YALOVA ÜNİVERSİTESİ SPOR BİLİMLERİ DERGİSİ
YALOVA UNIVERSITY JOURNAL OF SPORTS SCIENCES

CİLT: 4 SAYI: 2 YIL: 2025

ISSN: 2822-664X

Effects of Proprioceptive and Core Exercise Applications on Vertical Jump and Swimming Performance in Female Swimmers

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DOI: 10.70007/yalovaspor.1772099 ORIJINAL MAKALE

Abstract
The study investigated the effects of proprioceptive+core exercises on female swimmers' 25-meter freestyle technical swimming performance and vertical jump performance. Sixteen females aged 20-26 with at least three year of swimming experience participated in the study. Participants were divided into two groups: Proprioceptive+Core Exercise Group (PCEG) (n=8 women) and the Control Group (CG) (n=8 women). The experimental group applied proprioceptive+core exercises in addition to their swimming training twice a week for 6 weeks, while the control group continued their routine swimming training twice a week. When the pretest and posttest results were examined, the 25-meter freestyle technical swimming performance of the proprioceptive+core experimental group was measured as 23.33±2.51 in the pretest and 21.66±2.59 in the posttest. The vertical jump performance of the proprioceptive+core experimental group was 18.73±6.43 in the pretest and 23.48±7.30 in the posttest. When the pretest and posttest were compared, significant differences were found in the experimental group's 25-meter freestyle technical swimming performance (p=0.004) and vertical jump performance (p=0.001). In the control group, the 25-meter freestyle technical swimming performance was measured as 24.58±1.56 in the pretest and 24.25±1.34 in the posttest. The vertical jump performance of the control group was measured as 13.76±1.66 in the pretest and 16.07±1.74 in the posttest. Significant improvements were found in the 25-meter freestyle technical swimming performance of the proprioceptive+core experimental group (mean difference -1.67±1.13 sec; posttest 21.66±2.59 sec). The 25-meter freestyle technical swimming performance between the groups was found to be significant (p=0.020). The vertical jump performance of the proprioceptive+core group was higher (mean difference: 4.75±2.19 cm; posttest: 24.25±1.34 cm), while the vertical jump performance of the control group (mean difference: 2.31±1.37 cm; posttest: 16.07±1.74 cm) was lower. The difference between the groups was statistically significant (p=0.018). Six weeks of proprioceptive+core exercises were found to have positive effects on the 25-meter freestyle technical swimming times and the vertical jump performance test in female swimmers. The findings suggest integrating proprioceptive+core exercises into swimming training would improve performance.

Keywords: *Core Stability, Proprioception, Female Swimmers, Vertical Jump, Swimming Performance*

Kadın Yüzücülerde Proprioseptif ve Core Egzersiz Uygulamalarının Dikey Sıçrama ve Yüzme Performansına Etkisi

Özet

Çalışmanın amacı; kadın yüzücülerde proprioseptif+core egzersizlerinin 25 metre serbest teknik yüzme performansı ile dikey sıçrama performansı üzerine etkilerini incelemektir. Çalışmaya 20-26 yaş arası en az üç yıllık yüzme geçmişine sahip 16 kadın katılmıştır. Katılımcılar Proprioseptif+Core Egzersiz Grup (PCEG) (n=8) ve Kontrol Grubu (KG) (n=8) olmak üzere ikiye ayrılmıştır. Deney grubu 6 hafta boyunca haftada iki kez yüzme antrenmanlarına ek olarak proprioseptif+core egzersizler uygularlarken kontrol grubu haftada 2 kez rutin yüzme antrenmanlarına devam etmiştir. Ön-test ve son-test sonuçları incelendiğinde proprioseptif+core uygulayan deney grubunun 25 metre serbest teknik yüzme performansı ön-testte 23,33±2,51, son-testte 21,66±2,59 olarak ölçülmüştür. Proprioseptif+core uygulayan deney grubunun dikey sıçrama performansı ön-testte 18,73±6,43, son-testte 23,48±7,30 olarak bulunmuştur. Ön-test ve son-test karşılaştırıldığında deney grubunun 25 metre serbest teknik yüzme performansında (p=0,004) ve dikey sıçrama performansında (p=0,001) anlamlı farklılıklar bulunmuştur. Kontrol grubunda ise 25 metre serbest teknik yüzme performansı ön-testte 24,58±1,56, son-testte 24,25±1,34 olarak ölçülmüştür. Kontrol grubunun dikey sıçrama performansı ön-testte 13,76±1,66, son-testte 16,07±1,74 olarak ölçülmüştür. Proprioseptif+core uygulayan deney grubunun 25 metre serbest teknik yüzme performansında anlamlı iyileşmeler bulunmuştur (ortalama fark -1,67±1,13 sn; son-test 21,66±2,59 sn). Gruplar arasındaki 25 metre serbest yüzme performansı anlamlı bulunmuştur (p=0,020). Proprioseptif+core uygulayan deney grubunun dikey sıçrama performansı (ortalama fark 4,75±2,19 cm; son test 24,25±1,34 cm) daha yüksek, kontrol grubunun dikey sıçrama performans testi (ortalama fark 2,31±1,37 cm; son test 16,07±1,74 cm) daha düşük bulunmuştur. Gruplar arasındaki fark istatistiksel olarak anlamlıdır (p=0,018). 6 haftalık proprioseptif+core egzersizlerin kadın yüzücülerde 25 metre serbest teknik yüzme derecelerinde ve dikey sıçrama performans testinde pozitif etkiler yarattığı görülmüştür. Bulgular proprioseptif+core egzersizlerinin yüzme antrenmanlarına entegre edilmesinin performans gelişimi açısından yararlı olacağını göstermektedir.

Anahtar Kelimeler: *Gövde Stabilitesi, Propriyosepsiyon, Kadın Yüzücüler, Dikey Sıçrama, Yüzme Performansı*

Introduction

Because swimming takes place in an environment approximately 800 times denser than air, it requires athletes to develop not only a high level of fitness but also a complex adaptation process (Guignard et al., 2017). Factors that determine performance in competitive swimming are quite diverse; the primary factors are the muscular force generated during the stroke, the technique employed, aerobic capacity, and anaerobic energy production (Morouço et al., 2014). In fact, the role of force production in swimming performance has long been debated (Yeater et al., 1981), with many studies emphasizing that the force transferred into the water is a critical element for success (Dominguez-Castells et al., 2013; Morouço et al., 2014; Aspenes & Karlsen, 2012; Girold et al., 2007; Sadowski et al., 2020).

Strength and power training improves force transfer to the wall via short-term contact (Chow et al., 1984; Hermosilla et al., 2021; Jones et al., 2018a; Potdevin et al., 2011). Initial swimming performance requires reaction time, vertical and horizontal force from the block, and low resistance during underwater glide (Keiner et al., 2021). The importance of lower-body power at the start of the swim is evident in strong ($r = -0.74$) negative correlations with lower-limb maximum power at 10 meters and moderate to strong ($r = -0.59$) negative correlations at 15 meters (Tanner, 2001; West et al., 2011). Swim start and turn times are related to vertical jump performance; vertical jump tests also measure lower extremity explosive power in swimmers. (García-Ramos et al., 2016; West et al., 2011; Jones et al., 2018b).

Proprioception is the ability to determine body position and movements in space by integrating sensory signals from various mechanoreceptors (Han et al., 2015; Hoffman & Payne, 1995; Rivera et al., 2017; Yoo et al., 2018). High-skill performance requires better proprioceptive ability than routine activities (Han et al., 2015; Muaidi et al., 2009). Core training programs include processes that target muscle strengthening and motor control of core muscles (Hibbs et al., 2008). Core training has become a well-known practice for injury prevention and improving athletic performance (Al Attar & Husain, 2023; Hibbs et al., 2008; Tse et al., 2005). Therefore, we hypothesise that core and proprioceptive training induce neuromuscular effects that enhance swimming performance.

While the literature has examined the effects of core and proprioceptive training on sports performance in various sports, studies evaluating these two training approaches in conjunction with each other in female swimmers are limited. The current study investigates the effects of proprioceptive and trunk training on female swimmers' vertical jump and swimming performance. We hypothesise that the training program will significantly increase lower extremity explosive power and in-water performance measurements.

Materials and Methods

Research Group

The study included 16 female participants aged 20 to 26 who were involved in swimming, had a history of regular swimming for three years, were healthy, and were randomly selected from the adult population as volunteer participants. They were divided into two groups: the Proprioceptive+Core Exercise Group (PCEG) (8 women) and the Control Group (CG) (8 women). Two measurements were taken: a pretest and a posttest. All participants were informed about the research and were willing to participate by completing the consent form. The training programs were implemented at the Bingöl Provincial Directorate of Youth and Sports Swimming Pool. Demographic information about the participants is presented in Table 1.

Inclusion Criteria:

(1) Female, (2) Female between the ages of 20 and 30, (3) Regular participation in training sessions for the last 6 months, (4) Not dependent on any nutritional supplements or medications, (5) Not having an orthopedic, neuromuscular disease, or orthopedic injury, (6) Not having a musculoskeletal injury in the last 6 months

Exclusion Criteria:

(1) Individuals who took a break from swimming for any reason in the last 3 months, (2) Individuals who did not consistently participate in an exercise program, (3) Individuals with neurological, chronic diseases, or orthopedic injuries, (4) Those who regularly use medications or nutritional supplements, (5) Individuals who did not participate in pretest or posttest measurements.

Table 1.

Demographic Information of Participants

Variables	Experimental Group (n=8)			Control Group (n=8)		
	$\bar{x} \pm$ SD	Min	Max	$\bar{x} \pm$ SD	Min	Max
Age (years)	22.87±2.35	20.00	26.00	22.50±2.39	20.00	26.00
Height (cm)	164.50±4.98	157.00	172.00	162.50±3.85	155.00	167.00
Weight (kg)	62.25±9.05	53.00	78.00	57.50±5.90	50.00	67.00

$\bar{x}$: Mean, SD: Standard Deviation, Min: Minimum; Max: Maximum

Procedures

A total of 16 female participants were included in the study and were divided into two groups: the Proprioceptive+Core Exercise Group (PCEG) (n=8 women) and the Control Group (CG) (n=8 women). Two measurements were taken for the study: pretest and posttest. The exercise group implemented a training program for 90 minutes, twice a week, for 6 weeks. In addition to swimming exercises, the exercise group also included 30 minutes of proprioceptive+core training at the beginning of training. The control group implemented a training program for 60 minutes, twice a week, for 6 weeks. Height, body weight, vertical jump test, and 25-meter freestyle technical swimming times were evaluated.

The action was taken within the framework of the "Higher Education Institutions Scientific Research and Publication Ethics Directive".

Training Protocol

Swimming Training Program

The study group completed 90 minutes of swimming exercises (warm-up, main phase, and cool-down) twice weekly for 6 weeks. The Proprioceptive+Core Exercise Group (PCEG) group began each swimming training program with 30 minutes of proprioceptive+core training followed by 5-10 minutes of warm-up exercises in the water. During the 60-minute main phase, the exercise group performed drills and swimming performances in four strokes: freestyle, backstroke, breaststroke, and butterfly. In the final cool-down phase of the training, the exercise group completed 5-10 minutes of cool-down swimming exercises in the water. The control group participated in routine swimming training twice a week.

Proprioceptive Training Program

The exercise group completed 15 minutes of proprioceptive exercises twice a week for 6 weeks, in addition to swimming exercises. Each exercise was planned to be three repetitions, with each exercise lasting 1 minute and training was carried out with 30 seconds of rest between movements.

Table 2.

6-Week Proprioceptive Training Program

Training Content	Sets	Reps	Tempo	Rest
- Reaching forward on one leg *- Touching the skittle in 4 directions with the other foot on one foot* *- Ball squat on hands on Bosu ball* *- Jump squat on Bosu ball*	3	1 min.	Low intensity	30 seconds between exercises 2 minutes between sets.

Core Training Program

The exercise group performed 15 minutes of core exercises in addition to swimming training twice a week for 6 weeks. Each exercise was planned for 12 repetitions, three sets and 30 seconds of rest between repetitions. The movements were performed fluidly and at a moderate pace. Each training session included 3-5 minutes of basic stretching and stretching exercises.

Table 3.

6-Week Core Training Program

Training Content	Sets	Reps	Tempo	Rest
Plank *Hundred* *Reverse crunch* *Criss cross* *Double leg stretch* *Reverse table tabe* *Heel Touchers*	3	12 reps	Low Intensity	30 seconds between exercises 2 minutes between sets.

Data Collection Tools

Height: Subjects were measured with a stadiometer with a precision of 0.01 m, while holding their breath, without shoes, with their heels and big toes together, standing upright on a flat surface, and with their bodies straight.

Body Weight: Subjects were measured without shoes, in sportswear (tracksuit and T-shirt), and with an electronic scale with a precision of 0.1 kg, in accordance with the required measurement technique.

Vertical Jump Test: This test was conducted using a SmartJump mat. Subjects were asked to jump upwards with both feet on the mat, knees slightly bent, and arms down. When the feet leave the ground, the knees must be straight. Two repetitions were performed, and the best jump height was determined by passing a rock.

25 m Freestyle Technical Swimming Times: The participants' 25-meter freestyle swimming times were recorded using a sports stopwatch.

Data Analysis

Mac Excel and SPSS (Statistical Package for the Social Sciences) 29.0 programs were used to analyse the data obtained from the study. Descriptive statistics such as percentage, arithmetic mean, and standard deviation were used to evaluate the data set in detail. The Shapiro-Wilk test was applied to determine whether the data exhibited a normal distribution, and the distribution was found to be normal. In this regard, the Dependent Samples T-Test was used to examine the differences between the pretest and posttest measurements of the experimental and control groups, and the Independent Samples T-Test was used to evaluate the differences between the groups. In all statistical analyses, p<0.05 was considered a significance level.

Ethics of Research

The research was approved by the Atatürk University Faculty of Sports Sciences Ethics Committee with decision number 2025/6 (050.02.04-2500196374) dated June 18, 2025.

Results

Table 4.

Examination of Pretest and Posttest Changes in Participants' Swimming and Vertical Jump Performance

Groups	Variables	N	Pretest $\bar{x} \pm SD$	Posttest $\bar{x} \pm SD$	t	*p*
EG	25 m Freestyle Technical Swimming (sn)	8	23,33±2,51	21,66±2,59	4,176	0,004*
	Vertical Jump Performance (m)	8	18,73±6,43	23,48±7,30	-6,132	0,001*
CG	25 m Freestyle Technical Swimming (sn)	8	24,58±1,56	24,25±1,34	1,038	0,334
	Vertical Jump Performance (m)	8	13,76±1,66	16,07±1,74	-4,765	0,002*

*EG: Experiment Group; CG: Control Group, $\bar{x}$: Mean, SD: Standard Deviation, *: Statistical Significant p<0,05*

When Table 4 is examined, the 25-meter freestyle technical swimming performance of the experimental group applying proprioceptive+core exercises was measured as 23.33±2.51 in the pretest and 21.66±2.59 in the posttest. The vertical jump performance of the experimental group applying proprioceptive+core exercises was 18.73±6.43 in the pretest and 23.48±7.30 in the posttest. Significant differences were found in comparing the pretest and posttest in the experimental group's 25-meter freestyle technical swimming performance (p=0.004) and the vertical jump performance test (p=0.001). Looking at the control group, the 25-meter freestyle swimming performance was measured as 24.58±1.56 in the pretest and 24.25±1.34 in the posttest. The vertical jump performance of the control group was measured as 13.76±1.66 in the pretest and 16.07±1.74 in the posttest. While there was no significant difference in the 25-meter freestyle technical swimming performance of the control group, significant differences were found in comparing the pretest and posttest in the vertical jump performance test (p=0.002).

Table 5.

Examination of Differences Between Groups in Swimming and Vertical Jump Tests

Variables	Groups	N	$\bar{x}$ ± SD	$\bar{x}$ ± SD	t	p
25 m Freestyle Technical Swimming (sn)	**EG**	8	-1,67±1,13	21,66±2,59	-2,636	0,020*
	CG	8	-,32±0,89	23,48±7,30		
Vertical Jump Performance (m)	**EG**	8	4,75±2,19	24,25±1,34	2,667	0,018*
	CG	8	2,31±1,37	16,07±1,74		

*EG: Experiment Group; CG: Control Group, $\bar{x}$: Mean, SD: Standard Deviation, *: Statistical Significant p<0,05*

Table 5 shows the intergroup comparisons of the experimental and control groups in swimming and vertical jump tests. Significant improvements were found in the 25-meter freestyle technical swimming performance of the experimental group that applied proprioceptive+core exercises (mean difference -1.67±1.13 sec; posttest 21.66±2.59 sec). The mean change was much less in the control group (mean difference -0.32±0.89 sec; posttest 23.48±7.30). The 25-meter freestyle swimming performance between groups was statistically significant (p=0.020). The vertical jump performance test of the experimental group that applied proprioceptive+core exercises (mean difference 4.75±2.19 cm; posttest 24.25±1.34 cm) was found to be higher, while the vertical jump performance test of the control group (mean difference 2.31±1.37 cm; posttest 16.07±1.74 cm) was found to be lower. The difference between the groups is statistically significant (p=0.018).

Discussion

A total of 16 female participants were included in the study and were divided into two groups: the Proprioceptive+Core Exercise Group (PCEG) (n=8 women) and the Control Group (CG) (n=8 women). The exercise group implemented a training program for 90 minutes, twice a week, for 6 weeks. In addition to swimming exercises, the exercise group also included 30 minutes of proprioceptive+core training at the beginning of training. The control group implemented a training program for 60 minutes, twice a week, for 6 weeks.

Table 4 shows significant differences in the pre-test and post-test comparisons of the 25-meter freestyle technical swimming performance (p=0.004) and vertical jump performance test (p=0.001) of the experimental group that applied proprioceptive+core exercises. While no significant difference was observed in the 25-meter freestyle technical swimming performance of the control group, significant differences were found in the vertical jump performance test when the pre-test and post-test were compared (p=0.002).

Table 5 shows the intergroup comparisons of the experimental and control groups in the swimming and vertical jump tests. Significant improvements were found in the 25-meter freestyle technical swimming performance of the experimental group that applied proprioceptive+core exercises (mean difference -1.67±1.13 sec; post-test 21.66±2.59 sec). The mean change in the control group was much less (mean difference -0.32±0.89 sec; post-test 23.48±7.30). The 25-meter freestyle technical swimming performance between the groups was found to be statistically significant (p=0.020). The vertical jump performance test of the experimental group that applied proprioceptive+core exercises (mean difference 4.75±2.19 cm; post-test 24.25±1.34 cm) was higher, while the vertical jump performance test of the control group (mean difference 2.31±1.37 cm; post-test 16.07±1.74 cm) was lower. The difference between the groups is statistically significant (p=0.018).

Strengthening the muscle groups responsible for proper body position is essential for swimming technique. Harmonious alignment of the head, shoulders, trunk, pelvis, and legs minimizes hydrodynamic resistance, increasing performance efficiency (Bishop et al., 2013; Karpinski et al., 2020). Proprioceptive and core training are linked to improvements in muscle strength, joint stability, and postural balance, essential for mastering technical skills in sports (Khorjahani et al., 2021; Weston et al., 2015). Therefore, core and proprioceptive exercises may have improved trunk stability, enabled swimmers to maintain more accurate alignment in the water, and facilitated more efficient transmission of force generated from the upper and lower extremities. In this study, as a result of 6 weeks of proprioceptive and core exercises, significant differences were found in the vertical jump test in the experimental group in the comparison of pretest and posttest (p=0.001) and in the 25-meter freestyle technical swimming performance in the pretest and posttest (p=0.004) comparison. Statistically significant differences were found in the vertical jump performance test when comparing the pretest and posttest of the control group (p=0.002). This improvement may have occurred due to the natural effect of swimming training. Significant improvements were found in the 25-meter freestyle technical swimming performance of the experimental group that applied proprioceptive+core exercises (mean difference -1.67±1.13 sec; posttest 21.66±2.59 sec). 25-meter freestyle technical swimming performance between groups was statistically significant (p=0.020). The vertical jump performance test of the experimental group applying proprioceptive+core exercises was found to be (mean difference 4.75±2.19 cm; posttest 24.25±1.34 cm), while the vertical jump performance test of the control group was found to be (mean difference 2.31±1.37 cm; posttest 16.07±1.74 cm). The difference between the groups was statistically significant (p=0.018).

The findings of our study support the literature. In a study by Karpinski et al. (2020) on Polish swimmers, a statistically significant improvement of 0.3 seconds (-1.2%, p = 0.001) was observed in 50 m freestyle swimming performance following a 6-week specific training session to strengthen the core muscles. Similarly, Weston et al. (2015) observed increased performance in young swimmers after 12 weeks of core training. Gencer (2018) concluded that 8 weeks of low-intensity core exercises reduced 25- and 50-meter freestyle times and improved splash performance in 9- to 12-year-old swimmers compared to a control group. Patil et al. (2014) also found that core muscle strengthening exercises significantly improved 50-meter freestyle swimming. Core exercises use the body's trunk as a power transmission hub and optimize force transmission between the upper and lower extremities, improving athlete movement efficiency (Luo et al., 2022) These parallel findings suggest that core exercises may improve in-water performance.

As a result of this study found significant improvements in both vertical jump performance and 25-meter in-water performance in the group that performed an additional 6 weeks of proprioceptive+core exercises. These findings highlight proprioceptive exercises' potential to improve athletes' balance skills and dynamic neuromuscular control (de Vasconcelos et al., 2020; Yilmaz et al., 2024). Zacharakis et al. (2020) found that 8 weeks of proprioceptive exercises improved passing technique in both male and female basketball players and shooting technique in male players. Souglis et al. (2023) also reported that proprioceptive exercises effectively improved coordination, balance, and proprioception, crucial for improving technical skills in sports. Proprioceptive exercises can positively affect speed, agility, and jumping performance due to their effect on rapid power production, acceleration, and smoother direction changes (Winter et al., 2022; Yilmaz et al., 2024).

Gruber and Gollhofer (2004) stated that the rapid transition from eccentric to concentric muscle contractions in vertical jumps affects explosive force development and that proprioceptive exercises can activate more motor units, potentially affecting rapid power production. The increased vertical jump performance suggests that core and proprioceptive training improve athletes' explosive strength and neuromuscular efficiency.

The combined application of core stability and proprioception-focused exercises contributes to the development of trunk control and balance in swimmers, thereby increasing force transfer efficiency. Indeed, the literature has shown that proprioceptive training provides indirect contributions to athletic performance, particularly by improving balance (de Vasconcelos et al., 2020) and coordination (Yilmaz et al., 2024) and mediating more efficient use of motor skills (Romero-Franco et al., 2012). Therefore, the core and proprioceptive exercises implemented in our study likely contributed to the improvements observed in the swimmers' vertical jump performance and 25-meter swim time by more effectively directing whole-body strength into forward motion.

Conclusion

Proprioceptive exercise practices have improved vertical jump and swimming performance in female swimmers. Core exercises enhance muscular endurance and strength, while proprioceptive exercise methods are thought to strengthen the vestibular system by coordinating it. Developing muscle strength and endurance and maintaining and improving balance skills is crucial for preventing and mitigating injuries that may arise from accidents, joint-muscle problems, and falls.

Proprioception is closely linked to body movement control, which positively improves performance outcomes. Therefore, the effects of proprioceptive exercise practices added to training sessions may vary depending on the type of sport, age, and gender of the individual. In other words, when transforming athletic performance into measurable and verifiable methods, training content's intensity, duration, and frequency are crucial.

Recommendations

From a swimming training perspective, it is suggested that the proprioceptive+core exercise method positively impacts performance and can be incorporated into swimming training programs.

In addition to future swimming training, increasing the duration proprioceptive+core exercises and extending training programs over weeks or months are recommended, as these can positively impact performance development.

In future similar studies, it is recommended that gender-differentiated groups be included and incorporated into training programs.

Limitations

Although we found significant results in our study, the sample size was small (8 swimmers per group). All participants were adult female swimmers. There may be differences in the male population across different age groups.

Ethics Committee Permission Information

Ethics evaluation board: Ataturk University Faculty of Sports Sciences Ethics Board
Date of ethical evaluation document: 18.06.2025
Number of the ethics assessment document: E-70400699-050.02.04-2500196374

Declaration of Contributions by Researchers

The procedure part of the research was carried out by the first author, the processes related to the method and findings part were carried out by the first and second authors, the processes related to the introduction part were carried out by the second author, and the processes related to the discussion and conclusion part were carried out by all authors.

Conflict Statement

The authors have no conflict of interest declarations regarding the research.

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