEST, Closed Kinetic Chain Upper Extremity Stability Test; NHRT, Nelson Hand Reaction Test; MBTT, Medicine Ball Throwing Test; rho: Spearman Correlation Analysis | | | | | | | |

A significant and negative moderate correlation was found between dominant and nondominant NERT results and scapular muscular endurance ($p<0.05$). In other words, increasing scapular muscular endurance can reduce hand reaction time. Correlations between handball players' SPMS and performance-related physical fitness tests are shown in [Table 5]. There was no statistically significant relationship between the SPMS values performed to measure the motivation of the athletes for sports and the results of TTD, DT, CKC UEST, dominant NHRT, non-dominant NHRT and MBTT ($p>0.05$).

**Table 5:** The relationship between SPMS and performance-related physical fitness tests.

| | | TTD (sec) | DT (X/15s) | CKC UEST (X/15s) | NHRT (cm) dominant | NHRT (cm) non dominant | MBTT |
|---|---|---|---|---|---|---|---|
| **SPMS** | rho | ,172 | -,009 | -,338 | ,091 | ,259 | ,031 |
| | p | ,391 | ,963 | ,084 | ,651 | ,191 | ,879 |
| SPMS, Sport Participation Motivation Scale; rho: Spearman Correlation Analysis | | | | | | | |

## Discussion

As a result of our study, it was found that there are moderate and strong significant relationships between scapular muscle strength and muscular endurance and physical fitness parameters related to performance. On the other hand, there was no statistically significant relationship between motivation to participate in sports and physical fitness parameters related to performance. The period of 8-12 years of age in children is very important in terms of skill acquisition and increase in physical and motor development levels. In this age group, there are changes in body size due to growth, as well as muscle mass, muscle metabolic structure, muscle strength, muscular endurance, and reaction times. Accordingly, an increase is observed in anaerobic capacity and speed characteristics [31].

Muscle strength is one of the motor features that develop with participation in sports. Optimal upper extremity muscle strength during throwing, catching, passing, attacking and defending in overhead sports such as handball and volleyball is one of the important determinants of superior performance [32]. One of the most important requirements for optimal stability and functional movement of the scapulothoracic joint is to have strong scapular muscles [33, 34]. These muscles must have sufficient strength and endurance to maintain an appropriate scapulohumeral rhythm

during prolonged overhead activities [35]. In cases where scapular stabilization is insufficient, shoulder functions are also affected, and neuromuscular performance may decrease [36]. In a study conducted on handball players, it was found that there was a moderate correlation between upper extremity muscle strength, closed kinetic chain function and medicine ball throwing test [37]. In a study it was reported that movement speed and throwing performance and strength levels are closely related [38]. In a similar study, it was stated that upper extremity strength training caused an increase in anaerobic power and improved explosive strength [39]. While some studies [38, 40, 41] reported that there were significant relationships between throwing performance and upper extremity strength; in some studies [42, 43], it was stated that there was no relationship. Although it is known that upper extremity muscle strength increases anaerobic power, as a result of our study, it was found that there is a strong positive correlation between the results of the medicine ball throwing test, which evaluates the anaerobic power of children, and scapular muscle strength. In handball, which is a fast and small ball game, the most important factors determining performance are reaction time and agility [44]. Technical movements to the ball, especially in individual terms of offense and defense, require good agility and reaction time [2]. Reaction time, speed and agility are key components of sporting skill and are determining factors in performance in most sports and can be improved with regular training [45]. A sufficient muscle strength is required to develop speed, reaction time and agility, which are the most important criteria that determine sporting success in handball. It is known that the most suitable periods for the development of these parameters are school ages or adolescence. Pekmez et al. and Yıkılmaz et al. stated that there is a positive relationship between movement speed and reaction time and muscle strength, while there is a negative relationship between the sports year and hand reaction time [46, 47]. In our study, it was found that there was a positive relationship between scapular muscle strength and arm movement speed and upper extremity agility. When the relationship between hand reaction time and scapular muscle strength was examined, it was found that hand reaction time was shortened when serratus anterior and middle trapezoidal muscle strength increased. However, there was no relationship between upper and lower trapezoidal muscle strength and hand reaction time. We think that this result may be related to the stabilizing function of the serratus anterior and middle trapezoidal muscles during the hand reaction test and that the hand reaction time is shortened as the stabilization effect increases. However, we think that the scapular stabilizer muscles should be strengthened in order to improve the hand reaction times of athletes during the transition to professionalism.

Insufficient muscular endurance in the stabilizer muscles of the scapulothoracic joint contributes to reduced neuromuscular performance and shoulder problems. Muscular endurance in the scapular region allows the maintenance of upper extremity functionality and proximal stabilization, and the completion of long-term activities and training without fatigue and muscle damage. In sports where repetitive overhead activities such as handball and volleyball are intense, the risk of shoulder injuries increases due to muscle fatigue and decrease in muscular endurance, and upper extremity functionality and performance of the athlete decrease [48, 49]. Studies on this subject have also reported that scapular muscular endurance is associated with the risk of injury and performance [50-52]. The results of our study support the literature and it was found that there is a strong correlation between scapular muscular endurance and physical fitness parameters related to performance. In this context, it can be said that exercises that will increase upper extremity muscular endurance should be included in the training programs of handball athletes in order to reduce the risk of injury and increase upper extremity functionality and performance.

In a study examining the factors affecting children's participation in sports activities, it was stated that individuals mostly preferred it for the purpose of protecting their health and entertainment [53]. In another study, it was reported that the reason for children's participation in sports was the request and guidance of their families [54]. As a result of our study, it was found that there was no significant relationship between the SPMS values performed to measure motivation to participate in sports and the physical fitness tests related to performance. This result shows that amateur handball players who participate in sports for different reasons do not have any effect on the development of physical fitness parameters related to performance. In fact, amateur handball players with high motivation to participate in sports are expected to have higher performance values. Because children with low motivation to participate in sports can have negative effects on their performance that the result, we found is due to negative factors such as the age group in our study being 8-12, the fact that handball is not a widespread sport in this age group, the number of spectators is less, and the children are more engaged in this sport for entertainment purposes. On the other hand, since the amateur handball players who participated in the study do not have a full grasp of concepts such as competition and status, this situation may be reflected in the performance development.

## Conclusion

In order to increase sportive performance and upper extremity functionality in handball players, it is thought that it may be beneficial to include scapular muscle strengthening exercises in training programs to increase arm movement speed, upper extremity agility and anaerobic power, as well as exercises to improve scapular muscular endurance. The sports activities that children do at an early age are important in terms of adopting the philosophy of participating in physical activities and various sports branches throughout their lives and adopting an active lifestyle away from sedentary life. The results of this study show that it may be the active lifestyle directly affects the physical fitness levels of children.

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## Conflict of interest

No Conflict of interest.

## References


1. Faigenbaum AD, Kraemer W J, Blimkie CJ, Jeffreys I, Micheli LJ, et al. (2009) Youth resistance training: updated position statement paper from the national strength and conditioning association. The Journal of Strength & Conditioning Research 23(5 Suppl): S60-S79.
2. Sevim Y (2010). Antrenman bilgisi. (8.Baskı). Ankara: Pelin Ofset.
3. Hekim M, Hekim H (2015) Overview to Strength Development and Strength Trainings in Children. Güncel Pediatri 13(2).
4. Saygin Ö, Polat Y, Karacabey K (2005) Çocuklarda hareket eğitiminin fiziksel uygunluk özelliklerine etkisi. Fırat Üniversitesi Sağlık Bilimleri Tıp Dergisi 19(3): 205-212.
5. Vila H, Manchado C, Rodriguez N, Abraldes JA, Alcaraz PE, et al. (2012) Anthropometric profile, vertical jump, and throwing velocity in elite female handball players by playing positions. The Journal of Strength & Conditioning Research 26(8): 2146-2155.
6. Wagner H, Finkenzeller T, Würth S, Von Duvillard SP (2014) Individual and team performance in team-handball: A review. Journal of sports science & medicine 13(4): 808-816.
7. Karadenizli Akan I, Karacabey K (2002) Yıldız Kız ve Erkek Okul Hentbol Takımı Oyuncularının Fiziksel Uygunluk Derecelerinin Karşılaştırılması. Beden Eğitimi ve Spor Bilimleri Dergisi 4(2): 17- 22.
8. Eler S, Bereket S (2001) "Elit Türk ve Yabancı Hentbol oyuncularının Motorik ve Fizyolojik Parametrelerinin Karşılaştırılması", Gazi Üniversitesi Beden Eğitimi ve Spor Bilimleri Dergisi 6(4): 44-52.
9. Duda J, Hall H (2001) Achievement goal theory in sport: Recent extensions and future directions. In Handbook of sport psychology John Wiley & Sons pp: 417-443.
10. Koivula N (1999) Sport Participation: Differences in Motivation and Actual. Journal of Sport Behavior 22(3): 360-380.
11. Altıntaş A, Koruç PB (2014) Determining participation motivation of young athletes with regard to gender and sport type. International Journal of Sport Culture and Science 2(Special Issue 1): 61-67.
12. Wilk KE, Meister K, Andrews JR (2002) Current concepts in the rehabilitation of the overhead throwing athlete. The American journal of sports medicine 30(1): 136-151.
13. Czerwinski J, Taborsky F (2005) Basic Handball. Methods-Tactics-Technique.
14. Struyf F, Cagnie B, Cools A, Baert I, Van Brempt J, et al. (2014) Scapulothoracic muscle activity and recruitment timing in patients with shoulder impingement symptoms and glenohumeral instability. Journal of Electromyography and Kinesiology 24(2): 277-284.
15. Burn MB, McCulloch PC, Lintner DM, Liberman SR, Harris JD, et al. (2016) Prevalence of scapular dyskinesis in overhead and nonoverhead athletes: a systematic review. Orthopaedic journal of sports medicine 4(2): 2325967115627608.
16. Ortega-Becerra M, Pareja-Blanco F, Jiménez-Reyes P, Cuadrado-Peñafiel V, González-Badillo JJ, et al. (2018) Determinant factors of physical performance and specific throwing in handball players of different ages. The Journal of Strength & Conditioning Research, 32(6): 1778-1786.
17. Yıldırım İ (2009) "Elit Düzey Erkek Hentbol Takım Oyuncularının Antropometrik Özelliklerinin Dikey ve Yatay Sıçrama Mesafesine Etkisi", Afyon Kocatepe Üniversitesi Sağlık Bilimleri Enstitüsü, Anatomi Anabilim Dalı, Doktora Tezi, Afyonkarahisar.
18. Moss SL, McWhannell N, Michalsik LB, Twist C (2015) Anthropometric and physical performance characteristics of top-elite, elite and non-elite youth female team handball players. Journal of sports sciences 33(17): 1780-1789.
19. Emiroğlu O (2004) Yaş İlkokul Öğrencilerinin Eurofit Test Bataryası Uygulaması (Doctoral dissertation, Yüksek Lisans Tezi, Lefkoşa): 7–11.
20. Michener LA, Boardman ND, Pidcoe PE, Frith AM (2005) Scapular muscle tests in subjects with shoulder pain and functional loss: reliability and construct validity. Physical therapy 85(11): 1128-1138.
21. Edmondston SJ, Wallumrød ME, MacLéid F, Kvamme LS, Joebges S, et al. (2008) Reliability of isometric muscle endurance tests in subjects with postural neck pain. Journal of manipulative and physiological therapeutics 31(5): 348-354.
22. Hermassi S, Sellami M, Fieseler G, Bouhafs EG, Hayes LD, et al. (2020) Differences in body fat, body mass index, and physical performance of specific field tests in 10-to-12-year-old school-aged team handball players. Applied Sciences 10(24): 9022.
23. Souhail H, MS Chelly, LB Michalsik, Nilihan EMS, LD Hayes, et al. (2021) Relationship between fatness, physical fitness, and academic performance in normal weight and overweight schoolchild handball players in Qatar State 16(2): e0246476.
24. Ergun N Baltacı G (2015) Sporda Fizyoterapi ve Rehabilitasyon Prensipleri, Pelikan Yayınevi 1. Baskı. Ankara s: 65-67.
25. Medicine NAS (2020) Nasm Essentials of Personal Fitness Training: Jones & Bartlett Publishers.
26. de Oliveira VM, Pitangui AC, Nascimento VY, da Silva HA, Dos Passos MH, et al. (2017) Test-retest reliability of the closed kinetic chain upper extremity stability test (CKCUEST) in adolescents: reliability of CKCUEST in adolescents. International journal of sports physical therapy 12(1): 125-132.
27. Popović R, Aleksić A, Stojanović D, Stefanović M, Božić S, et al. (2017) Evaluation of the physical fitness level in physical education female students using" Eurofit-Test. International Journal of Sports Science and Physical Education 2(1): 1-15.
28. Gill DL, Gross JB, Huddleston S (1983) Participation motivation in youth sports. International journal of sport psychology 14(1): 1-14.
29. Çelebi M (1993) Orta Doğu Teknik Üniversitesi fiziksel aktivite kulüplerinde bulunan lider tipleri. Sosyal Bilimler Enstitüsü Yüksek Lisans Tezi. ODTÜ, Ankara.
30. Oyar ZB, Aşçı, FH, Çelebi M, Mülazoğlu Ö (2001) " Spora Katılım Güdüsü Ölçeği" nin Geçerlik ve Güvenirlik Çalışması. Spor Bilimleri Dergisi 12(2): 21-32.
31. Koşar Ş, Demirel A (2004) Çocuk sporcuların fizyolojik özellikleri. Çocuk Sporcuların Fizyolojik Özellikleri. Acta Orthopedica et Traumatologica Turcica 38(Suppl 1): 1-15
32. Alemany JA, Pandorf CE, Montain SJ, Castellani JW, Tuckow AP, et al. (2005) Reliability assessment of ballistic jump squats and bench throws. The Journal of Strength & Conditioning Research 19(1): 33-38.
33. Kibler WB, Press J, Sciascia A (2006) The role of core stability in athletic function. Sports medicine 36(3): 189-198.
34. Cools AM, Geerooms E, Van den Berghe DF, Cambier DC, Witvrouw EE, et al. (2007) Isokinetic scapular muscle performance in young elite gymnasts. Journal of athletic training 42(4): 458-463.
35. Schory A, Bidinger E, Wolf J, Murray L (2016) A systematic review of the exercises that produce optimal muscle ratios of the scapular stabilizers in normal shoulders. International journal of sports physical therapy 11(3): 321-336.
36. Paine R, Voight ML (2013) The role of the scapula. International journal of sports physical therapy 8(5): 617-629.
37. Schluter C (2016) Upper extremity strength and power field tests as predictiors of pole vault performance in female collegiate athletes.
38. Marques MC, Van Den Tillaar R, Vescovi JD, González-Badillo JJ (2007) Relationship between throwing velocity, muscle power, and bar velocity during bench press in elite handball players. International journal of sports physiology and performance 2(4): 414-422.

39. Kurt C, Taşkıran HG (2004). Plyometrik antrenmanların anaerobik güç farkı bulunan sporcular üzerindeki etkilerinin karşılaştırılması. 8. Uluslararası Spor Bilimleri Kongresi: 17-20.

40. Bayios IA, Anastasopoulou EM, Sioudris DS, Boudolos KD (2001) Relationship between isokinetic strength of the internal and external shoulder rotators and ball velocity in team handball. Journal of Sports Medicine and Physical Fitness 41(2): 229-235.

41. Hoff J, Almåsbakk B (1995) The effects of maximum strength training on throwing velocity and muscle strength in female team-handball players. The Journal of Strength & Conditioning Research 9(4): 255-258.

42. van den Tillaar R, Ettema G (2004) Effect of body size and gender in overarm throwing performance. European journal of applied physiology 91(4): 413-418.

43. Gillespie J, Keenum S (1987) A validity and reliability-analysis of the seated shot put as a test of power. Journal of human movement studies 13(2): 97-105.

44. Koç H, Kılınç F, Güna E, Kaya M (2008) Üniversite Erkek Hentbol Takımlarının Reaksiyon Zamanlarının Karşılaştırılması. 10.Uluslararası Spor Bilimleri Kongresi: 23-25.

45. Rudisill ME, Thoole T, (1992) The Effect of Physical Activity Programme on Reaction Time an Movement Time for Older Adult. Journal of Human Mow. Stu. 22: 205-212.

46. Pekmez GS (2019) Elit düzeydeki ve altyapı düzeyindeki hentbolcularda üst ekstremitenin fiziksel özellikleri, kavrama kuvveti, reaksiyon zamanı ve el bileği propriyosepsiyon duyusu arasındaki ilişkinin incelenmesi (master's thesis, Pamukkale Üniversitesi Sağlık Bilimleri Enstitüsü).

47. Yıkılmaz A, Biçer M, Gürkan AC, Özdal M (2015) 8-12 Yaş Grubu İlkokul ve Ortaokul Öğrencilerinin Performansla İlgili Fiziksel Uygunluklarının Değerlendirilmesi. Niğde Üniversitesi Beden Eğitimi ve Spor Bilimleri Dergisi 9(3): 300-307.

48. Miçooğulları M (2019) Düzenli Egzersizin Skapular Kassal Endurans, Skapular Stabilizasyon ve Diskinezi Üzerine Etkisinin Araştırılması (master's thesis, Uluslararası Kıbrıs Üniversitesi, Lisansüstü Eğitim Öğretim ve Araştırma Enstitüsü).

49. Cobanoglu G, Zorlular A, Polat EA, Akaras E, Gokdogan CM, et al. (2019) The relationship between scapular and core muscle endurance in professional athletes 26(7): 1295-1300.

50. Crotty NN, Smith J (2000) Alterations in scapular position with fatigue: a study in swimmers. Clinical Journal of Sport Medicine 10(4): 251-258.

51. Hébert LJ, Moffet H, McFadyen BJ, Dionne CE (2002) Scapular behavior in shoulder impingement syndrome. Archives of physical medicine and rehabilitation 83(1): 60-69.

52. Tsai NT, McClure PW, Karduna AR (2003) Effects of muscle fatigue on 3-dimensional scapular kinematics. Archives of physical medicine and rehabilitation 84(7): 1000-1005.

53. Öpözlü AK (2006) Çağımızda değişen sağlık bilincinin sportif rekreasyona katılım düzeyine etkisinin araştırılması (Kütahya Örneği). Yayınlanmamış Yüksek Lisans Tezi. Dumlupınar Üniversitesi Sosyal Bilimler Enstitüsü, Kütahya.