THORACIC INJURY EFFECTS OF LINEAR AND ANGULAR KARATE IMPACT

P. K. Smith[1], D. C. Viano[2], D. P. Faust[2], L. Faust[2]

[1]Department of Physical Education
West Chester University
West Chester, Pennsylvania, USA

[2]Institute for Preventative Sports Medicine
Ann Arbor, Michigan, USA

INTRODUCTION

Karate techniques are designed to inflict varying degrees of force on an opponent in an effort to control or limit physical aggression toward a defender. Skilled karateka are reputed to be able to completely disable an opponent with one blow. This is accomplished by impacting an aggressor with a punch or kick applied in a pushlike linear thrusting fashion (lower velocity-higher mass) or a throwlike, angular, striking (higher velocity-lower mass) method of force application (Kreighbaum and Barthels, 1990). The nature and degree of injury one receives from an impact depends on the site of impact and mass-velocity interactions involved in the collision. More highly skilled practitioners should be better able to coordinate the velocity-mass relationships with techniques to generate higher levels of impact (Smith, 1987).

Different types of impact may generate injuries of varying degrees of damage, depending on where on the body and how hard the person is hit, as well as how well the person is prepared to receive the blow (Smith, 1984). Viano (1988) and others (Viano and Lau, 1988) have devised the Viscous criteria (VC_{max}) to estimate level of injury to the thorax or chest. This index is based on how deeply and how fast the chest is compressed. Accordingly, a VC_{max} = 1.0 m/s is the level for a 25% probability of severe injury (Viano, 1988), such as liver or lung laceration (AIS, 1980).

This study was conducted to determine whether highly skilled karate practitioners have the ability to damage the body with specific linear or angular techniques above the medically "severe" injury level and can use readily available safety equipment, such as a chest protector, to temper blows to below the level of medically severe injury. Angular techniques evaluated were the roundhouse kick and backfist strike. Linear techniques evaluated were the side-thrust kick and the reverse punch.

METHODOLOGY

High ranking karate competitors of sandan, yondan, and master class (3rd, 4th, and 5th or higher degree black belt levels, respectively), having experience in at least one international level tournament, were used as subjects (n = 3 in each class). No distinction between participants still competing and those retired from competition was made because all subjects participated regularly in karate training. Subjects' ages ranged from 30 to 50 years (mean=38.44 ± 7.62 years), averaged 78 ± 7.66 kg in mass, and averaged 178 ± 7.60 cm in height. Subjects had been actively training for about two decades (mean=20.11 ± 9.27 years).

Subjects impacted the chest of an instrumented HYBRID III anthropometric test dummy (ATD), with and without a generic quilted vest-type chest protector. The

ATD was equipped with accelerometers on the posterior aspects of the upper and lower sternum, as well as the spine of the dummy. A chest deflection potentiometer was situated at the mid-sternal level. Data signals were sampled at 10,000 Hz, processed according to Society of Automotive Engineers (SAE) standards (SAE Handbook, 1985), and adjusted to the dynamic ranges for fist-foot impact with the dummy. Subjects were also videotaped for qualitative evaluation. Subjects were directed to the testing station wearing only swim trunks or similarly suitable attire, had their segmental end-points marked, and were asked to punch or kick the ATD as hard as possible three times using a predetermined technique. Subject order, chest protector usage, and technique type were counterbalanced to evenly distribute variability. Prior to data collection, subjects were given as many practice trials as desired and were using the hand or foot of their choice. The trial with the highest VCmax was used for analysis for each condition.

Data were analyzed using a 2 X 3 X 4 Analysis of Variance design with Tukey's Studentized Range follow-up tests to discriminate within condition differences. The adjusted viscous criterion (VC_{max}) was the dependent variable used for evaluation. Independent variables were the use of a chest protector (with and without), skill classification (sandan, yondan, and master), and technique (roundhouse kick, backfist strike, side-thrust kick, and reverse punch).

RESULTS AND DISCUSSION

Main Effects - Results indicated statistical differences among rank classes, $F(2,60)=7.57$, $p=0.0012$; with and without the use of a chest protector, $F(1,60)=4.28$, $p=0.0430$; and technique type, $F(3,60)=7.17$, $p=0.0003$. It must be stressed that these were preliminary data that will be subjected to considerable further scrutiny and may be combined with additional trials.

Class Effects - Of the three skill classes evaluated, sandan (mean: 1.2096 ± 0.5309 m/s) and yondan (mean: 1.1127 ± 0.4304 m/s) ranks both generated higher VCmax levels than the master class competitors (mean: 0.8036 ± 0.2797 m/s) ($p<0.05$). Specificity of training could reasonably explain this data trend. All master class participants were full-time practicing karate instructors and, as such, their training is oriented much more toward teaching students and movement refinement, as well as spiritual aspects of karate. Sandan and yondan training is usually more physically oriented with competition often being expected at those ranks.

Qualitative assessment of the videotapes confirmed the master class technique to be smoother, with less wasted movement, more consistent in execution, and generally of a higher quality than the lower ranks. Some credit may be given for the judgment of the master class when hitting an inanimate object "as hard as possible". The primary implication is that the higher ranking levels may have been more discriminating when hitting the ATD, rather than merely flailing away on the dummy. This may be a higher order skill effect.

Chest Protector Effects - The chest protector was found to slightly attenuate the impact of karate techniques, which in this case was below (mean=0.9535 ± 0.4575 m/s) the severe injury level ($p<0.05$). With the ATD outfitted with the chest protector the Viscous criteria was marginally below the cut-off point for severe injury of $VCma_x=1.0$ m/s. Without the protector, the Viscous criteria was slightly above the critical level (mean: 1.1382 ± 0.4423 m/s) to indicate a "severe" injury would probably occur 25% of the time. Though statistically significant differences were found, the overall level of the $VCma_x$ scores may indicate a lack of practical significance. It is a common sense matter to appreciate that an ecxcessive injury from a practical standpoint may be a qualitative matter and that substantial real damage may be present, even when "severe" criteria have not been met.

Technique Effects - There was a difference among the types of techniques used during these tests ($p<0.05$). The roundhouse kick generated higher VC_{max} (mean: 1.3778 ± 0.4674 m/s) than all other techniques: the reverse punch (mean: 1.0122 ± 0.3923 m/s); the side-thrust kick (mean: 0.9538 ± 0.4976 m/s); and the backfist strike (mean: 0.8189 ± 0.2986 m/s). No statistical difference was detected among the reverse punch, side kick, or backfist conditions. It was not surprising that the roundhouse kick and reverse punches generated forces high enough to cause severe injuries. It was surprising that the side-thrust kick and backfist strike did not. As qualitatively determined from compression-time curves, thrusting techniques did not compress the thorax as rapidly or as deeply as snapping techniques, however, they did hold the compression longer. In many cases, the thrusting kick maintained a near maximum degree of compression beyond the 100 ms time sampling duration. The low compression velocity reasonably indicates that the injury mechanism for the thrust kick may be of a crushing nature, rather than a function of rapid compression as indicated by Viano (1987).

This information, coupled with the qualitative observation of the relatively larger amount of ATD movement with the side-thrust kick, would indicate that a more "pushlike" effect was taking place with the thrusting techniques. In contrast, the rapid and deep compression of the thorax with the roundhouse kick supports the idea that shocking, rather than pushing, forces generate the damaging high internal accelerations of body organs. The side-thrust kick is difficult to coordinate for maximum foot velocity at impact. The result of an improperly executed side-thrust kick is a "push kick" effect. The impact of such a technique, though it can be very damaging, is less than optimal. Compression can damage internal tissues; however, within the ranges of karate impacts the main consideration is that this compression must be rapid.

CONCLUSIONS

It is evident that the highly skilled karate competitor has the potential to deliver medically severe and probably even higher levels of damage with linear or angular karate techniques. When impacting a target with full force, the roundhouse kick would be able to do the most damage to the thorax, though the reverse punch could inflict medically severe injury. The chest protector is capable of slightly reducing the potential risk of injury. The level of damage to the thorax reduced slightly below the severe cut-off level in this study with the use of a chest protector. From a practical and real standpoint, any of the above classifications of karate practitioner, using any of the above mentioned techniques, with or without a chest protector, could readily inflict enough damage to discourage further aggression.

REFERENCES

AIS Committee on Injury Scaling. The abbreviated injury scale (1980 revision). Morton Grove, IL: Am Assoc Auto Med.

Kreighbaum, E. and Barthels, K. M. (1990). Biomechanics: a Qualitative Approach for Studying Human Movement (3rd ed.). New York, NY: Macmillan Publishing Company.

SAEJ211. (1988). SAE Handbook Index: Instrumentation for Impact Test. Warrendale, PA: Soc Auto Eng, Inc.

Smith, P. K. (1987). Punching impact effect of the karate, boxing, and the thumbless boxing glove. In Biomechanics in Sports IV. J. Terauds, B. Gowitzke, L. Holt (eds.). Del Mar, CA: Academic Publishers.

Smith, P. K. (1984). Selected impact characteristics of karate and boxing gloves. Unpublished doctoral dissertation. Southern Illinois University at Carbondale, Carbondale, IL.

Viano, D. C. (1988). Cause and control of automotive trauma. Bulletin New York Acad of Med 64(5):376-421.

Viano, D. C. and Lau, I. V. (1988). A viscous criterion for soft tissue injury assessment. J Biomech 21(5):387-399.