A NEW APPROACH TO EVALUATE KARATE PUNCH TECHNIQUES

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The purpose of this study was to determine reaction time, attacking speed and punch force of the well-trained Karateka in various karate punch situations using a quick-feedback approach. Twelve subjects (8 male, 4 female), the ROC National Karate Team for the 1998 Bangkok Asian Games, were asked to perform four punch techniques in this study. The four conditions are stand straight, stand reverse, forward straight and forward reverse punches. The results showed that there were no systematic differences between straight and reverse punches. However, the reaction times in forward punch (550-650 ms) were longer than stand punch (350-450 ms), and the attacking speeds in forward punch (2.7-3.0 m/s) were faster than stand punch (1.9-2.1 m/s). In this study, the punch force was expressed by the impact acceleration of the target. The punch forces of the male subjects (43-54 g) were larger than female subjects (24-39 g) as expected. The results of this test could be used as a quantitative index for coaches to improve the punch techniques of the athletes.

KEY WORDS: karate, punch, reaction time, attacking speed, punch force, accelerometer

INTRODUCTION: Karate, an oriental art of self-defence, has gained considerable popularity since the development of tournament competition, Therefore, more attention has been directed toward the science of karate in recent years. Most karate skills are related to the punch techniques, the practice of using the fist as striking weapons has evolved into a unique and highly efficient self-defence system. Effective karate punch techniques are difficult to perform, and require the use of the entire body to apply optimum force for a very short time period. There are two basic karate punches in general competition, one is 'stand punch' and the other is 'forward punch'. The stand punch is executed in a right sparring stance, the attacking force is transferred by rotating the trunk and extending the arm. The forward punch is named for the way it is executed, move the entire body forward and transfer the whole body momentum into attacking force with either hand.

A good Karateka requires quick reaction, good flexibility, fast speed and great muscle power. In this case, the reaction time, attacking speed and punch force are the most important factors for evaluating karate techniques. Several studies had been conducted to determine the relationship between the maximum fist speeds and the punch forces using cinematography (Feld et. al., 1979) or mathematical models (Walker, 1975; Blum, 1979). Other series of studies had investigated the kinematics of the punches (Nakayama, 1966; Stuall, 1986). The above studies were time-consuming and not able to measure reaction times or real punch forces. In order to understand the karate techniques more thoroughly and effectively, Shiang and Chen (1995) used EMG and a wall-mounted force plate to detect the reaction time, average fist speed and punch force of the elite Karateka for various punch techniques. This experimental device could determine the accuracy reaction time and real punch force, but the EMG connecting cables would obstruct the punch movements, and punching on the rigid surface of the wall-mounted force plate could injure subjects. It is of interest to develop a more efficient and safe approach to evaluate the karate movement. Thus, the goal of our work was to detect reaction time, attacking speed and punch force of the well-trained Karateka in various karate punch situations using an instrumentation conducted by combining reaction device and an accelerometer on a suspended free-motion target together. The results could evaluate the punch techniques and give real time feedback information to athletes and coaches.

METHODS: Twelve subjects (8 male, 4 female) with black belts in karate were selected in this study. These subjects were the ROC National Karate Team for the 1998 Bangkok Asian Games. The male subjects' average height was 176.7 cm and average weight was 74.14 Kg.

The female subjects' were 161.8 cm and 54.8 kg. Each subject was asked to strike the target in a testing sequence with four punch techniques: (1) stand punch- stand straight punch and stand reverse punch; (2) forward punch- forward straight punch and forward reverse punch. Straight punch has the movements of the foot and the attacking fist on the same side, reverse punch in on the opposite side. A cylindrical metal target covered with 20-cm protective pad material was suspended vertically under the ceiling. The height of the target was adjusted to a suitable punching height for each subject. A tri-axial accelerometer (sampling rate: 1000Hz) was mounted into the target to identify punch timing and measure impact acceleration of the target. The subject stood on the reaction plate in front of the target by his or her front foot for stand punch, and rear foot for forward punch. The distance to the target was adjusted according to the subject's experience and punch style. A light was put beside the target in the subject visible position as a trigger. When the subject saw the light. the movement was then started. The experimental setup is clearly displayed in figure 1. Each punch condition had five trials, and two extreme data were omitted.

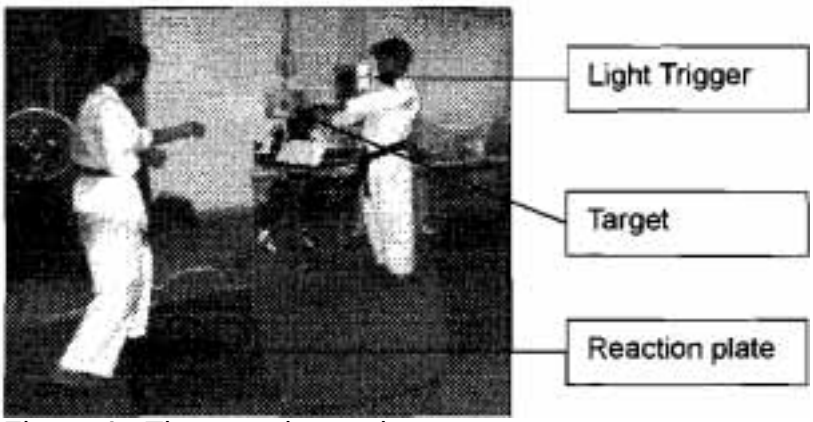

Figure 1 - The experimental setup

Figure 2 displays the typical experimental signals. The variables measured in this study were defined as:

1. Reaction Time: the time from the light flashing to the foot leaving the plate.
2. Motion Time: the time from the foot leaving the plate to fist punching the target.
3. Total Time: the time from the light flashing to fist punching the target.
4. Attacking Distance: the horizontal distance from the target to the foot on the plate.
5. Motion Speed: the ratio of 4 to 2.
6. Attacking Speed: the ratio of 4 to 3.
7. Impact: the maximum impact acceleration of the target calculated from three components:

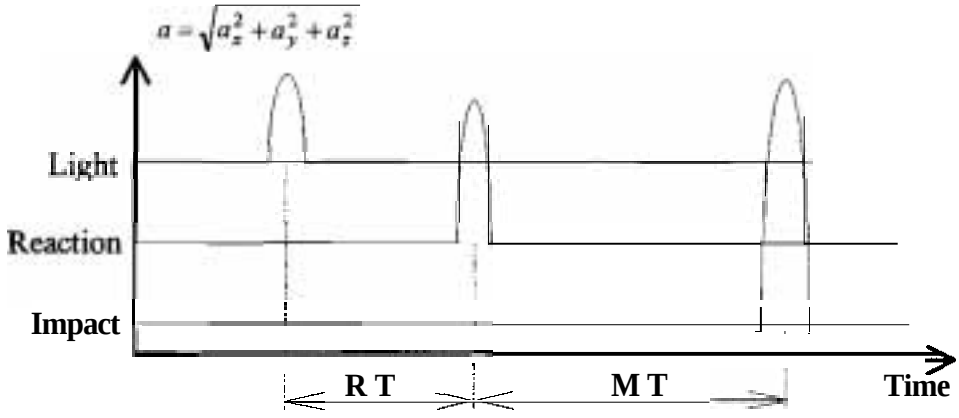

Figure 2 - The typical experimental signals

RESULTS AND DISCUSSION: Presented in table 1 are the details of the experimental results measured from four punch situations. Since all the subjects are the National Karate

Team, it is perhaps more reasonable to evaluate the punch techniques rather than statistically analyse the data. In general, the simple reaction time is about 200-300 ms. The reaction is associated with the individual's neural system function and cannot be improved significantly by training. Interestingly, the reaction times measured for different punch situations in this study ranged from 350 to 650 ms which is longer than normal simple reaction time. As already mentioned, the reaction time was defined from the light flashing to the foot leaving the plate. The karate punch movement first starts the fist followed by the foot, besides, the preparation before attacking and identification of the target position would contribute to the increased time. Therefore, the punching reaction time can determine the subject's reaction as well as concentration ability. The reaction times in forward punch (550-650 ms) were longer than stand punch (350-450 ms), because forward punches need more time to prepare pushing the body forward to maximise momentum. The motion time and total time are related to the attacking distance that was adjusted according to the subject experience and punch style. There is no question that larger distance requires longer time. Therefore, the motion time should be normalized by the attacking distance to describe the speed appropriately. As clearly shown in Table 1, the attacking distance in a stand reverse punch (113 cm) was larger than a stand straight punch (106 cm) for female subjects, but the motion time (98 ms) of a stand reverse punch was shorter than a stand straight punch (149 ms). This result indicated that the female subjects had faster motion speed in stand reverse punches indicating that they started the attacking fist much earlier than the foot movement. In addition to motion speed, attacking speed, the ratio of attacking distance to total time, is more appropriate to be used to evaluate the punch techniques among subjects. In forward punch situations, the rear foot pushing the ground caused faster attacking speeds (2.7-3.0 m/s) than in stand punches (1.9-2.1 m/s). However, there were no significant differences between straight and reverse punches.

Table 1 The Results Measured from Four Punch Situations (means and standard deviations)

	Punch Situations	Reaction Time (ms)	Motion Time. (ms)	Total Time (ms)	Attacking Distance (cm)	Motion Speed (m/s)	Attacking Speed (m/s)	Impact (g) (9.81 m/sec^2)
	Stand	388	173	561	111	8.5	2.0	43.7
	straight	(73)	(75)	(75)	(16)	(6.6)	(0.2)	(14.6)
	Stand	344	261	605	116	6.1	1.9	57.4
Male	reverse	(85)	(105)	(92)	(15)	(5.8)	(0.2)	(9.8)
	Forward	578	192	770	229	12.3	3.0	57.7
	straight	(47)	(46)	(71)	(15)	(2.3)	(0.2)	(10.3)
	Forward	638	163	801	233	13.6	2.9	53.9
	reverse	(56)	(49)	(99)	(19)	(1.8)	(0.2)	(11.2)
	Stand	354	149	503	106	7.4	2.1	23.9
	straight	(74)	(33)	(65)	(9)	(2.0)	(0.3)	(10.1)
	Stand	444	98	542	113	14.2	2.1	35.9
Female	reverse	(110)	(49)	(69)	(16)	(7.8)	(0.3)	(13.9)
	Forward	561	136	697	191	14.2	2.7	35.7
	straight	(48)	(15)	(34)	(16)	(2.2)	(0.3)	(16.0)
	Forward	581	105	686	195	25.1	2.8	38.7
	reverse	(49)	(63)	(83)	(30)	(15.8)	(0.1)	(19.3)

More importantly, punch force is also a useful index to evaluate punch techniques. In this study, the punch force was expressed by the impact acceleration (the unit is gravity g=9.81 m/sec^2) of the target. Although it was not the force directly measured from the target, the relative values could be used comparing differences among various punch situations. The punch forces of male subjects (43-54 g) were larger than female subjects (24-39 g) as

expected. The punch force of stand straight punches was significantly smaller than the other three punch situations. Apparently, stand straight punches required the shortest time to execute. A more likely explanation is that a stand straight punch is an effective movement to score points during competition. However, the impact force still plays an important role in punch techniques.

In order to more clearly demonstrate the results, a radar diagram is used to compare subject and group results. As figure 3 shows, the attacking speeds of the female subject 9 were faster than the mean speeds of all female subjects excluding the forward reverse punch. This results suggested that subject 9 should improve her forward reverse punch and use the other punches well to attack the opponents in real competition. Another radar diagram of the attacking speeds showed that subject 6 was better at reverse punches compared to other male subjects. With the help of the evaluation, this female subject improved her weakness and adjusted her competition strategy and finally got a gold medal in Bankok Asian Games.

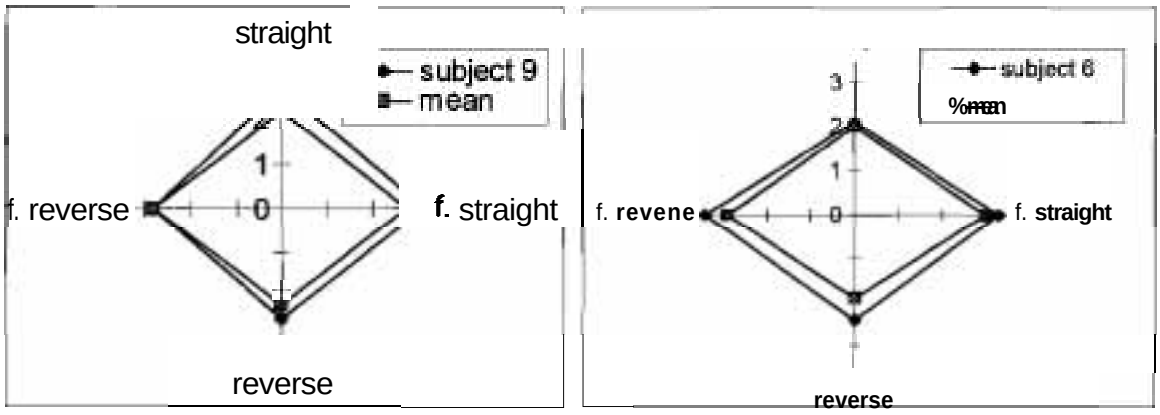

Figure 3 - The radar diagrams express the attacking speeds of female subject (left) and male subject (right) in different punch situations compared to mean speeds of all female and male subjects

CONCLUSION: We have presented a new quantitative approach to evaluating the karate punch techniques. The processes of the experiments are similar to the real competition situations that could determine several important factors of punch techniques in karate competition. This kind of information could be extremely valuable in charactensing each subject's technique, and in designing training programs as well as developing competition strategies. In the future, we hope to obtain more quantitative results by applying this approach in other sport activities.

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