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Immediate Effects of Core Training on Shoulder Muscle Strength and Pull Motion in Swimming

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Abstract

In competitive swimming, on-the-ground training, also called "dry-land training," is performed to improve swimming performance and prevent injury before and after underwater physical activity. This study aimed to elucidate the immediate effects of core muscle training, which is commonly performed by many athletes, on shoulder muscle strength and pull motion in water. Eleven swimmers enrolled in the Japan Intercollegiate Championship Division 1 participated in this study. The participants performed seven types of core training exercises, primarily focusing on abdominal drawing-in and stabilization training. Bilateral shoulder muscle strength was measured before and after core training and the time needed to perform a 15-m swim with pull motion without kicking was monitored. Shoulder muscle strength was measured using a handheld dynamometer in three different positions: catch, pull, and finish. The right and left shoulder muscle strength pre/post core training were, respectively, 15.1±3.5/17.1±4.3 kgf and 14.4±2.9/15.8±3.1 kgf in the catch position, 15.2±3.4/16.8±5.6 kgf and 16.3±3.4/16.7±4.1 kgf in the pull position, and 10.4±2.1/11.1±3.2 kgf and 12.6±1.0/13.0±2.9 kgf in the finish position. Significant improvements in bilateral shoulder muscle strength were observed in the catch position after the core training. Furthermore, the 15-m swim time improved significantly from 11.4±0.7 s to 10.9±0.5 s after core training ($p<0.05$). These findings suggest that shoulder muscle strength improved immediately after core training. Moreover, the muscle strength in the catch position significantly contributed to the improvement in swimming speed in the pull motion.

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Introduction

Training outside of the water, known as "dry-land training," is a very important in competitive swimming, as it can ameliorate the athlete's swimming performance, as well help to avoid injuries. The training program focuses on various aspects, such as stretching, core muscle training, and strength and endurance training. Different effects of dry-land training on swimming have been reported previously [1-8]. Hermosilla et al. and Amaro et al. concluded in their reviews that dry-land training is important to improve swimming turn performance [1,2]. Moreover, several studies have described the effects of core muscle training on swimming performance [4-8]. Core muscle training was originally performed as rehabilitation for patients with low back pain. In particular, patients with chronic low back pain have insufficient contraction of the transverse abdominal muscles and multifidus muscles located deep in the trunk, which adversely affects extremity movements. Therefore, training of the trunk, and especially of the deep muscles called the core, has positive outcomes not only in sports but also in rehabilitation. Karpiński et al. reported that a 6-week core training program comprising of relatively high-intensity exercise with trunk movement improved the 50m front crawl swimming performance of the study subjects [5]. Ji et al. observed that the core training group (in which participants performed stabilization exercises with limited movement) exhibited improvement not only in the personal record of swimming but also in core stability and muscle endurance of the upper extremities compared to the traditional weight training group [6]. Thus, the types and purposes of core training may be diverse. It should be noticed that most of the previous studies on the effects of core training have been longitudinal, with only a few reports on the short-term and immediate effects.

This study aimed to elucidate the immediate effect of core muscle training, which is commonly performed by swimmers, on shoulder muscle strength and swimming speed only in the pull motion of the upper extremities, without kicking.

Methods

Eleven male swimmers (mean age, 19.5±0.5 years) enrolled in the Japan Intercollegiate Championship Division 1 participated in this study. The participants performed seven types of core training exercises, primarily focusing on drawing-in the abdominal and stabilization training (Figure 1). They were instructed to perform two sets of 30-s exercise. Bilateral shoulder muscle strength was measured before and after core training using a handheld dynamometer (Mobie; Sakai Medical Co., Ltd.) in three different positions: entry-catch phase (catch position), pull-push phase (pull position), and finish phase (finish position) (Figure 2). Furthermore, the time needed to perform a 15m swim with pull motion without kicking was recorded after measuring shoulder muscle strength. To obtain this measurement, the participants were instructed to start with only a pull motion of the upper extremities and they were not allowed to jump from the diving platform or kick the wall underwater.

Wilcoxon signed-rank test and Pearson's correlation analysis were performed as statistical analysis, and the significance was set at $p< 0.05$. All statistical analyses were conducted using IBM SPSS Statistics 19.

This study was approved by the Research Ethics Review Board of the School of Science and Engineering of Kokushikan University (No.28-24, 2016), and we obtained informed consent from all participants.

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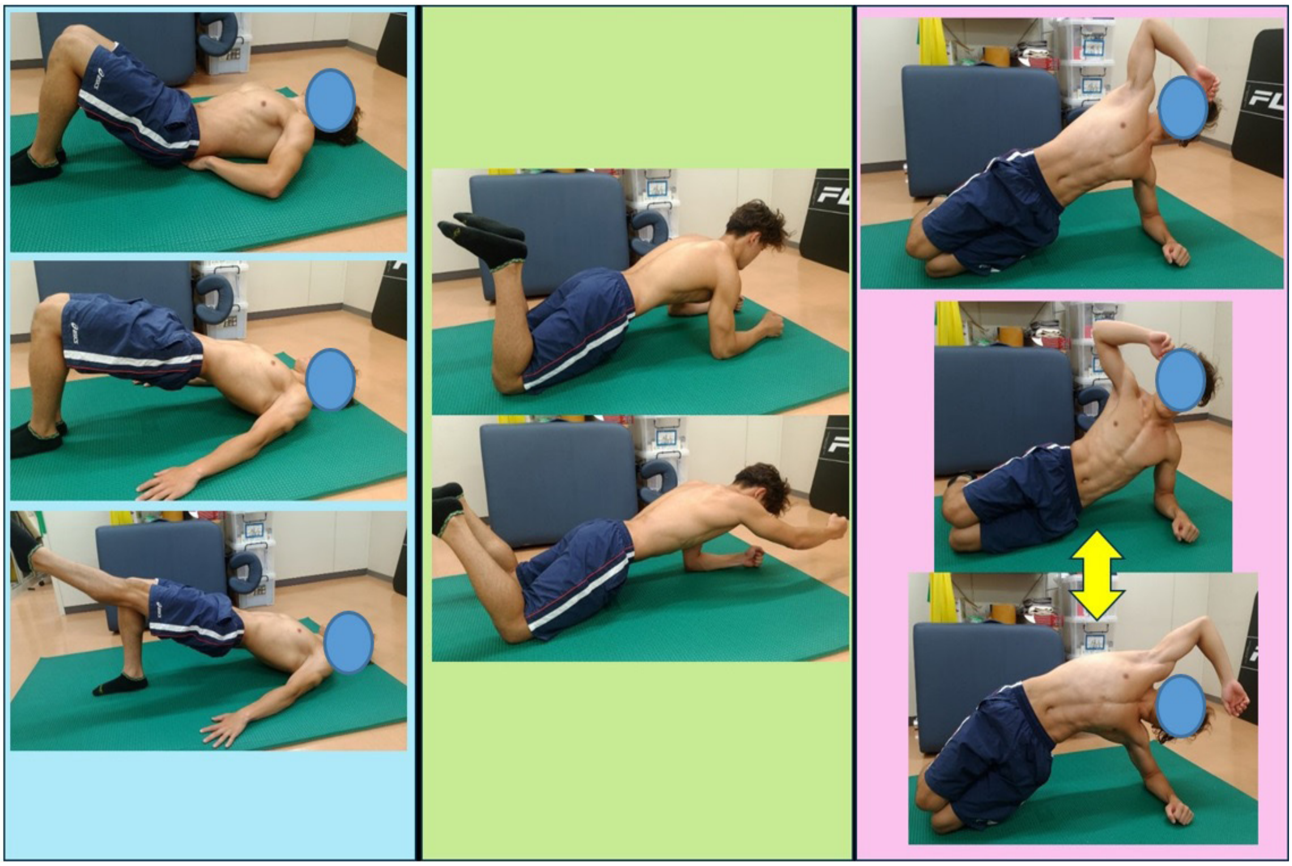

Figure 1: Intervention core training.

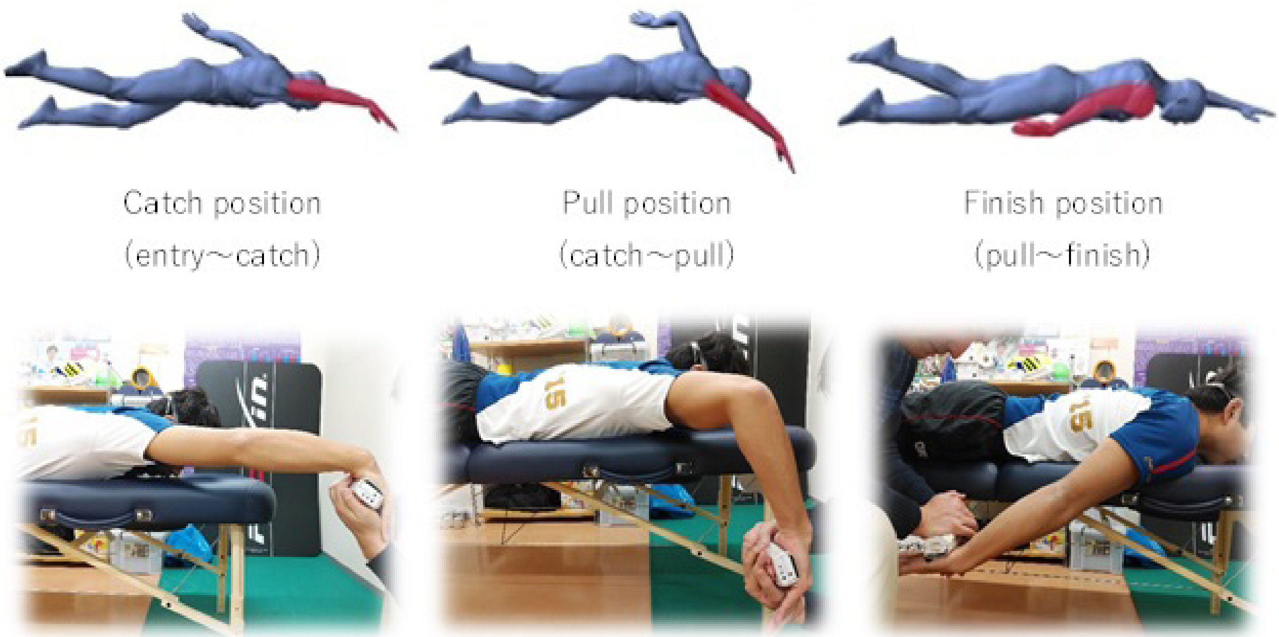

Figure 2: Measurement of shoulder muscle strength in three different positions.

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Results

The results of the right and left shoulder muscle strength pre-/post- core training were, respectively, 15.1±3.5/17.1±4.3 kgf and 14.4±2.9/15.8±3.1 kgf in the catch position (Figure 3), 15.2±3.4/16.8±5.6 kgf and 16.3±3.4/16.7±4.1 kgf in the pull position (Figure 4), and 10.4±2.1/11.1±3.2 kgf and 12.6±1.0/13.0±2.9 kgf in the finish position (Figure 5). After core training, although improvements in the bilateral shoulder muscle strength were observed in all positions, a significant improvement was observed only in the catch position (p= 0.003, p= 0.003) (Figure 3). In addition, the 15-m swim time with pull motion improved significantly from 11.4±0.7 s to 10.9±0.5 s after core training (p=0.018) (Figure 6). Only the muscle exertion in the catch position at the post-training showed a significant negative correlation with swimming time (Rt: r= -0.621, p=0.042, Lt: r= -0.613, p= 0.045) (Table 1).

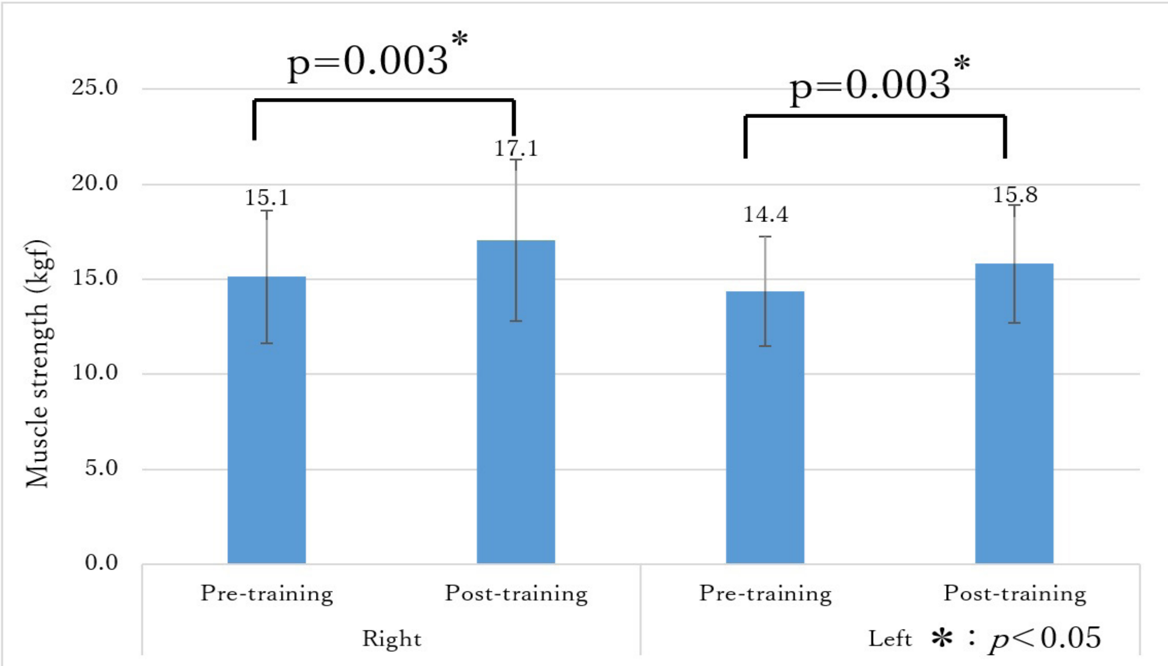

Figure 3: Right and left shoulder muscle strength in catch position Values are means ± standard deviation.
Wilcoxon signed-rank test was used to compare the values of pre- and post- training. Asterisk indicates a significant difference (p<0.05).

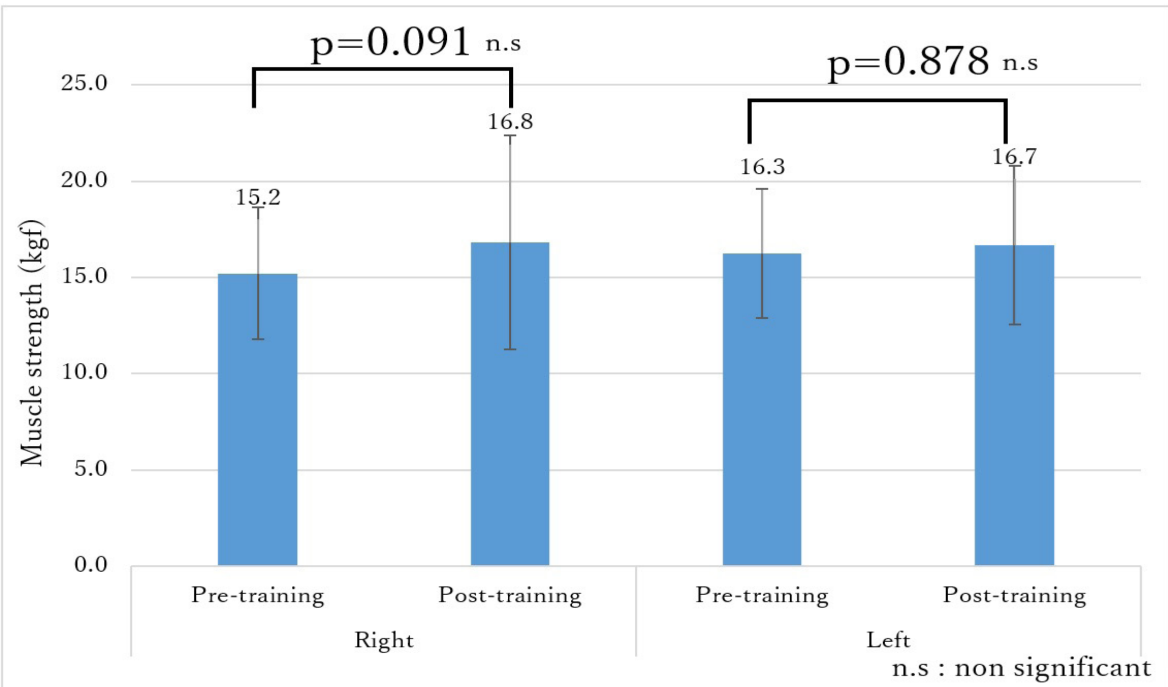

Figure 4: Right and left shoulder muscle strength in pull position Values are means ± standard deviation.
Wilcoxon signed-rank test was used to compare the values of pre- and post- training.

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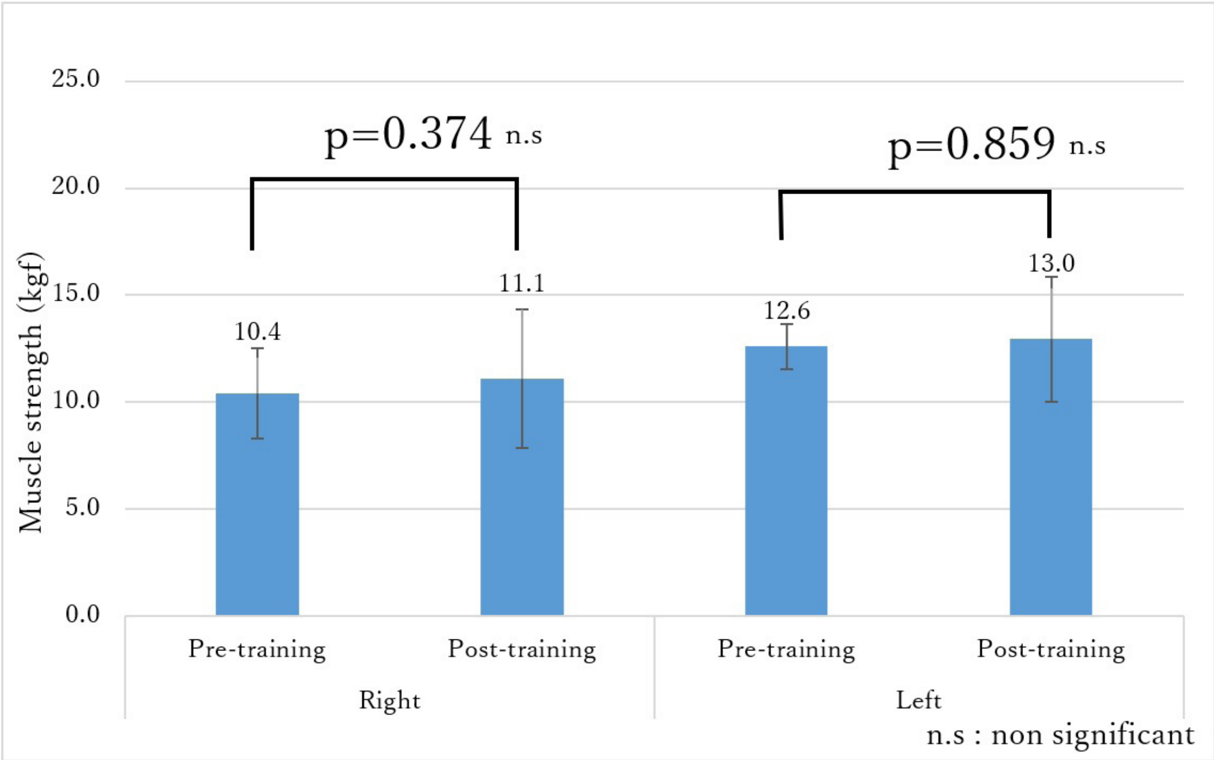

Figure 5: Right and left shoulder muscle strength in finish position Values are means ± standard deviation.
Wilcoxon signed-rank test was used to compare the values of pre- and post- training.

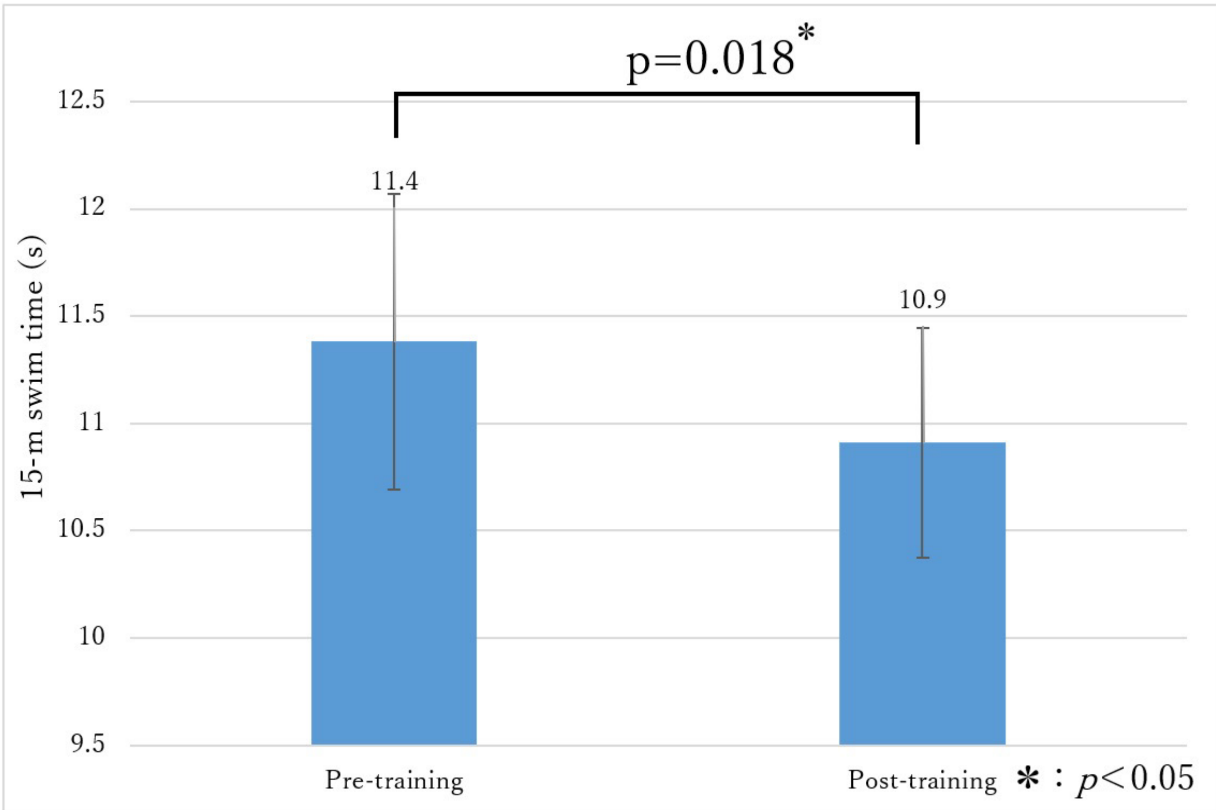

Figure 6: The 15-m swim time with pull motion Values are means ± standard deviation.
Wilcoxon signed-rank test was used to compare the values of pre- and post- training. Asterisk indicates a significant difference ($p<0.05$).

	Rt-Catch	Lt-Catch	Rt-Pull	Lt-Pull	Rt-Finish	Lt-Finish
pre-training	-0.250	-0.263	-0.212	-0.259	-0.335	-0.309
post-training	-0.621*	–0.613*	-0.545	-0.595	0.002	0.057

Table1: Correlation between 15-m swim time with pull motion and muscle strength in each position.
Pearson's correlation analysis was used to elucidate the correlation between 15-m swim time with pull motion and muscle strength in each position. Asterisk indicates a significant difference ($p<0.05$).

Discussion

In this study, a core training program, focusing primarily on stabilization, resulted in significant immediate enhancements in swimming performance and shoulder muscle strength. A significant improvement was observed only in the catch position, suggesting that the improvement in the 15m swim time with pull motion is closely related to the improvement in muscle strength in the catch position. Many studies have examined the longitudinal effects of 6-12 weeks of core training [4-7]; however, only few studies, including the present one, have reported an immediate improvement in performance after core training. Iizuka et al. described an immediate improvement in start performance following different types of trunk stabilization exercises in a plank position [8]. Silfies suggested that core stability is a dynamic process that requires optimal muscle capacity (strength, endurance, and power) and neuromuscular control (accurate joint and muscle receptors, and neural pathways) that can quickly integrate sensory information and alter motor responses relative to internal and external information [10]. Thus, in the present study as well, the improvements in nervous system function and core stability were considered to be responsible for the immediate enhancement in the muscle output of the upper extremities.

The core muscles stabilize the trunk during functional movements of the upper and lower extremities; therefore, it can be inferred that the muscle outputs of the upper and lower extremities improve with increased core stability [7,9,10]. Moreover, some researchers have reported that the enhancement of core function helps prevent injuries to the upper and lower extremities [9-12]. In this study, only the muscle contraction at the catch position is a movement that applies force toward the core which contracted by training, and the other two are muscle contractions in the opposite direction from the core. It was suggested that the improved stability of the core as the basis for extremity movements has made it easier for swimmers to apply force only to muscle contractions that approach the core.

Moreover, core training, especially stabilization training, can contribute to a stabilized posture under water. The improvement in the swimming speed observed in this study was possibly influenced not only by the improvement in shoulder muscle output in the catch position but also by the acquisition of a posture that conferred less resistance in water. Posture measurement was not performed in this study; therefore, further research is necessary to elucidate the effect of core training on underwater swimming performance.

Conclusion

Shoulder muscle strength improved immediately after core training. Moreover, the muscle strength in the catch position significantly contributed to an improvement in swimming speed in the pull motion.

Competing Interests

The authors declare that they have no competing interests.

Acknowledgement

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