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Araştırma Makalesi ● Research Article

The Effects of Open and Closed Kinetic Chain Exercises on Visual Reaction Times and Certain Motor Skills in Young Male Boxers

Genç Erkek Boksörlerde Açık ve Kapalı Kinetik Zincir Egzersizlerinin Görsel Reaksiyon Zamanına ve Bazı Motorik Özelliklere Etkisi

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Abstract: This study aimed to determine the effects of open kinetic chain (OKC) and closed kinetic chain (CKC) exercises on visual reaction times and certain motor skills in young male boxers. Twelve young male athletes (mean age: 16.92±1.08 years) voluntarily participated in this study, which employed a pretest-posttest experimental research model, a quantitative research method, without a control group. The Ethics Committee Approval required for the research was received from Muş Alparslan University Scientific Research and Publication Ethics Committee with decision number 9/73 dated 08.11.2023. Prior to and following training in OKC and CKC exercises, the athletes were tested on visual reaction times, vertical jumping, and flexibility. The paired samples t-test was applied to normally distributed data. According to our findings, there were no significant differences in the visual reaction time and flexibility tests with respect to the pre- and post-test results for the OKC exercises ($p > .05$), although a significant difference was detected for the vertical jump test ($p < .05$), with the post-test values determined to be lower than the pre-test values. While there were no significant differences in the CKC exercise pre-and post-test results for the vertical jump and flexibility tests ($p > .05$), a significant difference was observed in the visual reaction test ($p < .05$), for which the post-test values were lower than the pre-test values. Based on these results, OKC exercises were determined to have a negative impact on jumping ability, whereas CKC exercises exhibited positive effects on visual reaction times. The use of CKC exercises can thus be recommended for studies aimed at improving visual reaction performance in young male boxers.

Keywords: Boxing, Strength, Kinetic Chain Exercises

Öz: Bu çalışma, genç erkek boksörlerde açık kinetik zincir (AKZ) ve kapalı kinetik zincir (KKZ) egzersizlerinin görsel reaksiyon zamanı ve bazı motorik özelliklere etkisini belirlemek amacıyla yapılmıştır. Çalışmaya 12 genç erkek sporcu (yaş: 16,92±1,08 yıl) gönüllü olarak katılmıştır. Çalışmada kontrol grupsuz ön test-son test deneysel araştırma modeli kullanılmıştır. Etik Kurul Onayı 08.11.2023 tarih ve 9/73 sayılı karar ile Muş Alparslan Üniversitesi Bilimsel Araştırma ve Yayın Etiği Kurulu'ndan alınmıştır. AKZ ve KKZ antrenmanları öncesi ve sonrasında görsel reaksiyon, dikey sıçrama ve esneklik testleri yapılmıştır. Normal dağılım gösteren verilere paired

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samples t testi uygulanmıştır. Çalışma bulgularına göre AKZ egzersizi ön test-son test sonuçlarında görsel reaksiyon ve esneklik testlerinde anlamlı bir fark bulunmazken (p>0,05), dikey sıçrama testinde anlamlı bir fark tespit edilmiştir (p<0,05). Dikey sıçrama son test değerlerinin ön test değerlerine göre daha düşük olduğu belirlenmiştir. KKZ egzersizi ön test-son test sonuçlarında dikey sıçrama ve esneklik testlerinde anlamlı bir fark bulunmazken (p>0,05), görsel reaksiyon testinde anlamlı bir fark tespit edilmiştir (p<0,05). Görsel reaksiyon son test değerlerinin ön test değerlerine göre daha düşük olduğu belirlenmiştir. Sonuç olarak, AKZ egzersizlerinin sıçrama becerisini olumsuz, KKZ egzersizlerinin ise görsel reaksiyon değerlerinde olumlu etkiler oluşturduğu belirlenmiştir. Genç erkek boksörlerde görsel reaksiyon performansını artırmaya yönelik çalışmalarda KKZ egzersizlerinin uygulanması önerilebilir.

Anahtar Kelimeler: Boks, Kuvvet, Kinetik Zincir Egzersizleri

Introduction

Boxing is a sport in which two athletes wearing special gloves specific to the sport aim to outcompete each other using punches in accordance with predetermined rules (Çakmak, 2007). The basis of boxing is to score points by attacking the opponent as specified in the rules with solid, forceful punches and to defeat the opponent by taking guard against the latter's attacks and defending oneself effectively (Yurtsever, 1999). As such, boxing requires conscious training for long periods of time along with greater physical capacity than many other types of sports (Savaş, 2004). The main objective in boxing matches is to gain superiority by dodging the opponent's attacks and performing more accurate punches (Guidetti et al., 2002). During a boxing match, the athletes wear special boxing gloves with their hands in a fist position, punching with the area between their finger joints and hand joints. According to the rules, punches to the neck and below the waist are not permitted. Points are given by the five referees on duty during the competition. When evaluating points, the referees consider whether the fists hit the target directly and are good punches. The most important factors in achieving results are the ability to compete well and possessing technical and tactical superiority (Chaabène et al., 2015).

In the present era, attaining physical and physiological fitness is of critical importance in achieving success in sports. The proportion and intensity of an athlete's physiological ability to resist a workload are associated with that person's physical and body structure (Kahraman and Arslan, 2023). The increase in athlete performance is directly related to the number and quality of work performed in training (Ateş et al., 2007). An inability to develop physiologically in a manner suited to one's sport constitutes a major obstacle to an athlete's success (Zileli and Söyler, 2018). Although talent is a major factor in success in boxing, along with talent, the athlete also needs to be strong and intelligent, with well-developed skills. Success is based on enhanced physical and physiological capacity based on the development of such features as competent fighting, compliance with the rules, psychological superiority, strength, speed, endurance, flexibility, and persistence (Zorba et al., 1999). Boxing is an important sport that by its nature requires a high level of performance and great strength and effort, incorporating both static and dynamic features (Mitchell et al., 1994). Anaerobic power is very important in boxing, which is one of the branches of quick strength and short duration (Ozan, 2013). By virtue of boxing being an individual sport, athletes must cultivate a variety of qualities in order to be successful, the most essential being agility, strength, quickness, and balance. Boxers who have developed these possess an advantage over other athletes in the ring (Franchini et al., 2012). Studies in the field of sports training have determined that strength and flexibility can be improved with regular training. Muscle strength increases with the incidence of muscle hypertrophy (Gündüz, 1997).

Both OKC training and CKC training strength development exercises have been shown to increase muscle strength (Dannelly et al., 2011). In OKC training, movement refers to the freely occurring motion of the distal part of the organ while the proximal segment remains stationary. An essential task of OKC training is to isolate individual muscles, which tend to generate more dispersive and rotational forces and are often utilized in conjunction with coordinated muscle contraction (Augustsson, 2000). CKC exercises are based on closed contact in movement; in other words, when a movement occurs in a joint, if motion also ensues in other joints in this region, it is considered a CKC exercise. As the movement occurs in more than one joint, contraction occurs in both agonist and

antagonist muscles. To illustrate this with an example, during a knee extension using an OKC exercise, only the quadriceps, the most important muscle for this particular movement, is active, while performing the same movement with a CKC exercise also engages the hamstring muscles along with the quadriceps (Palmitier et al., 1991; Tagesson et al., 2008). In CKC exercises, the distal region remains in a motionless position. In this case, a movement of the joint during the kinetic chain exercises (KCE) causes movement in other joints, thus benefiting from strength training in both the proximal and the distal regions, and since it is fixed, movement in any joint of the KCE causes movement in the other joints. Thus, both proximal and distal segments are subject to strength training simultaneously. In lower extremity exercises, CKC exercises are more effective because weight-bearing exercises involve the CKC in the lower extremities. KCE are very efficient in eccentric contractions; while acting to reduce shear force, such exercises increase the compression force of the joints as well as joint stability (Balcı et al., 2009). Both OKC and CKC exercises are incorporated into strength training programs that aim to increase strength and muscle power. Leg press, squat, and deadlift CKC exercises added to a strength-building program for lower extremities generate more complex neurological responses in muscle strengthening and are thus more efficient than OKC exercises (Stone et al., 1998).

The vertical jump is a complex movement involving more than one joint and requires great muscle strength in the hip, knee, and ankle. Since the effect of rapid transition from eccentric contraction to concentric contraction during the strength generation phase of vertical jumping is well understood, proprioceptive training is certain to increase jump height by positively affecting the generation of power, boosting the participation of motor units in movement, and improving vertical jumping overall. In addition, the articulation of the hip joint is critical in vertical jumping, significantly affecting maximum vertical jump performance (Federici et al., 2020).

Strength represents the capacity of an organism to overcome internal and external resistances through its neuromuscular organization. The greatest force that an athlete can exert varies depending on the size of the muscle mass involved in the movement and the biomechanical characteristics of the movement itself. In other words, increase in strength is determined by the development of one or both of the two aforementioned features (Bompa, 2003). Therefore, it is possible to garner strength with the speed of movement and long-term application of force (Ergen et al., 2002). Strength is the most basic feature of an organism. Individuals can move a mass or their own body with force and overcome resistance by using their own muscles (Sevim, 2007).

According to De Ste Croix et al. (2001), leg strength increases in proportion to an increase in thigh area, calf area, muscle mass of the leg, muscle volume of the leg, and lean leg volume. This is because the muscle mass in the legs undergoes intense hypertrophy and muscle strength may improve due to the increase in muscle fibers (Özkan and Sarol, 2008).

Visual reaction time has attracted the curiosity of scientists since the nineteenth century. Some scientists consider total reaction time to include both pre-motor and motor components. The first phase of the reaction period, which starts with a stimulus and concludes with the onset of muscle movement, is known as the pre-motor phase, while the second phase is defined as the motor period (Açak et al., 2012).

This study was conducted to determine the effects of OKC and CKC exercises on visual reaction times and certain motor skills in young male boxers. Thus far, the literature has produced only a limited number of studies on KCE. For this reason, the results of the present study will be applicable to and may be incorporated into the training programs of a number of different sports, especially boxing, and will contribute to the literature on athletic training and sports sciences in general.

Materials and Methods

In the present study, a quantitative method of experimental research design was employed, based on a pretest-posttest model with no control group. The participants were comprised of 12 athletes in the youth category from the province of Muş, Turkey.

Ethical Approval

The Ethics Committee Approval required for the research was received from Muş Alparslan University Scientific Research and Publication Ethics Committee with decision number 9/73 dated 08.11.2023.

Data collection tools

Study Design: OKC and CKC strength exercises for the lower extremities were performed by the study participants at three-day intervals. Before the start of each session, the participants carried out stretching or special warm-up exercises for five minutes, focusing on the muscle groups to be engaged. Using 70% of the maximum weight lifted, each particular exercise (movement) was performed in sets of two with 15 (fifteen) repetitions and 90 seconds of rest between sets and a 3-minute rest period between movements. On the first day of the study, measurements and tests were conducted prior to and following the OKC exercises. Afterwards, the athletes were allowed a 3-day period of recovery. On the fourth day of the study, the same protocol was applied before and after the CKC exercises.

Open and Closed Kinetic Chain Exercise Protocols: Participants in the study were given the maximum loads that they could lift for between one and ten repetitions for each movement to be performed during the exercise, and the loads lifted were recorded in kg. During the maximal test, the participants were instructed to pay the utmost attention to their movements, and the mass of the load lifted when the motion was disrupted was determined and recorded. After establishing the loads lifted, the maximum weight was calculated using the coefficient given in the table, and training protocols were performed with 70% of the load.

Table 1. Open Kinetic Chain Training Protocol

Movement	Number of Sets	Repetitions	Weight	Rest between sets	Rest between movements
Leg Press	2	15	70%	90 sec	3 min
Leg Extensıon	2	15	70%	90 sec	3 min
Leg Curl	2	15	70%	90 sec	3 min

Table 2. Closed Kinetic Chain Training Protocol

Movement	Number of Sets	Repetitions	Weight	Rest between sets	Rest between movements
Trap Bar Squat	2	15	70%	90 sec	3 min
Lunge Walk	2	15	70%	90 sec	3 min
Deadlift	2	15	70%	90 sec	3 min

The following measurements were taken in this study:

Height: The height of the participants was measured in cm using a tape measure while barefoot.

Body Weight, Body Fat Percentage, Muscle Mass: The measurements of the participants were determined with the TANİTA MC 780 device.

Vertical Jump Force: Measuring were done with the Fusion Sport brand Smart Jump jumping mat, with both hands on the waist, feet shoulder-width apart and posture upright, and when the athletes were ready on the mat, they were asked to jump to the highest point they could, without taking a step and bending their knees at 90°. After the athletes jumped, they fell back onto the mat and their jump heights were measured with an accuracy of 0.1 cm. The two attempts were recorded and the highest score was evaluated (Atan, 2019).

Visual Reaction Speed: Visual reaction times were measured using the FitLight™ (Fitlight Sports Corp., Canada) device. The visual-motor reaction time consists of a simple reaction lasting 10 seconds to visual stimuli appearing on six wireless illuminated disks. The disks were placed on a table in the shape of a half-moon and the participants' hands were positioned in the middle of the half-moon. The midpoint of each disk was set at a distance of 40 cm from the center of the half-moon, and the disks

were arranged at a distance of 25 cm from each other. The participants placed their hands at the starting point before the test commenced. After the test began the participants extended their hands to whichever light came on, extinguished the light, brought their hands back to the center point, and then quickly extinguished the next light. The test ended automatically after 10 seconds. The FitLight device generated each participant's average reaction speed over the course of 10 seconds (Örs et al., 2019).

Flexibility: The participants placed the soles of their feet on the side of the sit-and-reach table facing them, reaching forward as far as possible without bending their knees, and waited for 2 seconds. The distance reached was measured and recorded in centimeters. Before the test, the participants performed 5-minute warm-up exercises and the highest of the 2 measurements was evaluated (Günay et al., 2019).

Statistical analysis

The SPSS package program was used for the statistical analysis of the data obtained in the study. The normality of the data was determined by means of the Shapiro-Wilk test. The paired-samples t-test, a parametric test, was applied to normally distributed data. A value of $p < .05$ was considered statistically significant.

Results

Normality distributions are shown in Table 3. The Shapiro-Wilk test was used to determine whether the data showed normal distribution. Since the significance value of the Shapiro-Wilk test is greater than 0.05 in all tests, the data show a normal distribution with 95% confidence.

Table 3. Normality Distribution Table of Data

Test	Statistic	df	Sig.
OKC Visual Reaction Pre-test	,953	12	,674
OKC Visual Reaction Post-test	,922	12	,302
OKC Vertical Jump Pre-test	,981	12	,988
OKC Vertical Jump Post-test	,976	12	,964
OKC Flexibility Pre-test	,944	12	,550
OKC Flexibility Post-test	,959	12	,771
CKC Visual Reaction Pre-test	,930	12	,378
CKC Visual Reaction Post-test	,910	12	,267
CKC Vertical Jump Pre-test	,956	12	,727
CKC Vertical Jump Post-test	,951	12	,650
CKC Flexibility Pre-test	,937	12	,465
CKC Flexibility Post-test	,977	12	,971

Descriptive statistics pertaining to the demographic characteristics of the young boxers participating in this study are presented in Table 4.

Table 4. Descriptive Statistics of the Athletes' Demographic Characteristics

Demographic Characteristic	n	Mean	Std. Dev.
Age (years)	12	16.92	1.08
Height (cm)	12	172.00	11.29
Weight (kg)	12	63.50	16.73

Table 5. Paired T-Test Results for Open Kinetic Chain Strength Training

Test		n	Mean	Std. Dev.	t	*p*
Visual Reaction (sec)	Pre-test	12	0.62	0.11	.196	.848
	Post-test	12	0.61	0.06		
Vertical Jump (cm)	Pre-test	12	32.20	6.34	3.282	**.007***
	Post-test	12	30.24	6.11		
Flexibility (cm)	Pre-test	12	27.88	5.97	-.701	.498
	Post-test	12	28.50	4.69		

*$p < .05$

According to Table 5, whereas there were no significant differences in the visual reaction time and flexibility measurements taken before and after the participants performed OKC strength training ($p > .05$), a significant difference was detected for the vertical jump test ($p < .05$). The post-test vertical jump values of the young male boxers were found to be lower than the pre-test values.

Table 6. Paired T-Test Results for Closed Kinetic Chain Strength Training

Test		n	Mean	Std. Dev.	t	*P*
Visual Reaction (sec)	Pre-test	12	0.67	0.06	3.423	**.006***
	Post-test	12	0.62	0.04		
Vertical Jump (cm)	Pre-test	12	32.11	6.05	.684	.508
	Post-test	12	30.89	4.96		
Flexibility (cm)	Pre-test	12	27.63	5.62	-.332	.746
	Post-test	12	27.96	5.69		

*$p < .05$

Based on the data in Table 6, no significant differences were observed for the vertical jump and flexibility tests conducted before and after the participants engaged in CKC strength training ($p > .05$), while there was a significant difference for the visual reaction test ($p < .05$). The visual reaction post-test values of the young boxers were lower compared to their pre-test values.

Discussion and Conclusion

The objective of the present study was to determine the effects of OKC and CKC exercises performed by young male boxers on visual reaction times and certain motor skills. According to our results, although there were improvements in the visual reaction and flexibility tests when comparing pre-test with post-test measurements (i.e., those taken before and following OKC strength exercise protocol, respectively), the differences were not found to be statistically significant. However, a significant difference was detected for the vertical jump test, with the post-test values of the young boxers being lower compared to the pre-test values. While there were no significant differences in the vertical jump and flexibility test measurements made before and after the participants engaged in CKC strength training, a significant difference was observed in the visual reaction test, for which the post-test values were lower than the pre-test values. Evaluating our findings in general, it was determined that while there were improvements in reaction speed and flexibility comparing the pre-test and post-test values, according to the results of both the OKC and CKC strength exercises, the vertical jump heights decreased. In addition, CKC strength training was shown to significantly improve visual reaction speed and produce more positive results in visual reaction times than OKC training. In his study examining the effects of CKC and OKC exercises on hormonal response and muscle damage, Hancıoğlu (2020) concluded that more muscle damage occurred when strength training with KCE, resulting in greater strength development. These findings, which are not consistent with those of our study, are thought to be due to differences in the study groups and training protocols. In a study on elite male boxers conducted by Okut, Kahraman, and Sarı (2023), pre-competition training was determined to provide positive developments in leg strength and muscle mass parameters. Kurt (2023), examining the acute

effects of KCE on vertical jumping in sedentary individuals, observed no significant differences in the parameters of strength, speed, power, thrust distance, jump height, and jump time on the acute jump test after participants performed OKC and CKC exercises, results which support the findings of the present study. Kahraman (2023) found that 8-week repetitive sprint exercise positively affected the development of vertical jump, speed and lower extremity strength in futsal players. In his study investigating the effect of stabilization exercises on athletic performance and injury risk in volleyball players, Erkan (2023) concluded that KCE created a significant positive difference in the vertical jump performance of volleyball players. The discrepancy between these results and those of our own study is believed to be due to the difference in the type of sport. Sharma et al. (2012) found that there was an improvement in the vertical jump performances of volleyball players following nine weeks of strength training. The reason why these results are not consistent with those of our study may be because the exercises we employed in our study were applied after season training, causing more intense fatigue in the athletes. Uluçay (2009), in a study involving basketball players aged 12-14 who engaged in an eight-week strength training program, also observed a significant difference in the athletes' vertical jump values. The difference in the training protocols applied may explain why the results of that study do not coincide with our findings.

No statistically significant differences were observed between the pre-test and post-test flexibility measurements in the present study, although the values did indicate improvement. Zemenu (2020) concluded that basic strength training exerted a statistically significant effect on the flexibility of volleyball players. The discrepancy between that result and our findings may be a consequence of the fact that the training exercises we employed were not directly aimed at developing flexibility. Can (2019) found that OKC and CKC exercises given in the early stages of total knee prosthesis applications increased joint range of motion, but this increase was not significant. In a study examining the effects of performed in the early stages following total knee replacement on pain, edema, joint range of motion, and functionality, Can (2019) determined that the joint range of motion of the subjects increased although there was no significant difference between the groups. This result supports our findings. Demirel et al. (2004) investigated the impact of static exercises on flexibility in girls, finding that they had a positive effect, in line with our results. Faigenbaum et al. (1996) examined the effects of an 8-week strength training program on vertical jump heights and flexibility in athletes and concluded that strength training did not statistically affect these values, a finding consistent with our results. Aktaş (2010) determined that although the strength training applied to male tennis players in the 12-14 age group increased the flexibility values, this increase was not significant. The results obtained from that study also support our findings. İşler (2017) determined that 6-week KCE added to conventional treatment in lower extremity amputee patients increased the flexibility parameter, but this increase was not significant. Seid et al., (2022) obtained positive, statistically significant results in the flexibility of 22 volleyball players following ten weeks of strength exercises. The reason why these study results are not consistent with our own may be explained by differences in the training protocol as well as the fatigue experienced by our study group after performing exercises in addition to their regular season training. Although numerous studies in the literature have argued that KCE support rehabilitation and the development of strength, they have nonetheless concluded that such exercises do not offer significant benefits in the development of flexibility, presenting results that support those of our study. However, as has been noted, there have also been studies that do not support our findings.

The post-test visual reaction times of the young boxers undergoing OKC strength training in our study were observed to be lower compared to the pre-test values. We also determined that the participants' post-test visual reaction times following CKC strength training were significantly lower than their pre-test values. Alpkaya and Mengütay (2004) examined the effect of physical activity on reaction time for ten weeks and found that physical activity improved visual reaction times. The reason that the results obtained from their study are not consistent with our findings may be due to the difference in training practices. In a study investigating the effects of exercise on neuropsychological functions in elderly individuals, Dustman et al. (1984) concluded that exercise positively affected visual reaction time. This discrepancy with respect to our findings may be a result of the difference in the age ranges of

the study groups. Keita et al. (2004) researched the effects of cognitive stimulation on different exercise intensities, finding that cognitive stimulation weakened as exercise intensity increased. They determined that strenuous exercises such as strength training negatively affect visual reaction time, in line with the results obtained in our study. In a study examining the effects of exercise on visual and auditory reaction times in university students, Chandra et al. (2010) reported that exercise decreased both visual and auditory reaction times. The fact that the exercise program in our study was combined with regular season training, producing more fatigue in the athletes, may explain the discrepancy between their results and ours. Kashihara et al. (2005) found that while positive effects on reaction times were observed following the first eight minutes of intense exercise, as the exercise time increased, reaction time worsened over a 20-minute period, a result that is consistent with our findings. Since both CKC and OKC exercises are strength exercises causing fatigue in athletes, the results we obtained may be considered predictable. In a study on the effects of exercise intensity and difficulty on cognitive processes, Kamijo et al. (2007) found that as the difficulty level of exercise increased, visual reaction times decreased, in support of our findings.

In conclusion, OKC exercises were determined to negatively impact the jumping ability of young male boxers. CKC exercises, meanwhile, were found to exert positive effects on visual reaction times.

The application of CKC exercises may be recommended for research aimed at improving visual reaction performance in young male boxers.

Recommendations

According to the research results, the following recommendations can be made:

- Research should be conducted to determine the chronic effects of OKC and CKC exercises in boxing as well as other types of sports.
- Intense OKC exercises are not advised for movements involving jumping.
- CKC exercises should be employed in studies directed toward improving visual reaction performance.

Beyan ve Açıklamalar (Disclosure Statements)

1. Araştırmacıların katkı oranı beyanı / Contribution rate statement of researchers: Birinci yazar /First author %60, İkinci yazar/Second author % 40.

2. Yazarlar tarafından herhangi bir çıkar çatışması beyan edilmemiştir (No potential conflict of interest was reported by the authors).

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