ORIGINAL ARTICLE

Simple and choice response time among elite and novice karate athletes and non-athletes

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B Data Collection
C Statistical Analysis
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Abstract

Background and Study Aim: Simple and choice response time (RT) are important determinants for karate competition. Studies showed notable controversy on a discrepancy in RT among different level of karate skill. This study's aim is knowledge about simple and choice RT elite and novice karate athletes and also non-athletes (all from college students).

Material and Methods: We recruited three groups from college students: elite karate athletes (n = 28), novice karate athletes (n = 34) and non-athletes (n = 97). RT was measured in five conditions: simple RT at zero and shoulder distance, along with choice RT at zero, shoulder and random distance, by using FITLIGHT Trainer™ System (FTS), for dominant and non-dominant hands.

Results: RT of dominant hand measured at simple with zero distance were 335.43 ±73.05 ms, 306.33 ±47.05 ms and 292.33 ±45.4 ms for non-athletes, novice and elite karate athletes, respectively. Compared with non-athletes, elite karate group had significantly faster simple and choice RT, while novice karate group had significantly faster choice RT ($p<0.01$ for all conditions). When compared between two karate groups, the elite group was faster in choice RT at a random distance than the novice group ($p<0.001$).

Conclusions: The findings suggest karate practice improves RT among young adults and there is a significant discrepancy between elite and novice level of karate athletes at choice RT. FTS is a potential standardised tool for response time assessment using light stimulation.

Keywords: combat sports • FITLIGHT Trainer™ System • kumite

Conflict of interest: Authors have declared that no competing interest exists

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Response time – time from acknowledging stimulation to completing the task as in respond with overt action [6].

Novice – an individual new and relatively less experience in certain area.

Elite – an individual with superior experience and ability in certain area.

INTRODUCTION

Karate is a popular combat sport involved in many international sporting events such as World and Continental Games (the first time in the programme of the Tokyo 2020 Olympic Games). The word 'Karate' literally means 'empty hand', it is an unarmed self-defence art, originally derived from a martial art developed in Okinawa, Japan, in the 17th century. Karate was then spread throughout the world after World War II, and nowadays there are millions of people practising this martial art around the world [1]. Karate is a physically high-demand sport where practitioners required high fitness levels, including cardiorespiratory endurance, muscular strength, muscular endurance and flexibility [2]. Additionally, skill-related components such as reaction time/response time (RT), speed, agility, power, balance, coordination and are essential for competition and performance [1, 3].

Reaction time and response time are often used interchangeably. However, there is a slight semantic difference between these two phrases [4, 5]. "Reaction time" refers to the duration taken to respond to the onset of a stimulus, without movement or motor action, whereas "response time" usually describes "time from acknowledging stimulation to completing a task as in respond with overt action" [6]. In other words, the response time (RT) is the sum of sensory and motor reaction times. RT refers to the speed at which a person moves in response to a stimulus and is a critical element in most sports, including karate. For instance, the sparring component of karate (kumite) requires rapid reaction to defend and attack. RT requires intact sensory skills, decision processing and motor performance [4, 7]. Sensory RT basically relies on the task imposed to either simple or choice situation. The simple situation involves only one type of stimuli while choice situation challenges with more than one type of stimuli.

On the other hand, motor RT is the duration from identification of external stimulus to completion of corresponding action [8]. In karate, RT reflects the time an athlete takes to identify the opponent's gesture or movement, interpret it and initiate a corresponding action. Visual RT is usually the decisive factor in winning a contest [9]. Furthermore, choice RT is often more important in kumite with attack and defence that occurs within very short period.

RT in combat sports was studied for at least three decades. However, research in karate involving this skill is scarce compared to other skill-related components. Various factors such as age, sex, hand dominance, visual ability, fatigue, fasting, exercise, sport activities, and medical condition influence RT. Bamne's study reported that, among students between 17-25 years old, RT in females is longer as compared to males and RT to red light stimuli is longer as compared to green light stimuli in both sexes [10]. From the aspect of sports, studies had been showing controversial conclusions on the discrepancy of visual RT among athletes at different games or level and non-athletes [1, 11-15]. Divergent measuring condition and tools could be the biggest factor leading to this inconclusive phenomenon.

Therefore, this study's aim is knowledge about simple and choice visual RT in different conditions elite and novice karate athletes and also non-athletic (all from college students).

MATERIAL AND METHODS

Participants

This study recruited three groups of collegiate students from Dec 2016 to Oct 2017. A total of 170 participants were recruited initially, but only 159 observations were left for analysis due to irreversible damage to the FTS tablet in an incident and failure to retrieve the set of 11 collected data stored in the tablet. The first group was elite karate athletes (n = 28) with at least five years practising karate and had participated in national levels of karate competition within the past year: 7 females (25.0%), mean age: 21.57 ±2.37 years; 21 males (75.0%), mean age 21.19 ±1.57 years. The second group was novice karate athletes (n = 34) with at least one-year practice in karate:

Table 1. Elementary data about young non-athlete, karate novice and karate elite (n = 159).

Variable	Total (n = 159)	Non-athletes (n = 97)	Karat athletes		p value
			novice (n = 34)	elite (n = 28)	
Sex					
Female	88 (55.35%)	70 (72.16%)	11 (32.35%)	7 (25.0%)	<0.001
Male	71 (44.65%)	27 (27.83%)	23 (67.65%)	21 (75.0%)	
Age (years)					
Female	20.43 ±1.93	20.23 ±0.82[A]	21.09 ±1.70	21.57 ±2.37[B]	0.0024
Male	20.78 ±1.36	20.53 ±0.68	20.74 ±1.74	21.19 ±1.57	0.2401
Hand dominance (female)					
Left	6 (6.82%)	3 (4.29%)	1 (9.09%)	2 (28.57%)	0.0583
Right	82 (93.18%)	67 (95.71%)	10 (90.91%)	5 (71.43%)	
Hand dominance (male)					
Left	11 (15.49%)	3 (11.11%)	4 (17.39%)	4 (19.05%)	0.7724
Right	60 (84.51%)	24 (88.89%)	19 (82.61%)	17 (80.95%)	

[A, B] Different letter represents a significant difference between groups.

11 females (32.35%), mean age: 21.09 ±1.70 years; 23 males (67.65%), mean age 20.74 ±1.74 years. The third group consisted of 97 non-athletic students: 70 females (72.16%), mean age: 20.23 ±0.82 years; 27 males (27.83%), mean age 20.53 ±0.68 years.

There was a significant difference in sex among the three study groups (p<0.001). Men in the three groups have no difference in age, but women in elite karate group were significantly older than women in the non-athlete group (p<0.0024). Most participants were right-handed, and there was no significant difference in hand dominance among groups (p = 0.0583 and 0.7724 for women and men, respectively) (Table 1).

This study was approved by the Institutional Review Board from Chang Gung Medical Foundation, Taiwan (no. 201600729A3, 201601220B0 and 201601955B0). Written informed consent (ICF) was obtained for all participants. For those whose age from 18-19 years old, parental consent was obtained because the legal age of adults in Taiwan is 20 years old.

Tools

In this study, FITLIGHT Trainer™ System (FTS), FITLIGHT Sports Corp., Canada, was used to measure RT. FTS is a wireless light system comprised of eight RGB LED powered lights controlled by a tablet (Figure 1A and B). The lights served as visual stimuli and were used as targets for the user to deactivate. Time taken to deactivate the lights enables measuring of RT abilities, while the number, colour and position of the lights allow a variety of condition. Immediate feedback of user's performance was captured in milliseconds (ms) and recorded automatically in the tablet. The sequence of the flashing lights, the delay between lights and runtime of the light-on were programmable. We standardised the program for all participants. Data was subsequently downloaded to a central computer for future analysis.

We obtained the test-retest reliability of RT using FTS by having 12 karate athletes take the measurement twice within two weeks.

Procedure

RT was measured by the speed at which the participant in response to the flashing light discs. Participants were to respond by touching on the light disc using their palm/fingers to deactivate the light as quickly as possible. Simple RT measurement consisted of green light ('go' task) while choice RT measurement consisted of green and red lights ('go' and 'no-go' task respectively). There was only one light flashing at a time for all measurements. Both simple and choice RT were measured at zero and shoulder distance (SRT_zero, SRT_shoulder, CRT_zero, CRT_shoulder, respectively) (Figures 2 and 3) which indicated

Figure 1: A. FITLIGHT Trainer™ system (FTS); **B.** LED light of the FTS.

by the position of light discs. The random distance of light discs was added to the choice RT measurement (CRT_random) (Figure 4). Hence in addition to the judgment of light colours, the unexpected location of flashing light served as the other stimulus to the participants. We tested both dominant and non-dominant hands for all conditions.

The participant was standing facing the wall with one-arm-length distance from the wall, raising the tested arm to eye-level at front chest with palm gently touching the wall. Light discs were positioned according to the measuring distance as shown in Figures 2 to 4. For zero distance, one light disc was placed immediately next to the

Figure 2. Measuring SRT/ CRT_zero.

Figure 3. Measuring SRT/ CRT_shoulder.

Figure 4. Measuring CRT_random.

participant's tested palm on the wall (Figure 2); while for shoulder distance, and the light disc was placed shoulder-width away from the participant's palm (Figure 3). For random distance, eight light discs were positioned around the tested palm, as showed in Figure 4. Five trials were given for SRT_zero and SRT_shoulder, ten trials for CRT_zero and CRT_shoulder, while 30 trials for CRT_random, because of higher variation of RT in more difficult conditions. In order to

avoid the outlier effect on the mean due to inattention or external disturbances, we eliminated the highest and lowest measured values of the trials and only used an average of remained values for data analysis.

Each RT measuring condition indicates certain abilities of RT. Subtracting the duration of certain RT measurements yielded the biological phases of RT circle. For instance, measuring simple RT at the minimal distance between initiating and ending position indicates the sensory ability of a person in response to a stimulus. The sensory pathway involved depends on the stimulation of either vision or auditory, etc. On the other hand, motor performance could be determined by the difference of RT between zero and shoulder distance (measured at the same simple or choice condition). The discrepancy of duration to deactivate the lights between simple and choice conditions indicates the decision making of an individual. The smaller discrepancy indicates better performance of that RT ability [4].

Data analysis

We compared sex or hand dominance among the three study groups by Chi-square test or Fisher's exact test, where appropriate. We applied the two-way analysis of variance (ANOVA) to compare the RT among three study groups and between two genders. The interaction between the study group and gender were examined first. Scheffe's multiple comparisons were made to find out which group was different from which group. The significance level was set at 0.05. The intraclass correlations of RT measurements were 0.70-0.95 for the dominant hand and 0.80-0.94 for non-dominant hand.

RESULTS

We observed no significant interaction between group and gender and significant main effects of gender and group in RTs for both dominant and non-dominant hand. Obviously, RT increased from simple to choice condition and from zero to random followed by shoulder distance. Under all conditions, all participants generally performed fastest at zero distance. Under simple conditions, longer duration needed for SRT_shoulder compared to SRT_zero (20 to 30 ms) was observed. Under choice conditions, there were longer RT from CRT_zero to random to shoulder distance. RT took approximately 70 ms more from CRT_zero to CRT_shoulder; around 10 to 40 ms more from CRT_shoulder to CRT_random among three groups. Male college students significantly responded faster in all RT conditions, compared to females ($p<0.01$ for all conditions). For SRT_zero of dominant hands, males took 303.71 ±59.24 ms while females took 336.07 ±68.20 ms. Duration increased for both group in choice conditions or farther distance. For CRT_zero of dominant hands, males took 368.99 ±57.31 ms while females took 426.74 ±61.02 ms. Males generally were 30 to 40 ms faster than females in simple RT condition and increased to 50 to 70 ms in choice RT condition at a different distance. Similarly, the discrepancy between both gender by non-dominant hands ranged from 50 to 90 ms (Figures 5 and 6).

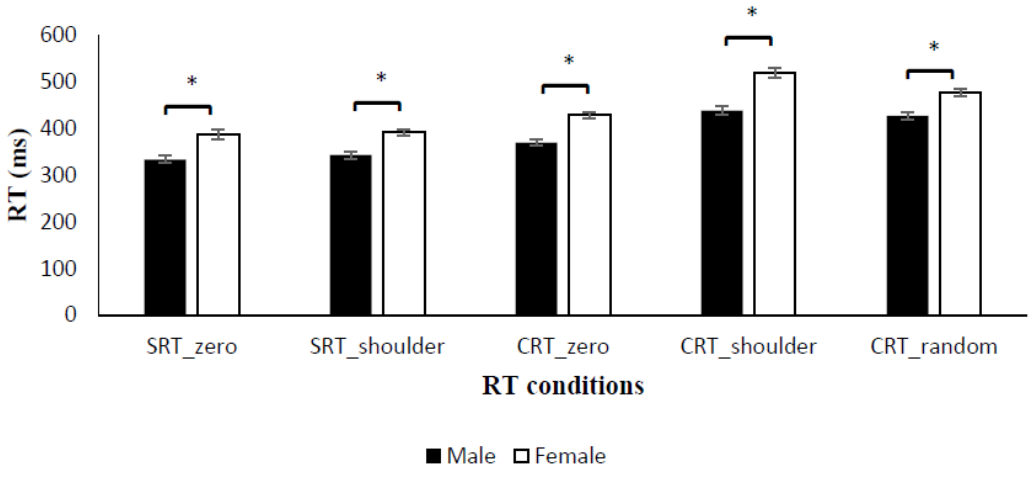

Figure 5. Response time (millisecond) of dominant hand between male (n = 71) and female (n = 88) college students.

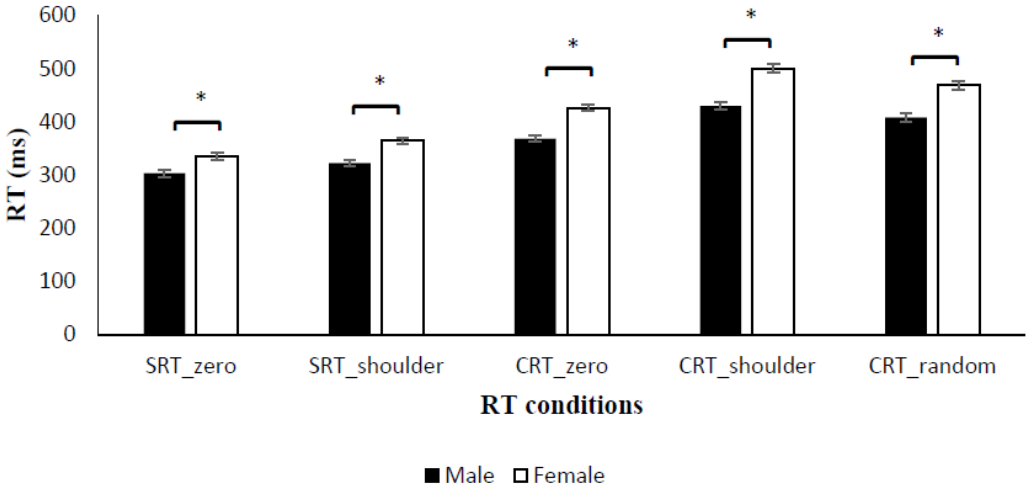

Figure 6. Response time (millisecond) of non-dominant hand between male (n = 71) and female (n = 88) college students.

SRT – simple response time; **CRT** – choice response time; presented error bar is for standard error (SE). **SRT_zero** – simple response time at zero distance; **SRT_shoulder** – simple response time at shoulder distance; **CRT_zero** – choice response time at zero distance; **CRT_shoulder** – choice response time at shoulder distance; **CRT_random** – choice response time at random distance.

RT of dominant hand measured at SRT_zero was 335.43 ±73.05 ms, 306.33 ±47.05 ms and 292.33 ±45.4 ms for non-athletes, novice and elite karate athletes, respectively. While RT of dominant hand measured at CRT_zero were 423.7 ±63.58 ms, 376.28 ±61.38 ms and 352.11 ±35.9 ms for non-athletes, novice and elite karate athletes, respectively. In general, karate athletes responded faster in all conditions compared to non-athletes (Figures 7 and 8), but significant difference was only seen between elite karate group and non-athletic students in all conditions for both dominant and non-dominant ($p<0.001$ for all). Elite athletes responded significantly quicker in choice RT with random distance compared to novice karatekas ($p<0.001$). Novice karatekas are significantly quicker than non-athletes under choice conditions only ($p<0.001$ for CRT_zero and CRT_shoulder).

DISCUSSION

The main finding of this study showed that karate athletes responded faster than non-athletes in all conditions. Comparing to non-athletes, and-novice karate athletes were significantly faster in choice RT while elite karate athletes were faster in both simple and choice conditions. Practising karate improves young people's RT, especially decision-making process in a visuomotor task. This finding is supported by previous studies [16-19]. Muinos et al. [18] compared RT of martial arts athletes (judo and karate) with non-athletes and reported that martial arts athletes were significantly faster than non-athletes. On the other hand, Lee et al. [20] measured the RT by having the participants to perform ballistic finger extension movements and finding showed that karate athletes were significantly faster than sedentary participants.

Moreover, elite karate athletes were significantly better than novice athletes in choice RT at random distance but not in the other conditions. Through years of practice and experience, expertise in sport enables faster decision-making ability, particularly in more challenging situations. Our finding is partly in accordance with previous studies. A study by Mori et al. [12] reported a significant difference in choice RT but not simple RT between high-level and novice karate athletes, although Layton's [11] study reported a significant lower simple RT from karate black belt practitioners as compared to novice karate athletes. While another study reported a significant difference between karate athletes with at least 10 years of experience in competition and beginners [21]. Fontani et al. [22] also found that expert karate athletes were more superior in visual RT compared to sub-expert karate athletes.

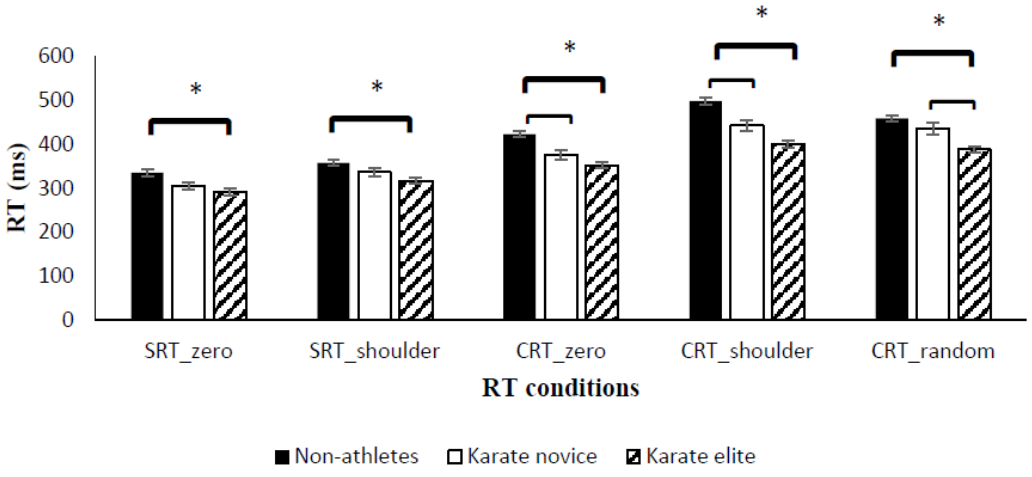

Figure 7. Response time (millisecond, ms) of dominant hand among college non-athletes (n = 97), karate novice (n = 34) and karate elite (n = 28).

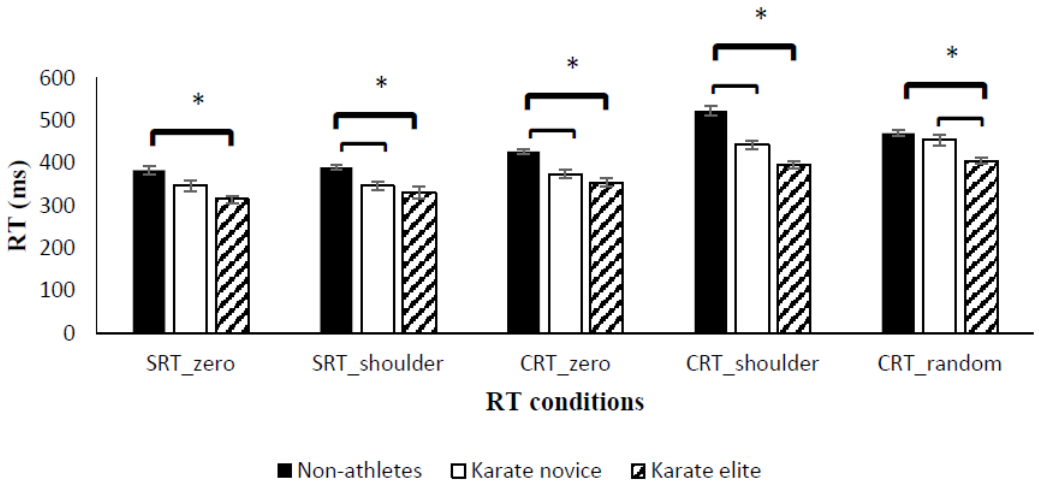

Figure 8. Response time (millisecond) of non-dominant hand among college non-athletes (n = 97) , karate novice (n = 34) and karate elite (n = 28).

SRT – simple response time; **CRT** – choice response time; presented error bar is for standard error (SE). **SRT_zero** – simple response time at zero distance; **SRT_shoulder** – simple response time at shoulder distance; **CRT_zero** – choice response time at zero distance; **CRT_shoulder** – choice response time at shoulder distance; **CRT_random** – choice response time at random distance.

Our result showed that RT increased from simple to choice conditions and from zero to random followed by shoulder distance. Our finding is in line with Hick's [23] law which reported a person requires more time to make a decision as a result of the possible choices the individual faced. Different distance from the initial point to ending point during RT measurement resulted in different duration. Zero distance in our study was presumed by placing palm right next to the stimulus, therefore only minimum motor action required for this condition, while shoulder distance required more motor action from bigger muscle groups. Among three distances tested for choice RT, random distance appeared to be shorter than shoulder distance as the distance between closer and farther lights was averaged out.

Our study also showed that RT of males significantly faster than females. This result is in line with a couple of studies investigated factors associated with RT among young adults [10, 24, 25]. Adam [24] suggested that the superiority of males in RT is due to a specific information processing strategy which differed from females.

This study implied a referring RT target among karate practitioners. The average RT scored by elite athletes in this study could be the desired result to novice or beginners during training. It could also be used as a passing mark to differentiate elite and novice karate athletes. Besides, we noticed that most of the current measurement tools for RT research involves video-based method [12, 21], self-invented device [13, 26], mobile technology [27] or medical diagnostic devices such as electroencephalography (EEG), electromyography (EMG) [16, 28]. FITLIGHT Trainer™ System is commercially available and was used as a testing tool for physical performance in a few studies [29, 30]. We saw the potential of this system as a standardised measuring tool for RT in future, given its features such as reliable results, user-friendly and reasonable cost. Using a standard measuring instrument allows more comparable results among similar studies.

There were a few limitations in this study. Firstly, there was an unmatched percentage of females among the three groups. This is due to the nature of gender difference whereby there were more female students willing to participate in the study, but not many of them practised karate. However, there is a trivial impact on our result since data were already stratified by gender. Secondly, we had an unfortunate loss of 11 sets of observations from the non-athletes group. This possibly reduced the sample size of data between groups. Thirdly, there were a few participants in this study who had 1st dan black belt but did not participate in the national level competition were categorised into karate novice group which comprised of as novice as 6th-grade karatekas. This is due to the criteria set for elite karate group were at least five years of practice and experience in national level competition for the past year. Consequently, there was wider range in standard deviation for karate novice group as compared to the elite group. Future study may consider a more discrete categorisation on karate athletes and to continue to exploring the probability in using FITLIGHT Trainer™ System as a standard measuring tool for RT.

CONCLUSIONS

The findings suggest karate practice improves RT among young adults and there is a significant discrepancy between elite and novice level of karate athletes at choice RT.

HIGHLIGHTS

- Choice response time required longer processing time compared to simple response time.
- Male young adults have a quicker response time than females.
- Young adults practising karate are faster in both choice and simple response time compared to non-athletic young adults.
- Elite karate athletes have quicker choice response time when tested with random distance than novices.
- FITLIGHT Trainer™ System is a potential standardised tool for response time assessment using light stimulation.

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