THE EFFECT OF KARATE STANCE ON ATTACK-TIME: PART I - JAB

Yen-Hsiu Liu and Nenzi Wang
Chang Gung University, Taoyuan, Taiwan

This report presents an empirical study of the effect of stance on attack-time during the movement of a jab in a simulated karate contest. A t-test and linear regression method are used to analyze the data collected from 24 elite karate competitors. The results show the larger the impulse generated by lower extremities, the shorter the attack-time in a jab movement. Comparing with 5:5 stance, 7:3 stance exhibits significant shorter attack-time in the t-test and randomized paired comparison analysis. It can be concluded that the impulse generated in a jab movement contributes to the body CG and hand-movement speeds. And the training in strengthening the impulse-generated leg and the duration of net GRF should be examined with the aid of a force plate. Similar analysis for various stances can also be applied when hand-movement is the key factor in some sports.

KEYWORDS: karate, jab, stance.

INTRODUCTION: The frontal-attack using jab is one of the most common practices in karate training (Nakayama, 1986). The jab movement is started with a fight-ready stance. The fight-ready stance is a stance when a subject facing forward and standing with two feet separated about the same length of the shoulder-width (Figure 1). The distance of the fore-foot and rear-foot is also the same as the shoulder-width. In the fight-ready stance, both hands are positioned in a protective pose in the front of the body. A jab movement is performed by stepping out the fore-foot and attacks the target with the front-positioned fist. However, the weight distribution on each foot in fight-ready stance can be different. And an ideal stance is a long-debating topic among coaches and competitors and is usually treated according to personal experience and preference. In 1975, Walker indicated the variation of momentum, reaction force, and speed due to various postures in karate strikes. The results in his study are focused on impact forces of the strikes. Yoshihuku et al. (1987) performed detailed motion analysis for several types of martial arts. They concluded an ultimate speed as well as large impact forces could be obtained by harmonizing the motion of lower and upper extremities in a movement of jab or reverse punch. Nevertheless, the attack-time determines the performance in a frontal attack in a karate tournament. The purpose of this study was therefore to obtain quantitative information pertaining to attack-time during the movement of a jab.

METHODS: Twenty-four elite karate competitors (12 female subjects: age = 19.6±5.0 yr, weight = 522.1±52.4 N, height = 159.9±3.1 cm; 12 male subjects: age = 21.6±3.2 yr, weight = 623.5±87.0 N, height = 170.8±7.1 cm) participated as experimental subjects in this study. The major apparatus used are two 3-D Kistler force plates (600 sample/sec), one video camera (60 frames/s), a timing device, and a target dummy. The two force plates are aligned and positioned for each foot such that the body weight as well as the ground reaction force (GRF) can be recorded separately. The camera was positioned 12 meters away from the subjects and was projected perpendicular to the line of the subject forward-backward direction. The attack-distance in each test was 110 cm measured from the body CG to the frontal plane of the dummy. The dummy position was readjusted before each trial. When 7:3 stance was adopted, the body CG would lean forward as well as the hand position, the dummy was then move away further to compensate the change. The resultant distance between the fore-hand and the dummy was roughly about the same as that of 5:5 stance. Two stances were conducted for each subject: (1) 7:3 stance - the fore-foot contributes 63 to 77% and the rear-foot contributes 37 to 23% of the body weight respectively; (2) 5:5 stance - the fore-foot contributes 43 to 57% while the rear-foot contributes 57 to 43% of the body weight respectively. The distribution of the weight of each foot was recorded in each trial. At the fight-ready stance, the subject adopted one of the two stances while waiting for the starting signal indicated by an illuminated signal light. The signal light was illuminated by turning on the switch attached on a force plate. The resultant spike shown in the force signal due to the switch turn-on motion indicates the starting sign. Figure 1 shows the experimental setup and two types of stance in a jab movement. Note that during a test each foot stands on one force plate. Three consecutive tests were carried out for each stance type. The attack-time is obtained by counting the frames required to hit the target from the initial signal. Two-sample paired t-test, linear regression, and a randomized paired comparison test are used to analyze the data (Box et al., 1987). The main purpose of this study was to study the factors affecting the attack-time in a karate hand movement. Since both the hand and body CG speeds would affect the attack-time and the mechanism of the hand movement is very complicated which may call for a complete musculo-skeletal analysis. In this study, we conducted the above-mentioned tests to identify the factors important to the attack-time of karate hand movement empirically.

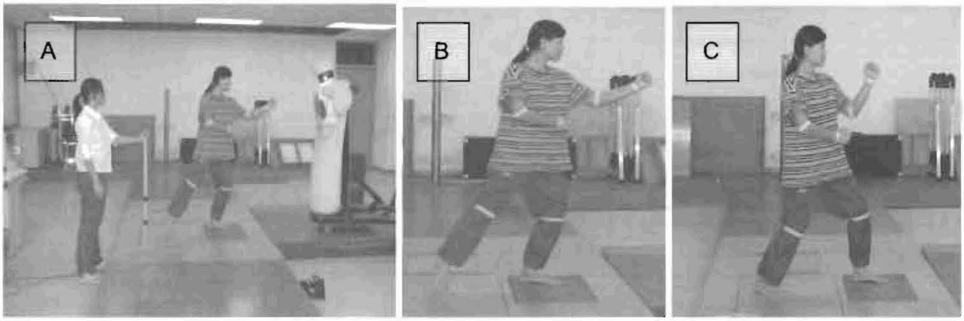

Figure 1. Experimental setup (part A), 7:3 stance (part B) and 5:5 stance (part C) of jab movement on the force plates.

RESULTS AND DISCUSSIONS: Figure 2 shows the three components of GRF recorded on the force plate for fore-foot in a typical jab movement. The vertical GRF is near 300 N at the fight-ready stance. While Figure 3 shows the GRFs recorded on the second force plate for rear-foot of the same person. The weight distribution for the fore-foot to rear-foot before the jab is thus 30:27 and was registered as a 5:5 stance. The spike of force signal in Figure 3 near 4.4 second indicates the starting signal of the jab movement. The vertical force for the fore-foot remains 300 N or below and levels off after 0.3 second when the fore-foot leaves the force plate. While the rear-foot contributes the impulse required to deliver the hand movement with the maximum force near 1000/(300+270) = 1.75 BW. Figures 4 and 5 show the two force patterns generated by two subjects with about the same maximum GRF (1000-1050 N) but with much different time-duration. Thus, the impulse generated is much larger in the case with the larger time-duration. Since the resultant body CG and strike-hand speeds are affected by the impulse generated ($\int_{t_1}^{t_2} f dt$), the impulse produced by the net GRF of rear-foot is used to correlate the time required to hit the target. Figures 6 and 7 are the distributions of impulse for 7:3 and 5:5 stance respectively. The standard deviation curves are also plotted in the corresponding figures. The mean attack-time difference of 7:3 and 5:5 stances is statistically significant at 0.05 level by conducting a two-sample paired t-test (Table 1). Linear regression analysis is also carried out to show the correlation of attack-time and the impulse generated by the GRF. A fitted straight line with negative slope (Figure 8) denotes the variation of impulse to the attack-time. It can be seen that the larger the impulse generated, the shorter the time required for the subject to reach the target. Finally, a simple randomized paired comparison test is conducted to eliminate the subject-to-subject variation in attack-time. Due to the effect of various stances, the attack-time difference for each subject is obtained by subtracting the time required by 7:3 stance to the time required by 5:5 stance. The negative time difference denotes 7:3 stance was performed better than 5:5 stance for that subject. Figure 9 shows the randomized paired comparison of attack-time difference for the 24 subjects.

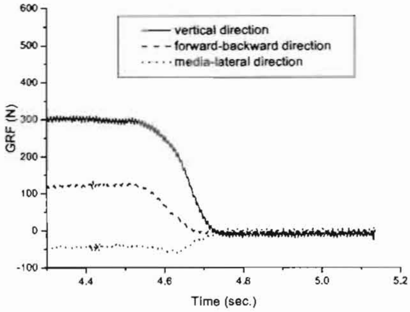

Figure 2. GRFs of fore-foot in a jab movement.

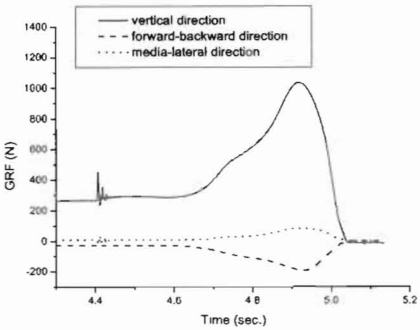

Figure 3. GRFs of rear-foot in a jab movement.

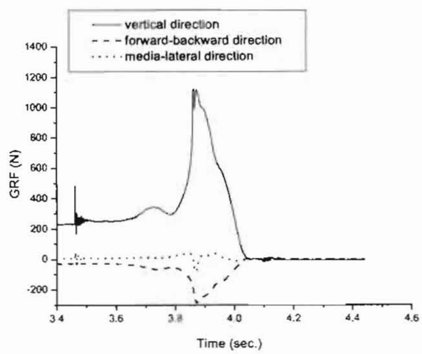

Figure 4. GRFs of rear-foot in a jab movement (case 1).

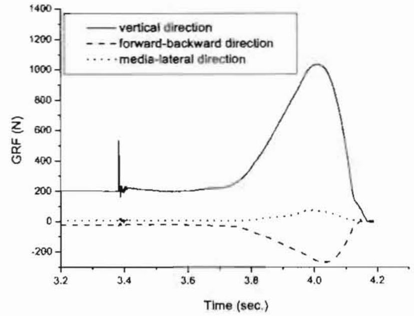

Figure 5. GRFs of rear-foot in a jab movement (case 2).

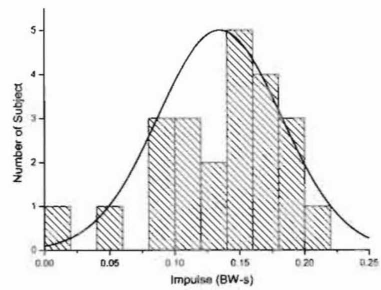

Figure 6. The distribution of impulse in 7:3 stance and the corresponding standard deviation curve.

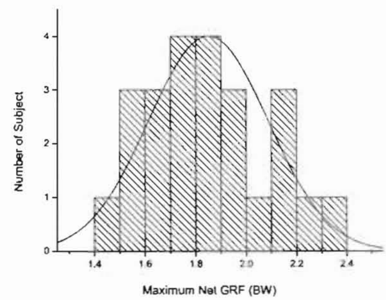

Figure 7. The distribution of maximum net GRF in 5:5 stance and the corresponding standard deviation curve.

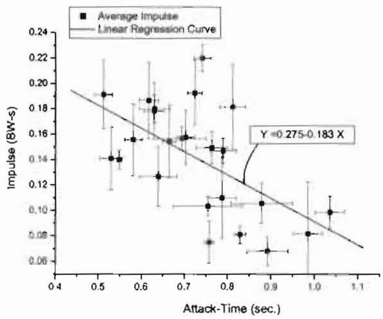

Figure 8. Linear regression analysis of impulse versus attack-time (7:3 stance).

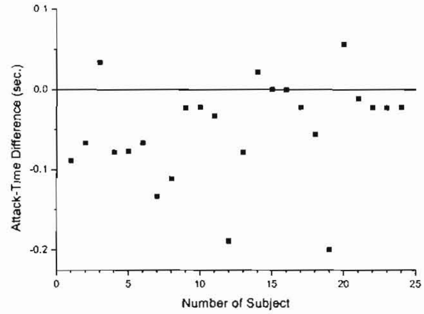

Figure 9. Randomized paired comparison of attack-time difference.

Table 1. Two-sample paired t-test for attack-time difference subject to various stances.

Sample	Number of Sample	Mean±SD	t value	d.o.f.	P value
7:3 stance	24	0.713±0.132	-3.915	23	0.001
5:5 stance	24	0.763±0.145			

CONCLUSIONS: This study presents an empirical study of the effect of karate stance on attack-time during the movement of a jab. Since the attack-time determines the performance in a frontal attack in a karate tournament. The purpose of this study is to obtain quantitative information pertaining to attack-time during the movement of a jab. In this study, the net GRFs and corresponding impulses are used for the analyses. Since the net GRF or the impulse may benefit the chain actions of leg, waist, trunk, and upper extremities, which may result in a higher attack-hand speed. And the horizontal forward GRF affect the body CG forwarding speed alone but not the hand speed. The results obtained in this empirical study show the larger the impulse generated by lower extremities, the shorter the attack-time in a jab movement. Comparing with 5:5 stance, 7:3 stance exhibits significant shorter attack-time in the two-sample paired t-test and the randomized paired comparison. It can be concluded that the impulse generated in a jab movement contributes to the final hand-movement speed. And the training in strengthening the impulse-generated leg and the duration of the net GRF should be examined with the aid of a force plate. Similar results and analysis for various stances can also be applied to other sports (e.g., fencing, Ken-Do) when the hand-movement speed is the key factor in some circumstances.

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