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Investigation of the Effect of Swimming Exercises on Body Fat Percentage and Anthropometric Characteristics in Sedentary Women

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Abstract

The aim of this study is to examine the effects of regular swimming exercises on certain physical parameters, anthropometric characteristics, and body fat percentage in sedentary women. Twenty sedentary women (31.05 ± 5.04 years; 163 ± 5 cm; 66.15 ± 11.68 kg) who had not previously engaged in regular physical activity participated in the study. Participants underwent a swimming exercise program three days a week for six weeks, with each session lasting 60 minutes. To evaluate the effects of the exercise program, anthropometric circumference measurements, subcutaneous fat thickness measurements, and body mass index (BMI) calculations were conducted at the beginning and end of the study. The swimming sessions were held at the Ankara Eryaman Swimming Pool, and the physical measurements were carried out in a performance measurement laboratory. Data were analyzed using SPSS 22 for Windows. According to the results, there was no statistically significant difference in shoulder, chest, thigh, and forearm circumference measurements ($p>0.05$), while statistically significant differences were found in waist, abdominal, hip, leg, and arm circumference measurements ($p<0.05$). In terms of subcutaneous fat thickness, significant reductions were observed in the biceps, triceps, suprailiac, and quadriceps regions ($p<0.05$), whereas no significant differences were found in the pectoral, subscapular, abdominal, and calf regions ($p>0.05$). Additionally, participants' body weight, body mass index, and body fat percentage showed statistically significant decreases ($p<0.05$). In conclusion, swimming exercises were found to positively affect certain components of body composition in sedentary women. The findings of this study are supported by similar results in the existing literature. Accordingly, swimming can be considered an effective form of exercise for individuals aiming to lose weight and achieve a healthier anthropometric profile. Future studies are recommended to examine different age groups, genders, and variations in exercise duration and frequency for a more comprehensive understanding of swimming's effects.

Keywords: Swimming, Body Fat Ratio, Anthropometry.

Özet

Sedanter Kadınlarda Yüzme Egzersizlerinin Vücut Yağ Yüzdesi ve Antropometrik Özellikler Üzerine Etkisinin İncelenmesi

Bu çalışmanın amacı, düzenli yüzme egzersizlerinin sedanter kadınların bazı fiziksel parametreleri, antropometrik özellikleri ve vücut yağ yüzdesi üzerindeki etkilerini incelemektir. Araştırmaya, daha önce düzenli spor yapmamış 20 sedanter kadın (31,05 ± 5,04 yaş; 163 ± 5 cm; 66,15 ± 11,68 kg) katılmıştır. Katılımcılara haftada 3 gün, 6 hafta süresince her biri 60 dakika süren yüzme egzersizleri uygulanmıştır. Egzersiz programının etkilerini değerlendirmek amacıyla çalışmanın başında ve sonunda antropometrik çevre ölçümleri, cilt altı yağ kalınlığı ölçümleri ve beden kitle indeksi hesaplamaları yapılmıştır. Egzersizler Ankara Eryaman Yüzme Havuzu'nda gerçekleştirilmiş, ölçümler ise performans ölçüm laboratuvarında yapılmıştır. Elde edilen veriler SPSS 22 for Windows programı ile analiz edilmiştir. Analiz sonuçlarına göre; omuz, göğüs, uyluk ve ön kol çevresi ölçümlerinde anlamlı bir fark görülmezken ($p>0,05$), bel, karın, kalça, bacak ve kol çevresi ölçümlerinde istatistiksel olarak anlamlı fark tespit edilmiştir ($p<0,05$). Cilt altı yağ kalınlığı ölçümlerinde ise biseps, triseps, suprailiak ve kuadriseps bölgelerinde anlamlı azalma görülmüş ($p<0,05$), pektoralis, subskapularis, abdominal ve baldır bölgelerinde anlamlı bir fark saptanmamıştır ($p>0,05$). Ayrıca, katılımcıların vücut ağırlığı, beden kitle indeksi ve vücut yağ yüzdesi değerlerinde istatistiksel olarak anlamlı düşüşler belirlenmiştir ($p<0,05$). Sonuç olarak, yüzme egzersizlerinin sedanter kadınların vücut kompozisyonunun bazı bileşenleri üzerinde olumlu etkiler yarattığı belirlenmiştir. Elde edilen bulgular, literatürdeki benzer çalışmalarla örtüşmektedir. Bu doğrultuda, yüzme egzersizlerinin kilo vermek ve uygun bir antropometrik yapıya sahip olmak isteyen bireyler için etkili bir egzersiz türü olduğu söylenebilir. Gelecekte farklı yaş grupları, cinsiyetler ya da egzersiz süre ve sıklıklarının karşılaştırıldığı çalışmalarla bu etkilerin daha ayrıntılı incelenmesi önerilmektedir.

Anahtar Kelimeler: Yüzme, Vücut Yağ Oranı, Antropometre.

INTRODUCTION

Today, technological advancements that facilitate nearly every aspect of life have increasingly led individuals toward a sedentary lifestyle (2). Individuals who adopt this lifestyle from childhood are at a higher risk of developing health problems due to physical inactivity over time (22). Consequently, sedentary individuals face a significantly elevated risk of hypokinetic diseases such as coronary heart disease, hypertension, hypercholesterolemia, cancer, obesity, and musculoskeletal disorders (21).

Swimming is defined as a series of purposeful movements that enable an individual to move through water over a certain distance. Compared to many other sports, swimming carries a lower risk of injury and contributes significantly to the development of motor skills (11). One of the most distinguishing features of swimming is the high energy expenditure required to perform horizontal movements by simultaneously or alternately using the arms and legs. Furthermore, swimmers must overcome water resistance, which hinders movement, and deal with the hydrostatic pressure of water, which makes breathing more difficult. Therefore, it is stated that "the energy required to swim a given distance is approximately four times that required to run the same distance" (18).

Due to its positive effects on developmental processes, swimming has become a mandatory sport for children in many countries. It is a widely preferred physical activity across all age groups, providing excellent cardiovascular conditioning without the weight-bearing impact on the musculoskeletal system. As such, it is considered an ideal form of exercise for obese children. Additionally, the high temperature and humidity of the swimming environment make it a beneficial option for individuals with asthma. However, achieving the intensity required for fitness gains and calorie burning in swimming requires a certain level of technical proficiency (7).

Among the major physiological consequences of a sedentary lifestyle are obesity and being overweight. Swimming, which is based on aerobic principles, is effective in addressing these issues. The aerobic energy system involves the oxidation of nutrients in the mitochondria to produce energy. In this process, carbohydrates and fats are broken down into water and carbon dioxide in the presence of oxygen, allowing fat to be used as a primary energy source (17).

Swimming is one of the few sports performed in water that optimally supports physical development. The sport, which nearly eliminates the effect of gravity, ensures the harmonious activation of all muscle groups. Performed against the resistance of water, it enhances endurance without exerting a detrimental impact on the body. Moreover, it is utilized in physical therapy due to its role in promoting the symmetrical and balanced development of muscle structures (6).

Empirical studies have demonstrated that swimming improves physical appearance, aids in weight management by increasing energy expenditure capacity, and constitutes an important means of combating physical inactivity (7). Swimming is one of the few sports performed in an aquatic environment that optimally supports physical development. The water's buoyancy nearly eliminates the effect of gravity, enabling all muscle groups to work in harmony. Performing movements against water resistance improves endurance without placing harmful stress on the body. Moreover, swimming is widely used in physical therapy due to its role in promoting symmetrical and balanced muscular development (6).

Empirical studies have demonstrated that swimming improves physical appearance, aids in weight management by increasing energy expenditure capacity, and constitutes an effective means of combating physical inactivity (7). In this context, the aim of this study is to investigate the effects of swimming exercises on certain physical parameters, anthropometric characteristics, and body fat percentage in sedentary women.

METHOD

Participants

The study included 20 middle-aged women residing in Ankara who had no prior experience with regular swimming training or participation in any other regular physical activity. All swimming sessions were conducted at the Eryaman Swimming Pool in Ankara. The study was approved by the local ethics committee (Protocol number 120, 11.11.2024, Ethics Committee of Selçuk University, Faculty of Sports Science, Konya, Turkey). Before the assessment, every participant received the same detailed information about the testing procedure. Every participant signed the informed consent.

Data Collection Tools: Height and Weight Measurements

Participants' height and weight were measured in a performance testing laboratory. Height was measured using a stadiometer, and body weight was measured using a digital scale.

Anthropometric Circumference Measurements

Anthropometric measurements were performed using a measuring tape, and the values were recorded in centimeters. The measurement sites and procedures were as follows:

- Shoulder: Measured from the maximum protrusion of the deltoid muscle to the junction of the sternum and the second rib.
- Biceps: Measured at the midpoint between the acromion of the scapula and the olecranon of the ulna while the arm was extended.
- Abdomen: Measured approximately 5 cm below the navel with the subject standing upright, heels together, and arms at the sides.
- Waist: Measured at the narrowest point of the waist during normal respiration.
- Hip: Measured horizontally over the maximum protrusion of the gluteal muscles.
- Chest: Measured horizontally at the level of the fourth rib at the junction with the sternum, while the participant stood with feet shoulder-width apart. Measurements were taken after a normal exhalation.
- Thigh: Measured at the point of maximum circumference just below the gluteal fold.
- Calf: Measured at the point of maximum circumference of the calf muscles.

Skinfold Thickness Measurements

Skinfold thickness was measured using a Holtain brand skinfold caliper, with values recorded in millimeters. All measurements were performed by the same trained specialist to ensure consistency and reduce inter-rater variability. The caliper used has been widely validated in anthropometric research and is known for its high reliability and accuracy. The measurement points and procedures were as follows.

- Triceps Skinfold: Measured vertically at the midpoint between the acromion and olecranon on the posterior aspect of the right upper arm, with the participant standing and arms relaxed at the sides.
- Biceps Skinfold: Measured vertically over the midpoint of the biceps muscle on the right upper arm with arms relaxed at the sides.
- Subscapular Skinfold: Measured diagonally at a 45° angle below the inferior angle of the scapula.
- Suprailiac Skinfold: Measured diagonally at a 45° angle above the iliac crest along the midaxillary line.
- Abdominal Skinfold: Measured vertically at a 90° angle along the midline of the abdomen.
- Quadriceps Skinfold: Measured vertically at the point of maximum circumference of the right thigh with the participant seated and knees flexed at 90°.
- Calf Skinfold: Measured vertically at a 90° angle at the midpoint of the calf muscle while the participant was standing (3).

Body Fat Percentage

Body fat percentage was calculated using the Lange formula

% Body Fat = (bi + tr + sc + si + chest + thigh) × 0.097 + 3.64

BMI Calculation

Body Mass Index (BMI) was calculated using the formula:

BMI = Body Weight (kg) / Height² (m^2)

Procedure

Before the initiation of the study, the topic was determined, literature was reviewed, and a hypothesis was formulated. The experimental group was then identified. Pre-test measurements were taken from the 20 selected participants. After a 6-week swimming training program, post-test measurements were conducted and compared with the pre-test values using statistical analysis. The findings obtained at the end of the study were interpreted in light of the relevant literature.

Training Model

The swimming sessions, conducted three times per week, included the following components:

- 10 minutes of general stretching exercises targeting major muscle groups before entering the pool,
- 5 minutes of free swimming as warm-up in the pool,
- 3 sets of 50-meter freestyle swimming,
- 15 minutes of resistance exercises for the arms, trunk, and legs performed in water,
- 2 sets of 50-meter backstroke swimming,
- 10 minutes of swimming in the participant's preferred style.

Statistical Analysis

Parametric data in the study were analyzed using the SPSS 22 software. Initially, the Shapiro-Wilk normality test was conducted to assess whether the data met the assumptions required for parametric tests. This test was utilized to determine if the data were normally distributed. A p-value greater than 0.05 indicated that the data satisfied the normality assumption, thus allowing the application of parametric tests.

After confirming the normality assumption, the Paired Sample T-Test was employed to evaluate whether there were statistically significant differences between the pre-test (before exercise) and post-test (after exercise) values. The significance level was set at $p < 0.05$. The analysis results reported the statistical significance of changes observed in the measured parameters.

FINDINGS

Table 1. Mean Age and Height Values of the Sedentary Participants in the Study

Variables	N	Min	max	Mean	S.d
Age (years)	20	25,00	40,00	31,05	5,04
Height (meters)	20	1,52	1,74	1,63	0,05

Table 2. Comparison of Pre- and Post-Test Circumferential Measurements of Sedentary Participants

Parameters	Time	N	X	Ss	t	P
Shoulder circumference (cm)	Pre test	20	103,50	9,15	1,422	,171
	Post test	20	103,01	9,35		
Chest circumference (cm)	Pre test	20	94,00	10,19	1,270	,219
	Post test	20	93,41	10,54		
Waist circumference (cm)	Pre test	20	80,80	10,58	2,378	*,028
	Post test	20	79,95	10,23		
Abdomen circumference (cm)	Pre test	20	90,70	11,75	2,861	*,010
	Post test	20	89,00	12,13		
Hip circumference (cm)	Pre test	20	103,95	9,71	4,030	*,001
	Post test	20	102,00	9,73		
Thigh circumference (cm)	Pre test	20	54,40	6,10	1,962	,065
	Post test	20	53,63	5,29		
Leg circumference (cm)	Pre test	20	36,35	3,56	2,162	*,044
	Post test	20	35,60	3,19		
Arm circumference (cm)	Pre test	20	28,35	3,83	2,210	*,040
	Post test	20	27,60	3,59		
Forearm circumference (cm)	Pre test	20	23,30	2,05	2,015	,058
	Post test	20	22,40	4,60		

* Significant differences (P<0.05).

The pre-test and post-test mean shoulder circumference measurements of the sedentary participants were found to be 103.50 ± 9.15 cm and 103.01 ± 9.35 cm, respectively. The participants' mean chest circumference was 94.00 ± 10.19 cm in the pre-test and 93.41 ± 10.54 cm in the post-test. The mean waist circumference decreased from 80.80 ± 10.58 cm to 79.95 ± 10.23 cm ($p<0.05$), and abdominal circumference decreased from 90.70 ± 11.75 cm to 89.00 ± 12.13 cm ($p<0.05$). The hip circumference also declined from 103.95 ± 9.71 cm to 102.00 ± 9.73 cm ($p<0.05$).Additionally, the participants' mean thigh circumference changed from 54.40 ± 6.10 cm to 53.63 ± 5.29 cm, while calf circumference decreased from 36.35 ± 3.56 cm to 35.60 ± 3.19 cm ($p<0.05$), arm circumference from 28.35 ± 3.83 cm to 27.60 ± 3.59 cm ($p<0.05$), and forearm circumference from 23.30 ± 2.05 cm to 22.40 ± 4.60 cm. Statistical analysis revealed no significant differences between the pre-test and post-test measurements of shoulder, chest, thigh, and forearm circumferences ($p > 0.05$). However, significant differences were observed in waist, abdominal, hip, calf, and arm circumferences ($p < 0.05$).

Table 3. Comparison of Pre- and Post-Test Subcutaneous Fat Measurements of Sedentary Participants in the Study

Parameters	Time	N	X	Ss	t	P
Biceps subcutaneous fat (mm)	Pre test	20	11,40	7,30	2,165	*,043
	Post test	20	10,55	6,41		
Triceps subcutaneous fat (mm)	Pre test	20	17,95	5,22	2,320	*,032
	Post test	20	17,15	4,52		
Pectoral subcutaneous fat (mm)	Pre test	20	9,55	5,23	1,022	,320
	Post test	20	9,20	5,01		
Subscapularis subcutaneous fat (mm)	Pre test	20	15,80	6,46	1,140	,269
	Post test	20	15,40	5,88		
Abdominal subcutaneous fat (mm)	Pre test	20	18,00	6,58	1,610	,124
	Post test	20	17,40	5,58		
Suprailiac subcutaneous fat (mm)	Pre test	20	14,10	3,92	2,156	*,044
	Post test	20	13,45	3,72		
Quadriceps subcutaneous fat (mm)	Pre test	20	17,00	6,14	5,205	*,000
	Post test	20	15,85	6,23		
Calf subcutaneous fat (mm)	Pre test	20	14,11	5,90	,360	,723
	Post test	20	13,86	5,51		

* Significant differences (P<0.05).

Statistical analysis revealed significant reductions in subcutaneous fat thickness at specific sites following the six-week swimming exercise program. The biceps skinfold thickness decreased from 11.40 ± 7.30 mm to 10.55 ± 6.41 mm ($p<0.05$), the triceps from 17.95 ± 5.22 mm to 17.15 ± 4.52 mm ($p<0.05$), the suprailiac from 14.10 ± 3.92 mm to 13.45 ± 3.72 mm ($p<0.05$), and the quadriceps from 17.00 ± 6.14 mm to 15.85 ± 6.23 mm ($p<0.05$). No statistically significant changes were observed in the pectoral (9.55 ± 5.23 mm to 9.20 ± 5.01 mm), subscapularis (15.80 ± 6.46 mm to 15.40 ± 5.88 mm), abdominal (18.00 ± 6.58 mm to 17.40 ± 5.58 mm), and calf (14.11 ± 5.90 mm to 13.86 ± 5.51 mm) skinfold thicknesses.

Table 4. Comparison of Pre- and Post-Test Body Weight, Body Mass Index, and Body Fat Percentage Measurements of Sedentary Participants in the Study

Parameters	Time	N	X	Ss	t	P
Body Weight (kg)	Pre test	20	66,15	11,68	3,022	*,007
	Post test	20	63,05	11,08		
Body Mass Index (kg/m²)	Pre test	20	25,02	4,70	3,041	*,007
	Post test	20	23,86	456		
Body Fat Percentage (%)	Pre test	20	23,93	4,65	2,735	*,013
	Post test	20	23,22	4,06		

* Significant differences (P<0.05).

The mean body weight of the participants was 66.15 ± 11.68 kg before the intervention and 63.05 ± 11.08 kg after the intervention ($p<0.05$). The Body Mass Index (BMI) decreased from 25.02 ± 4.70 kg/m² to 23.86 ± 4.56 kg/m² ($p<0.05$). Additionally, the mean body fat percentage declined from 23.93 ± 4.65% to 23.22 ± 4.06% ($p<0.05$).

DISCUSSION

Anthropometric circumference measurements taken before and after the swimming exercise program in sedentary women were compared. No statistically significant differences were found in the shoulder, chest, thigh, and forearm circumferences between pre- and post-test values. However, significant reductions were observed in waist, abdomen, hip, leg, and arm circumferences. A partially supporting study examined the effects of Pilates, an aerobic exercise method, and reported significant reductions in the 40–50 age group for

biceps (1.2 cm), chest (1.65 cm), abdomen (1.72 cm), hip (2.43 cm), upper leg (0.83 cm), calf (0.78 cm), and waist (0.9 cm) circumferences. In contrast, the same study found that in the 18–25 age group, only abdominal circumference showed a significant decrease (1.2 cm), while changes in other regions were not statistically significant (3).

There is a well-established relationship between reductions in body circumference measurements and decreases in both body fat percentage and overall weight. Previous studies have demonstrated a significant association between circumference measurements and body fat levels (26). In our study, statistically significant reductions were observed in the biceps, triceps, suprailiac, and quadriceps skinfold measurements. However, no significant changes were found in the pectoral, subscapularis, abdominal, and calf regions. The absence of reduction in certain sites may be attributed to the lack of region-specific exercises in our program, which did not target localized fat loss.

A comparable study involving aerobic exercise in individuals aged 18–25 reported a significant decrease of 1.6 mm in the suprailiac region, while reductions in the triceps, subscapular, thigh, and abdominal areas were not statistically significant (1). In contrast, among participants aged 40–50, the same study found significant decreases in the triceps (9.1 mm), subscapularis (2.61 mm), suprailiac (1.36 mm), abdomen (1.43 mm), and thigh (2.3 mm) skinfolds (3). These findings are largely consistent with the outcomes of our study.

Participants' body fat percentages and Body Mass Index (BMI) values were measured at the beginning and end of the study. The results revealed statistically significant decreases in both parameters following the swimming exercise intervention. Similarly, a previous study on swimmers reported that regular swimming led to a significant reduction in body fat percentage (13).

Swimming predominantly relies on the aerobic energy system (Tamer, 1995), and aerobic exercises have been shown to reduce body fat when applied consistently across different age groups (14). In a study conducted on 45 sedentary middle-aged women, a moderate-intensity exercise program was performed three times per week for one hour per session. By the end of the program, participants experienced a 9.06% reduction in body weight and a 21.4% decrease in body fat percentage (15). Another study involving middle-aged men and women also reported significant improvements. Tortop et al. (24) demonstrated that a 12-week aerobic exercise regimen resulted in marked decreases in both body weight and body fat percentage. These findings are consistent with the outcomes observed in our study. A similar study supporting our findings involved a group of middle-aged women who participated in a 12-week running–walking program, performed three times per week for 30 minutes. A significant reduction in body fat was observed between the pre- and post-test measurements (8). While many studies have reported that aerobic exercises significantly reduce body fat percentage, some have found non-significant changes. For instance, in a study involving middle-aged and older women who engaged in aerobic resistance exercises, reductions in body fat percentage were not statistically significant (3). This discrepancy may be due to the low intensity or short duration of the training sessions. Therefore, to achieve meaningful reductions in body fat through swimming, the exercise intensity must be sufficient to stimulate fat metabolism. This is particularly important, as the physiological adaptations gained through exercise can quickly regress once physical activity ceases (4). In a related study by Çolakoğlu and Karacan (9), aerobic resistance training led to a statistically significant reduction in BMI, from 35.87 ± 6.86 kg/m² to 32.75 ± 5.60 kg/m², further supporting the effectiveness of appropriately structured aerobic exercise programs.

Okyar (19) also reported that aerobic exercise led to a significant decrease in BMI. In contrast, another study involving middle-aged women who participated in an 8-week step aerobics program found a slight reduction in BMI—from 27.18 ± 4.20 kg/m² to 26.91 ± 4.29 kg/m²—which was not statistically significant (16). In a separate study, 31 healthy women took part in a 6-month combined resistance and aerobic training program, performed five days a week. By the end of the intervention, BMI had decreased by 2.2% (20). Similarly, a study on 41 middle-aged women who engaged in 45–60-minute aerobic exercise sessions three times per week for eight weeks reported significant reductions in BMI (25). Numerous studies in the literature have similarly reported that aerobic exercise programs, including swimming, lead to significant reductions in body fat percentage (5, 10, 12). Taken together, these findings indicate that the results of our study are consistent with the existing literature. However, one limitation of the present study is the small sample size, which may affect the generalizability of the findings.

CONCLUSION

In conclusion, this study demonstrated that swimming, as a form of aerobic exercise, resulted in reductions in subcutaneous fat and several anthropometric circumference measurements. Statistically significant decreases were also observed in participants' body fat percentages and Body Mass Index (BMI) values following the six-week swimming program. These results are consistent with findings from similar studies in the literature. Based on the evidence obtained, it can be concluded that swimming positively contributes to improvements in body composition. Furthermore, swimming appears to offer favorable physiological effects not only on body structure and fat metabolism but also potentially on motor skills and cardiovascular health. Therefore, swimming-based training can be considered an effective exercise method for enhancing both physical fitness and overall well-being in sedentary individuals.

Recommendations

1. Future studies could investigate the extent to which accompanying nutritional programs support reductions in body fat percentage when combined with swimming.

2. The effects of training duration and intensity on body composition in swimming programs could also be examined.

3. Future studies may compare the changes in body composition observed after swimming programs based on age and gender differences.

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