Effectiveness of visuomotor program via light signal on simple and choice static eye-hand response time among collegiate karate kumite athletes: pretest-posttest design with a control group

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Abstract

Background and Study Aim: Quick response time (RT) is crucial in karate kumite. Current training rarely use light as training tool. This study aim is the effectiveness of visuomotor training via light signal with human signal on the simple and choice eye-hand RT among collegiate karate athletes.

Materials and Methods: We recruited 18-25 years old collegiate karate kumite athletes from three non-sport universities. The routine karate practice was standardized to once a week, consisted of 1-hour fitness training in Gym and 1-hour kumite skill training. Subjects were assigned to group A (light signal) or B (human signal) based on the universities. Both groups were trained twice a week for consecutive 6 weeks. RT was measured before and after training, including 2 simple and 3 choice tasks measured at zero, shoulder-width or random distance: SRT_zero, SRT_shoulder, CRT_zero, CRT_random and CRT_shoulder.

Results: Group A had 13 athletes and group B had 11 athletes. Baseline SRT_shoulder for dominant hands was significantly different for both groups but not the other measures. After 6 weeks of training, group A showed significant improvement in SRT_zero and SRT_shoulder for dominant hands (p = 0.0066 and p = 0.001, respectively); and SRT_shoulder and CRT_zero for non-dominant hands (p = 0.0138 and p = 0.0015, respectively). Group B showed deterioration for CRT_shoulder at non-dominant hands after training (p = 0.0037) but no significant difference at other tasks. When compared the difference before and after training, for dominant hands, group A improved significantly more in CRT_shoulder (p = 0.0201) than group B; for non-dominant hands, group A improved significantly more in SRT_shoulder and CRT_shoulder (p = 0.0206 and p = 0.0029, respectively) than group B.

Conclusions: Six weeks of visuomotor training via light signal improved simple RT and some choice RT in collegiate karate athletes than using human signal. Thus, the visuomotor training method can also be used in health-related training, in improving human motor safety, especially developing self-defense capabilities.

Keywords: light training program • visual stimuli • FITLIGHT TrainerTM System

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INTRODUCTION

Karate is a physically high-demand sport [1] which involves essential skills such as response time (RT), speed, agility, power, balance, and coordination [2, 3]. RT is particularly important in kumite, the sparring component of karate. Karate kumite is a combat sport where two athletes confront directly with each other in a variable and interfering situation. Quick sensory and motor response determine the chance to outperform the opponent.

RT refers to the speed at which a person moves in response to a stimulus and is a critical element in most sports. RT requires intact sensory skills, decision processing, and motor performance. Kumite athletes need rapid reaction and have more pronounced dependence on perceptual and anticipatory skills given the fast movement between two athletes in a short distance.

Simple situation involves only one type of stimulus while choice situation challenges with more than one type of stimuli. On the other hand, motor RT is the duration from the identification of external stimulus to completion of corresponding action [4]. Choice RT involves information processing such as the four identified stages of stimulus coding, stimulus-stimulus translation, stimulus-response translation, and response selection, as suggested by Donders's law [5]. In karate, RT reflects the time an athlete takes to identify the opponent's gesture or movement, interpret it and initiate a corresponding action. RT is usually the decisive factor in winning a contest [6]. Furthermore, choice RT is often more important in kumite with attack and defense that occurs within a very short period.

Visuomotor training for RT among athletes has been long practiced [7-11] but not many involves evaluate the effectiveness among karate athletes. Vando et al [10] designed a visual feedback training program for young karate athletes and reported a positive outcome for the trained group. RT training for karate athletes mostly involved video or human as the stimuli [12-14]. Recent call for light as a stimulus has risen. Paul et al. [13] suggested light stimulus is a better training method than video and human stimuli because it is more reliable, consistent and easy to reproduce. Video stimulus needs specific equipment and is time constrained. Whereas, human involvement affects accuracy, repeatability, costly and safety.

This study aim is the training effect of light signal with human signal on the simple and choice static eye-hand RT among collegiate karate kumite athletes.

MATERIAL AND METHODS

Study design
This was a pretest-posttest design with a control group. The participants were assigned to either light signal visuomotor training (group A) or human signal visuomotor training (group B) based on the university in order to avoid exchange information or technique between the two study groups. The three universities involved are non-sport university. The routine karate practice for all 3 universities were standardized to once a week, consisted of 1-hour fitness training in Gym and 1-hour karate kumite skill training for the karate athletes involved in this study. In addition to the routine karate practice, the visuomotor training session was not combined with the routine karate training and was on a separate day. Various RTs were measured before and after the training for both groups.

This study was approved by the Institutional Review Board of the study institute. All subjects signed the informed consent form (and by their parents if age <20 y/o) after explaining the nature and possible consequences of the study.
Participants
We recruited 24 karate athletes aged 18-25 years old. Exclusion criteria was myopia without correction (best corrected visual acuity ≤0.8 in both eyes or astigmatism of ≥0.75D). Group A (n = 13, mean age 21.31 ±2.25, BMI 23.76 ±3.30 kg/m²) had 6.08 ±2.75 years in practicing karate. Group B (n = 11, mean age 21.64 ±1.57, BMI 21.64 ±2.06 kg/m²) had 4.73 ±5.1 years in practicing karate (Table 1). The group A had more participants experienced in karate contest (p=0.0045) and exercised more hours in a week (p = 0.0115) compared to the group B. There was no significant difference in sex distribution, age, BMI, hand and foot dominance, karate practicing years, hours spent with computer or playing video games in both groups. Noted that no one in both groups withdrew from this study.

Measurements
Subjects were first measured for their static visual acuity (SVA) and then baseline RT by testing on the simple and choice RT tasks. After 6 weeks of training, the subjects were tested again on the RT tasks. SVA was performed using a standard Landolt C chart. SVA in decimal acuity for both eyes were recorded. All participants received an auto-refractometric exam and refractive correction to obtain their refractive state and best corrected visual acuity of each eye. Subjects with best corrected visual acuity ≥0.8 in both eyes and astigmatism of ≤0.75D were eligible.

RT was measured using FITLIGHT Trainer™ system, FITLIGHT Sports Corp., Canada. The FITLIGHT Trainer™ system (FTS) is a wireless light system comprised of 8 RGB LED powered lights controlled by a tablet (Figure 1). The lights are used as targets for the user to deactivate as per the examination routine. Various measurements can be captured for immediate feedback in relation to the user’s performance or can later be downloaded to a central computer for future analysis. The lights can be deactivated by use of the user’s hands, feet, head, or sport/fitness related equipment, either through full contact or proximity. In this study, eye-hand RT was

Table 1. Elementary characteristics and karate experience at baseline among collegiate karate athletes (n = 24) between group A and group B.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Group A (n = 13)</th>
<th>Group B (n = 11)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex (n(%))</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>8 (61.54)</td>
<td>5 (45.45)</td>
<td>0.4307</td>
</tr>
<tr>
<td>Female</td>
<td>5 (38.46)</td>
<td>6 (54.55)</td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td>21.31 ±2.25</td>
<td>21.64 ±1.57</td>
<td>0.6876</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>23.76 ±3.30</td>
<td>21.64 ±2.06</td>
<td>0.0822</td>
</tr>
<tr>
<td>Hand dominance (n(%))</td>
<td></td>
<td></td>
<td>1.0000</td>
</tr>
<tr>
<td>Right</td>
<td>12 (92.31)</td>
<td>10 (90.91)</td>
<td></td>
</tr>
<tr>
<td>Left</td>
<td>1 (7.69)</td>
<td>1 (9.09)</td>
<td></td>
</tr>
<tr>
<td>Foot dominance (n(%))</td>
<td></td>
<td></td>
<td>0.0983</td>
</tr>
<tr>
<td>Right</td>
<td>9 (69.23)</td>
<td>11 (100)</td>
<td></td>
</tr>
<tr>
<td>Left</td>
<td>4 (30.77)</td>
<td>0 (0)</td>
<td></td>
</tr>
<tr>
<td>Karate practicing years (year)</td>
<td>6.08 ±2.75</td>
<td>4.73 ±5.1</td>
<td>0.4306</td>
</tr>
<tr>
<td>Karate contest experience in the past 5 years</td>
<td>2 (15.38)</td>
<td>8 (72.73)</td>
<td>0.0045</td>
</tr>
<tr>
<td>No</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>11 (84.62)</td>
<td>3 (27.27)</td>
<td></td>
</tr>
<tr>
<td>Exercise habit (hour/week)</td>
<td>10.88 ±6.62</td>
<td>3.64 ±2.38</td>
<td>0.0115</td>
</tr>
<tr>
<td>Hours spent with computer (hour/week)</td>
<td>11.88 ±20.3</td>
<td>26.73 ±18.88</td>
<td>0.0790</td>
</tr>
<tr>
<td>Hours spent playing video games (hour/week)</td>
<td>13.08 ±14.59</td>
<td>11.73 ±17.2</td>
<td>0.8370</td>
</tr>
</tbody>
</table>

Group A: light signal training; Group B: human signal training
measured for both dominant and non-dominant hands, included 2 simple and 3 choice tasks measured at zero, shoulder-width or random distance: SRT_zero, SRT_shoulder, CRT_zero, CRT_shoulder and CRT_random (Figure 2-4). A detailed description of procedure was written in our previous study, Liu et al. [15].

Training program
The visuomotor training program was designed by the first author who is a karate coach, health fitness instructor, university professor for 20 years, and was a national-level karate athlete. Group A was trained via light signals while group B was trained via human signals. Both groups followed the same program as shown below, but only group A had set signal time. Light signal flashed blue or red light as pre-programmed in FTS (Figure 5). Both groups’ duration and frequency are very similar. Participants practiced biweekly for a consecutive 6 weeks with a progressive plan of punches and kicks. Table 2 showed the details of the training program.

The training program was progressively intensified every week in terms of the number of simultaneous signals, the duration of each round, the number of rounds, and the breaks between rounds. All sessions were conducted in the evening. Before each session, participants performed general warm up exercise for 15 minutes. The program focused on simple task for week 1 to 4 and progressed to a choice task at week 5 and 6. Blue signal was used as go task and red signal was used as no/go task. For week 1, only one blue signal was flashed (simple task) at a time, 5 sets in total (12.5min) and each set lasted for 2min. From week 2 to 3, two blue signals were flashed in each set, 6 sets in total (14.5min) and each set lasted for 2min. For week 4, three blue signals were flashed in each set, 6 sets in total (14.5min) and each set lasted for 2min. For week 5, 4 blue signals and 2 red signals (choice tasks) were flashed at each set, 4 sets in total (16min) and each set lasted for 2min. For week 5, 4 blue signals and 2 red signals (choice tasks) were flashed at each set, 4 sets in total (16min) and each set lasted for 3min. For week 6, 5 blue signals and 2 red signals were flashed at each set, 4 sets in total (16min) and each set lasted for 3min. Week 1 to 4, 30s rest was given and prolonged to 60s at week 5 and 6. Table 2 showed the details of the training program.

For group A (light signal), the signal time was set at 8 seconds for week 1 and 2, subsequently reduced to 6 seconds for week 3 and 4 then 5 seconds at week 5 and 6, to increase the difficulty. For group B, human signal involved other
teammates wearing two-colored (blue and red) sparring gloves (Figure 6). A line was marked on the floor using black tape and participants were asked to stand behind the black line and act according to two conditions: hit the blue signals and hold for the red signals. For a blue signal, participants were instructed to hit the target as quickly as possible with any standard karate technique (jabbing punch, reverse punch, lunge punch, back fist strike, front kick, and roundhouse kick) and returned to the starting position. For a red signal, participants were instructed to hold and do nothing.

**Data analysis**

Descriptive statistics, such as mean, standard deviation (SD or ±) and frequency (%), was used. Paired t-test was made to compare the RT before and after training within the group. Independent t-test was made to compare the RT and the difference of RT before and after training between two groups. The significant level was set at 0.05.

**RESULT**

At baseline, all the collegiate karate kumite athletes (n = 24) averagely spent 314.5 ±39.05 ms and 347.42 ±59.69 ms for SRT_zero and SRT_shoulder; and 400.21 ±58.52ms, 445.56 ±56.19ms, 455.06 ±64.09ms for CRT_zero, CRT_shoulder and CRT_random, respectively for dominant hands (Figure 7). RT for non-dominant hands was shown in Figure 8. RT by dominant hands was faster than non-dominant hands. Before training, group A and group B differed significantly in only SRT_shoulder for dominant hands but not the other measures (Figure 7). RT for non-dominant hands had no significant difference at baseline between both groups (Figure 8).

After training, the group A showed significant improvement in SRT_zero and SRT_shoulder for dominant hands (p = 0.0066 and p = 0.001, respectively); and SRT_shoulder and CRT_zero for non-dominant hands (p = 0.0138 and p = 0.0015, respectively). The group B did not
show significant changes for RT tasks by dominant hand, but took longer time for CRT_shoulder for non-dominant hands (p = 0.0037). When compared the difference before and after training, for dominant hands, group A improved significantly more in CRT_shoulder (p = 0.0201) than group B (Figure 9); for non-dominant hands, group A improved significantly more in SRT_shoulder and CRT_shoulder (p = 0.0206 and p = 0.0029, respectively) (Figure 10).

DISCUSSION

Comparable at baseline between the two study groups

Participants in group A were recruited from two universities while group B were from one university. Although both groups had similar age, sex distribution, BMI and did not differed statistically in the years of practising karate, group A has more participants experienced in karate contest for the past 5 years. This is due to grouping according to university and the participation in karate contest varied in each university.

Regarding to various RT, group A reacted faster in SRT_shoulder by dominant hands at baseline than group B. Simple task did not involve decision making and is a one action-required task [5, 16]. Simple task that tested at shoulder width distance required some core stability and satisfactory shoulder girdle control. This possibly affects the motor response. In order to have a fairer comparison to examine their training effect between the two study groups, we
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used the difference of RT before and after training, rather than the RT after training, as the outcome measures.

**RT measurements**

Shorter RT indicates better response. In this study, the karate kumite athletes (n = 24) averagely spent 315ms to 350ms for simple tasks; and 400ms to 450ms for choice tasks using dominant hands and generally took approximately 20ms more for the same task when using non-dominant hands. In other words, eye-hand RT increased from simple to choice tasks 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 was observed. Under choice conditions, there were longer RT from CRT_zero to random to shoulder distance. These results fulfilled the Hick’s law as reported in year 1952 [17]. Our result showed that dominant hands were consistently faster than non-dominant hands in both simple and choice RT task. This is in accordance with previous studies [18, 19]. A transcranial magnetic stimulation (TMS) study showed that non-dominant hands had a different motor-pathway excitability during RT task compared to dominant hands [19]. Iglesias-Soler et al. [20] trained 30 young judo practitioners and reported that practices of non-dominant side improved judo skills.
Training effects

After training, the light signal training group (group A) simple tasks for dominant hands significantly improved after 6 weeks of training. Average SRT_zero improved from 307.5 ±32.93ms to 282.4 ±30.23ms; average SRT_shoulder improved from 322.8 ±37.19ms to 279 ±27.79ms. Our previous study, Liu et al. [15] reported that SRT_zero and SRT_shoulder for elite karate was 292.33 ±45.4ms and 316.95 ±37.54ms, respectively. This shows that a light signal training with a duration of 6 weeks is sufficient to promote kumite athletes’ simple RT to elite level.

On the other hand, the human signal training group (group B) somehow did not show any improvement in either simple or choice RT tasks, but deteriorated in CRT_shoulder after training. Group B was not trained to complete the Go/NoGo task in limited time, resulting in the deterioration.

Whether the training effects are able to transfer beyond the trained task or to real world conditions is inconclusive as shown in published studies. Although using light to substitute human as the signal in training seems to give promising result in improving the both simple and choice RT, we are uncertain whether the results in laboratory are able to transfer to the field. Deveau et al. [21] and Rylander et al. [22] reported that general task training significantly influence the sports performance. In contrary, Ellision et al. [23] and Giboin et al. [24] reported weak correlation between laboratory and field task and no transfer to similar tasks was observed.

Comparison of the two programs

Training in karate kumite requires more than practice and physical preparation [25], quick sensory and motor reaction are significant to kumite athletes [26, 27]. Our training specifically aimed the visual response and explored two methods in carrying out the training: light signal and human signal. Main finding is a significant improvement in simple and choice task measured in zero-width distance (CRT_zero) for light signal groups. This is in accordance with recent studies which also showed positive impact of training on athlete’s response time [10, 14, 28, 29]. Petri et al. showed promising improvement in response time but not response quality after training 15 young karate kumite athletes using virtual reality [29]. Balkó et al.[28] trained 19 adolescent fencers using light as a stimulus and reported a significant improvement of choice response task after 9 weeks of training. Our study suggested a 6-week visual training program using light signal could improve the choice RT which involves Go/NoGo decision making capacity. Nevertheless, we could not be sure for the sustaining period of this improvement.

Comparing the training effect between the light signal and human signal groups, light signal group had better RT at simple task measured in shoulder-width distance (SRT_shoulder) after training but not the human signal group. The difference of RT before and after training between two groups was significantly different too. Using light as a stimulus is capable to improve both simple and choice tasks; while human signal showed none of the tasks. Therefore, we suggest light signal is potentially an effective training tool. Our study indeed designed the human signal as close as possible to the light signal where the teammates wore blue and red gloves as signal.

There were a few limitations to our study. Sample size is relatively small. The training program was carried out at different universities with intention to avoid cross-information between groups, but also potentially affect the training style as it was given by different coaches. The colors of light and gloves may not simulate the real situation of karate competition. We did not restrict the karate technique in response to the signal during training, the athletes were allowed to used either punches or kicks. However, only eye-hand RT was tested without involving lower limbs or agility. Future study would have to recruit more participants, design a training program that could simulate the real contest situation, evaluate the contest performance after training and include more physical performance such as eye-foot RT and agility.

CONCLUSIONS

Six weeks of visual response training using light signals improved simple RT in collegiate karate athletes and have better result than human signal. Thus, the visuomotor training method can also be used in health-related training, in improving human motor safety, especially developing self-defense capabilities.
REFERENCES


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