



THE EFFECT OF MIRROR DRILLS AND BALL DROP DRILLS ON THE REACTION SPEED OF KARATE KUMITE ATHLETES

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Abstract

Penelitian ini bertujuan untuk mengetahui pengaruh latihan *mirror drill* dan *ball drop drill* terhadap kecepatan reaksi atlet karate kumite. Penelitian kuantitatif ini menggunakan metode eksperimen dengan desain pre-test post-test dua kelompok. Sampel penelitian terdiri dari 20 atlet karate kumite aktif dari Zenteka Karate Club Lembang Dojo yang dipilih melalui teknik *purposive sampling*. Sampel dibagi secara merata ke dalam dua kelompok menggunakan teknik pemasangan ordinal (*ordinal pairing*) untuk memastikan kemampuan awal yang setara: Kelompok A (latihan *mirror drill*, $n=10$) dan Kelompok B (latihan *ball drop drill*, $n=10$). Program latihan dilaksanakan selama 6 minggu dengan frekuensi 3 kali seminggu. Waktu reaksi diukur menggunakan aplikasi pengukuran waktu reaksi berbasis ponsel pintar (dalam satuan detik). Data dianalisis menggunakan uji-t sampel berpasangan (*paired samples t-test*) dan uji-t sampel independen (*independent samples t-test*) pada tingkat signifikansi $\alpha = 0,05$. Hasil uji-t sampel berpasangan menunjukkan peningkatan yang signifikan pada waktu reaksi ($p = 0,000$), di mana rata-rata skor aplikasi reaksi membaik dari $3,18 \pm 0,36$ detik menjadi $3,01 \pm 0,32$ detik. Hasil uji-t sampel independen terhadap skor peningkatan (*gain score*) menunjukkan tidak adanya perbedaan pengaruh yang signifikan antara kedua kelompok latihan ($p > 0,05$). Kesimpulan penelitian ini adalah bahwa latihan *mirror drill* dan *ball drop drill* memiliki tingkat efektivitas yang setara dalam meningkatkan kecepatan reaksi atlet karate kumite.

Keywords: mirror drill, ball drop drill, waktu reaksi, kumite, karate

Abstract

This study aims to determine the effect of mirror drill and ball drop drill training on the reaction speed of karate kumite athletes. This quantitative study employed an experimental method with a pre-test-post-test two-group design. The sample consisted of 20 active kumite athletes from the Zenteka Karate Club Lembang Dojo, selected via purposive sampling. The participants were divided equally into two groups using the ordinal pairing technique to ensure equivalent baseline abilities: Group A (mirror drill training, $n=10$) and Group B (ball drop drill training, $n=10$). The training program was conducted over 6 weeks at a frequency of 3 times per week. Reaction speed was measured using a smartphone-based reaction speed measurement application (seconds). Data were analyzed using a paired samples t-test and an independent samples t-test at a significance level of $\alpha = 0.05$. The results of the paired samples t-test showed a significant improvement in reaction speed ($p = 0.000$). The mean score on the Reaction App improved from 3.18 ± 0.36 seconds to 3.01 ± 0.32 seconds. The independent samples t-test on the gain scores indicated no significant difference in effectiveness between the two training groups ($p > 0.05$). This study concludes that mirror drill and ball drop drill training are equally effective in enhancing the reaction speed of karate kumite athletes.

Keywords: mirror drill, ball drop drill, reaction speed, kumite, karate.

INTRODUCTION

Karate is a martial art divided into two main disciplines: kata and kumite. Kumite is a form of free sparring that requires athletes to execute attacks and defenses quickly, accurately, and tactically within a very short match duration. Success in kumite heavily depends on physical fitness and a high level of technical mastery, including agility, explosiveness, strength, and—most crucially—the athlete's reaction speed in anticipating an opponent's moves (Syamsulrizal et al., 2022). Without good reaction speed, a kumite athlete will not be able to respond to an opponent's attack in a timely manner, potentially leading to a loss of points or injury.

Reaction speed in karate kumite is an athlete's ability to respond quickly and accurately to visual stimuli and an opponent's movements through coordination between the nervous and neuromuscular systems. This ability is crucial because it determines the effectiveness of attacks and defenses during a match. Kumite athletes tend to have faster reaction times than kata athletes due to the nature of the competition, which demands responses to dynamic stimuli and rapid decision-making (Syaquro et al., 2016). In the context of karate, particularly in kumite, reaction speed is a key determinant of performance success because athletes must be able to anticipate and respond to an opponent's attacks within a very limited timeframe. Kumite athletes generally possess better whole-body reaction time and anticipation reaction time compared to kata athletes, given the dynamic nature of kumite competition, which requires rapid responses to constantly changing stimuli (Syaquro et al., 2016). Thus, superiority in reaction speed often distinguishes high-performing athletes from non-elite athletes in competitive situations.

Improving reaction speed in karate kumite athletes can be achieved through training programs specifically designed to meet the demands of competition. Speed-agility training has been proven effective in enhancing athletes' neuromuscular responses, thereby shortening the time required to respond to stimuli (Apsari Hasibuan et al., 2022).

The mirror drill is a partner exercise that requires athletes to respond to and immediately mimic their partner's movements. This exercise is effective for improving the ability to recognize stimuli, anticipate movements, and generate rapid responses, making it relevant for supporting the improvement of reaction speed in karate kumite athletes (Kusnanik et al., 2019). *The ball drop drill* is a visual stimulus-based exercise aimed at improving reaction speed through rapid responses to a ball dropped suddenly. This exercise is effective in developing hand-eye coordination, information processing speed, and motor responses, making it relevant to the needs of kumite athletes in responding quickly and accurately to an opponent's movements (Mawarti et al., 2021).

Although both training methods have been widely used in coaching practice, scientific research specifically comparing the effects of the mirror drill and the ball drop drill on the reaction time of karate kumite athletes remains very limited, particularly in Indonesia. Therefore, this study aims to (1) determine the effect of the mirror drill on the reaction time of kumite karate athletes, (2) determine the effect of the ball drop drill on the reaction time of kumite karate athletes, and (3) determine the differences in the effects of the mirror drill and the ball drop drill on the reaction time of kumite karate athletes.



THEORETICAL REVIEW

Karate Kumite

Karate is a martial art that originated in Japan and has evolved into an internationally recognized competitive sport. This development is marked by karate's transformation from a traditional martial art into a sport with a standardized competition system and rules (Kim et al., 2022). In practice, karate encompasses three main components: kihon (basic techniques), kata (a systematic sequence of movements or forms), and kumite (sparring or training against an opponent). At the competitive level, karate is contested in two main categories: kata and kumite. Kata emphasizes technical mastery, movement coordination, balance, and precision in performing a sequence of forms, while kumite is a form of sparring that involves the direct application of offensive and defensive techniques against an opponent to score points according to competition rules (Paweł et al., 2016).

Kumite matches are characterized by fast, dynamic movements and require the ability to make decisions in a short amount of time. Therefore, kumite athletes are required to be in optimal physical condition, including strength, speed, explosive power, agility, coordination, endurance, and reaction speed. These physical components work together to support the effectiveness of both attacks and defenses during a match (Indrajaya, 2017)

Among these various physical components, reaction speed is a key factor determining an athlete's success in kumite matches. Athletes must be able to recognize stimuli from an opponent's movements, process information quickly, and generate an appropriate response in the shortest possible time. The ability to react quickly enables athletes to capitalize on attacking opportunities while effectively anticipating their opponent's attacks (Syaquiro et al., 2017)

Reaction Speed

Reaction speed is an individual's ability to respond to a stimulus in the shortest possible time. This ability involves a series of processes that begin with the reception of stimuli through the senses, followed by information processing by the central nervous system, and culminating in the execution of a response through the motor system. The more efficient the processes of reception, processing, and response execution, the better. In the context of sports, reaction speed is one of the biomotor components that plays a crucial role in supporting an athlete's performance, particularly in sports that demand rapid responses to changes in match situations. Reaction speed is influenced by various factors, such as concentration level, physical condition, fatigue, experience, and the athlete's level of training. A structured and consistent training program can enhance the nervous system's ability to receive and process information, resulting in faster and more accurate responses (Apsari et al., 2021)

In karate, particularly in the kumite discipline, reaction speed plays a crucial role because athletes must be able to recognize their opponent's movements, anticipate attacks, and determine and execute the appropriate response in a short amount of time. Good perceptual abilities and neuromuscular control have been shown to contribute to improved reaction speed and technical effectiveness in karate athletes (Goethel et al., 2023)

Mirror Drill

The mirror drill is a partner-based training method that requires athletes to follow their partner's movement changes in real time. As a form of reactive agility training, this exercise demands the ability to recognize movement stimuli, anticipate changes in direction, and generate rapid and precise responses, making it effective for developing reaction speed in kumite karate athletes (Kusnanik et al., 2019)

From a neuroscientific perspective, the mirror drill is based on the concept of the mirror neuron system (MNS), a neural network that becomes active when a person performs a movement or observes a movement performed by another person. Activating the MNS through repeated observation and imitation of movements can enhance an individual's ability to recognize movement patterns, predict actions, and generate faster motor responses. In the context of karate kumite, this mechanism plays a crucial role because athletes are required to anticipate an opponent's attacks and determine the appropriate response in a short amount of time (Li & Smith, 2021)

The findings of this study align with those of Akbaş et al. (2019), who explained that athletes' performance in open-skill sports is heavily influenced by their ability to process visual information and anticipate opponents' movements. Mirror drill exercises allow athletes to continuously practice observing and responding to changes in their training partner's movements, thereby supporting improvements in visual-motor reaction speed.

Ball Drop Drill

The ball drop drill is a type of reaction time exercise that uses a visual stimulus in the form of a ball suddenly dropped by a coach or training partner. Athletes are required to respond as quickly as possible to the falling ball by catching or chasing it before it reaches a specific point. This exercise aims to improve the nervous system's ability to receive and process visual stimuli and generate rapid and accurate motor responses. Additionally, the ball drop drill can improve hand-eye coordination, concentration, and the ability to make quick decisions. The difficulty level of the exercise can be adjusted by changing the direction of the ball's fall, the athlete's distance from the point of impact, or the type of ball used, thereby making the response demands more complex and challenging (Charan, 2023).

The ball drop drill directly trains the three main components of reaction speed: visual perception speed, information processing speed in the brain, and motor response speed. Research shows that athletes who consistently train using reaction time drills experience significant improvements in overall reaction time and the success rate of reaction tasks (Lenik, 2021). In martial arts, these components are crucial because they determine how quickly an athlete can react to an opponent's attack.



Research by Śliz et al. (2022) indicates that athletes at higher competitive levels have faster reaction times compared to those at lower competitive levels. This suggests that psychomotor abilities—particularly reaction time—develop in tandem with higher training intensity and quality. Furthermore, the study’s findings also show that reaction speed is related to cognitive abilities such as attention, movement anticipation, and rapid decision-making in dynamic game situations.

METHODS

The research method used in this study was quantitative with a quasi-experimental design. This design was chosen because the research subjects were karate kumite athletes who were already part of naturally established training groups, making it impossible for the researcher to randomly assign subjects to experimental and control groups without disrupting the ongoing training program. This aligns with the view (Frankel, 2019) that a quasi-experimental design serves as a methodological solution when researchers cannot manipulate or randomly assign subjects but still wish to evaluate the effectiveness of a treatment—which, in this study, consists of the mirror drill and ball drop drill training exercises.

The study population consisted of all active kumite karate athletes at the Zenteka Karate Club Dojo in Lembang. The research sample was determined using purposive sampling, a technique for selecting a sample based on specific considerations or criteria aligned with the research objectives (Sugiyono, 2019). The inclusion criteria used were as follows: (1) active karate athletes aged 12–22 years (cadet to senior categories according to World Karate Federation/WKF standards); (2) having at least one year of training experience; (3) participating in regular training sessions at least three times a week; and (4) not currently suffering from musculoskeletal injuries that could affect the implementation of the training program or the research measurements.

Based on these criteria, a sample of 20 athletes ($n = 10$ per group) was selected. This sample size is sufficient to detect a *medium effect size* ($d \geq 0.5$) with 80% *statistical power* and is consistent with research methodologies applied to karate athletes (Petri et al., 2019; Yudhistira & Tomoliyus, 2020). Group assignment used the ordinal pairing technique based on *pre-test* score rankings to balance the subjects’ baseline abilities (Fraenkel, Wallen, & Hyun, 2012; Thomas et al., 2015). Group A received the *mirror drill* ($n = 10$), and Group B received the *ball drop drill* ($n = 10$). The equivalence of the initial abilities of the two groups was subsequently verified statistically using a test for homogeneity of variances ($p > 0.05$).

Instruments and Data Collection

Reaction time was measured using one instrument during the *pre-test* and *post-test*:

1. The Reaction Time Smartphone Application was used to measure a visual stimulus in the form of a changing number on the device’s screen. Athletes were asked to respond as quickly as possible after the stimulus appeared, and reaction time was automatically recorded by the app. Data collection consisted of two trials for each instrument, and the average value was established as the final research data.

The training program for both groups was conducted over 6 weeks at a frequency of 3 sessions per week (a total of 18 sessions). This duration and frequency were chosen to allow sufficient time for

neuromuscular adaptation while maintaining optimal recovery, thereby minimizing the risk of overtraining (Harsono, 2017).

Data Analysis Techniques

Data analysis was performed using SPSS version 25. Prerequisite tests included a normality test of data distribution using the *Shapiro-Wilk* test ($n < 50$) and a homogeneity of variances test using *Levene's test* (Field, 2018). Hypothesis testing was conducted using a *paired-samples t-test* to measure the effect of the treatment within groups (*pre-test* vs. *post-test*), as well as an *independent-samples t-test* on *gain scores* to compare the effectiveness across treatment groups. All statistical decisions were set at a significance level of $\alpha = 0.05$ (Pallant, 2020).

RESULTS AND DISCUSSION

Research Results

This study involved 20 karate kumite athletes divided into two treatment groups: the mirror drill group ($n = 10$) and the ball drop drill group ($n = 10$). Reaction time measurements were conducted using one instrument: the Reaction App (in seconds).

Based on a descriptive statistical analysis of the entire sample ($n = 20$), the mean pre-test score for the Reaction App was 3.18 ± 0.36 seconds, which decreased (indicating an increase in speed) in the post-test to 3.00 ± 0.32 seconds, with an average gain score of 0.17 ± 0.04 seconds.

Table 1. Normality Table

Group		Kolmogorov-Smirnov			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	Df	Sig.
Pre-Reaction App	Mirror Drill	.202	10	.200	.892	10	.180
	Ball Drop Drill	.140	10	.200	.849	10	.662
Reaction App	Mirror Drill	.222	10	.177	.874	10	.110
	Ball Drop Drill	.135	10	.200	.938	10	.532

The normality test was conducted using the Shapiro-Wilk method because the sample size for each group was small ($n = 10$). The test results showed that the significance values (p) for the Reaction App variable in the Mirror Drill group (pre-test $p = 0.180$; post-test $p = 0.110$) and the Ball Drop Drill group (pre-test $p = 0.662$; post-test $p = 0.532$) were all greater than 0.05 ($p > 0.05$). Thus, it can be concluded that all data are normally distributed.

Table 2 Homogeneity Test

	Levene Statistic	df 1	df 2	Sig.
Pre-Reaction App	.182	1	18	.675



Reaction App Rank	.091	1	18	.766
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The results of *the Levene's Test* for homogeneity of variances showed a significance value of 0.675 for the pre-test Reaction App data and 0.766 for the post-test Reaction App data. Since all significance values were greater than 0.05 ($p > 0.05$), the variances of the data across groups were deemed homogeneous.

Table 3. Paired Sample Statistics

	Test	Mean	N	Std. Deviation	Standard Error of the Mean
Reaction App	Pretest	3.18065	20	.363449	.801270
Reaction App	Post-test	3.00995	20	.326926	.073103

The results of the paired-sample test are shown in Table 4 below.

Table 4. Paired Sample Test

	Mean	Standard Deviation	Standard Error of the Mean	Lower	Upper	T	df	Sig. (2-tailed)
Pre-test Reaction App – Post-test Reaction App	.170700	.047779	.010684	.148339	.193061	15.978	19	.000

Based on the results of *the paired-sample t-test* in Table 4, it is evident that there is a significant difference between the pretest and posttest scores on the Reaction App variable, with a mean difference of 0.1707 ($t = 15.978$; $df = 19$; $p = 0.000$). The hypothesis testing criteria state that if the significance value (p) is less than 0.05, then H_0 is rejected and H_a is accepted, whereas if p is greater than 0.05, then H_0 is accepted. Since the significance value obtained ($p = 0.000$) is smaller than 0.05, H_0 is rejected and H_a is accepted, indicating that the treatment administered resulted in a significant increase in the athletes' reaction speed.

Discussion

Based on the research results, the 6-week training intervention was shown to produce significant changes in the athletes' visual-motor performance. This conditioning of the nervous system is discussed in depth based on each data measurement instrument as follows:

Analysis of Reaction Time Using a Smartphone Application

Consistent with the results of the mechanical tests, measurements using smartphone applications (Reaction Apps) also showed a significant trend toward increased speed. The average pre-test visual reaction time of 3.18 ± 0.36 seconds was reduced to 3.00 ± 0.32 seconds at the post-test, with an average gain score difference of 0.17 ± 0.04 seconds ($t = 15.978$; $p = 0.000$).

Although there were differences in input media, functional adaptation in the brain remains based on the principle of neuroplasticity (Luu et al., 2021). The success in reducing response time demonstrates the efficiency of visual information processing in the occipital cortex in recognizing changes in color stimuli on device screens.

Theoretical Integration of Content Regarding Karate Kumite Categories

The most important comparative finding in this study shows that there was no significant difference in effectiveness between the mirror drill and ball drop drill groups ($p > 0.05$). This indicates a degree of equivalence in the effects between the two methods. Why do these two exercises produce equivalent outcomes? The answer lies in the comparable neuromuscular loading characteristics on both the simple and choice reaction time components.

The mirror drill exercise conditions a dynamic interactive response. Through the activity of the Mirror Neuron System (MNS) in the brain, athletes practice mapping visual perceptions of the opponent's biomechanical cues (anticipatory cues) directly to their own motor representations in real time (Petri et al., 2020). Meanwhile, the ball drop drill relies on a free-falling mechanical object that demands eye-hand coordination as well as convergent spatial attention (Lenik, 2021).

Given that karate kumite is an "open skill sport" where situations change in milliseconds (Mori et al., 2002), both of these training mechanisms are equally crucial. Therefore, this equivalence confirms that physical trainers can combine these two drills in various ways within specialized physical conditioning programs to boost psychomotor performance while preventing psychological boredom in athletes (the "boredom effect").

CONCLUSION

Based on the results of data analysis, hypothesis testing, and discussion in this study, the following conclusions can be drawn:

1. The *mirror drill* exercise has a significant effect on improving the reaction speed of kumite karate athletes at the Dojo Zenteka Karate Club in Lembang.
2. The *ball drop drill* has a significant effect on improving the reaction speed of kumite karate athletes at the Dojo Zenteka Karate Club in Lembang.
3. There is no significant difference in the effects of the *mirror drill* and *ball drop drill* on improving athletes' reaction speed. Both training methods are equally effective in training and improving the visual-motor reaction speed component in senior and cadet kumite karate athletes.

Recommendations / Suggestions for Further Action: Based on the above conclusions, the researchers recommend that sports physical trainers, particularly in karate, integrate these two *drill* methods into their weekly training programs as a means of conditioning biomotor reaction functions. For future researchers, it is recommended to measure other supporting variables, such as *whole-body reaction time*, using *Light Reaction System-based* sensors (such as *Blazepod*), as well as to extend the duration of the intervention or include a pure control group to obtain more comprehensive generalizable data.



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