AN ANALYSIS OF MOVEMENT PATTERNS UTILIZED BY DIFFERENT STYLES IN THE KARATE REVERSE PUNCH IN FRONT STANCE

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Research Hypotheses

The purpose of this study was to obtain baseline kinematic data on the spatial and temporal organization of selected segmental movements of the body during the execution of the karate reverse punch in front stance. The two research hypotheses (H) tested in the study were:

H_1: The reverse punch in front stance when performed by advanced performers (karateka) will conform to the "kinetic link principle" and "serape effect" movement models.

H_2: A similar movement pattern will appear irrespective of karate style.

The Reverse Punch in Front Stance

The reverse punch is a closed fist strike in which the fist follows a horizontal straight line path. The punch is commonly done in a front stance where the punching hand is on the opposite or contralateral side to the leading foot. A typical front stance position has the front knee directly over the toes of the leading foot; the leg and thigh form a 90 degree angle to each other; the back is straight. The rear foot is approximately two shoulder widths back and placed one shoulder width wide. The back knee is slightly flexed, toes pointing between 30-45 degrees laterally. The hips are at 135 degrees relative to the line of the punch. Body weight is balanced with approximately 60% on the front foot and 40% on the rear foot.

The reverse punch is the most widely used technique in karate (Corcoran and Farkas, 1983). Schroeder and Wallace (1976) assert that the reverse punch is also one of the most powerful karate techniques citing that: (a) the performer (karateka) is in a very stable stance with a large base of support, (b) the rear knee is straightened upon impact preventing the body from recoiling, and (c) the force of the reverse punch is a result of the summation of many forces that are successively applied.

The Movement Models

There is very little information in the literature about the mechanical bases of specific karate punching techniques. In spite of this, it may be instructive to see how closely the karate strike conforms to the models for optimal transfer of angular momentum in throwing skills An interesting question, for example is whether the "whiplike action" at the distal end of a lever system discussed by Broer and Zernicke (1979) is present in a karate punch? According to this model the key to obtaining maximum linear velocity is to bring a greater number of body parts into the sequence with the correct timing. Each new body part is brought into play at the greatest velocity of the preceding part. Cooper, Adrian, and Glassow (1982) describe the summations of different limb velocities as a "crescendo at time of release." Northrip, Logan and McKinney (1983) describe the rotational motion that occurs during high velocity ballistic throwing or striking actions as a "serape effect." The "serape effect" applies to an oblique chain of muscles which contract concentrically in a given sequence. They include the internal and external obliques, the serratus anterior, and the rhomboideus major and minor. Logan and McKinney describe these pairs of muscles as forming a "muscular serape" wrapping the trunk. The critical movement in the "serape effect" is initiated by left transverse pelvic rotation in conjunction with right rotation of lumbar and thoracic spine putting the contralateral spinal rotators on "stretch" to optimize the subsequent rotation of the limb. This also has the effect of increasing the total range of motion through which force can be applied to the object of the throw. Rasch and Burke (1978) refer to those active muscles as the "seraptors" and the muscles that act during the preparation or "wind-up" phase as the "deraptors."

Related to the "serape effect" is Kreighbaum and Barthels (1985) discussion of "open kinetic chain" activities where the final or distal segment is "free" at the end of the chain. When the purpose is to impart maximum linear velocity to an object in a specific direction, the largest and most forceful segments precede the weaker more distal segments in order to transfer maximum angular momentum. This illustrates the "kinetic link principle."

The Research Procedure

Four highly ranked male volunteer black belt performers were selected to participate in the study. The best performer available was selected from each karate style studied which were the Shotokan, Tae Kwon Do, Kung-fu, and Kempo styles.

The four subjects were filmed in the sagittal plane using their dominant punching hand in front stance. They punches at a "focus mitt" held by an assistant at the level between their navels and xiphoid processes which is the standard target area for a "middle punch." The mitt was positioned to ensure that the fist would strike the target with the forearm parallel with the ground, and perpendicular to the camera angle.

The subjects wore only bikini type bathing suits. Black electrical tape was attached to the centers of the ankle, knee, hip, shoulder, elbow, and wrist joints for film digitizing. Three trials for each subject were filmed. Filming was done with a 16 mm Photo-Sonic camera at 100 frames per second located approximately 15 feet from the subjects.

The trials with the highest peak horizontal velocity (V_x) for the striking fist were selected for each subject. Kinematic data were acquired using a Vanguard Motion Analyzer. The data were then typed into a computer. Two computer programs developed in the Kinesiology Laboratory at the University of Northern Colorado were used for data reduction. The programs output the displacements and instantaneous velocities for the wrist, elbow, shoulder, hip and knee joint markers.

Analysis of Movement Patterns

The Results

Velocity-time curves for the hips, shoulders, and wrists of the four subjects are presented in Figures 1 through 4. The Shotokan style (Figure 1) registered a peak hip velocity of 1.55 m/s at 42% of the total movement time. Peak shoulder velocity was 3.21 m/s and occurred at 53% of total movement time. Peak wrist velocity was 8.58 m/s and occurred at 80% of total movement time. The Shotokan style registered the highest peak hip velocity and greatest horizontal hip displacement of all 4 styles. Additionally, peak hip, shoulder and wrist velocities occurred earlier as a percentage of total movement time than the other three styles. The Shotokan style registered the highest average wrist velocity.

The Kempo style (Figure 2) registered a peak hip velocity of 1.11 m/s at 75% of the total movement time. Peak shoulder velocity was 3.46 m/s and occurred at 75% of total movement time. Peak wrist velocity was 8.82 m/s and occurred at 95% of total movement time. Peak hip and shoulder velocity coincided at 75% of total movement time.

The Kung-fu style (Figure 3) registered a peak hip velocity of .55 m/s at 35% of the total movement time. Peak shoulder velocity was 3.23 m/s and occurred at 80% of total movement time. Peak wrist velocity was 7.19 m/s and occurred at 95% of total movement time. Peak velocity of the hip occurred early in the movement pattern. In addition, there was a marked acceleration of the wrist in the first .05 seconds of the movement although peak velocity of the wrist was slowest of the four styles.

The Tae Kwon Do (Figure 4) style registered a peak hip velocity of .92 m/s at 61% of the total movement time. Peak shoulder velocity was 3.81 m/s and occurred at 84% of total movement time. Peak wrist velocity was 9.97 m/s and occurred at 94% of total movement time. There was very little horizontal displacement of hip, shoulder, or wrist during the first 50% of movement time during which the performer rose up on his toes in a preparatory movement. There was a tremendous acceleration of the wrist and shoulder the last 25% of the movement. The Tae Kwon Do performer had the highest peak wrist velocity and the lowest average wrist velocity.

The most striking difference in the selected variable velocity patterns of the four styles was measured in the Tae Kwon Do pattern. In addition, the arm (humerus) was observed to be abducted to 90 degrees (parallel with the ground during the punch. This was in contrast to some textbook admonitions to keep the elbows in to allow the forearm to follow a direct line to the target (Nakayama, 1966). While the film revealed that the elbow was moved laterally through shoulder joint abduction in all subjects to some degree, none showed the pronounced degree of abduction as observed in the Tae Kwon Do pattern.

In summary, peak velocities of the hip ranged from .51 m/s to 1.55 m/s and occurred between 35% and 75% of total movement time. Peak velocities of the shoulder ranges from 3.21 m/s to 3.81 m/s and occurred between 53% and 84% of total movement time. Peak velocities of the wrist ranged from 7.19 m/s to 9.97 m/s and occurred between 80% and 95% of total movement time.

Discussion

The research hypothesis that the reverse punch in front stance would conform to models for producing maximum velocity in the striking limb was found to be only partially true in this study. Deviations from the ideal model perhaps should be expected for the following reasons.

1. Lack of an apparent wind-up. Movement time must be limited due to the possibility of the strike being anticipated and/or countered. This precludes the possibility of a "wind-up" or applying force over relatively large distances as is possible in a number of throwing skills.

2. Relatively straight path of the fist. Due to movement time limitations, the karateka must deliver a punch along a straight horizontal line, thereby shortening the potential radius of the arm and other body segments. This limits potential linear velocity at the end of the fist since linear velocity is proportional to the radius multiplied by angular velocity. Another reason for punching in a straight line with the elbow "tucked in" is to use a larger effective mass to generate more force by putting one's "body behind the punch." In addition, by punching in a straight line and keeping the elbow in tight against the body, the striker reduces resistive torque which will be transmitted back to the striker upon impact with an object or opponent.

3. Limited follow-through. The karate strike has a limited follow through. The focus point for the strike is just inside the target

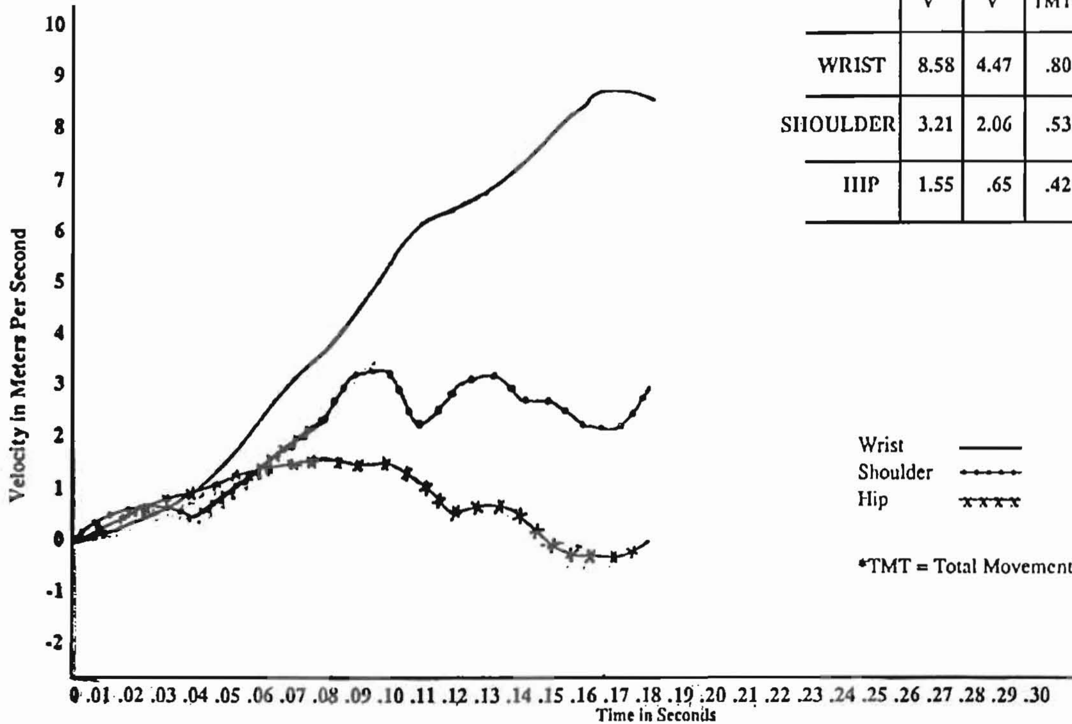
area. After impact the karateka is taught to rapidly return the striking limb to the starting position for defensive purposes or for another strike.

4. The need to maintain balance. The strike must be made within the limits of the front stance. The karateka is taught to remain in balance by keeping his/her center of gravity within the base of support. This is so as not to expose the attacker to counter attacks should the initial strike fail. Thus, since a single strike is not an all or nothing event, some of the available energy from the strike must be held back or controlled in order to remain stable.

The data of this study appear to indicate that due to movement time limitations the karateka cannot make maximum use of the serape effect for optimum "stretch" and range of motion as would someone throwing a javelin for example. This would, in part, limit applicability of the kinetic link model as well. The karateka must nonetheless achieve rapid accelerations and develop a high maximum velocity for a strike within the above constraints. To do this he/she must apply successive muscular torques with rapid precision to prevent the movement from taking too long and thereby risking a counter-strike. We have chosen to call the limited "serape effect" resulting from the reduced range of motion possible in a karate strike the "shrunken serape" or "short-sheeted" serape.

In summary, the results of this analysis indicate that the karate reverse punch in front stance is a highly specialized movement that requires alteration of standard movement models, such as the kinetic link principle and serape effect, in order to be thoroughly understood.

	Peak V	Ave. V	Peak V as % TMT*	TMT*
WRIST	8.58	4.47	.80	.19
SHOULDER	3.21	2.06	.53	.19
HIP	1.55	.65	.42	.19



*TMT = Total Movement Time

Figure 1. A comparison of joint velocity versus time elapsed in Shotokan style.

	Peak V	Ave. V	Peak V as % TMT*	TMT*
WRIST	8.82	3.60	.95	.20
SHOULDER	3.46	1.90	.75	.20
HIP	1.11	.65	.75	.20

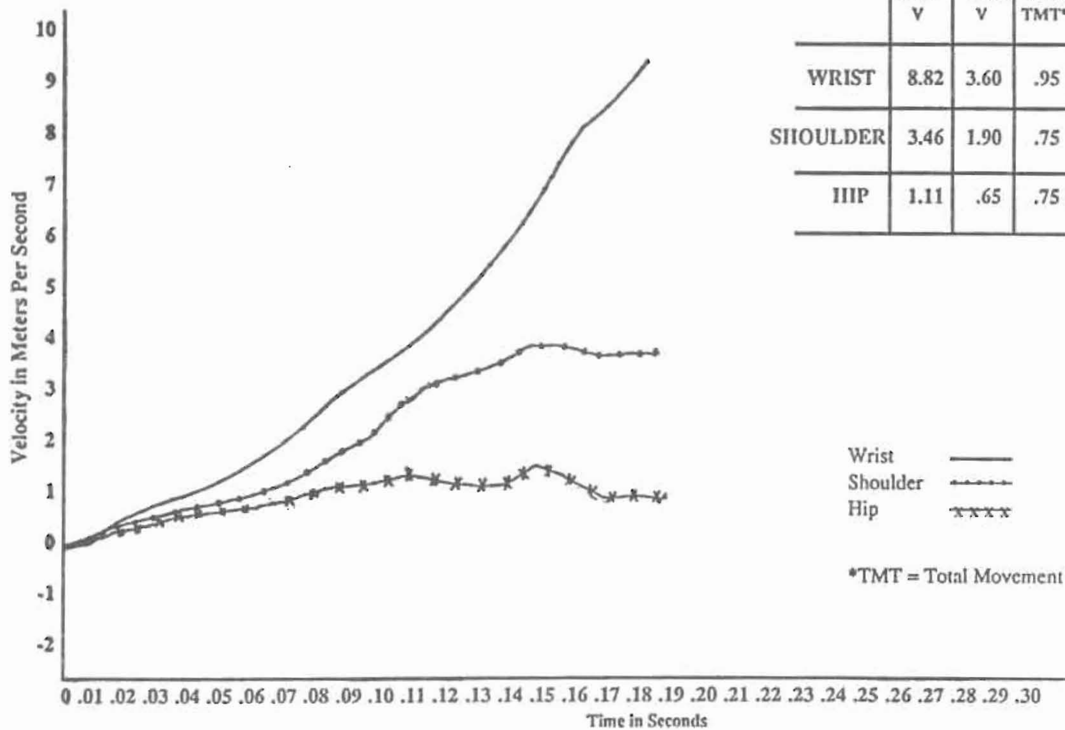


Figure 2. A comparison of joint velocity versus time elapsed in Kempo style.

	Peak V	Ave. V	Peak V as % TMT*	TMT*
WRIST	7.19	3.85	.95	.20
SHOULDER	3.23	1.55	.80	.20
HIP	.51	.10	.35	.20

*TMT = Total Movement Time

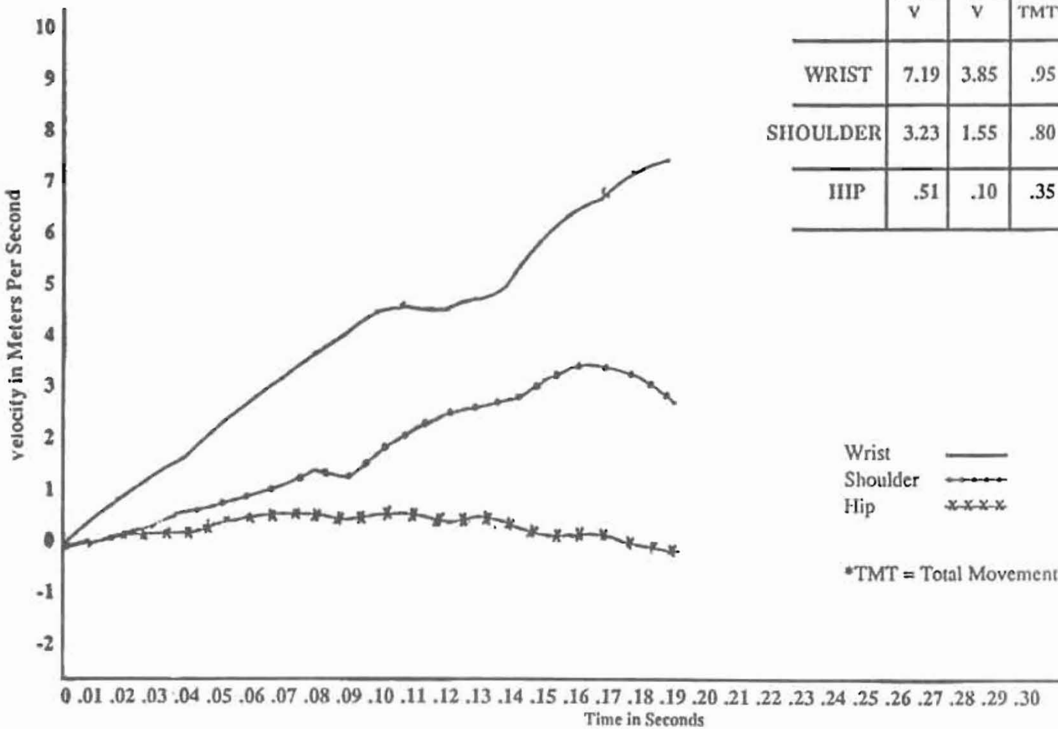
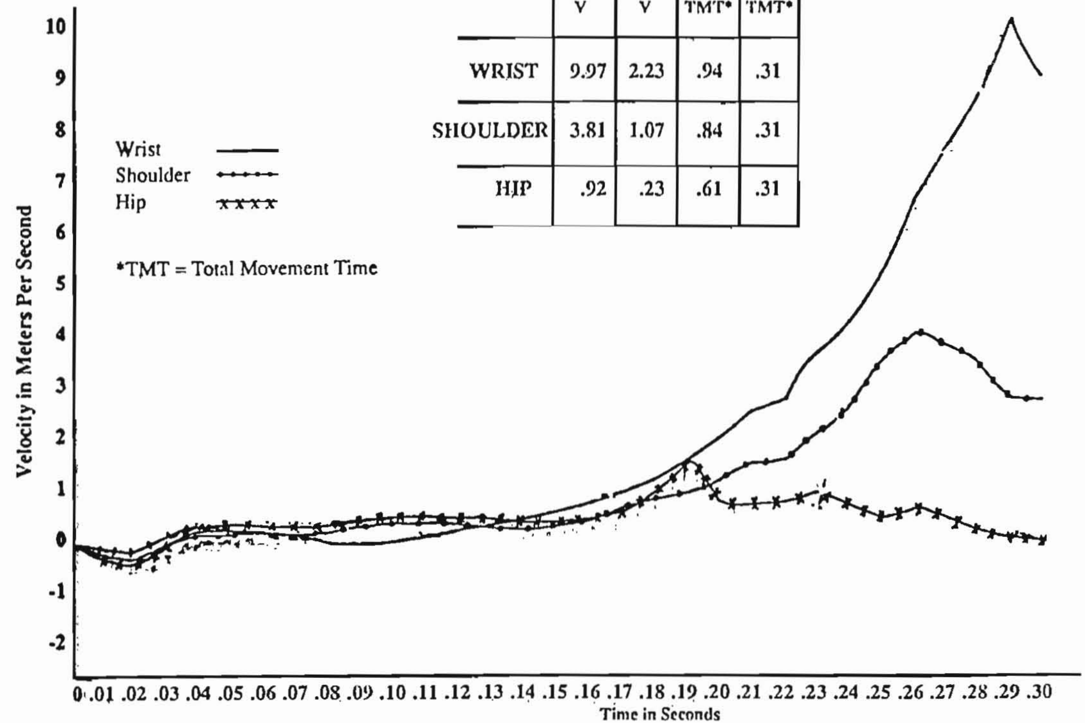


Figure 3. A comparison of joint velocity versus time elapsed in Kung-fu style.



	Peak V	Ave. V	Peak V as % TMT*	TMT*
WRIST	9.97	2.23	.94	.31
SHOULDER	3.81	1.07	.84	.31
HIP	.92	.23	.61	.31

Figure 4. A comparison of joint velocity versus time elapsed in Tae Kwon Do style.

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