PRESSURE DISTRIBUTION OF THE FIST IN PUSH-UP EXERCISES OF KARATE COMPETITORS

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This report presents an empirical study of pressures distributed within the fingers of karate competitors while the subjects performed static and dynamic push-up exercises on their fists on a hard floor. As was expected, results revealed that peak pressures were localized in the index and middle fingers of the karate competitors during both the static and dynamic modes whereas the pressure was uniformly distributed in all fingers, except the thumb, in a control group of untrained college students. To avoid permanent hand injuries and an eventual reduction in gripping strength due to highly concentrated pressures, wearing adequate protective knuckle pads should be enforced in all matches and push-up exercises in karate training.

KEY WORDS: karate, pressure distribution, fist

INTRODUCTION: The frontal attack using the fist is one of the most important hand movements in karate training. In 1979, Dank conducted an extensive survey on injuries in karate competitors, and found that 66% of these competitors incurred injuries in their wrists and fingers. Later in 1993, Donkers et al. used electromagnetic motion sensors and a piezoelectric force plate in a similar study to record simultaneously upper-extremity motion and forces in healthy subjects during push-ups performed in six different hand positions. The stability of the wrist and elbow joints and the balancing mechanisms of normal subjects during push-ups were investigated in several hand positions of physical therapy based on three-dimensional floor reactions of the hand (Ikawa and Tokuhiro, 1995). The push-up tests were also used to examine fist pressure of karate competitors (Chen et al., 1997). The results indicate that higher mean peak pressure (2100 kPa) was localized in the index and middle fingers in the tested karate competitors. It was hypothesized that potential injuries may occur in the finger joints of competitors as a consequence of this static pressure distribution. However, the tests conducted were restricted to only a static mode with a small sample size. Using a monofilament wire and grip tests, Liu et al. (1999) showed that both the hands nerve sensibility and gripping force were lower among karate competitors than in a group of untrained college students. For a frontal attack in a karate match, the impact force delivered to the fingers is expected to be larger than that of the static push-up. The purpose of this study was therefore to obtain quantitative information pertaining to finger pressure distributions generated during dynamic push-up tests performed on the fists on a hard floor.

MATERIALS AND METHODS: Twelve elite male karate competitors (EXP group, age = 19.3±3.5 yr; weight = 654.4 ± 99.9 N; height = 169.4 ± 6.4 cm) participated as experimental subjects in this study. An additional 12 male college students (CON group, age = 24.3±2.8 yr; weight = 663.7 ± 72.2 N; height = 172.9 ± 7.0 cm) also participated in the study as control subjects to provide a basis for comparison. The pressures distributed over the fists of the subjects were measured using a Kistler force plate and a Teckscan HRmat pressure pad as shown in Figures 1 and 2. During testing, the pressure pad was placed on top of the force plate to record the finger pressure data. Force platform data were simultaneously collected to verify these pressure results. The sampling frequency during the dynamic push-up tests was 60 Hz. As illustrated in Figure 3, the finger pressure data during the static tests were collected at an arms-straight position (left picture) whereas the dynamic (right picture) data were sampled for five separate push-ups. In each push-up test, the subject started at the arms-straight position and then lowered their body to the lowest position at a self-selected speed, staying at the lowest position for 3 seconds.

Figure 1 - Kistler force plate.

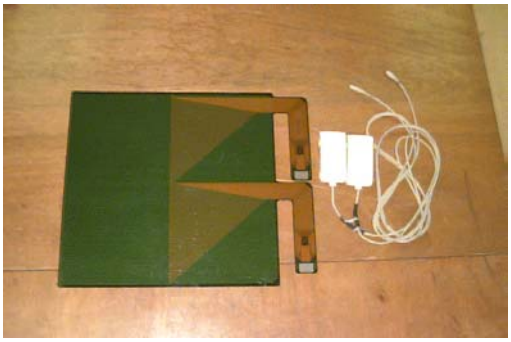

Figure 2 - Teckscan HRmat pressure pad.

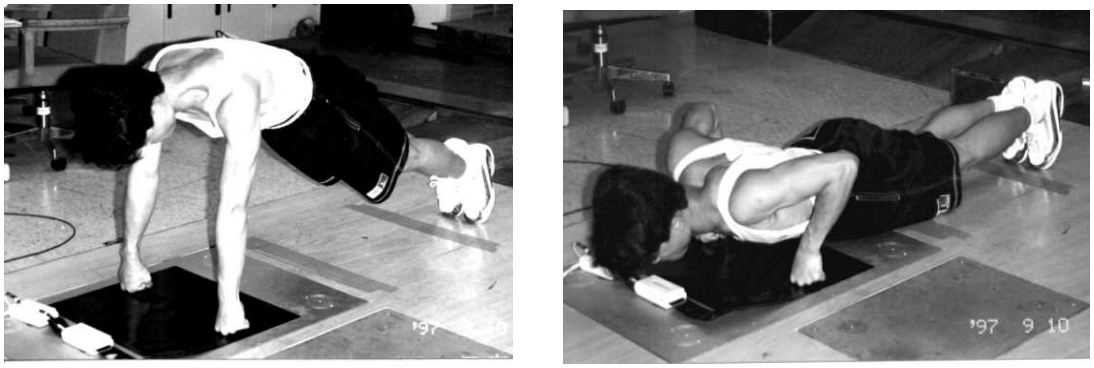

Figure 3 - The poses of static and dynamic push-up exercises.

RESULTS AND DISCUSSION: The collected finger-pressure data were analyzed by averaging the pressure on the first phalanx of each finger of the subjects. Table 1 summarizes the fingers' mean peak pressures with standard deviations on the fist in the static push-up tests at the arms-straight position. For the dynamic mode, the peak pressure is obtained by averaging the peak values from the five push-ups performed by each subject. The results are shown in Table 2. It can be seen that the control group displayed approximately the same mean pressure value across all their fingers, except the thumb. The large standard deviation values shown in the data are attributed to poor wrist muscle control in this untrained group of control subjects. In contrast, the data of the regularly trained karate subjects, the experimental group, show higher consistency in wrist muscle control as indicated by much smaller standard deviations in the pressure data. Figure 4 shows the peak finger pressures on the index and middle fingers of individual subject in dynamic push-up tests. Figures 5 and 6 respectively show the mean pressure distributions with standard deviations on left and right hands of the test groups in dynamic mode. It can be seen that in the push-up tests, pressure on the fingers of the fists of a regularly trained karate competitor was focused on the index and middle fingers. As all the subjects were right handed, the mean peak pressure of data collected for the right hand was higher than that of the left hand. In this simulated hard floor push-up test, the mean peak pressures were concentrated in the index (2144 ± 226.1 kPa) and middle (2612 ± 610.8 kPa) fingers of the experimental group. These highly concentrated pressures may cause a decline in hand nerve sensibility and reduce the gripping strength of karate competitors in the course of their professional lives.

Table 1 The Fingers' Mean Peak Pressure (kPa) on the Fist in Static Push-Up Tests at Arms Straight Position (Left picture of Figure 3)

	Group	Index Finger	Middle Finger	Ring Finger	Little Finger
Left Hand	EXP	735.2±649.7	2120±992	533.3±994	48.1±103.3
	CON	45.7±158.4	1052±711.1	1331±1018	274.8±379.2
Right Hand	EXP	1267±1079	1899±926.8	447.3±894.4	75.8±188.6
	CON	55.3±191.6	1276±934.1	1921±936.2	569.4±772.2

Table 2 The Fingers' Mean Peak Pressure (kPa) on the Fist in Dynamic Push-Up Tests at the Lowest Position (Right picture of Figure 3)

	Group	Index Finger	Middle Finger	Ring Finger	Little Finger
Left Hand	EXP	1734±472.1	826±644.1	30±199.9	3.83±13.28
	CON	1654±619.3	1290±791.2	1751±744.5	1314±936.8
Right Hand	EXP	2144±226.1	2612±610.8	43±98.3	0±0
	CON	1773±590.7	1913±915.7	1958±814.4	870±853.9

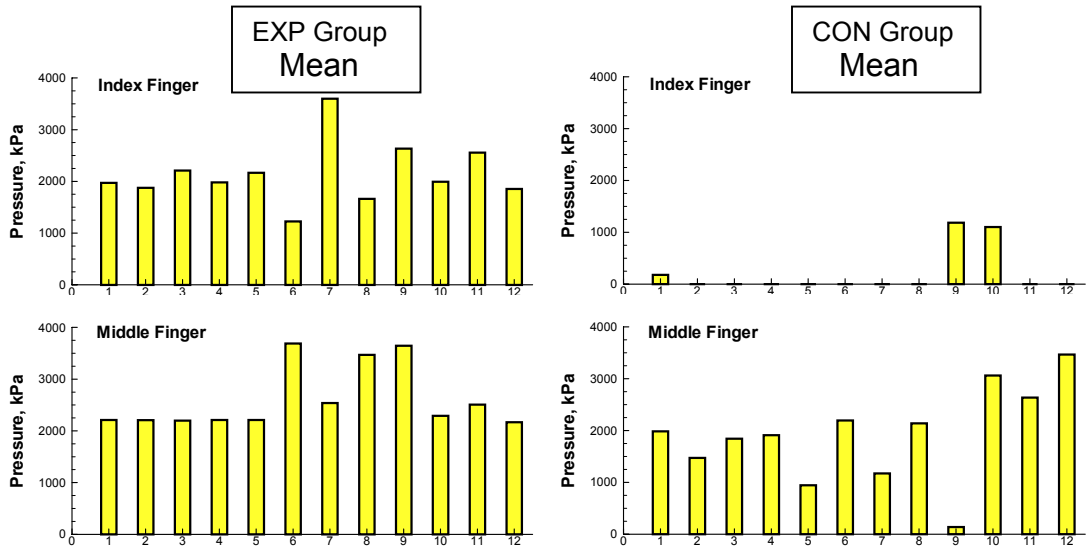

Figure 4 - Peak finger pressures of individual subject in dynamic push-up tests.

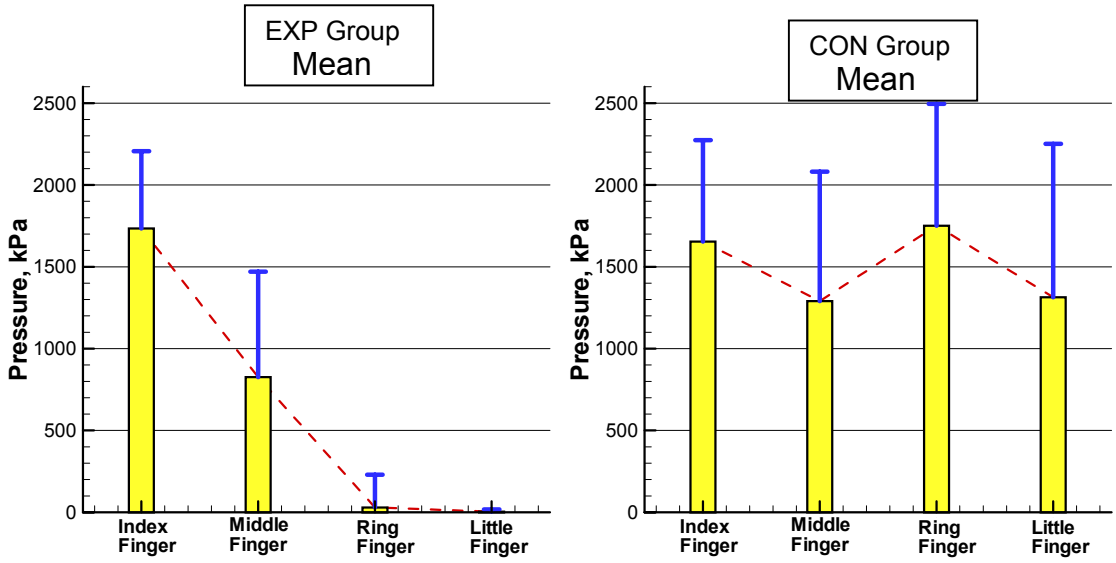

Figure 5 - Mean finger pressures (shown with standard deviations) in the dynamic push-up tests (left-hand).

EXP Group
Mean

CON Group
Mean

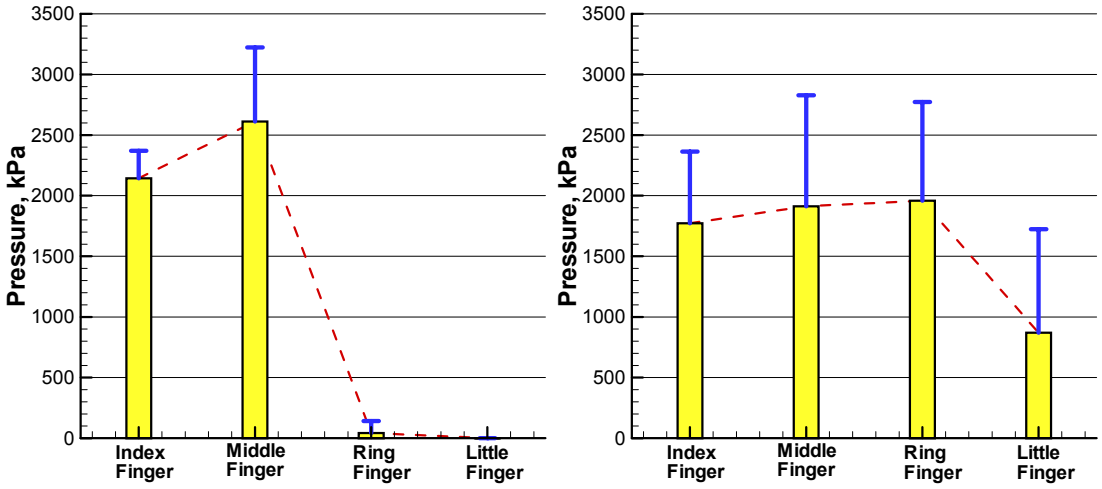

Figure 6 - Mean finger pressures (shown with standard deviations) in the dynamic push-up tests (right-hand).

CONCLUSIONS AND RECOMMENDATIONS: To prevent wrist injuries, karate competitors are trained to use the index and middle fingers as the strike points in a fist motion during a frontal attack. Consequently, the reported cases of hand injuries due to incorrect training, such as conducting extensive push-ups on a hard floor as simulated in this study, are continuously increasing. This research presents an empirical study of the pressure generated across the fingers when holding on the fist during static and dynamic push-up exercises performed by karate competitors. As a correctly trained karate competitor can precisely control his/her fist orientation using their wrist muscles during a fist motion, both the static and dynamic test results show that the peak pressures are localized in the index and middle fingers of the karate-competitor group. To avoid permanent hand injuries and eventual reduction of gripping strength due to highly concentrated pressures, wearing adequate protective knuckle pads should be enforced in all matches and push-up exercises in karate training.

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