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THE CHRONIC EFFECT OF CORE TRAINING ON DIFFERENT SWIMMING SKILLS PERFORMANCE IN YOUTH SWIMMERS

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Abstract:
The purpose of this research is to examine the chronic effect of core training on swimming performance in different styles. 16 male swimmers with at least 5 years of competitive swimming history participated in this study as subjects. The subjects were divided into two equal groups and core training was applied to the experimental group in addition to the swimming training routine for 8 weeks, while the control group was not given any application other than routine swimming training. Before starting the training, the athletes' height, weight and 50 M Sprint times in 4 different styles were noted and recorded. From the moment I started training, I gave the experimental group core training for 8 weeks and did not take trial sprints. After 8 weeks of loading, I recorded 50 M Sprint times in 4 different styles as a final test. A two-way analysis of variance (2x2) was applied in repeated measurements to analyze the differences between applications. The Greenhouse Geiser correction test was used in measurements where the assumption of sphericity was not met. LSD test was used for post hoc analysis. Statistical results were evaluated at $p<0.05$ significance level. Statistical analyzes of the differences in the mean freestyle swimming degrees between the pre-test and post-test applications in the control and experimental groups are presented. According to the results of a two-way analysis of variance in repeated measurements, a statistically significant difference was found

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between groups (F = 7.03, p = 0.033) and between times (F = 38.83, p = 0.001); No statistically significant difference was detected in the group*time interaction (F = 5.19, p = 0.057). As a result, it can be said that core exercises are the reason for strengthening the body part and increasing stability needed in all movements of freestyle, breaststroke, butterfly and backstroke styles.

Keywords: swimming, style, core, strength

1. Introduction

Just as there are requirements of our age, great changes are also occurring in the world of sports. With these changes, there are researches and studies to help athletes achieve high performance in shorter periods of time. The sports world aims to shorten the athlete's adaptation process to training and competitions by analyzing human physiology and psychology together with science (1). It will be examined whether the acute changes that occur in swimmers during the core training to be applied in the swimming branch become chronic at the end of the process. At the same time, it will be examined whether core training in swimming is more effective in which styles at the end of the process and which muscle groups will develop more in these styles. The impact of this study on the swimming branch will be to provide information to our coaches and athletes. In the modern age, it has become clear that success will be even greater when sports are combined with positive science (2). The findings obtained will contribute to the country's economy through achievements in the field of swimming. It is aimed to change society's thoughts about swimming.

With this study, it will be proven that core training, which affects chronic results in swimming, is cost-free, material-free and more useful. Nowadays, no matter what branch you are interested in, it is recommended to do activities that include swimming, because swimming is an activity based on human health, muscles, bone development and coordination. The effect of swimming on breathing and muscles has been proven (3). Each piece of research proves that sports will be taken to even higher levels in our country and around the world (4). The purpose of this research is to examine the chronic effect of Core training on swimming performance in different styles.

2. Method

16 male swimmers with at least 5 years of competitive swimming history will participate in this study as subjects. The subjects will be divided into two equal groups, and while core training will be applied to the experimental group in addition to the swimming training routine for 8 weeks, the control group will not be given any exercise other than routine swimming training. Participants will be given detailed information about the research. Participation in the research will be voluntary. The inclusion criteria will be that the participants are not in the process of any injury or have not recently experienced any

injury that will affect performance. It will be designed according to the full experimental model with a control group.

A. Height Measurement

The height of the subjects will be measured with a stadiometer (SECA, Germany) with a precision of 0.01 m. Height will be determined in cm by measuring the distance between the vertex of the head and the foot following a deep inspiration while the head is in the Frankfort plane (5).

B. Body Weight Measurement

Body weight measurements will be made with an electronic scale with a precision of 0.1 kg. Body weight measurements will be measured in kg, and the subjects will be measured in standard sports clothing (shorts, t-shirts) without shoes, according to standard techniques (5).

C. 50 m Swimming Test

Before the 50 m swimming test in different styles, we warm up on land and then say 'Ready' while in the pool. Get out! command, and the time from the moment the swimmer touches the wall of the pool with his feet to the moment he touches the opposite wall will be measured with a hand stopwatch. This test will be applied to all 4 styles. Values will be recorded in seconds (sec) (6).

D. Core Training Application

The training program is 8 weeks, 3 days a week and 60 minutes a day. Provided that the principle of gradually increasing loading is observed every two weeks, the training will be continued by determining new maximals every two weeks, in the 80-100% intensity range, according to the athletes' maximal endurance times or maximal number of repetitions (one of the two techniques will be chosen depending on the nature of the movement). Plank, Russian twist, Bicycle crunch, bird dog, Diagonal plank, reserve crunch, mountain climber, and double leg lower and lift will be performed in 3 repetitions and intensity percentage according to the duration / number of repetitions, with a one-minute rest between sets (7).

E. Statistical Method

SPSS package program (SPSS for Windows, version 22.0, SPSS Inc., Chicago, Illinois, USA) was used to statistically analyze the data obtained at the end of the research. Data is presented as an arithmetic mean and standard deviation. Shapiro-Wilk test for normality test; Levene test was applied to test homogeneity. Skewness and kurtosis values were checked for data sets that did not show a normal distribution, and data sets within ±2 were considered to have a normal distribution (8).

3. Results

To analyze the differences between applications, a two-way analysis of variance (2x2) was applied in repeated measurements. The Greenhouse Geiser correction test was used in measurements where the assumption of sphericity was not met. LSD test was used for post hoc analysis. Statistical results were evaluated at $p<0.05$ significance level.

Table 4.1: Descriptive statistics of participants

	N	Mean	SD	Min	Max
Age (yıl)	16	16.5	1.37	15	19
Size (cm)	16	174.3	7.77	160	190
Weight (kg)	16	65.3	7.02	56	78
BMI (kg/m²)	16	21.5	1.95	17.5	25.2

Table 4.2: Statistical analysis of freestyle swimming degrees between groups and times

		Mean	SD	Group		Time		Group*Time	
				F	p	F	p	F	p
Control	Pre	36.3	6.70	7.03	**0.033***	38.83	**0.001***	5.19	0.057
	Post	34.2	6.47						
Experiment	Pre	29.9	1.77						
	Post	28.8	1.46						

* $p<0.05$

Table 4.3: Pairwise comparison of freestyle swimming degrees

Test-Group	Mean Difference	SE	t	p
Pre Control - Post Control	2.07	0.409	5.06	**0.001***
Pre experiment - Post experiment	1.11	0.227	4.89	**0.002***

Table 2 presents the statistical analysis of the differences in the average freestyle swimming degrees between the pre-test and post-test applications in the control and experimental groups. According to the results of a two-way analysis of variance in repeated measurements, a statistically significant difference was found between groups ($F = 7.03$, $p = 0.033$) and between times ($F = 38.83$, $p = 0.001$); No statistically significant difference was detected in the group*time interaction ($F = 5.19$, $p = 0.057$) (Figure 1).

Table 3 presents the pairwise comparison post hoc analysis of the freestyle swimming parameter control and experimental groups. According to the analysis results, a statistically significant difference was found between the pre-post test results of the control group ($t = 5.06$, $p = 0.001$) and the pre-post test results of the experimental group ($t = 4.89$, $p = 0.002$).

Table 4.4: Statistical analysis of butterfly style swimming degrees between groups and times

		Mean	SD	Group		Time		Grup*Time	
				F	p	F	p	F	p
Control	Pre	41.4	8.67	3.54	0.102	11.15	**0.012***	3.74	0.094
	Post	38.2	6.55						
Experiment	Pre	34.2	6.59						
	Post	33.1	6.01						
* p<0.05									

Table 4.5: Pairwise comparison of butterfly-style swimming degrees

Test-Group	Mean Difference	SE	t	p
Pre Control - Post Control	3.19	1.140	2.80	**0.027***
Pre experiment - Post experiment	1.06	0.342	3.10	**0.017***

Table 4 presents the statistical analysis of the differences in butterfly-style swimming scores between the pre-test and post-test applications in the control and experimental groups. According to the results of a two-way analysis of variance in repeated measurements, a statistically significant difference was detected between times (F = 11.15, p = 0.012); No statistically significant difference was detected between groups (F = 3.54, p = 0.102) and group*time interaction (F = 3.74, p = 0.094) (Figure 2).

Table 5 presents the pairwise comparison post hoc analysis of the butterfly-style swimming parameter control and experimental groups. According to the analysis results, a statistically significant difference was found between the pre-post test results of the control group (t = 2.80, p = 0.027) and the pre-post test results of the experimental group (t = 3.10, p = 0.017).

Table 4.6: Statistical analysis of frog-style swimming degrees between groups and time

		Mean	SD	Group		Time		Group*Time	
				F	p	F	p	F	p
Control	Pre	49.3	6.17	17.98	**0.004***	8.78	**0.021***	1.55	0.254
	Post	46.5	4.73						
Experiment	Pre	39.4	4.10						
	Post	38.4	4.29						
* p<0.05									

Table 4.7: Pairwise comparison of frog-style swimming degrees

Test-Group	Mean Difference	SE	t	p
Pre Control - Post Control	2.80	1.353	2.07	0.077
Pre experiment - Post experiment	1.01	0.176	5.74	**0.001***

Table 6 presents the statistical analysis of the average differences in frog-style swimming degrees between the pre-test and post-test applications in the control and experimental groups. According to the results of two-way analysis of variance in repeated measurements, a statistically significant difference was found between groups (F = 17.98,

p = 0.004) and between times (F = 8.78, p = 0.021); No statistically significant difference was detected in the group*time interaction (F = 1.55, p = 0.254) (Figure 3).

Table 7 presents the pairwise comparison post hoc analysis of the frog swimming parameter control and experimental groups. According to the analysis results, while the pre-post test results of the control group (t = 2.07, p = 0.077) were not found to be statistically significant, a statistically significant difference was found between the pre-post test results of the experimental group (t = 5.74, p = 0.001).

Table 4.8 Statistical analysis of backstroke swimming degrees between groups and time

		Mean	SD	Group		Time		Group*Time	
				F	p	F	p	F	p
Control	Pre	42.9	7.50	4.70	0.067	21.25	**0.002***	0.08	0.783
	Post	41.5	5.99						
Experiment	Pre	37.8	1.35						
	Post	36.2	0.86						

* p<0.05

Table 4.9: Pairwise comparison of backstroke swimming degrees

Test-Group	Mean Difference	SE	t	p_{tukey}
Pre Kontrol - Post Kontrol	1.42	0.574	2.48	0.149
Pre experiment - Post experiment	1.62	0.350	4.62	**0.010***

Table 8 presents the statistical analysis of the differences in backstroke swimming scores between the pre-test and post-test applications in the control and experimental groups. According to the results of a two-way analysis of variance in repeated measurements, a statistically significant difference was detected between times (F = 21.25, p = 0.002); No statistically significant difference was detected between groups (F = 4.70, p = 0.067) and group*time interaction (F = 0.08, p = 0.783) (Figure 4).

4. Conclusion and Discussion

This study was conducted to examine the effects of core exercises on different swimming styles in swimmers. 16 volunteer male swimmers participated in the study and the participants were randomly divided into two groups: control group (n = 8) and swimming + core exercise group (n = 8). While both groups continued their regular swimming training, swimmers in the experimental group were also subjected to a core exercise program 3 days a week for 8 weeks. Pretests were administered to all participants at the beginning of the study, and posttests were performed at the end of the eight-week period, and the results were analyzed.

When freestyle swimming performance data were examined, significant differences were found between groups (F = 7.03, p = 0.033) and between times (F = 38.83, p = 0.001), according to the results of two-way analysis of variance in repeated measurements. However, no significant difference was detected in the group*time

interaction (F = 5.19, p = 0.057). According to post hoc analysis, a significant difference was found between the pre-post test results of the control group (t = 5.06, p = 0.001) and the pre-post test results of the experimental group (t = 4.89, p = 0.002).

In the butterfly style swimming performance analysis, a significant difference was detected between times (F = 11.15, p = 0.012), while there was a significant difference between groups (F = 3.54, p = 0.102) and group*time interaction (F = 3.74, p = 0.094). not observed. In the post hoc analysis, a significant difference was found between the pre-post test results of the control group (t = 2.80, p = 0.027) and the pre-post test results of the experimental group (t = 3.10, p = 0.017).

In the analyzes conducted for frog-style swimming performance, significant differences were detected between groups (F = 17.98, p = 0.004) and between times (F = 8.78, p = 0.021). However, no significant difference was found in the group*time interaction (F = 1.55, p = 0.254). According to the post hoc results, while the pre-post test results of the control group (t = 2.07, p = 0.077) were not found to be significant, a significant difference was detected between the pre-post test results of the experimental group (t = 5.74, p = 0.001).

In the backstroke style swimming performance analysis, a significant difference was found between times (F = 21.25, p = 0.002), but there was a significant difference between groups (F = 4.70, p = 0.067) and group*time interaction (F = 0.08, p = 0.783) not detected. In the post hoc analysis, while the pre-post test results of the control group (t = 2.48, p = 0.149) were not found to be significant, a significant difference was determined between the pre-post test results of the experimental group (t = 4.62, p = 0.010).

When the literature is examined, there are many studies examining the acute and chronic effects of core exercises on swimming performances in terms of various variables (age, gender, years spent as a swimming athlete, swimming level, training duration, swimming distance, etc.).

In his study, Yiğit (2021) investigated the effects of core training applied to male swimmers in the 11-12 age group on the 50 and 100 meter butterfly style swimming performance. As a result of the research, a significant improvement was found in 50 and 100 meter butterfly style swimming performance after core training application ($p<0.05$).(9)

Ardalı (2019) examined the effects of core training applied to 10-12 year old male swimmers on motoric characteristics and swimming performance. In line with the findings obtained, a positive, statistically significant difference was detected in the 50m swimming performance of the athletes in the experimental group. (10)

Hepsert (2022), in his study examining some psychomotor and 50-meter freestyle swimming performance of 6-week core exercises in children, did not detect a significant positive difference in 50-meter freestyle swimming performance (11).

Gönener et al. (2017), in their study examining the effect of 8-week core exercises on backstroke style 100 m performance in male swimmers aged 13-15, 24 participants were randomly divided into two groups: experimental and control groups. In line with

the data obtained, the 100 m backstroke performances of the experimental group were found to be positively significant (12).

Öz Doğru (2018) investigated the effect of core training on swimming performance in male swimmers aged 10-12. As a result of the study conducted with 60 volunteer athletes, it was observed that an 8-week core training program had a statistically significant positive effect on swimming performance (13).

Sarıkaya and Öner (2019), in their study examining the effect of 8-week core training on the 50 m backstroke swimming performance of swimmers in the 10-12 age group, found that the data of the experimental group was statistically significant ($p < 0.05$). As a result of the study, it was reported that core training had a positive effect on swimming degrees (14).

According to the findings of the study by Gönener and Akyüzlü (2019), in which they examined the effect of Swiss ball training on 50-meter butterfly style swimming performance, a positive significant difference was detected between the pre-post test data of the experimental group. As a result, it has been reported that Swiss ball training significantly improves swimming performance (15).

İlhan et al. (2024) examined the effects of core exercises in addition to swimming training in 7-10 year old children on freestyle and backstroke swimming performance. According to the findings, statistically significant differences were found in the control and experimental group data. According to the results of the study, it was reported that core training had no effect on swimming performance for children aged 7-10 who received basic swimming training (16).

Mu-Yeop et al. (2021) examined the effect of 12-week core training on physical fitness and swimming performance in elite swimmers. 30 participants were randomly divided equally into a core training group and a traditional weight training group. According to the results of the two-way analysis of variance, no significant interaction effect was reported in the swimming degrees parameter ($p>0.05$) (17).

Khiyami et al. (2022) examined the effect of core exercises on swimming performance and neuromuscular parameters in young swimmers. This study, conducted on 18 young swimmers with an average age of 13±2 years, was divided equally into control and experimental groups using randomization. In addition to swimming training, a core exercise program was applied to the experimental group for 6 weeks, 3 times a week. As a result of the findings, positive, statistically significant differences were detected in 50 m freestyle swimming performance ($p<0.05$) (18).

Weston et al. (2015) investigated the effect of core training applied for 12 weeks on swimming performance in national-level swimmers. 20 swimmers participated in the study voluntarily. In addition to swimming training, a core training program was applied to the experimental group 3 times a week for 12 weeks. According to the results obtained from the research, the 50 m swimming times of the experimental group decreased statistically significantly compared to the control group ($p <0.05$) (19).

Dhiman and Kapri (2024), in their study examining the effects of core exercises on kinematic parameters and 50 m swimming performance in elite swimmers, found a

statistically significant improvement of 0.3 seconds in the swimming performance of the experimental group ($p<0.05$) (20).

Gul et al. (2020) examined the effect of core training on swimming performance and some motoric characteristics in swimmers aged 10-13. According to the results obtained from the research, it was reported that core training had a significant positive effect on 50 m swimming performance ($p <0.05$). As a result, it is recommended to program core training in addition to swimming training for swimmers in the 10-13 age group (21).

Boonprawet et al. (2011) examined the effect of a 6-week combined core training program on 25-meter swimming performance in their study. According to the findings of the study, statistically significant results that would positively affect 25-meter swimming performance in the combined core training group were not achieved ($p>0.05$). (22).

Tatlısu (2023), in his study examining the effects of core, resistance and plyometric exercises on various strength parameters and swimming performance in female swimmers, found that core training had a positive effect on swimming performance. (23) In his study where Saygı (2022) examined the effect of plyometric and core training on swimming performance in swimmers, no significant effect of plyometric and core training on 50-meter swimming performance was reported ($p>0.05$) (24).

Erdem (2021) examined the effect of core training on short and long-distance swimming performance. 40 swimmers participating in the study were randomly divided into two groups: 20 control and 20 experimental groups. In addition to swimming training, core training was applied to the experimental group for an 8-week period. In line with the findings, it was concluded that core training significantly increased short-distance and long-distance swimming performance ($p<0.05$) (25).

Geçer (2024), in his study examining the effects of 8-week core training applied to swimmers in the 10-13 age group on swimming and motoric performance, found statistically significant differences in the 50-meter and 100-meter swimming performances of the core training group ($p <0.05$) (26).

Core muscles must be strengthened in order to maintain a stable body during body rotation and foot strikes aimed at reducing friction in the supine style (27).

During frog style leg kicks, core strength as well as lower extremity strength is of great importance in gathering the legs towards the body and pushing the body forward better to make a whipping movement (28).

It is important that the core muscles are durable and strong so that a strong dolphin movement can be made from the beginning of the butterfly style movement with the hands entering the water and the body can be pushed forward (29).

As in other styles, in the freestyle swimming style, the arms and legs become more efficient and effective only when the trunk muscles are strengthened (30).

There are various reasons why the findings of our study are similar to the literature and that the hypothesis of the research is confirmed. We can say that core exercises are the reason for strengthening the body part and increasing stability needed

in all movements of freestyle, breaststroke, butterfly and backstroke styles. Core training performed for a minimum of 8 weeks has been shown in our study, as in the literature, that the strength and endurance of the core group muscles increased, and this strength was positively reflected in swimming performance. When we examine the results we obtained, we can say that core training has a positive effect on swimming performance in different styles. Chronic core training may be recommended to coaches who want to improve their swimmers' scores.

Conflict of Interest Statement
The authors declare no conflicts of interest.

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