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MEASUREMENT OF REACTION TIME IN QWAN KI DO

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ABSTRACT: The aim of this study is to identify the simple and choice reaction time to visual stimuli, for the upper limbs, in beginner and advanced practitioners of the Qwan Ki Do martial art, and also to identify differences between the various populations of the study. We used a total of 73 male subjects, aged between 18 and 33, taken from three groups. The first group (control) was composed of 47 students in physical education and sport (group 1), the second group was composed of 18 beginner (less than 1 year) athletes practising Qwan Ki Do (group 2), and the third group was composed of 8 athletes practising Qwan Ki Do with great experience (group 3). As a result of the measurements, we concluded that the simple reaction time has, in general, similar values in all the research groups (239.6±7.4 in group 1, 221.9±5.5 in group 2 and 207±6.6 in group 3 – data are expressed as mean ± standard error mean). Also, the choice reaction time in group 3 (376±4.7 ms for the dominant hand and 376±5.4 ms for the non-dominant hand) is significantly lower ($p < 0.05$) as compared to group 1 (424.5±11.4 ms and 430.9 ± 12.2 ms) and to group 2 (429.5±7.3 ms and 438.8±6.9 ms), due to more efficient activity of the central nervous system. Low values of the choice reaction time in group 3, for both the dominant and non-dominant hands, where there have not been found significant differences between them ($p > 0.05$), are probably due to the specific training in Qwan Ki Do, based on equal involvement in effort of both body halves.

KEY WORDS: martial arts, training, speed, computer-based test

INTRODUCTION

The reaction time, especially to visual stimuli, is very important in the practice of martial arts. In the Qwan Ki Do fight competition, the athletes must make as soon as possible appropriate responses to movements of the opponent's body or body parts [2]. From the physiological point of view, there are well-known important roles of the retina [6,13], visual cerebral pathways [4,12], motor cortex and cerebellum [5] in control of the reaction time to visual stimuli.

Reaction time values are quite different, depending on age, state of training and level of central or peripheral fatigue (when the values are significantly increased). Normal values are usually around 200 ms [1], while the lowest values can be as low as 140-160 ms [9], out of which about half is consumed at the central level. Values concern less the acoustic than the visual stimuli. Regarding the choice reaction time, the central nervous system conduction time is considerably higher and also increases at the appearance of neuro-muscular fatigue.

Within the selection for the performance and the preparation process, both the simple reaction time (SRT) and especially the choice reaction time (CRT – where the person must, as soon as possible, choose the appropriate reaction from several alternatives) are investigated. Regarding the SRT, it does not reveal significant differences between athletes and non-athletes and the studies suggest that it cannot be trained [10]. However, investigation of the simple reaction time is useful, as previously stated, for selection and as an indicator of fatigue [3]. On the other hand, there are data demonstrating that the CRT can be improved through specific training [7].

We should point out that the literature provides limited data regarding reaction time in martial arts. So far, we have no data on the measurement of reaction time in Qwan Ki Do. Thus, researchers [14,15] have tested the CRT for the lower limb in several other martial arts and combat sports. They found values of the CRT of about 400 ms in individuals with moderate physical activity, around 335 ms in fencers and 340 ms in karateka. In another study [11], performed on 13 experienced athletes (of Taekwondo, Shaolin Nam Pai and Wu-Shu), the SRT and CRT for the upper limb and the speed of movement (both for the simple and choice reaction time) were measured, the latter by recording the time to press a button at

the distance of 25 cm. The analysis of the results revealed that there were no differences in reaction time between the dominant and the non-dominant hand. The values of SRT were 210.91±3.75 ms for performers and 222.18±6.61 ms for the control group. The CRT values were 312.33±8.77 ms for performers and 343.10±15.69 ms for the control group. The study confirms previous results [8] indicating that martial arts training improves the speed of movement.

The purpose of this study is to identify the simple and choice reaction time to visual stimuli, in the upper limb, for beginner and advanced athletes of the martial art Qwan Ki Do, and also to identify differences between the various populations of the study.

MATERIALS AND METHODS

Participants. In the study, we used three groups (Table 1) and a total of 73 male subjects, aged between 18 and 33. The first group (control) was composed of 47 students in physical education and sport (but no performance athletes), aged between 20 and 24, at the "Alexandru Ioan Cuza" University of Iaşi, Romania (group 1). The second group was composed of 18 beginner athletes (aged between 18 and 27) practising Qwan Ki Do (group 2). Their training lasted for on average 8 hours/week for less than 1 year. The third group was composed of 8 athletes practising Qwan Ki Do, with great experience (aged between 24 and 33), most of them members of the Romanian Qwan Ki Do national team (group 3). Their training lasted for on average of 10 hours/week for more than 10 years. None of them smoked, drank alcohol or was on medication at the time of the investigations.

Ethics

We had the consent of all the subjects and the study protocol was in accordance with the ethical standards of the Helsinki Declaration.
Investigation of the reaction time

Measurements were performed under the same conditions for all groups, at 10 AM-12 AM. This period of time was chosen because the subjects should not be tired (the reaction time is obviously altered by muscular and nervous fatigue). We used four tests: the first test – measuring the simple reaction time; the second test – measuring the choice reaction time only for the dominant hand; the third test – measuring the choice reaction time only for the non-dominant hand; the fourth test – measuring the choice reaction time using both hands for the task.

TABLE I. SUBJECTS OF THE RESEARCH.

	Group 1 students	Group 2 beginners	Group 3 advanced
Number of subjects	47	18	8
Body height	179.4±5.3	178.6±6.5	178.2±5.3
Body weight	73.6±7.6	74.4±7.0	76.6±5.7

Note: data are expressed as mean ± standard deviation

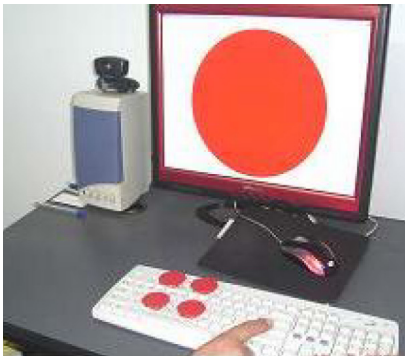

FIG. 1. MEASUREMENT OF SIMPLE REACTION TIME (TEST 1)

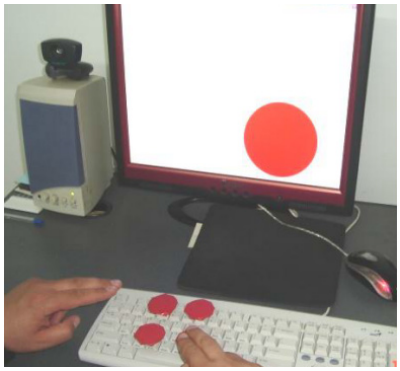

FIG. 2. MEASUREMENT OF CHOICE REACTION TIME (TEST 4)

Method of measuring the reaction time

The method allows indirect measurement of reaction time. We used a computer and adapted keyboard (Figure 1). The keyboard presents four buttons close to each other, so that they form a square. We also used our own design software, which allows recording and storing of reaction times, showing the average, maximum and minimum values for a number of determinations.

Test 1. Measurement of simple reaction time

When a large dot, coloured red, appears on the monitor (on a white background), the subject must press a default key as soon as possible, using the index finger, which is in contact with the key. There are 30 executions for each subject (Figure 1).

Test 2. Measurement of choice reaction time for the dominant hand

The program is set to allow the appearance of a randomly coloured dot in one of the four corners of the screen. When it appears, the subject, using the dominant hand and the same set of fingers in contact, will press as soon as possible the appropriate red button on the keyboard. There are 30 measurements for each subject.

Test 3. Measurement of choice reaction time for the non-dominant hand

It is the same as test no. 2, but using the non-dominant hand (30 measurements).

Test 4. Measurement of choice reaction time using both hands in the task

The program is set to allow the appearance of a randomly coloured dot in one of the four corners of the screen, the same as test 2 and 3. When it appears, the subject, using the same set of fingers in contact and the dominant or non-dominant hand, will press as soon as possible the appropriate red button on the keyboard (Figure 2), as follows: if the dot appears in the top left or bottom left, use the left hand, pressing the appropriate red button on the keyboard; if the dot appears in the top right or bottom right, use the right hand, pressing the appropriate red button on the keyboard (40 measurements).

Assignation

We used the second and third tests to compare the choice reaction time for the two hands, using only one of them. The 4th test is designed to compare the choice reaction time for the two hands, using both in the task. This is a common situation in martial arts, in which athletes must react with the appropriate arm, depending on the opponent's actions. In the four tests we used protocols that require more determinations, using for statistical analysis the mean values obtained for each subject in each test. Thus, in tests 1, 2 and 3 we used the mean of 30 measurements for each subject, while in test 4, which involves working with both hands, we used the mean of 40 measurements for each subject.

Statistical analyses

For statistical processing we used SPSS 13.0 for Windows in the following situations:

- One-way ANOVA with post-hoc for test 1 – groups 1, 2, 3;
- Two-way ANOVA for repeated measures with post-hoc for tests 2 and 3 (dominant and non-dominant hand) – groups 1, 2, 3;
- Two-way ANOVA for repeated measures with post-hoc for test 4 (dominant and non-dominant hand) – groups 1, 2, 3.

The significance level for all analyses was set at $p<0.05$. Data are expressed as mean ± SEM (standard error mean).

RESULTS

The values of the reaction time (means ± SEM) for the three groups in all four tests are presented in Table 2.

Test 1 – Simple reaction time

Statistical analysis with one-way ANOVA reveals no significant differences between the three groups ($p>0.05$) – see Table 3.

Particularly, the Games-Howell post-hoc for this test (equal variances not assumed) shows significant differences only between students in physical education (group 1) and advanced students of Qwan Ki Do (group 3) with $p=0.008$ (Table 3).

Tests 2 and 3 - Choice reaction time for dominant and non-dominant hands

TABLE 2. VALUES OF THE REACTION TIME (ms) FOR STUDENTS IN PHYSICAL EDUCATION, BEGINNERS AND ADVANCED STUDENTS OF QWAN KI DO, IN THE FOUR TESTS. DATA ARE IN MEANS (±SEM).

	Group 1 students	Group 2 beginners	Group 3 advanced
Simple reaction time, Test 1	239.6 (7.4)	221.9 (5.5)	207 (6.6)
Choice reaction time dominant hand, Test 2	424.5 (11.4)	429.5 (7.3)	376 (4.7)
Choice reaction time non-dominant hand, Test 3	430.9 (12.2)	438.8 (6.9)	376 (5.4)
Choice reaction time dominant hand, Test 4	410.8 (9.1)	409.2 (4.4)	357.5 (6.8)
Choice reaction time non-dominant hand, Test 4	412.3 (18.5)	424.3 (7.6)	358.8 (10.9)

TABLE 3. VALUES OF THE SIMPLE REACTION TIME (ms) AND THE SIGNIFICANCE (*p*) FOR STUDENTS IN PHYSICAL EDUCATION, BEGINNERS AND ADVANCED STUDENTS OF QWAN KI DO, IN TEST 1. DATA ARE IN MEANS (±SEM).

	Group 1 students	Group 2 beginners	Group 3 advanced
Simple reaction time, Test 1	239.6 (7.4) #	221.9 (5.5)	207 (6.6) *
Between all groups		p=0.085	

Note: * denotes significantly ($p < 0.05$) different from Group 1.
# denotes significantly ($p<0.05$) different from Group 3.

TABLE 4. VALUES OF THE CHOICE REACTION TIME (ms) AND THE SIGNIFICANCE (*p*) FOR STUDENTS IN PHYSICAL EDUCATION, BEGINNERS AND ADVANCED STUDENTS OF QWAN KI DO, IN TEST 2 (DOMINANT HAND) AND TEST 3 (NON-DOMINANT HAND). DATA ARE IN MEANS (±SEM).

	Group 1 students	Group 2 beginners	Group 3 advanced
Choice reaction time dominant hand, Test 2	424.5 (11.4) #	429.5 (7.3) #	376 (4.7) *$
Choice reaction time non-dominant hand, Test 3	430.9 (12.2)	438.8 (6.9)	376 (5.4)
Between all subjects		p=0.214	
Between all groups		p=0.728	

Note: * denotes significantly ($p < 0.05$) different from Group 1.
$ denotes significantly ($p < 0.05$) different from Group 2.
# denotes significantly ($p<0.05$) different from Group 3.

Statistical analysis with two-way ANOVA for repeated measures reveals no significant differences comparing the choice reaction time for the dominant (test 2) and non-dominant hand (test 3) either between all the subjects ($p>0.05$) or between the three groups ($p>0.05$) – see Table 4.

TABLE 5. VALUES OF THE CHOICE REACTION TIME (ms) AND THE SIGNIFICANCE (*p*) FOR STUDENTS IN PHYSICAL EDUCATION, BEGINNERS AND ADVANCED STUDENTS OF QWAN KI DO, IN TEST 4 (BOTH DOMINANT AND NON-DOMINANT HANDS IN THE TASK). DATA ARE IN MEANS (±SEM).

	Group 1 students	Group 2 beginners	Group 3 advanced
Choice reaction time dominant hand, Test 4	410.8 (9.1) #	409.2 (4.4) #	357.5 (6.8) *$
Choice reaction time non-dominant hand, Test 4	412.3 (18.5)	424.3 (7.6)	358.8 (10.9)
Between all subjects		p=0.575	
Between all groups		p=0.776	

Note: * denotes significantly ($p < 0.05$) different from Group 1.
$ denotes significantly ($p < 0.05$) different from Group 2.
# denotes significantly ($p<0.05$) different from Group 3.

The Games-Howell post-hoc for these tests (equal variances not assumed) shows (Table 4):

- Differences are significant between students in physical education (group 1) and advanced students of Qwan Ki Do (group 3) with p=0.000;
- Differences are significant between beginners (group 2) and advanced students of Qwan Ki Do (group 3) with p=0.000;
- No significant differences were found between students in physical education (group 1) and beginners of Qwan Ki Do (group 2) with p=0.879.

Test 4 – Choice reaction time for both dominant and non-dominant hands in the task

Statistical analysis with two-way ANOVA for repeated measures reveals no significant differences comparing the choice reaction time for the dominant and non-dominant hand either between all the subjects ($p>0.05$) or between the three groups ($p>0.05$) – see Table 5.

The Games-Howell post-hoc for these tests (equal variances not assumed) shows (Table 5):

- Differences are significant between students in physical education (group 1) and advanced students of Qwan Ki Do (group 3) with p=0.004;
- Differences are significant between beginners (group 2) and advanced students of Qwan Ki Do (group 3) with p=0.004;
- No significant differences were found between students in physical education (group 1) and beginners of Qwan Ki Do (group 2) with p=0.929.

Therefore, comparative values of the reaction time between students in physical education (group 1) and advanced athletes in Qwan Ki Do (group 3) are different. Thus, we found significant differences ($p<0.05$) between the two groups in all tests.

The comparative values of the reaction time between beginners in Qwan Ki Do (group 2) and advanced athletes of Qwan Ki Do (group 3), except for the simple reaction time in test 1 (where $p>0.05$), show significant differences ($p<0.05$), meaning that athletes within group 3 have better results in tests 2, 3 and 4.

Thus, we found that advanced athletes in Qwan Ki Do (group 3) presented the lowest values of reaction times, particularly in tests 2, 3 and 4 (choice reaction time), suggesting that the specific training reduces the cerebral conduction and processing time.

Comparing the choice reaction time between the dominant and non-dominant hand, we did not find significant differences ($p> 0.05$) in all groups of subjects. However, we should note that the values for the dominant hand are usually slightly lower for all research subjects, and this is probably caused by a functional inequality of the two hemispheres of the brain.

We also noted that the errors made during testing are reduced as average values from all three groups and the differences between them are insignificant ($p>0.05$).

DISCUSSION

We should point out that, at this time, there are no studies on the reaction time in Qwan Ki Do, so all comparisons are made with similar studies in other martial arts. Also, the method of measurement used in the present study is slightly different from those used in other studies, so all comparisons are more or less relevant.

The simple reaction time

We concluded that the simple reaction time is slightly higher than 200 ms, i.e. close to the average found in various individuals [1]. Concurrently, we have not found, in general, significant differences between the simple reaction time for the three groups, although the advanced athletes of Qwan Ki Do (group 3) are closer to 200 ms (207±6.6 ms). This supports the assertion that there are not large differences between athletes and non-athletes, in terms of the simple reaction time [10].

From another perspective, the values obtained for the advanced athletes of Qwan Ki Do (207±6.6 ms) are similar to those found for experienced athletes in Taekwondo and Wu-shu (210.9 ms) [11].

The choice reaction time

Regarding the choice reaction time, there are significant differences ($p<0.05$) for both hands, between advanced athletes of Qwan Ki Do, on the one side, and students in physical education and beginners of Qwan Ki Do, on the other side. The values for advanced practitioners of Qwan Ki Do are comparable to those found in karate [14,15].

Moreover, the difference between beginners and those advanced in Qwan Ki Do confirms that the choice reaction time can be improved [7]. This is done mainly by reducing the cerebral conduction and processing time and developing the appropriate motion response, through specific training.

Moreover, we should mention that differences in choice reaction times for the dominant versus the non-dominant hand were not significant in all groups included in the research. Accordingly, there are two aspects that may be taken into consideration: 1. The choice

reaction time for the subjects within the study is not influenced by the functional inequality of the two hemispheres of the brain; 2. it is possible that the advanced athletes of Qwan Ki Do have the lowest values as a consequence of the practice at the same level of both halves of the body, which generates an equal reduction of the choice reaction time for the dominant and non-dominant hand.

CONCLUSIONS

It is clear that the reaction time is extremely important in martial arts fighting competitions, allowing the athlete to respond to the adversary's actions with maximum speed.

Following the study, we find that the simple reaction time has, in general, similar values for the three research groups. If we accept that the simple reaction time cannot be significantly improved through training, the slightly higher results in the advanced group (most of them members of the Romanian Qwan Ki Do national team) justify the importance of selection for performance, taking into account this neuromuscular parameter.

Also, as an adaptive response, the choice reaction time of the advanced athletes in Qwan Ki Do is considerably improved probably due to more efficient activity of the central nervous system. Research results show that specific training of Qwan Ki Do decreases the choice reaction time, making the trained athlete more efficient in combat. It is interesting that the advanced athletes have the choice reaction time almost the same in both upper limbs. This suggests that specific training involves both halves of the body, causing a considerable improvement of the choice reaction time in the non-dominant hand, too. Thus, the athletes acquire the ability to use the non-dominant hand effectively in combat, increasing their chances of winning.

I believe this study offers the perspective of investigating ways to optimize the methods and means used in the training of Qwan Ki Do for decreasing the choice reaction time.

Therefore, I recommend that coaches test the simple and choice reaction time for the selection of athletes for high performance. I also recommend that they identify the most efficient means of improving training for the choice reaction time, given the significant contribution of this neuromuscular parameter to victory in the fight competition.

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