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Comparison of Swimmers' Health-Related Fitness Parameters in General and Special Preparation Periods

Yüzmede Genel ve Özel Hazırlık Döneminde Sağlığa İlişkin Fitness Parametrelerinin Karşılaştırılması

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ABSTRACT

This study aimed to compare the health-related fitness parameters of swimmers in the general and special preparation periods. Thirty-six swimmers participated in study voluntarily. Before and after general and after special preparation, measurements of the swimmers' endurance, strength, flexibility, body composition, and respiratory parameters were taken. The pre and post-tests were conducted at two-month intervals before and after general preparation, as well as after special preparation. After the initial measurements, swimmers undertook the general training program for eight weeks, followed by repeated measurements. Following this, speed-based special training was continued for eight weeks, after which the measurements were repeated. Data was analyzed using the SPSS 24.0. As the data displayed normal distribution, we performed a repeated measures variance analysis to compare all parameters among swimmers across three different periods. Significant differences were found in the body composition (lean body weight pre-general 36.79±3.97kg, post-general 37.25±3.96kg, post-special 37.73±3.88kg), respiratory function (FVC pre-general 3.30±0.56L, post-general 3.44±0.55L, post-special 3.59±0.54L), flexibility (pre-general 26.00±7.74cm, post-general 26.44±6.94cm, post-special 27.51±7.79cm), hand grip strength (pre-general 42.35±12.58kg, post-special 51.33±11.71kg), and isokinetic shoulder strength (ΔAverage power≈4W, ΔAverage peak torque≈2Nm) (*p<.05*). Speed-focused training during the special preparation period can improve health-related fitness parameters.

Keywords: Swimming, general preparation period, special preparation period, fitness parameters

ÖZ

Çalışmanın amacı, genel ve özel hazırlık dönemlerindeki yüzücülerin sağlıkla ilgili fitness parametrelerini karşılaştırmaktır. Araştırmaya otuz altı yüzücü gönüllü olarak katılmıştır. Genel hazırlıktan önce, sonra ve özel hazırlıktan sonra yüzücülerin dayanıklılık, kuvvet, esneklik, vücut kompozisyonu ve solunum parametrelerinin ölçümleri alınmıştır. Ön ve son testler, genel hazırlıktan önce, sonra ve özel hazırlıktan sonra iki aylık aralıklarla yapılmıştır. İlk ölçümlerden sonra yüzücüler sekiz hafta boyunca genel antrenman programını uygulamış ve ardından ölçümler tekrarlanmıştır. Bunu takiben, hıza dayalı özel antrenman sekiz hafta boyunca sürdürülmüş ve ardından ölçümler tekrarlanmıştır. Veriler SPSS 24.0 kullanılarak analiz edilmiştir. Veriler normal dağılım gösterdiğinden, üç farklı dönemde yüzücüler arasındaki tüm parametreleri karşılaştırmak için tekrarlanan ölçümler varyans analizi yapılmıştır. Vücut kompozisyonu (yağsız vücut ağırlığı genel öncesi 36.79±3.97kg, genel sonrası 37.25±3.96kg, özel sonrası 37.73±3.88kg), solunum fonksiyonu (FVC genel öncesi 3.30±0.56L, genel sonrası 3.44±0.55L, özel sonrası 3.59±0.54L), esneklik (genel öncesi 26.00±7.74cm genel sonrası 26.44±6.94cm özel sonrası 27.51±7.79cm), el kavrama gücü (genel öncesi 42.35±12.58kg özel sonrası 51.33±11.71kg) ve izokinetik omuz gücü (ΔOrtalama güç≈4W, ΔOrtalama pik tork≈2Nm) (*p<.05*). Özel hazırlık döneminde hız odaklı antrenman, sağlıkla ilgili fitness parametrelerini iyileştirebilir.

Anahtar Kelimeler: Yüzme, genel hazırlık dönemi, özel hazırlık dönemi, fitness parametreleri

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Introduction

Swimming is a highly prevalent sport among all age groups, and the mastery of this skill is generally regarded as crucial for living. Swimmers require well-coordinated movements of their upper and lower extremities to move through water (Peyton & Krabak, 2023). Swimming provides various health benefits, including enhancing general fitness, cardiovascular endurance, muscular strength, flexibility, coordination, balance, and other motor skills. Furthermore, swimming education encourages children's socialization (Silva et al., 2020). The development of health-related fitness parameters in swimming can notably impact the performance of adolescent swimmers. Endurance, strength, flexibility, body composition, and respiratory function have been identified in certain investigations as influential factors (Fiori et al., 2022; Muthusamy et al., 2022), although other studies have arrived at different conclusions (Gokhan et al., 2011; McNarry et al., 2020). For instance, Fiori et al. (2022) analysed 3 macrocycles in a 47-week season to assess swimmers' changes in anthropometrics and stroke mechanics (n=11 girls; 8 boys). Results showed a Δ12.5% decrease in body weight and a Δ3.8% decrease in height from the beginning to the end of the season. These findings suggest that long-term training can have a significant impact on the physical characteristics of swimmers (Fiori et al., 2022). In a separate study, it was found that the anthropometric features of 22 male swimmers (mean age of 14.52±0.77 years) had an 82% effect on the performance of the 200 m freestyle swim (Nasirzade et al., 2015). Additionally, Bond et al. discovered that anthropometric characteristics had a 63.8% impact on the performance of the 100 m freestyle swim, and this effect considerably explained the variation (Bond et al., 2015).

There is a significant impact on swimming performance attributed to the act of breathing whilst in the water. This impact is associated with the high oxygen flow rate of competent swimmers. It has been observed that individuals possessing elevated oxygen capacity and endurance levels demonstrate superior performance in aquatic competitions. Pulmonary function tests represent a means of evaluating this capacity in swimmers (Rosser-Stanford et al., 2019). Sable et al. (2012) claimed that swimming exercises have an impact on lung volume and that swimmers should use all respiratory muscles, including the diaphragm while breathing in and out of water.

Flexibility is one of the factors that affects performance in swimming. In achieving the desired motor skill in sports, flexibility holds an important place and serves as a core element of training (Cañas-Jamett et al., 2020). Loss of flexibility can hinder the efficiency of movement and increase the risk of sports injuries. Joint range of motion and mobility are important for swimming and other branches of sports (Nikšić et al., 2020). Therefore, it is essential to maintain joint functionality for optimal athletic performance and injury prevention. Inan and Saygin found a significant improvement in the swimming performance of female swimmers in the 50-meter race as their flexibility increased ($p<.05$) (Inan & Saygin, 2019). In contrast to the findings of previous studies, Gokhan et al. (2011) reported that swimming did not result in any improvement in flexibility.

Maximal handgrip strength is commonly employed in clinical settings as an indicator of the health and integrity of upper motor neurons and motor unit function. Handgrip strength denotes the capacity of the fingers and hand to generate muscle force (Kim et al., 2018). Athletes' strength performance is assessed using handgrip strength. The study reports the dimensional and anatomical features of the human hand, such as size and shape, impact grip formation, and strength. It was concluded that a longer finger and hand surface to grip an object leads to less fatigue during the grip (Nag et al., 2003). Additionally, the study found that swimming training had a significant positive impact on hand grip strength (Ceylan, 2021). Cicek et al. (2018) reported higher grip strength in the right and left hands of swimmers compared to sedentary individuals.

Isokinetic shoulder strength exercise involves the constant-speed contraction and relaxation of shoulder muscles while changing the angle of movement. This form of exercise is particularly beneficial for strengthening shoulder muscles in swimming (Gaudet et al., 2018). Strong shoulders enable the swimmer to regulate the paddle's angle as it enters the water and obtain a stronger grip on the water from the point where the arm enters the water, leading to the swimmer being able to apply more force to the water and thus swim faster (Matthews et al., 2017; Vila Dieguez & Barden, 2022). It is also crucial for the swimmer to position their shoulders correctly when their arm enters the water. Maintaining the correct shoulder position can reduce strain on the shoulders and upper back muscles while enhancing a swimmer's performance in the water (Matsuura et al., 2023; Gonjo et al., 2020).

The annual training periodization for adolescent swimmers is categorized into preparation, competition, and transition periods. The preparation period is divided into two segments: general and special. The goal of the preparation period is to enhance endurance, strength, and mobility while achieving the fundamental technical model. During the general preparation period training, the objective is to enhance the tempo of oxygen consumption and lactate evacuation of circulatory and respiratory functions, leading to increased oxygen supply to the muscles. Additionally, this section focuses on augmenting muscle strength and joint flexibility. In the special preparation period, swimmers should further develop the oxygen consumption and lactate evacuation rates of slow twitch muscle fibers. Swimmers should aim to enhance their stroke length without sacrificing stroke tempo when competing. It is advisable to plan training sessions to boost both the strength and flexibility of muscles and joints. Throughout this period, it is essential to evaluate changes in elements like sprint speed, muscle strength, and joint flexibility (Maglischo, 2018).

A literature review found studies investigating swimmers' health-related fitness parameters, including endurance, strength, flexibility, body composition, and lung capacity (FVC, FEV1, FVC/FEV1, PEF, MVV). However, studies comparing athletes' answers regarding endurance, strength, flexibility, body composition, and respiratory parameters in general and special preparation periods in swimming training are quite limited.

Therefore, the uniqueness of this study lies in measuring these parameters three times to determine whether there are any differences based on period. If there are differences in health-related fitness parameters between the general and special preparation periods, the study aims to examine whether the addition of speed-based training during the special preparation period can explain these differences. The aim of this study was to compare health-related fitness parameters of swimmers during general and special preparation periods, including endurance, strength, flexibility, body composition and lung capacity.

Methods

Subjects

The G-Power analysis (G-Power 3.1.9.4) determined an optimal sample size of 36 at 95% power and 10% type I error levels. Thirty-six swimmers aged 12-14 years (mean age: 13.08±0.81 years) took part voluntarily, fulfilling the requirements of residing in Istanbul, belonging to private swimming clubs, and holding athletic licenses for at least 3 years. Criterion sampling method was used for participation in the research group. Research model is experimental method. Approval was obtained from the Ethics Committee for Non-Interventional Clinical Research at Haliç University for conducting the study (25/04/2023-116). Prior to the commencement of the study, all participating swimmers and their families provided informed voluntary consent/assent by signing the appropriate forms.

Data Collection

Body Composition, Body Weight, Height, and Arm Length: During the swimmers' body weight measurement, participants were required to be barefoot and in swimsuits, standing still and upright without any support. For height measurement, participants were instructed to keep their heads upright, gaze forward, and heels together. Body weight, height, percentage of body fat, lean body weight, waist-to-hip ratio, and body mass index values were obtained using the Gaia Kiko Bioelectric Impedance, which measures bioelectric impedance (Wang et al., 2024). Arm length was measured using a Holtain horizontal stadiometer (Hoechstmass, Germany) fixed to the wall, with an accuracy of ±1 mm.

Subcutaneous Fat Thickness: We measured the subcutaneous fat thickness of swimmers in seven regions using a Holtain skinfold caliper (Holtain Ltd, Bryberian, UK) with a precision of 0.2 mm and a pressure of 10 g/mm. The regions measured were subscapular, triceps, biceps, chest, abdominal, suprailiac, and calf. An expert held the skinfold area, and a single person measured it with two fingers from 1 cm behind. The result was recorded three seconds after the caliper was placed. The swimmers' subcutaneous fat thickness was measured from seven regions using a Holtain skinfold caliper (Holtain Ltd, Bryberian, UK) with an accuracy of 0.2 mm and a pressure of 10 g/mm. All Anthropometric evaluations were performed by an experienced expert according to the Anthropometric Standardization Guide. Measurements were made in the morning while the athletes were at rest.The regions measured were subscapular, triceps, biceps, chest, abdominal, suprailiac, and calf (Cerqueira et al., 2022).

Respiratory Function Assessment: We conducted a respiratory function assessment using a COSMED-Pony FX portable spirometer. All participants completed the test by exhaling with maximum effort. Following the breathing volume connected to the spirometer via a mouthpiece, participants were instructed to take several breaths while seated and with their noses clamped shut. All measurements were made after participants were accustomed to this type of breathing. Swimmers conducted the pulmonary function tests once. A passive rest period of 1 minute was given to the swimmers between the forced vital capacity and maximal voluntary ventilation tests. The study measured parameters such as forced vital capacity (FVC), forced expiratory volume (FEV1), forced expiratory volume to forced vital capacity ratio (%FEV1/FVC), peak flow velocity (PEF), and maximal voluntary ventilation (MVV). Forced vital capacity measures the amount of air expelled quickly and forcefully with a maximal exhalation after a maximal inhalation. Forced expiratory volume is the amount of air expelled in the first second of the test. Peak flow velocity is assessed during rapid expiration after maximal inhalation. Maximal voluntary ventilation was measured by rapid and forceful inhalation and exhalation for 12 seconds in a seated position to determine the volume of air (l/min) that swimmers can take in within 60 seconds (Honório et al., 2019).

Sit-and-Reach Test: The participants positioned the soles of their feet on a flexible bench while keeping their knees straight. The distance in centimeters was measured at the furthest point where both hands reached the bar on the stand. Each participant performed the sit-and-reach test twice, and the best score was recorded (Cañas-Jamett et al., 2020).

Hand Grip Strength: The hand grip strength of the swimmers was assessed using a Baseline hydraulic hand dynamometer that can measure between 5.0 and 100.0 kg with a precise accuracy of 0.1 kg. Participants were instructed to stand with their feet shoulder-width apart and their elbows fully extended, looking straight ahead during the measurement. The dynamometer was calibrated to fit the hand size of the volunteers prior to the grip strength assessment. The dynamometer had to be held in a comfortable hand position (not in flexion or extension), with the index finger at a 90-degree angle. Participants were instructed to exert their maximum force while squeezing the handle for three seconds. They were directed to avoid holding their breath and shaking the dynamometer during the test. The grip strength of both hands of the volunteers was measured three times, and the highest recorded value in kilograms (kg) was documented. A minimum of one-minute breaks were allowed between each trial (Kim et al., 2018).

Isokinetic Shoulder Strength and Endurance: We conducted isokinetic shoulder strength measurements using the Computerised Biodex System 4 Pro™ dynamometer from Biodex Medical Systems Inc., New York. Before each measurement, we programmed the test protocol into the system and calibrated it. We adjusted the seat height so that the swimmer was in an upright position and the acromion head and lever arm were in alignment before beginning the test. The swimmer was secured to the seat using pelvic and trunk belts. The length and direction of the lever arm holding device were adjusted for maximal extension and flexion movements of the swimmer. The device's user manual was referred to for positioning and aligning the joints of the swimmer. The swimmer's gender, age, body weight, and height were documented while noting their dominant side and any injuries. To eliminate the effect of gravity, the swimmer's arm and device weight were measured in horizontal and vertical positions. Prior to commencing the measurement, the swimmers were briefed on the test and instructed on the appropriate behaviors to exhibit or avoid during the test. Subsequently, the designated swimmer completed a single trial to enable familiarisation with the device. Following the trial, and with the guidance of the device's signal, the swimmer completed three repetitions at an angular speed of 60°/s, and ten repetitions at an angular speed of 180°/s, on both the right and left sides. All swimmers received equal motivational speeches and verbal warnings during the test, supplemented by increased visual motivation provided by monitoring their own graphs on the computer screen. A rest break of 60 seconds was granted between each measurement. Finally, average power and average peak torque values for the right and left flexion-extension muscle groups of the swimmers at both angular velocities were recorded (Wiażewicz and Eider, 2021; Sheha et al., 2014).

Before the measurements throughout the study, training that would affect the performance of the swimmers positively/negatively was avoided and the swimmers were not allowed to take any food until 2 hours before the measurements. The research was carried out at Haliç University, Faculty of Sports Sciences, Performance Laboratory. The research group participated in the measurements in groups on the measurement days within the framework of predetermined hours. After obtaining the personal information of the swimmers, the swimmers' arm length, body composition, body weight, height, and subcutaneous fat thickness were measured respectively. After these measurements, the swimmers were given a 1-minute passive rest. After this rest, pulmonary function tests and hand grip strength were measured. Swimmers were given 1 minute passive rest between these measurements. Finally, isokinetic shoulder strength was measured. All of these measurements were performed in three different periods. These tests were performed two months apart before and after general preparation and two months apart after special preparation. After the first measurements, the swimmers performed their general training program for eight weeks (Figure 1). Afterwards, the measurements were repeated. After the second measurements, the swimmers continued with speed-based special training for eight weeks (Figure 2). After the special training period, the measurements were repeated. During the general and special preparation period, the micro cycle was prepared as a peak. The content of the workouts was prepared according to A Coach's Guide To Energy Systems as stated in Swimming World July 2021 Issue. Speed-based workouts were added to the training performed in the special period. The implementation of the research is given in Figure 3.

		Total Set Distance (m)	Heart Rate (% of maximal)
Warm-up	Warm-up	800 – 1200	
Main			
Monday (PM)	Endurance 1	1600 – 2400	70-80
Tuesday (PM)	Endurance 2	1600 – 2400	80-90
Wednesday (PM)	Endurance 1	1600 – 2400	70-80
Thursday (PM)	Endurance 1	1600 – 2400	70-80
Friday (PM)	Endurance 2	1600 – 2400	80-90
Saturday (AM)	Endurance 3	1200 – 2000	90-100
Sunday	Off		
Cool-down	200m any stroke	200	

Figure 1.
General term training program

		Total Set Distance (m)	Heart Rate (% of maximal)
Warm-up	Warm-up	800 – 1200	
Main			
Monday (PM)	Endurance 1 + Sprint 2	1600 – 2400 + 200 – 600	70-80 + 100
Tuesday (PM)	Endurance 2 + Sprint 3	1600 – 2400 + 100 – 400	80-90 + 100
Wednesday (PM)	Endurance 1 + Sprint 1	1600 – 2400 + 600 – 1200	70-80 + 95-100
Thursday (PM)	Endurance 1 + Sprint 2	1600 – 2400 + 200 – 600	70-80 + 100
Friday (PM)	Endurance 2 + Sprint 3	1600 – 2400 + 100 – 400	80-90 + 100
Saturday (AM)	Endurance 3 + Sprint 1	1200 – 2000 + 600 – 1200	90-100 + 95-100
Sunday	Off		
Cool-down	200m any stroke	200	

Figure 2.
Special term training program

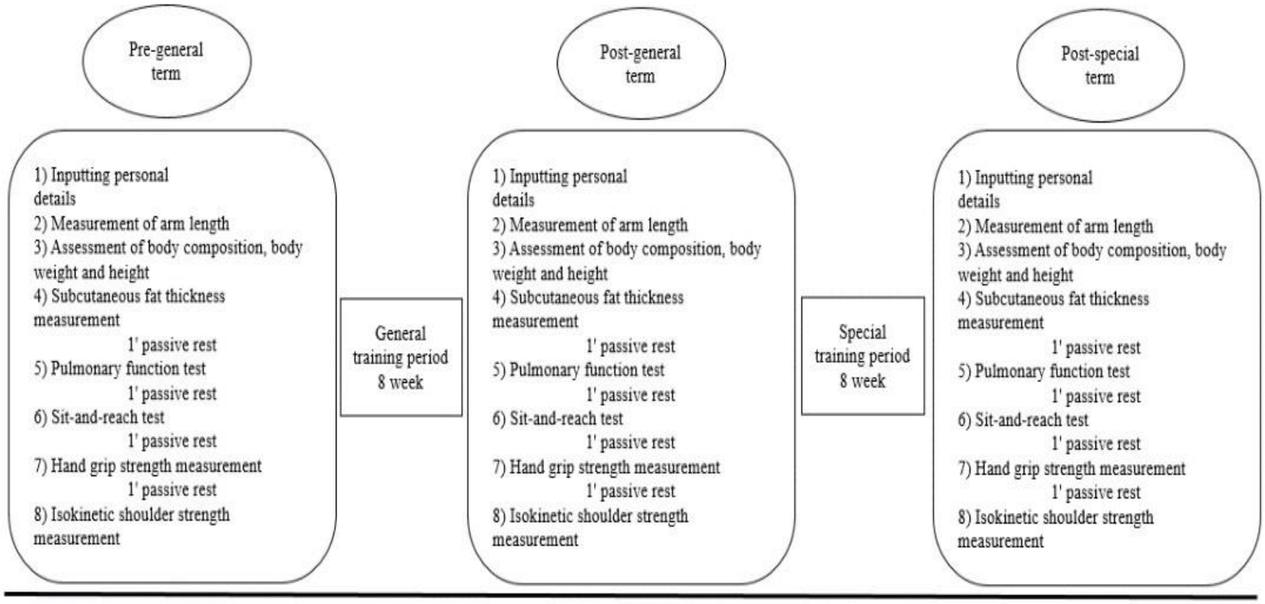

Figure 3.
Research implementation

Data Analysis

Data were analyzed using IBM SPSS version 24.0 (IBM SPSS Statistics for Windows, Version 24.0. Armonk, NY: IBM Corp.) statistical program. The suitability of the data for normal distribution was determined by Skewness and Kurtosis values. Skewness and Kurtosis values were found to be between "-1.5" and "+1.5" and in this direction, it was accepted that the data showed normal distribution (Tabachnick et al., 2013). The comparison of parameters of body composition, respiration, flexibility, strength, and endurance of the swimmers according to three different periods (before, after general preparation, and after special preparation) was analyzed by repeated measures variance. As a result of Mauchly's Test of Sphericity test, if the p-value was greater than .05, Sphericity Assumed test was used; if the p-value was less than .05, Wilks' Lambda test was used. Post-hoc Bonferroni test statistics and a Pairwise Comparisons table were used to find out which of the parameters with significant results was different from the others. Confidence interval was accepted as $p<.05$.

Results

The mean and standard deviation values of the parameters regarding the swimmers' body composition and the differences between measurements are displayed in Table 1. Table 1 highlights statistically significant differences in measurements of arm length, lean body weight, waist-to-hip ratio, body weight, height, and skinfold thickness for the biceps and chest ($p<.05$). Additionally, significant differences were discovered in pairwise measurements of arm length, lean body weight, and height. Significant differences were observed in the waist/hip ratio between the pre-general and post-general as well as in body weight between the post-special vs pre-general and post-general. Additionally, variations were detected in biceps skinfold thickness between the pre-general vs post-general and post-special, and in chest skinfold thickness between the post-general vs pre-general and post-special ($p<.05$). There were no significant statistical differences between the measurements of the percentage of body fat, body mass index, subscapular, triceps, abdominal, suprailliac, and calf skinfold thickness ($p>.05$).

Table 1.
Mean and standard deviation values of body composition parameters of swimmers and differences between measurements

	Pre-general	Post-general	Post-special	Difference (*p*-values)	Pre-general vs Post-general (*p*-values)	Pre-general vs Post-special (*p*-values)	Post-general vs Post-special (*p*-values)
Arm Length (cm)	158.71±6.90	160.27±6.89	161.08±6.86	*.001**	*.001**	*.001**	*.004**
Percentage of Body Fat (%)	16.12±5.89	15.46±5.92	15.76±6.21	*.077*			
Lean Body Weight (kg)	36.79±3.97	37.25±3.96	37.73±3.88	*.001**	*.002**	*.001**	*.019**
Waist-to-Hip Ratio	0.70±0.04	0.69±0.04	0.69±0.04	*.001**	*.004**		
Body Mass Index (kg/m²)	19.28±2.07	19.08±2.00	19.27±1.97	*.069*			
Body Weight (kg)	47.56±7.31	47.73±7.04	48.83±7.04	*.001**		*.001**	*.001**
Height (cm)	156.64±6.56	158.21±6.33	158.93±6.27	*.001**	*.001**	*.001**	*.008**
Subscapular (mm)	9.41±4.86	8.91±3.87	8.93±3.67	*.372*			
Triceps (mm)	12.28±4.48	12.32±4.09	12.50±4.34	*.620*			
Biceps (mm)	6.43±1.84	5.79±1.63	5.93±1.70	*.002**	*.002**	*.034**	
Chest (mm)	8.52±4.08	7.81±3.42	8.31±3.45	*.003**	*.049**		*.022**
Abdominal (mm)	14.68±7.24	13.89±6.09	14.22±5.92	*.273*			
Suprailiac (mm)	9.16±4.86	8.81±3.64	9.01±3.51	*.408*			
Calf (mm)	12.32±3.85	12.39±3.82	12.53±4.14	*.776*			

**p<.05*

The mean and standard deviation values for parameters related to pulmonary function, flexibility, and hand grip strength of the swimmers, along with differences between measurements, have been tabulated in Table 2. The table indicates statistically significant variations in FVC, FEV1, PEF, and MVV values between different measurements. Further, differences were observed in dominant (right)-nondominant (left) hand grip strength, FEV1, and PEF, between the post-special vs pre-general and post-general. There were variances in flexibility measurements between the pre-general and post-special (*p<.05*). However, no significant statistical dissimilarities were observed in the measurements of FVC/FEV1 values (*p>.05*).

Table 2.
Mean and standard deviation values of body composition parameters of swimmers and differences between measurements

	Pre-general	Post-general	Post-special	Difference (*p*-values)	Pre-general vs Post-general (*p*-values)	Pre-general vs Post-special (*p*-values)	Post-general vs Post-special (*p*-values)
FVC (L)	3.30±0.56	3.44±0.55	3.59±0.54	*.001**	*.002**	*.001**	*.001**
FEV1 (L)	2.68±0.50	2.82±0.48	2.98±0.51	*.004**		*.004**	*.012**
FVC/FEV1	80.86±10.48	82.08±9.38	83.00±9.73	*.610*			
PEF (L/s)	4.12±1.32	4.60±1.19	5.17±1.34	*.002**		*.001**	*.014**
MVV (L/min)	92.31±17.10	101.60±18.18	108.71±15.57	*.001**	*.004**	*.001**	*.015**
Sit-and-Reach Test (cm)	26.00±7.74	26.44±6.94	27.51±7.79	*.005**		*.002**	
Dominant Hand Grip Strength (kg)	42.35±12.58	40.83±8.36	51.33±11.71	*.001**		*.001**	*.001**
Non-dominant Hand Grip Strength (kg)	39.42±12.79	38.61±8.76	50.56±11.58	*.001**		*.001**	*.001**

**p<.05;* FVC: Forced Vital Capacity; FEV1: Forced Expiratory Volume; %FEV1/FVC: Forced Expiratory Volume to Forced Vital Capacity Ratio; PEF: Peak Flow Velocity; MVV: Maximal Voluntary Ventilation

The average and standard deviation values of the parameters linked to the isokinetic shoulder strength of the swimmers and the disparities between the measurements are presented in Table 3. Analysis of this table reveals variations between measurements in 60°/s right-left flexion-extension mean power, 180°/s right-left flexion mean power, 180°/s left extension mean power, 60°/s right-left flexion mean peak torque and 180°/s left flexion-extension mean peak torque. Differences were observed in the mean power parameters during 60°/s left flexion and 180°/s right-left flexion between the pre-general and post-special. Furthermore, differences were found in the mean power during 60°/s right flexion-extension, 60°/s left extension, 180°/s right-left flexion, and 180°/s left extension as well as in the mean peak torque during 60°/s right-left flexion and 180°/s left flexion-extension between the post-general and post-special (*p<.05*). There were no statistically significant differences found in the measurements of mean power for 180°/s right extension, peak torque for 60°/s right extension and left extension, and peak torque for 180°/s right flexion and right extension (*p>.05*).

Table 3.
Mean and standard deviation values of parameters related to isokinetic shoulder strength of swimmers and differences between measurements

	Pre-general	Post-general	Post-special	Difference (p-values)	Pre-general vs Post-general (p-values)	Pre-general vs Post-special (p-values)	Post-general vs Post-special (p-values)
60°/s R-FLX Avg Power (W)	18.17±4.63	17.06±4.22	19.38±5.03	*.001**			*.001**
60°/s L-FLX Avg Power (W)	17.73±5.49	17.83±4.70	19.22±6.03	*.011**		*.019**	
60°/s R-EXT Avg Power (W)	21.74±5.78	20.64±5.23	22.33±6.06	*.047**			*.036**
60°/s L-EXT Avg Power (W)	21.37±5.37	20.21±5.34	21.51±5.83	*.024**			*.035**
180°/s R-FLX Avg Power (W)	33.66±10.20	32.78±8.97	37.65±11.65	*.001**		*.009**	*.001**
180°/s L-FLX Avg Power (W)	31.03±11.53	30.07±11.50	33.62±12.70	*.003**		*.040**	*.008**
180°/s R-EXT Avg Power (W)	41.14±11.20	42.43±11.67	43.97±12.92	*.148*			
180°/s L-EXT Avg Power (W)	39.10±11.09	38.06±10.87	41.54±12.27	*.035**			*.024**
60°/s R-FLX Avg Peak Torque (Nm)	29.68±7.18	28.50±6.29	31.83±7.11	*.005**			*.004**
60°/s L-FLX Avg Peak Torque (Nm)	28.04±7.50	27.73±6.56	29.94±7.76	*.020**			*.022**
60°/s R-EXT Avg Peak Torque (Nm)	34.21±7.86	32.59±6.32	34.09±8.30	*.122*			
60°/s L-EXT Avg Peak Torque (Nm)	36.09±8.46	34.16±7.50	35.43±8.85	*.144*			
180°/s R-FLX Avg Peak Torque (Nm)	23.22±6.13	22.66±5.47	24.69±7.49	*.074*			
180°/s L-FLX Avg Peak Torque (Nm)	22.17±6.63	20.68±5.73	23.74±7.12	*.001**			*.003**
180°/s R-EXT Avg Peak Torque (Nm)	27.81±6.15	27.41±6.06	28.33±6.71	*.527*			
180°/s L-EXT Avg Peak Torque (Nm)	30.88±6.64	28.96±6.37	30.86±6.56	*.028**			*.030**

**p<.05;* Avg: Average; FLX: Flexion; EXT: Extension; R: Right; L: Left

Discussion

The study aimed to compare health-related fitness parameters (including endurance, strength, flexibility, body composition, and lung capacity) of swimmers during general and special preparation periods. The results showed significant differences in body composition (including arm length, lean body weight, waist-to-hip ratio, body weight, height, biceps, and chest skinfold thickness), respiratory function, flexibility, and hand grip strength. Differences were discovered in isokinetic shoulder strength, with statistically significant effects in 60°/s right-left flexion-extension mean power, 180°/s right-left flexion mean power, 180°/s left extension mean power, 60°/s right-left flexion mean peak torque, and 180°/s left flexion-extension mean peak torque values (*p<.05*). Our investigation found that these differences were mainly between the post-special and pre-general or post-general periods.

Several studies in the literature have investigated the health-related fitness parameters of swimmers (Oliveira et al., 2021; McNarry et al., 2020). For instance, it was demonstrated by Dos Santos et al. (2021) that body fat percentage plays a vital role in determining the 50 m freestyle swimming performance, Oliveira et al. (2021) demonstrated that all anthropometric and body composition variables, except for body fat percentage, facilitate biological maturation and have a favorable correlation with performance. Lima-Borges et al. (2022) reviewed the relationship between anthropometric variables and performance in swimmers competing in various styles and acknowledged that anthropometric variables have an impact on swimming performance. Our study found results in line with the existing literature. We discovered that the body composition values of swimmers during the special preparation period differed from those observed in the general preparation period. This suggests that speed-based swimming training during the special preparation period has a positive effect on body composition.

In this study, the respiratory functions (FVC, FEV1, PEF, and MVV) of swimmers saw an improvement following a period of special preparation speed-based training. Additionally, Muthusamy et al. (2022) reported a significant improvement in the respiratory functions of swimmers after four weeks of swimming training and various respiratory muscle exercises. Okrzymowska et al. (2019) found that swimming training improved respiratory function among swimmers. Similarly, Ozgul et al. (2015) recorded positive effects on respiratory functions among swimmers aged 10-13 years who underwent swimming exercises with breathing exercises.

Efficient swimming movements rely on increased flexibility and mobility in the upper extremities. Niksic et al. (2020) demonstrated that a motor predictor system incorporating flexibility variables significantly impacted criterion variables in swimming training during a regression analysis. Supporting this study, previous research has demonstrated a connection between flexibility and performance in freestyle swimming (Inan & Saygin, 2019; Alaydin & Kamuk, 2020). Willems et al. (2014) reported that swimmers with greater flexibility had faster stroke and foot movements due to mechanical advantages. However, Geladas et al. (2005), Gokhan et al. (2011), Cicek et al. (2018), and Kistak et al. (2019) have suggested that swimming proficiency does not impact flexibility values. Our research demonstrates that young swimmers attained the highest flexibility outcome during the special preparation training phase, which endorses existing literature showing that flexibility has an effect on swimming performance.

Propulsion is a key factor in achieving peak swimming performance. Research has shown a positive correlation between hand grip strength and swimming performance (Geladas et al., 2005; Cronin et al., 2017). However, Alshdokhi et al. (2020) suggest that the relationship between hand grip strength and swimming performance is still unclear. Furthermore, some authors argue that hand grip strength does not impact performance. For instance, Inan and Saygin (2019) found no significant correlation between hand grip strength and swimming performance over 50m or 400m distances ($p>.05$). McNarry et al. (2020) similarly failed to identify any changes in grip strength among swimmers during a six-month training program. Finally, Alaydin and Kamuk (2020) observed no variance in hand grip strength as related to swimming performance. Unlike previous studies, Ucar and Cimen-Polat (2023) documented an improvement in hand grip strength for swimmers in an eight-week period. In our own research, we observed a consistent development in hand grip strength for swimmers during each period, with the most significant improvements occurring after special preparation period training.

Excessive shoulder injuries in swimming are linked to the inability to sustain movement patterns, leading to continuous stress on tender tissues that exacerbates with fatigue due to declines in range of motion. It is essential to maintain movement patterns to avoid injuries to delicate tissues and enhance shoulder resilience in swimming. Research has shown that rotator muscle fatigue can negatively affect shoulder stability, cause injury, and increase the risk of future shoulder pathologies (Lynch et al., 2010; Nadobnik & Wiażewicz, 2021). To determine asymmetries in swimmers' bodies, medical professionals measure the dominant and non-dominant shoulder strength at varying angular velocities and use asymmetric indices for calculations (Sanders et al., 2012). For instance, Chang et al. highlighted that excessive strength imbalance between the right and left shoulder in swimmers, if exceeding 15%, results in a deviation from swimming in a straight line, due to the shoulder strength discrepancy (Chang et al., 2013). A comprehensive analysis of scientific studies on strength capacity in swimming demonstrates that the shoulder girdle muscles' strength is crucial for swimmers' athletic proficiency. It has been asserted that robust strength training is a crucial aspect in attaining superior swimming performance (Nadobnik & Wiażewicz, 2021). This study employed flexion-extension mean power and peak torque measurements of swimmers at two distinct angular velocities to investigate the importance of shoulder strength in swimming. In the present study, it was observed that the average flexion-extension power and peak torque values achieved at both angular velocities improved following speed-based training during the specialized preparation period.

Conclusion and Recommendations

To summarize, the training conducted during both generalized and specialized preparation phases had an impact on the body composition, respiratory function, flexibility, hand grip strength, and isokinetic shoulder strength of swimmers. Variations in body composition, respiratory function, flexibility, hand grip strength, and isokinetic shoulder strength were discovered among swimmers during both general and special preparation periods. Improvements in fitness parameters linked to health were observed during both phases. However, the most significant progress was made following the special preparation period. As a result, incorporating speed-based training in the special preparation phase could have a positive impact on health-related fitness parameters.

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Hakem Değerlendirmesi: Dış bağımsız.
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References

Alaydin, A., & Kamuk, Y. (2020). Physical and physiological characteristics of 11 – and 12-year-old swimmers participated in the Turkish swimming championship qualification round. *Eurasian Research in Sport Science, 5*(1), 26-43. https://doi.org/10.35333/ERISS.2020.168

Alshdokhi, K., Petersen, C., & Clarke, J. (2020). Effect of 8 weeks of grip strength training on adolescent sprint swimming: a randomized controlled trial. *Exercise Medicine, 4*(1), 1-5. https://doi.org/10.26644/em.2020.001

Bond, D., Goodson, L., Oxford, S. W., Nevill, A. M., & Duncan, M. J. (2015). The association between anthropometric variables, functional movement screen scores and 100 m freestyle swimming performance in youth swimmers. *Sports, 3*(1), 1-11. https://doi.org/10.3390/sports3010001

Cañas-Jamett, R., Figueroa-Puig, J., Ramirez-Campillo, R., & Tuesta, M. (2020). Plyometric training improves swimming performance in recreationally-trained swimmers. *Revista Brasileira de Medicina do Esporte, 26*(5), 436-440. https://doi.org/10.1590/1517-8692202026052019_0052

Cerqueira, M. S., Amorim, P. R. S., Encarnação, I. G. A., Rezende, L. M. T., Almeida, P. H. R. F., Silva, A. M., Sillero-Quintana, M., Silva, D. A. S., Santos, F. K. & Marins, J. C. B. (2022). Equations based on anthropometric measurements for adipose tissue, body fat, or body density prediction in children and adolescents: A scoping review. *Eating and Weight Disorders-Studies on Anorexia, Bulimia and Obesity*, 27, 2321-2338. https://doi.org/10.1007/s40519-022-01405-7

Ceylan, R. (2021). How do swimming and tennis trainings affect hand grip strength?. *Journal of Physical Education and Sport Sciences, 23*(3), 71-80.

Chang, S., Cheng, L., & Zhou, J. (2013). Research on isokinetic shoulder strength testing of female elite swimmers. ISBS-Conference Proceedings Archive.

Cicek, G., Gullu, A., & Gullu, E. (2018). Comparison of body composition and some physiological parameters of swimmer and sedanter children. *Gaziantep University Journal of Sport Science, 3*(2), 85-97. https://doi.org/10.31680/gaunjss.421261

Cronin, J., Lawton, T., Harris, N., Kilding, A., & McMaster, D. T. (2017). A brief review of handgrip strength and sport performance. *The Journal of Strength & Conditioning Research, 31*(11), 3187-3217. https://doi.org/DOI: 10.1519/JSC.0000000000002149

Dos Santos, M. A., Henrique, R. S., Salvina, M., Silva, A. H. O., Junior, M. A. D. V., Queiroz, D. R., Duncan, M. J., Maia, J. A. R., & Nevill, A. M. (2021). The influence of anthropometric variables, body composition, propulsive force and maturation on 50m freestyle swimming performance in junior swimmers: an allometric approach. *Journal of Sports Sciences, 39*(14), 1615-1620. https://doi.org/10.1080/02640414.2021.1891685

Fiori, J. M., Zacca, R., & Castro, F. A. D. S. (2022). 200-m front crawl performance over a training season in 12 years and underage-group swimmers: growth and kinematics effects. *Motriz: Revista de Educação Física, 28*, 1-9. https://doi.org/10.1590/s1980-657420220001222

Gaudet, S., Tremblay, J., & Dal Maso, F. (2018). Evolution of muscular fatigue in periscapular and rotator cuff muscles during isokinetic shoulder rotations. *Journal of Sports Sciences, 36*(18), 2121-2128. https://doi.org/10.1080/02640414.2018.1440513

Geladas, N. D., Nassis, G. P., & Pavlicevic, S. (2005). Somatic and physical traits affecting sprint swimming performance in young swimmers. *International Journal of Sports Medicine, 26*(02), 139-144. https://doi.org/10.1055/s-2004-817862

Gokhan, I., Kurkcu, R., & Aysan, H. A. (2011). The effect of swimming training on body composition and motoric features in adult sedentary young men. *Journal of Clinical and Experimental Investigations, 2*(1), 69-73. https://doi.org/10.5799/ahinjs.01.2011.01.0212

Gonjo, T., Fernandes, R. J., Vilas-Boas, J. P., & Sanders, R. (2020). Upper body kinematic differences between maximum front crawl and backstroke swimming. *Journal of Biomechanics, 98*, 1-7. https://doi.org/10.1016/j.jbiomech.2019.109452

Honório, S., Mendes, P. D. M., Batista, M., Serrano, J., Duarte, R. M., Oliveira, J., & Petrica, J. (2019). Effects of swimming and water walking on body composition and spirometric values in young children. *Journal of Human Sport and Exercise, 14*(1proc), 47-58. https://doi.org/10.14198/jhse.2019.14.Proc1.06

Inan, S., & Saygın, O. (2019). The investigation the effect of anthropometric, physiological and physical properties on competition performance of young swimmers. *International Journal of Sport Exercise and Training Sciences, 5*(4), 183-191. https://doi.org/10.18826/useeabd.644211

Kim, C. R., Jeon, Y. J., Kim, M. C., Jeong, T., & Koo, W. R. (2018). Reference values for hand grip strength in the South Korean population. *PLoS One, 13*(4), e0195485. https://doi.org/10.1371/journal.pone.0195485

Kistak, B., Bulgan, C., Meric-Bingul, B., & Basar, M. A. (2019). The relationship between 25m different style swimming performances and motor skills of 8-10 age group. *Journal of Sports and Performance Researches, 10*(2), 94-103. https://doi.org/10.17155/omuspd.469102

Lima-Borges, D. S., Portilho, N. O., Araujo, D. S., Ravagnani, C. F. C., & Almeida, J. A. (2022). Anthropometry and physical performance in swimmers of different styles. *Science & Sports, 37*(7), 542-551. https://doi.org/10.1016/j.scispo.2021.07.007

Lynch, S. S., Thigpen, C. A., Mihalik, J. P., Prentice, W. E., & Padua, D. (2010). The effects of an exercise intervention on forward head and rounded shoulder postures in elite swimmers. *British Journal of Sports Medicine, 44*(5), 376-81. https://doi.org/10.1136/bjsm.2009.066837

Matsuura, Y., Matsunaga, N., Akuzawa, H., Oshikawa, T., & Kaneoka, K. (2023). Comparison of muscle coordination during front crawl and backstroke with and without swimmer's shoulder pain. *Sports Health*, Article ID 19417381231166957. https://doi.org/10.1177/19417381231166957

Matthews, M. J., Green, D., Matthews, H., & Swanwick, E. (2017). The effects of swimming fatigue on shoulder strength, range of motion, joint control, and performance in swimmers. *Physical Therapy in Sport, 23*, 118-122. https://doi.org/10.1016/j.ptsp.2016.08.011

McNarry, M. A., Lester, L., Brown, J., & Mackintosh, K. A. (2020). Investigating the modulatory role of chronological and biological age on performance predictors in youth swimmers. *Journal of Science in Sport and Exercise, 2*, 349-358. https://doi.org/10.1007/s42978-020-00082-1

Muthusamy, S., Balasubramanian, K., Subramaniam, A., & Balasubramnaiyam, A. (2022). Effects of individualized training and respiratory muscle training on pulmonary function among collegiate swimmers: an experimental study. *Physical Education Theory and Methodology, 22*(3), 64-70. https://doi.org/DOI: 10.17309/tmfv.2022.3s.09

Nadobnik, J., & Wiażewicz, A. (2021). Strength abilities in sports swimming a systematic review. *Acta Kinesiologica, 15*(2), 22-41. https://doi.org/10.51371/issn.1840-2976.2021.15.2.4

Nag, A., Nag, P. K., & Desai, H. (2003). Hand anthropometry of Indian women. *Indian Journal of Medical Research*, 117, 260-269.

Nasirzade, A., Sadeghi, A., Sobhkhiz, A., Mohammadian, K., Nikouei, A., Baghaiyan, M., & Fattahi, A. (2015). Multivariate analysis of 200-m front crawl swimming performance in young male swimmers. *Acta of Bioengineering and Biomechanics, 17*(3), 137-143. https://doi.org/10.5277/ABB-00160-2014-03

Nikšić, E., Beganović, E., Joksimović, M., & Mušović, A. (2020). The influence of balance and flexibility on the performance of freestyle swimming. *Journal of Physical Education and Sports Studies, 12*(2), 59-65. https://doi.org/10.30655/besad.2020.28

Okrzymowska, P., Kurzaj, M., Seidel, W., & Rożek-Piechura, K. (2019). Eight weeks of inspiratory muscle training improves pulmonary function in disabled swimmers—a randomized trial. *International Journal of Environmental Research and Public Health, 16*(10), Article ID 1747. https://doi.org/10.3390/ijerph16101747

Oliveira, M., Henrique, R. S., Queiroz, D. R., Salvina, M., Melo, W. V., & Moura dos Santos, M. A. (2021). Anthropometric variables, propulsive force and biological maturation: a mediation analysis in young swimmers. *European Journal of Sport Science, 21*(4), 507-514. https://doi.org/10.1080/17461391.2020.1754468

Ozgul, F., Elioz, M., Otag, A., & Atan, T. (2015). The comparison of the children group's respiratory parameters between 10-14 age who engaged in the sport of swimming. *Turkiye Klinikleri Journal of Sports Sciences, 7*(2), 35-40. https://doi.org/DOI: 10.5336/sportsci.2014-43151

Peyton, M., & Krabak, B.J. (2023). Swimming. In The Youth Athlete (pp. 913-928). Academic Press.

Rosser-Stanford, B., Backx, K., Lord, R., & Williams, E. M. (2019). Static and dynamic lung volumes in swimmers and their ventilatory response to maximal exercise. *Lung*, 197, 15-19. https://doi.org/10.1007/s00408-018-0175-x

Sable, M., Vaidya, S., & Sable, S. (2012). Short communication comparative study of lung functions in swimmers and runners. *Indian Journal of Physiology and Pharmacology, 56*(1), 100-104.

Sanders, R., Thow, J., Alcock, A., Fairweather, M., Riach, I., & Mather, F. (2012). How can asymmetries in swimming be identified and measured?. *Journal of Swimming Research,19*(1), 1-15.

Sheha, S. M., El Tohamy, A. M., & El Shemy, S. A. (2014). Isokinetic shoulder torque development in children six through twelve years old. *Journal of Medical Science and Clinical Research, 2*(8), 1968-1974.

Silva, L. A. D., Doyenart. R., Henrique Salvan, P., Rodrigues, W., Felipe Lopes, J., Gomes, K., Thirupathi, A., Pinho, R. A. D., & Silveira, P. C. (2020). Swimming training improves mental health parameters, cognition and motor coordination in children with attention deficit hyperactivity disorder. *International Journal of Environmental Health Research, 30*(5), 584-592. https://doi.org/10.1080/09603123.2019.1612041

Tabachnick, B. G., Fidell, L. S., & Ullman, J. B. Using multivariate statistics (Vol. 6, pp. 497-516). Boston, MA: Pearson, 2013.

Ucar, E., & Cimen-Polat, S. (2023). The effect of strength training applied to 15-16 years old swimmers on free style swimming performance. *CBU Journal of Physical Education and Sport Sciences, 18*(1), 28-37. https://doi.org/10.33459/cbubesbd.1177188

Vila Dieguez, O., & Barden, J. M. (2022). Body roll differences in freestyle swimming between swimmers with and without shoulder pain. *Sports Biomechanics, 21*(10), 1277-1290. https://doi.org/10.1080/14763141.2020.1760923

Wang, Y., Yang, X., Deng, J., Wang, Z., Yang, D., Han, Y., & Wang, H. (2024). Combined high-intensity interval and resistance training improves cardiorespiratory fitness more than high-intensity interval training in young women with overweight/obesity: a randomized controlled trial. *Frontiers in Endocrinology*, 15, 1450944. https://doi.org/10.3389/fendo.2024.1450944

Wiażewicz, A., & Eider, J. (2021). The relationship between swimming performance and isokinetic shoulder strength of elite swimmers. *Human Movement, 22*(4), 10-19. https://doi.org/10.5114/hm.2021.103285

Willems, T. M., Cornelis, J. A. M., De Deurwaerder, L. E. P., Roelandt, F., & De Mits, S. (2014). The effect of ankle muscle strength and flexibility on dolphin kick performance in competitive swimmers. *Human Movement Science*, 36, 167-176. https://doi.org/10.1016/j.humov.2014.05.004