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The Effect of Core Training on Swimmers' Functional Movement Screen Scores and Sport Performances

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Abstract The aim of this study was to examine the effect of core exercises on swimmers Functional Movement Screen (FMS) test scores and swimming performance. A total of 32 volunteer children aged 12-15 participated in this study. Participants were separated into 3 main groups: the control group (CG; $N = 10$) that did not perform any exercises, the swimming group that only performed swimming training (SG; $N = 11$), and the core exercise training group (TG; $N = 11$) that performed core exercises in addition to swimming training. The functional movement patterns of the children were determined by the FMS test, and their swimming performances of 50 meters and 100 meters were measured by means of a stopwatch. The Wilcoxon Signed Ranks test was utilized to determine the in-group difference between the pre-tests and post-tests of the children's FMS scores and swimming performances. According to the statistical analysis results, it was observed that swimming training increased FMS total score and active straight leg raising test score. Besides, core exercises significantly increased all FMS sub-tests and total score values in the post-test. At the end of the study, although there was no significant difference between pre and post-tests in SG both 50m and 100m swimming performances, statistical results also proved that the 100m swimming performances of the TG increased significantly in the post-test ($p < 0.05$). As a result, it can be stated that the swimmers', who performs core exercises, swimming performance increased, and improved FMS test scores, which is a significant element regarding the decrease in sports injury.

Keywords: *Functional movement screen test, swimming, core exercise, performance*

1. Introduction

Core muscles, which play an important role in the functioning of the spine as a whole during the movement of the lower and upper extremities, are among the determining factors of sportive performance (Sever, 2016; Yıldız, 2012). Core strength, which represents the strength of all deep and superficial core muscles in the body, plays an important role in providing body control and increasing the quality of movement during difficult movements (Jones, 2013). As in many sports, the strength of the core muscles is very important in swimming. In all swimming styles (freestyle, backstroke, and butterfly), core strength is required to maintain horizontal stability of the body and legs in water (Cook et al., 2010). In addition, insufficient development of the core muscles may have a negative effect on the performance of the athletes by preventing the application of the techniques specific to swimming at the desired level (Willardson, 2014).

Core exercises are utilized in several areas such as rehabilitation, general health, and increasing sportive performance. Initially, core exercises were first utilized for the purposes of rehabilitation (Vezina & Hubley, 2000; McGill, 2001; Barr et al., 2005), yet they have recently been preferred by athletes and coaches for athletic performance development (Yang, 2014; Gür, 2015; Tayshete et al., 2020; Yilmaz, 2021). The lack of support surface in water in swimming makes it more difficult to maintain in-water posture (Nichols, 2015) and the core region undertakes the deficiency of the support point in water (Willardson, 2007). It is possible to progress with the least exposure to water resistance, but only by providing the highest level of hydrodynamic posture (Maglischo, 2003). The inadequacy and instability of the core area components make the position of the underwater posture difficult, such a difficulty causes the swimmer to lose control over the core area, and this leads to a decrease in performance in the lower extremity (Willardson, 2014). Moreover, weakness or imbalances in the core muscles may lead to sports injuries and dysfunction in functional movement patterns, as well as reduce sports performance (Willardson, 2014).

Functional movement patterns play a very important role in reaching sports performance to higher levels. That the functional movement patterns of an athlete are not proper has negative effects on athletes' performance (Kiesel et al., 2007). For this reason, it is important to define athletes' functional movement forms in the swimming branch and to follow the joint stability and mobility regularly (Başar et al., 2021). Functional Movement Screen (FMS) test, which is used to evaluate athletes' functional movement patterns in predicting that may occur in athletes, allows the analysis of basic movement patterns that can be applied quickly and easily in the field without the need for a laboratory or expensive equipment. FMS provides information about athletes' functional movement performance and asymmetric forms (Kraus et al., 2014; Aka et al., 2019a; Aktuğ et al., 2019).

It is important to determine the asymmetric structures of the athletes specifically in branches such as swimming in which both the right and left sides of the body are used together. Asymmetries in the body may cause discomfort on the spine in the long term, as well as increase muscular imbalances and have negative effects on sport performance (Aka, 2019; Altundağ et al., 2019). Although previous studies have evaluated the functional movements of athletes at the range of different ages and sports branches (Aka et al, 2019a; Aka et al., 2019b; Altundağ et al., 2019), few studies have implemented to the swimmers on the FMS test results and swimming performance. In this context, the current study aims to seek the answer to the question "Whether the core exercises swimmers perform have any effects on FMS test scores and their performances or not?". It is hypothesized that ''8-week core exercises improves swimmers FMS test scores and their performances''.

2. Method

2.1. Research Model

Participants were separated to Training Group (TG), Control Group (CG) and Swimming Group (SG) by sided assignment. Participants in TG and SG were grouped according to FMS pre-test results. The participants in TG performed a 30-minute core exercise program prior to each training session, in addition to their routine training for 4 days a week over an 8-week period. SG members only continued the stable training program of team during this period. No training program was applied to the control group. To get valid results, participants were separated into 3 main groups to see whether their improvement results from participants' growing period, swimming training or core exercises.

2.2. Universe and Sample

The participants were 12–15-year-old sedentary children and swimmers in the province of Niğde. They consist of 32 sedentary and swimming children selected through accessible sampling.

2.3. Data Collection Techniques

Participants' height and weight were measured through a scale with a height measuring bare feet, paying attention to wearing only shorts, t-shirts and swimsuits. Body weight (kg) / height (m^2) formula was used to calculate Body Mass Index (BMI).

2.4. Functional Movement Screen Test (FMS)

FMS is a test used for asymmetry and weak connections found in functional movement patterns. This test consists of seven different movements which include deep squat, hurdle step, inline lunge, shoulder mobility, active straight leg raise, trunk stability push-up and rotary stability, respectively. FMS was performed in order to determine the risk of injury by finding out the functional movement capacity and limitations of the athletes as well as eliminating the risk factors of injury and injury by applying corrective exercise programs. The total score is obtained as a result of seven movements measures the functional movement capacity of the participant (Cook et al., 2010). Before the participants started FMS, they were informed about the test by the expert.

The test started after the relevant movements performed before the test were shown to the participants in details. Participants, whose basal conditions were taken into account, were included in the test without any warming up during the test. In order to eliminate the effects of learning and practice on FMS measurement results, each participant was tested separately. During the test, each movement repeated three times. The participants were asked to report anything that caused any pain or discomfort while performing the movements. Movements first evaluated unilaterally (deep squat, trunk stability push-up), then movements evaluated bilaterally; (hurdle step, inline lunge, shoulder mobility, active straight leg raise, and rotary stability) were scored separately as right and left. During test, the participants scores were obtained from both sides of the body, the lowest score was accepted as the test result. Each movement was scored between 0 and 3 points. Therefore, the individual participating in the assessment can get a total score between 0-21. The total FMS score of the participant was calculated by calculating the scores obtained as a result of each movement. As a result of the calculation, 14 points and six participants' FMS capacity is low and the risk of injury is high; the score of 14 and above indicates a high FMS capacity and low risk of injury.

2.5. Implemented Core Exercise Protocol

TG participants regularly performed core exercise protocol for 4 days a week and 90 minutes before swimming training. It was determined that the pre-test total screen scores of the participants were selected for this group (FMS). An exercise program was applied to each participant in line with the missing total screen scores. According to the FMS pre-test results, problematic movements were determined, and corrective exercises applied to participants. The problematic movements and corrective exercises are given in Table 1.

2.6. Measurement of 50m and 100m Swimming Performance

Swimming performance of swimmers were measured with a Casio hand chronometer. Dimensions of the pool are 25 meters long and 12.5 meters wide. The swimmers started to swim by the command to exit from the starting stone of the pool to measure the swimming performance of 50m and 100m. The turns are rolled over.

Table 1. Corrective exercise programs which was applied according to FMS pre-test results

Problem Situation	Applied Exercise	Application Aim
Deep Squat: Meet criteria of 3 points with 2x6 board under heels; Knees are not aligned over feet. Tibia and upper torso are not parallel. Femur is not below horizontal; Knees are not aligned over feet.	Deep Squat Assisted with FMT	While doing squatting it was applied to the participants who had problems in ankle-knee-hip and shoulder mobility and could not get full points for this reason.
Hurdle Step: Alignment lost between hips, knees, and ankles. Lumbar flexion is noted; Contact between foot and hurdle occurs	Single-Leg Bridge	This exercise was applied to participants who had problems with the joint gap of the leg.
Hurdle Step: Alignment lost between hips, knees, and ankles. Lumbar flexion is noted; Contact between foot and hurdle occurs.	Rolling Lower Body	Participants with more core connection weaknesses to strengthen the dynamic balance deficiency and core connection
In-Line Lunge: Movement is noted in lumbar spine. Dowel and hurdle do not remain parallel. Movement is noted in torso. Feet do not remain in sagittal plane. Knee does not touch behind heel of front foot; Loss of balance is noted.	Dorsiflexion from Half Kneeling with Dowel	This movement was applied intended for participants who have problems with ankle mobility and balance.
Shoulder Mobility: Fists are within 1.5 hand Length; Fists are not within 1.5 hand lengths	Quadruped T-Spine Rotation	Due to limited T-spine mobility, it was applied to participants who could not perform shoulder mobility movement. As a result of this exercise, it is aimed to increase mobility by minimizing lumbar support.
Active Straight Leg Rise: Dowel resides between mid-thigh and joint line of knee; Dowel resides below joint line.	Active Leg Lowering	This movement was applied participants with low hip mobility and an impaired balance.
Active Straight Leg Rise: Dowel resides between mid-thigh and joint line of knee; Dowel resides below joint line.	Active Leg Lowering to Bolster	Using a brace, it was applied to participants who had much lower hip mobility and were unable to maintain balance.
Trunk Stability Push Up: Subjects perform 1 repetition in modified position. Male-thumbs aligned with chin. Female-thumbs aligned with chest; Subjects are unable to perform 1 repetition in modified position	Push-up Walkout	It was applied to athletes with low spinal stability.
Trunk Stability Push Up: Subjects perform 1 correct diagonal flexion and extension lift while maintaining torso parallel to board and floor; Subjects are unable to perform diagonal repetition.	Bird Dog - Leg Slide with lift and opposite arm lift	It was applied to athletes with low or no resistance to rotation of the body.
Rotatory Stability: Subjects perform 1 correct diagonal flexion and extension lift while maintaining torso parallel to board and floor; Subjects are unable to perform diagonal repetition.	Bird Dog - Leg slide with lift	The body's resistance to rotation was applied only to athletes with low feet.

2.7. Data Analysis

In order to determine whether the data distributed normally, Shapiro Wilk was used. As data distributed in a normal manner, non-parametric tests were conducted. The Wilcoxon Signed Ranks Test, one of the non-parametric tests, was used to determine the differences between the pre-test and post-test results of in-groups by the FMS scores of all groups and the swimming performances (TG, SG) of the participants. The effects of dependent variables on a test point of core exercises were determined through Mixed ANOVA test. The significance level in the study was accepted as $p < 0.05$.

3. Results

When Table 3 is examined, it can be seen that the FMS pre-test and post-test values of the participant are compared. As a result of the analysis, firstly, a significant difference was found between the FMS subtests and the total scores of the TG Participants ($p < 0.05$). This difference was found in favor of the post-test values in all score values. Moreover, it can be seen that there is a significant difference between the active straight leg lift and total score in SG's pre-tests and post-tests results ($p<0,05$). This difference was found in favor of the post-test values in both score values. As a result of the analysis of the pre-test and post-test values of the CG, no significant difference was observed in any of the tests. On the contrary, when the pre-test and post-test mean values were examined, a decrease occurred in the post-test values when compared to the pre-test. Occurring difference in CG can be explained by the effects of the physical activity and training on the performance and sports. It was determined that there was significant development in favor of TG in inter-groups, deep squat

Table 2. Descriptive statistical data of the physical characteristics of the TG, SG and CG participants according to pre-test and post-test.

Measurement	Variable	Training Group		Swimming Group		Control Group	
		$\bar{x}$	*SD*	$\bar{x}$	*SD*	$\bar{x}$	*SD*
Pre-Test	Height (m)	1.62	0.12	1.55	0.11	1.46	0.07
	Bodyweight (kg)	48.45	9.77	41.91	8.12	38.30	6.58
	BMI (kg/m^2)	18.47	2.80	17.34	2.35	17.96	2.53
Post- Test	Height (m)	1.64	0.12	1.57	0.11	1.49	0.09
	Bodyweight (kg)	53.36	11.32	45.45	8.81	39.20	7.04
	BMI (kg/m^2)	19.71	2.87	18.49	2.68	17.65	2.71

Table 3. Comparing the FMS pre-test and post-test measurement values of the participant groups by Wilcoxon Signed Ranks test.

	Training Group			Swimming Group			Control Group			
Parameters	Pre test	Post test	*p* value	Pre test	Post test	*p* value	Pre test	Post test	*p* value	Mixed Anova
Deep Squat	1.64±0.67	2.55±0.69	0.00*	1.82±0.60	1.73±0.65	0.32	1.30±0.48	1.20±0.42	0.56	0.001
Hurdle Step	1.55±0.82	2.4±50.52	0.01*	1.45±0.69	1.73±0.65	0.08	1.20±0.42	1.50±0.71	0.08	0.03
Inline Lunge	1.64±0.67	2.82±0.41	0.00*	1.82±0.75	1.91±0.70	0.32	1.70±0.48	1.40±0.52	0.18	0.001
Shoulder Mobility	1.82±0.75	2.64±0.51	0.02*	1.91±0.70	1.91±0.70	1.00	1.20±0.42	1.10±0.32	0.32	0.01
Active Straight Leg Raise	2.00±0.45	2.91±0.30	0.00*	1.64±0.67	2.18±0.41	0.03*	2.10±0.88	1.60±0.70	0.10	0.001
Trunk Stability Pushup	1.82±0.98	2.64±0.51	0.02*	2.27±0.91	2.27±0.65	1.00	1.70±0.48	1.40±0.52	0.18	0.001
Rotary Stability	1.00±0.45	2.00±0.63	0.01*	1.27±0.47	1.27±0.47	1.00	1.00±0.00	0.90±0.32	0.32	0.001
FMS Total Score	11.45±2.34	17.91±1.76	0.00*	12.09±2.39	13.18±1.99	0.02*	10.20±1.81	9.20±1.32	0.09	0.001

Table 4. Wilcoxon signed ranks test by comparing the swimming performances pre-test and post-test values of the TG and SG participants.

	Training Group			Swimming Group			
Parameters	Pre test	Post test	*p* value	Pre test	Post test	*p* value	Mixed Anova
50m (sec)	39.62±7.69	38.12±7.55	0.05	43.87±5.99	43.37±5.46	0.59	0.30
100m (sec)	95.84±24.91	89.24±16.68	0.01*	95.09±11.71	95.06±11.14	0.79	0.04

$p < 0.05$

Table 5. FMS total score and swimming performances of the groups pre-/post-test percentage change table.

Groups	FMS Total Score	50 m Swimming	100 m Swimming
Control Group	9.80%	-	-
Swimming Group	9.01%	1.13%	0.03%
Training Group	56.41%	3.78%	6.88%

, hurdle step, inline lunge, shoulder mobility, active straight leg raise, trunk stability pushup, rotary stability, and FMS total score parameters. In addition, it was determined that there was a statistically significant development in favor of SG between SG and CG in the parameters such as active straight leg raise, trunk stability, pushup, and FMS total score.

When Table 4 is examined, the comparison of the pre-test and post-test values of the swimming performances of the TG and the SG are given. It was determined that there was a significant difference at the pre-test/post-test values in TG 100 m swimming performance in both groups ($p < 0.05$). It was found that there was difference which was in favor of the post-test measurement group. In addition, although there was no statistically significant difference in AG 50 m swimming performance, in the post-test value, the performance period of the group decreased compared by the pre-test. Although there was no difference between the groups in the 50 m swimming performance, it was determined that there was a statistically significant difference between SG and TG in favor of TG.

When Table 5 is examined, it was determined that the highest improvement FMS total score (with 56.41%) was in TG. Besides, it was also determined that the highest improvement was in TG 50m and 100m swimming (with 3.78% and 6.88 %) respectively.

4. Discussion

One of the main requirements to be a strong swimmer is have strong core zone. Core exercises provides strength to muscle groups that keep the body in balance. Strength training without the basis of the core, restricts technical skills and increases the risk of injury. Core exercises enables athletes to apply their technical movements spending less energy as well as being exposed to the effects of fatigue less (McGill, 2004). The aim of this study was to examine the effect of core exercises on swimmers' FMS test results and swimming performance. The core exercises which was used in this study, did not create difference significantly between the pre-test and post-test values of the swimming performance of the TG and CG. In this study, when the pre-test and post-test values of the 100 m swimming performances of the

TG participants were examined, a significant difference was found in favor of the post-test (p<0,05). When inter-groups 100 mt performances are compared, it was determined that the development in TG was higher that the one in SG.

Previous studies evaluating the effect of core training applied to participants on sport performance are limited. Bıyıklı (2018) stated in his study which is performed with 40 female swimmers between the ages of 11-13 that core training sessions improved abdominal, back and leg muscles and positively contributed to physical performance. In a similar study, Özdoğru (2018) applied to dynamic core exercises 60 male swimmers between the ages of 10-12 during 8 weeks to see whether their performance improved swimming performance with selected motoric parameters. In a study conducted by Sever (2017), it was found that static and dynamic core exercises applied to 38 football players and exercises had a positive effect on core stabilization and Stork balance performance. Smart et al. (2011) stated that although the core exercises applied during 8 weeks did not have a direct effect on tennis service, they had an indirect effect as a result of the strength development in the muscles. In addition, there are different studies in the literature suggesting that applied core exercises and strength exercises improved basic motor skills and sport performance (Afyon & Boyacı, 2013; Basset & Leach, 2011).

Considering the effect of core exercises which was applied in the current study on FMS test results, a significant difference was found between the results of FMS subtests and total scores of the TG in favor of the post-test (p<0,05). In addition, when the development of FMS subtests and total scores were analyzed, it was determined that the highest development was in TG. The core exercises performed provide the improvement of functional movement patterns by reducing the asymmetries and dysfunctionalities in the body. Core exercises athletes perform provide strength development and reduce performance losses by reducing the possibility of injury. According to the FMS test results, in SG it was determined that active straight leg raising and FMS total scores of FMS subtests increased significantly in the post test (p<0,05). This may due to the fact that swimmers who train regularly reduce the asymmetries in the body as a result of generally applying bilateral movements during swimming. According to this result, it is thought that as a result of the coordinated use of body parts in swimming, can provide the improvement of functional movement patterns of athletes.

There is no study in the literature to compare with the current study to see the effects of the core exercises and swimming training on FMS test. In the literature, it is seen that there are studies examining the effect of corrective exercises on FMS test results. Aktuğ et al. (2019) calculated the shoulder mobility and FMS total scores of corrective exercises applied to female volleyball players during 12 weeks. Campa et al. (2019) calculated the total score of the young elite male soccer players by means of FMS test of the corrective exercise program which was applied for 20 weeks. Stanek et al. (2017) suggested that FMS total score of the 8-week personalized corrective exercise program applied to firefighters have effects on their performance. Tejani et al. (2019) conducted the FMS test results with a standardized exercise program and corrective exercise programs of female athletes (football, softball, basketball); Kiesel et al. (2011) was determined that corrective exercises applied to the professional football players significantly improved the FMS total score in the post-test.

The common point of the above-mentioned studies shows that corrective exercises can improve functional movements in different types of sports, so it supports our conclusion that corrective exercises and core exercises with similar characteristics can also improve functional movements.

As a result, swimming training improved the FMS total score; it was found that core exercises adopted to swimming training additionally improved swimming performance with FMS subtests and total score. Therefore, it is thought that the feature of the swimming branch is important in the improvement of functional movement patterns, and that the core exercises which were applied additionally, improved the performance by increasing the efficiency of functional movements and can create a protective strategy in injuries. When it is desired to improve the functional movement patterns of athletes, it may be recommended to participate in swimming training and perform core exercise programs additionally, especially in transition periods when athletes perform no exercises.

It is thought that participants of the current study consist of young athletes aged between 12 and 15 and performing only 10 exercises related to core area are considered as limitations. Moreover, it is recommended that in the studies which will be conducted later, different exercise protocols should be applied to the core area as well as evaluating different sport branches with different age groups.

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