Research Paper

The Effect of Core Stability Exercises on Lower Limb Alignment, Upper and Lower Limb Function in Kyokushin Girls

Mohammad Rahimi[1*], Hadi Samadi[1], Afsane Rahnama[1], Zohre Nikzade Abbasi[1]

1. Department of Corrective Exercises and Sport Injuries, Faculty of Sport Sciences, Shahid Rajaee Teacher Training University, Tehran, Iran.

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ABSTRACT

Purpose: This study was conducted to investigate the effect of 6 weeks of core stability exercises in the trunk area on lower limb alignment and lower and upper limb function in Kyokushin athletes.

Methods: The statistical sample of the research included 30 female Kyokushin players aged 14-18 years, who were randomly divided into two experimental and control groups. The control group performed common Kyokushin exercises and the experimental group performed core stability exercises for 6 weeks. Analysis of covariance (ANCOVA) and paired t-tests were used to compare between groups and within groups.

Results: The results of the paired t-test showed a significant effect of training programs on changes in upper and lower limb function in both experimental and control groups ($P \leq 0.05$); however, a significant difference was observed between the pre-test and post-test in both control and experimental group. The test was not observed in the Q angle ($P > 0.05$). The results of ANCOVA test showed that after controlling the effect of the pre-test, a significant difference was observed in lateral jump ($P \leq 0.05$) between the experimental and control groups. However, no difference was observed between the two groups in the changes of closed kinetic chain upper extremity stability test (CKCUEST), square jump, and Q angle ($P > 0.05$).

Conclusion: Considering the nature of Kyokushin and the research results, it is suggested that people working in Kyokushin do not feel the need for core stability exercises separately.

*** Corresponding Author:**
Mohammad Rahimi, Assistant Professor.
***Address:** Department of Corrective Exercises and Sport Injuries, Faculty of Sport Sciences, Shahid Rajaee Teacher Training University, Tehran, Iran.*
***Phone:** +98 (912) 8668695*
***E-mail:** mohammad.rahimi@sru.ac.ir*

Highlights

• According to the research, the misalignment in the lower and upper limbs has been identified as a risk factor for injuries of the lower and upper limbs.

• Moderate evidence shows the popularity of Kyokushin karate among different strata of society.

• Evidence shows a relationship between upper and lower limb alignment and core stability.

Plain Language Summary

Maintaining alignment and postural balance during functional activities is one of the tasks of the Core, which leads to preventing wrong patterns and maintaining alignment. After searching for core stability, alignment, and lower and upper limb function, no paper was found that investigated the effect of core stability exercises on Kyokushin Karate athletes. Therefore, this research aims to investigate the effect of core stability exercises on the lower and upper limb performance of Kyokushin athletes.

1. Introduction

Karate is one of the most popular martial arts in the world, which is characterized by different types of hand and foot strikes in static and dynamic conditions [1, 2]. Kyokushin karate is the most common style of full-contact karate in the world, which means "ultimate truth" and was founded by Masutatsu Oyama [3]. This discipline, derived from the branch of karate, performs in the combination and coordination of the hand and especially the foot with the brain. The combination of aerobic exercises, balance, and coordination in this field leads to the improvement or maintenance of cognitive functions [4]. The ability to execute and change direction with speed is vital in techniques requiring high levels of coordination and balance [5, 6].

In recent years, researchers have investigated the role of the core muscles in the production and transmission of force and control of body posture. Various papers have used the word "stability" in examining the functional ability of the core. The definitions proposed for core stability are based on its functional area [7, 8], for example, in sports that need high agility and speed, due to the ability to produce, core stability training is defined as controlling and transferring force and movement from the upper limb to the lower limb [9]. Also, in another definition, core stability is elucidated by controlling the movement and muscle capacity of the lumbar, thigh, and hip complex [10].

Maintaining alignment and postural balance during functional activities is one of the tasks of the core leading to preventing wrong patterns and maintaining alignment. Also, misalignment has been identified as a risk factor for lower limb injuries [11]. Practically, maintaining the alignment of the hip, knee, and ankle is crucial in preventing sports injuries [12]. Among the different factors of lower limb alignment, the Q angle is one of the cases whose relationship with various lower limb injuries [13, 14] has been studied. The Q angle is defined as the angle formed between the two lines connecting the anterior superior articular spine (ASIS) to the center of the patella and the line connecting the center of the patella and the tibial prominence [15].

Nowadays, paying attention to core strengthening has become a common recommendation of rehabilitation specialists and sports coaches, and numerous researches have been conducted in this major [16]. In a study, Jalili investigated the effect of six weeks of CX VORX exercises on the core muscle endurance, balance, and upper limb function of 30 female athletes with trunk defects. The results of this research indicate that resistance core exercises can have a significant effect on the performance of the lower and upper limbs by influencing core endurance [17]. In a study titled the effect of core exercises on balance and movement performance test scores, conducted on 30 young male soccer players, it was concluded that core stability exercises can improve the functional tests of soccer players, as well as, static and dynamic balance [18].

Figure 1. Lateral jump PHYSICAL TREATMENTS

After searching for core stability, alignment, and lower and upper limb function, no paper was found to investigate the effect of core stability exercises on Kyokushin karate athletes. Therefore, this research was conducted to investigate the effect of 6 weeks of core stability exercises on the lower and upper limbs performance of Kyokushin athletes.

2. Methods and Methods

The current research was quasi-experimental and practical in terms of purpose, which was conducted in two phases, pre/post-test with a control group. After reviewing the criteria for entering the research, including (the age of participants 14-18 years old, no history of injury or surgery of the upper and lower limbs or neuromuscular diseases in the last 6 months, participation in Karate training from two last years. One year of regular training in Kyokushin karate, and at least three training sessions per week) assigned participants to two experimental (core stability exercises) and control groups (common Kyokushin-karate exercises). The criteria for withdrawing from the research included (non-attendance in three alternate sessions and two consecutive sessions, injury during the training program, and non-cooperation in the continuation of the research process [19]. The number of subjects was calculated based on similar articles and G*Power sample size software, version 3.1 and considering parameters of effect size=0.7, α coefficient=0.05, and test power=0.8.

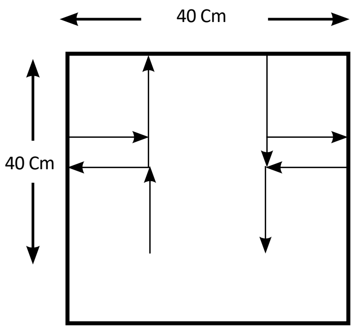

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Figure 2. Square and lateral jump test

After evaluating the age, height, and weight of the subjects and the information related to the tests, the subjects were randomly divided into two control and experimental groups. Before starting the research, during a meeting, the research method was explained to the participants, and the research consent was obtained, and the alignment of the lower limbs, and the function of the lower and upper limbs were measured. Lower limb alignment was evaluated by measuring the Q angle and photogrammetry method, upper limb function was evaluated by closed motor chain stability test closed kinetic chain upper extremity stability test (CKCUEST), and lower limb function was evaluated by side jump and square jump test.

Lateral jump test: The subject jumped a distance of 30 cm, which was marked by two pieces of parallel tape on the ground, (10 times back and forth) (Figure 1). The subject's record was calculated by a stopwatch (Yonic with 0.01 accuracy) before and after the core stability training protocol. The inter-examiner reliability of this test has been reported as 0.97 in healthy athletes [20].

Square jump test: In this test, a square with sides of 40 cm was drawn on the ground with adhesive tape. The subject was asked to jump as fast as possible 5 times along the path drawn in the figure inside and outside the square with the superior leg (right leg counterclockwise and left leg clockwise). If during the test, the person's opposite foot fell, lost his balance, or could not jump on the marked strips for landing, or his foot hit the sides, the test was not acceptable. The inter-examiner reliability of this test has been reported as 0.90 [20] (Figure 2).

CKCUEST: This test examines muscle strength, endurance, and upper extremity closed chain stability. Its reliability is reported as 0.92. To perform the test, two strips with a width of 5 cm were placed parallel to each other at a distance of 91 cm from each other. The starting posi-

Figure 3. CKCUEST

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tion for the test was while the hands were placed on each piece of the tape and the subject was in the Swedish push-up position. Subjects were instructed to pass one hand under their body and reach the bar under their opposite hand and return to the starting position after touching the bar line. The subject repeated the same movement for the other hand. The repetition of this movement was counted in 15 s. The number of hand contact was the individual's test score [21] (Figure 3). Before the test, the body was warmed up for 5 minutes.

Q angle: The axis of the long bones of the lower limb forms angles to each other and to the vertical line, which is called the alignment of the lower limb. The quadriceps angle or the angle of the quadriceps muscle. This angle is considered the acute angle between two hypothetical lines. These two lines are as follows, from the upper anterior cruciate ligament to the center of the kneecap and the center of the patella to the tibial [22, 23]. This angle is a reasonable estimation of the external force vector acting on the patella by quadriceps contraction and shows the position of the tibial tuberosity concerning the midline of the femoral pulley [24]. A larger angle indicates the bad alignment of the knee extensor mechanism and is directly related to anterior knee pain, partial dislocation or dislocation of the patella, and injuries caused by excessive use of the lower limb [25]. Factors, such as increased knee valgus, weakness of the vastus medialis muscle, spasm of the vastus lateralis muscle, biceps femoris and iliotibial band, higher or lower placement of the patella bone, and the angle of rotation to the front of the femur, cause a change in the size of the quadriceps angle [25]. The normal value for this angle is reported from 10 to 14 degrees for men [23].

The Q angle was measured with the participants in a standing position, then the pointers were placed on the ASIS and the center of the patella and the tibial tuberosity for measurement. To take the image in the anterior view, a line was drawn from ASIS to CP and another line from TT to CP to calculate the angle. The angle between the junctions of these two lines was considered as the Q angle [26] and to capture the image from the front view by a digital camera (Canon, 5 megapixels), which was placed on a tripod from the lower limb at a height of 150 cm from the subject. Subjects were photographed when the camera lens was aligned with the longitudinal center of the thigh. Then the photos were saved in pdf format and the angle measurement between two hypothetical lines from the ASIS to the center of the patella and from the center of the patella to the tibial tuberosity was measured by Adobe Acrobat Reader DC software, version 15 (Figure 4).

The control group performed their common Kyokushin karate exercises for six weeks, and the experimental group performed Kyokushin karate common exercises and Core stability training protocol for 6 weeks, 3 sessions per week, and 30 minutes each session. The basis of duration and training sessions were matched (the duration of each training session was 90 minutes, the control group performed Kyokushin common exercises, and the experimental group performed core stability exercises after warming up for 30 minutes) and the suggested core stability training program was used by Jeffries program [27]. During the sessions, the number of repetitions, the difficulty of the exercises, and the addition of new exercises (the number of exercises) increased. Training programs were implemented before the start of specialized Kyokushin training. The training protocol in each train-

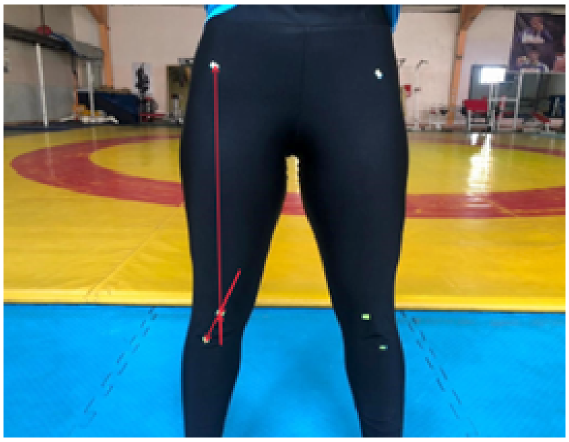

Figure 4. Measurement of Q angle

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ing session was performed after the general warm-up according to pre-prepared instruction under the supervision of an expert, and then subjects continued with their Kyokushin karate training.

The core stability training protocol includes 5 movements (lower abdominal training, half sit-up, rotation sit-up, side plank, and prone bridge) (Table 1). Each exercise is based on the previous level and higher-level movements are not allowed until the lower level is sufficiently skillful. The overload and gradual increase of each exercise was controlled and determined according to correct the implementation and pressure of the exercise in the previous session. Before starting the exercises, the subjects were taught how to maintain the correct posture and the importance of proper breathing.

Core stability training protocol: Exercises focusing on strengthening the core muscles were mainly performed in semi-sit-ups, rotational sit-ups, lateral bridges, and palmar exercises.

Descriptive and inferential statistical methods were used to analyze the collected data. The Shapiro-Wilk test was used to check the normality of data distribution. To compare the average of the research variables before and after the exercise protocol in each group, the paired t-test was used, and for the inter-group comparison of the variables, the analysis of covariance (ANCOVA) test was used at the significance level of $P \geq 0.05$.

3. Results

Table 2 presents the descriptive analysis of individual characteristics (age, height, weight, and BMI) of the subjects according to research groups. The results showed no significant difference in these variables between the research groups in the pre-test ($P>0.05$). Due to the normality of the data, which was determined by the Shapiro-Wilk test, ANCOVA and paired t-tests were used to compare between and within the study variables in the training and control groups. Table 3 presents the results of the paired t-test.

Table 1. Core stability training protocol

Weeks	Training
1	Lower abdominal training, half sit-up, rotation sit-up, side plank (all the exercises 2 sets and 10 reps)
2	Lower abdominal training, half sit-up, rotation sit-up, side plank (all the exercises 3 sets and 10 reps)
3	Lower abdominal training, half sit-up, rotation sit-up, side plank (all the exercises 2 sets and 15 reps)
4	Lower abdominal training, half sit-up, rotation sit-up, side plank (all the exercises 2 sets and 15 reps), prone bridge (2 sets and 10 s)
5	Lower abdominal training, half sit-up, rotation sit-up, side plank (all the exercises 2 sets and 20 reps), prone bridge (3 sets and 10 s)
6	Lower abdominal training, half sit-up, rotation sit-up, side plank (all the exercises 2 sets and 10 reps), prone bridge (2 sets and 15 s)

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Table 2. Descriptive information of the subjects in the research groups in the pre-test

Groups	Variables	Mean±SD
Control	Height (cm)	158.27±5.32
	Weight (kg)	55.53±6.18
	Age (y)	16.53±1.45
	BMI (kg/m²)	22.11±1.42
Experimental	Height (cm)	157.40±5.48
	Weight (kg)	56.60±5.56
	Age (y)	16.60±1.24
	BMI (kg/m²)	22.78±0.84

BMI: Body mass index.

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The results of the paired t-test showed a significant effect of the exercise programs on the function variables of the lower and upper limbs in both the control and experimental groups ($P\leq0.05$). However, in both the experimental and control groups, no significant difference was observed between the pre and post-test in Q angle variable ($P>0.05$).

The results of the ANCOVA test showed that after controlling the effect of pre-test (cority), a significant difference was observed in the lateral jump variable ($P\leq0.05$) between the experimental and control groups. However, no difference was observed between the two groups in CKCUEST variables, square jump, and Q angle ($P>0.05$) (Table 4).

4. Discussion

This paper was conducted to investigate the effect of 6 weeks of core stability exercises on the lower limbs, and upper and lower limb performance of Kyokushin girls. The results of the paired t-test showed that both the control group who performed Kyocushion exercises and the experimental group who performed Kyocushin exercises and core stability exercises had a significant difference between pre and post-test in the test of upper limb movement chain (Davis), side jump and square jump. But regarding Q angle, this difference between pre/post-test was not significant. Based on the results, both Kyokushin exercises alone and Kyokushin exercises together with core stability exercises were significant on the research variables (Davis, side jump, and square

Table 3. Correlated t-test results for intra-group comparison of research variables in exercise and control groups in pre and post-test

Groups	Variables	Mean±SD		P
		Pre	Post	
Control	CKCUEST	12.62±3.22	10.80±3.67	0.001
	Lateral jump	9.61±1.55	8.14±1.51	0.001
	Square jump	18.0±2.41	16.47±2.60	0.001
	Q angle	19.73±0.62	19.74±0.63	0.83
Experimental	CKCUEST	13.74±1.93	12.61±1.51	0.001
	Lateral jump	11.29±2.73	12.34±2.79	0.001
	Square jump	14.68±2.55	16.11±2.54	0.001
	Q angle	19.64±0.65	19.65±0.70	0.87

CKCUEST: Closed kinetic chain upper extremity stability test

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Table 4. The results of ANCOVA test to investigate the effect of core stability exercises on research variables

Variables	Sum of Squares	df	Mean Square	F	P	Effect Size	Test Power
CKCUEST	2.79	1	2.79	2.67	0.11	0.09	0.35
Lateral jump	2.04	1	2.04	3.60	0.04	0.11	0.44
Square jump	0.03	1	0.03	0.04	0.84	0.002	0.05
Q angle	0.006	1	0.006	0.14	0.71	0.005	0.06

CKCUEST: Closed kinetic chain upper extremity stability test.

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jump). The results of ANCOVA also showed no significant difference between the experimental and control groups except for side jump, in other variables, i.e. in square jump and Davis test (P<0.05).

Kyokushin karate is considered one of the hardest styles of karate, which has knockdown system [28]. The fight between two opponents is done without any weapons and with maximum speed and strength [29]. Since this style emphasizes real combat from a close distance, it affects people's parameters, including body composition and especially the skeletal-muscular system [3, 30]. As karate training requires a high level of movement and functional abilities including speed, strength, and coordination [5, 6]. Rzepko et al. (2019) in research entitled the effect of Kyokushin karate exercises on static and functional balance in teenage karatekas, which was conducted on 28 people who had at least 7 years of karate training experience, showed that the karate group had functional stability. They have superiority. Also, significant changes exist in the postural characteristics of teenage karate practitioners [31].

The purpose of core stability exercises is to create the physical capacity to maintain a neutral position in the spine during daily life activities, which is created by increasing endurance and coordination of the spine stabilizing muscles [32]. Core stability refers to the control and coordination of the thigh group and the pelvic girdle and has three core levels that affect and cooperate. These three levels include local vertebra control, lumbar-pelvic control, and postural control. Disruption of performance in each of these three parts can affect other parts of the movement chain. For example, the disturbance in the local control of the vertebrae and lumbar-pelvic control can ultimately affect the postural control and overall balance of the body. Loss of postural control may lead to falling, placing the person at risk, and as a result, increasing the probability of injury to the lower limbs. In this regard, Peate et al. at the unstable level, pointed out the improvement in the core strength, followed by the core endurance core [33]. On the other hand, the larger core muscles provide the body with a stable level of movement by creating a solid cylinder and then producing more inertia against physical disturbances. Abdominal muscles, including rectus abdominis, transversus abdominis, external oblique, and internal oblique contract in an integrated manner to provide spine stability and a stronger support surface for upper and lower limb movements. When the transverse abdominis muscle contracts, the pressure of the internal oblique muscle increases and forces the lumbar spine to increase tension. These contractions occur before the movement of the organs to allow the organs to have a stable surface for movement and muscle activation. On the other hand, the rectus abdominis muscle and the oblique abdominal muscles also start to work in special patterns relative to the movement of the limbs that provide support for the stature [33].

The core muscles influence the activation of the muscles of the upper and lower limbs so that in healthy people, the transversus abdominis and multifidus muscles are active 30 ms before the movement of the upper limb and 110 ms before the movement of the lower limb. They are used to increase the stability of the spine. Therefore, any type of weakness in these muscles leads to delayed activation of lower limb muscles and various injuries [34].

Through research and investigations conducted in various studies, it is evident that exercises related to core stability can help improve the muscle activation patterns of the trunk muscle structure. The mentioned variables are effective in this research. The results of this research are consistent with the findings of McCaskey, Kahle and Gribble, and Johnson et al. regarding the improvement of balance after core stability exercises. It is [35-37]. However, the present research was inconsistent with the results of Jeffrey [27]. Among the possible reasons for the alignment or non-alignment of the results of the present research with other results, we can mention the similarity or difference between the type of exercises, the intensity, the duration of the exercises, and the type and individual characteristics of the subjects.

The results of the present research showed that both Kyokushin exercises and core stability exercise cause changes in the function of the lower and upper limbs. But regarding the Q angle, Kyokushin exercises and core stability exercises were not effective. Considering that the nature of the Q angle is affected by the parts of the quadriceps muscles. Maybe these exercises do not have much role in the strength of the quadriceps muscles.

Based on the results of the present research, the core stability and Kyokushin exercises in both experimental and control groups did not show any difference in the research variables except lateral jump. And this can indicate the similarity of these two exercises and the reason for the non-significance of the lateral jump variable because the lateral jump is performed in the frontal plane and the stability in the core area of the trunk is vital and the core stability exercises specifically works on the stability in the core area of the trunk, the possibility of this effect can be justified. But in other items, this difference was not significant.

Many studies have been conducted on the effect of core stability of the trunk. However, no research was found whose results can be directly compared to the results of the current research. Considering this issue, the results of the research conducted in the field of investigating the effect of a training method on the performance of athletes can be indirectly examined and compared to the results of the current research.

Mohammadi et al investigated the effect of 8 weeks of strength training, core stabilization and combined training on the dynamic balance of elite basketball girls. The results of the research showed that the strength training, the core stabilizer, and the combination showed a significant increase in the reach distance of the subjects in all eight directions, as well as the combined training of balance and strength training and balance training also showed a greater improvement in dynamic balance than strength training [38]. Willison et al. during a review of research about the core stability and its relationship with lower limb function and injury concluded that a decrease in core stability may provide the basis for injury [10]. Naderi et al. compared the effect of core and neuromuscular stability exercises on dynamic balance and lower limb performance of athletes with functional ankle instability. The research results indicate that six weeks of progressive exercises under the supervision of core and neuromuscular stability significantly improved dynamic balance and improves the measured lower extremity function of athletes with ankle functional instability (FAI), but these two different types of training protocols have the same effect on improving these factors in athletes with functional ankle instability [39]. Kimberly's results, the activation of the core muscles in the movement pattern of the lower limb causes better postural control, and the activation of the core muscles can be used to produce rotational torques around the spine [40].

The results of Wilson et al.'s research showed a clear relationship between the stability of the core muscles and the occurrence of injuries in the lower limbs as well as the function of the lower limbs [10]. Stronger core muscles create more stability in the trunk area and this factor prepares the upper and lower limbs for mobility. The abdominal muscle group, which includes the transversus abdominis muscle, the external and internal oblique muscle, and the rectus abdominis muscle, stabilizes the spine with its contraction and provides stronger support for the movements of the lower limbs [41]. When the transverse abdominal muscle contracts, the intra-abdominal pressure and tension of the pectoral-lumbar fascia increase, and these contractions create a strong support for movement and muscle activation before the body movement. The rectus abdominis muscle and the internal and external oblique muscles are also activated in a specific movement pattern based on the movement of the body and control of the posture. According to Kibler's results, the activation of the core muscles in the movement pattern of the end organs improves posture control, and the body uses the activation of the core stabilizing muscles to produce the torque of the rotational force around the body and create the movement of the organs [11].

It has been proven in many papers that a person who has control over the middle muscles of his body and cannot stabilize the core parts of his body is highly exposed to immediate injuries [42]. It is essential to point out that core exercises significantly improve the defects of the neuromuscular system, and this issue creates optimal arthrokinematics in the entire lumbar-pelvic-femoral region during the movements of the functional movement chain and optimal muscle balance, therefore the stability of the proximal region causes movement in the distal part [39].

5. Conclusion

Considering the nature of Kyokushin and the research results, it is suggested that people who work in Kyokushin do not feel the need for core stability exercises separately.

Ethical Considerations

Compliance with ethical guidelines

In the implementation of the research, ethical considerations were considered according to the instructions of the Ethics Committee of the Research Institute of Sports Sciences (Code: SSRI.REC-2112-1420(R1).

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Authors' contributions

Data analysis and writing–review & editing: Mohammad Rahimi and Hadi Samadi; Data collection and investigation: Afsane Rahnama and Zohre Nikzade Abbasi.

Conflict of interest

The authors declared no conflict of interest.

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