The Physics of Kenpo Karate

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Kenpo Karate is a modern, sophisticated system of self-defense. In fact, during one of the Karate Connection seminars I attended, Damon Excell, a highly respected Kenpo instructor stated, "Kenpo is physics in motion." As anyone who studies Kenpo knows, Kenpo can be very difficult to understand and apply with great skill. The precision that is required of a Kenpo practitioner requires an enormous amount of practice; and the concepts can be difficult to understand without the aid of science, such as physics. In the early 1980's, Mr. Parker consulted with one of his black belts, Kevin Lamkin, a Physics professor, on the specific applications of Kenpo as it relates to physics. Mr. Parker sought to gain a better understanding on the application of force, power, and other concepts in the art he was developing. He felt it was important to use accurate physics terminology to explain the concepts in Kenpo. Mr. Lamkin also dedicated a column in the International Kenpo Karate Association newsletter where he regularly contributed his knowledge of Physics and its relation to Kenpo. In my graduate studies, I was required to write a paper for my physics class. Naturally, I chose to write on the Physics of Kenpo. During my research, I had the privilege to consult with Mr. Lamkin personally. Over the next few issues of our newsletter, I will be sharing the knowledge I acquired in physics. Read it carefully and try to start using the terminology such as force, velocity, kinetic energy, and inertia when you speak about your strikes. This is your first step in "talking the talk." The following is the first segment of my paper, it discusses the focus of the punch for gaining maximum power.

"Carol, a Kenpo Karate black belt, is walking down the street when she is assaulted by a mugger, Burt. Burt, who's mass is 100 kg, rushes 2.5 m/s toward Carol in an attempt to tackle her. Carol, who's mass is 50kg, is faster on her feet and sidesteps Burt while launching a rear hand punch to his body at 5m/s. What happens?" (Lamkin, p.2) Scenarios, such as this one are all too common in today's society. Therefore, it is imperative that one should learn to defend themselves or their loved ones in a situation such as this.

Edmund K. Parker, founder of the American Kenpo Karate system once stated that, "To understand Kenpo techniques and how they function, you must have knowledge of physics."(Parker, p.182) Martial arts students have a history of studying their environment in order to gain an understanding of motion for the purpose of becoming more effective in self-defense. The earliest history of martial arts stems from the rich traditions of the monks of the Shaolin Temple in China. The monks studied the movements of animals in order to mimic their movements in combat. Today, those who study science such as physics and biomechanics make modern martial arts movements, such as punches and kicks, more effective. The strikes are analyzed, outcomes are predicted, and the overall effects are evaluated in order to maximize the effectiveness of human movement in combat.

One such example is the Kenpo Karate punch. Kenpo Karate punches are "focused" to terminate several centimeters within the body being struck, as opposed to the follow-through punches used by the untrained. There are scientific reasons why focused punches are better than wide swinging, follow-through punches. If contact is made at some point during a wide swing, significant torque will be produced that may throw the puncher off balance. In addition, energy is transferred to the target via pushing rather than by deformation if contact is made during the follow-through. Pushing generally does less damage than deformation, a concept that will be addressed later in this paper.

In a standard Kenpo Karate punch, the fist begins at the chest and terminates with the arm fully extended at shoulder height. Figure 1 displays a graph of the velocity of the fist as a function of its position (measured as a percentage of the total arm length). Notice that the maximum velocity is attained at about 75% of the distance to the stopping point. This corresponds to roughly 10-14 cm. Thus, by focusing the punch several centimeters inside the target, the Kenpo Karate punch is guaranteed to make contact closer to the point where the fist has its maximum velocity. This maximizes the potential for damage, as shown in Figure 1 below.

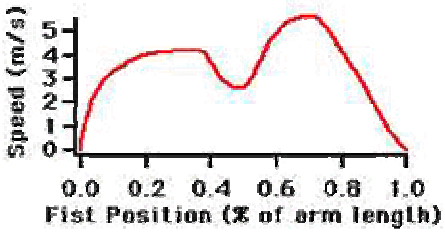

Figure 1

Martial arts students should develop an understanding of force, momentum, and work, in order to increase the effectiveness of kicking and punching. This knowledge will allow a smaller person, such as Carol in the case study, to overpower a much larger opponent. Utilizing momentum to increase the power of kicks and punches is the most basic concept of striking. Momentum (p) is defined as the product of an object's mass (m) and velocity (v). Momentum is represented by the equation: p=mv. In the case study discussed earlier, an assumption can be made that if Burt has a mass of 100kg and Carol, has a mass of 50kg, then Burt's attack would have much more momentum than Carol's counter-attack, allowing Burt to easily overpower and tackle Carol. This statement would be true if the situation was being analyzed strictly from a mass standpoint. After all, Burt's mass is 50kg greater than Carol's. However, since momentum is equal to mass times velocity, Carol can do several things to equal or even overcome Burt's momentum and stop his attack. Carol can either increase her mass, which may not be practical for her, or she can increase the velocity of her counterstrike through martial arts training, the latter being a more reasonable choice. By increasing the velocity of her strike, she will be able to overcome Burt's momentum and not only stop him, but also inflict trauma, thus gaining an advantage over an obviously larger attacker. If the idea of a smaller person being able to have the capacity of overcoming a larger attacker is hard to believe, we can verify this by comparing Burt and Carol's momentum mathematically. Burt's momentum can be calculated as follows: 2.5 m/s x 100 kg = 250 kgm/s. Carol's momentum equals 5 m/s x 50 kg.= 250 kgm/s. It can be determined that Burt and Carol's momentum is equal, which allows Carol to cancel Burt's momentum, thus stopping him in his tracks.

A question remains—how can we assess the damage of Carol's strike? Can

Carol's punch inflict injury on Burt and just how is this damage caused? There are two ways to approach the answer to this question, both equally accurate. The first looks at the strike in terms of force and momentum; the other in terms of energy. Force (F) is mass (m) times acceleration (a), F = ma. Force is defined as the effect of acceleration on a mass over a distance in space. Since acceleration measures change in velocity over time (t), force is the derivative of momentum with respect to time. Equivalently, force times time equals change in momentum (p), or impulse (Δp), Δp = Ft. This is important because momentum is a conserved quantity. It can be neither created nor destroyed, but is passed from one object (Carol's fist) to another (Burt's body). Conservation can be explained by Newton's third law of motion, which states that if an object exerts a force on another object for a given time, the second object exerts a force equal in magnitude but opposite in direction of the first object for the same amount of time so the second object gains exactly the amount of momentum the first object loses. (Chananie p. 1) Momentum is then transferred. One can deliver a given amount of momentum by transferring a large force for a short time. This short amount of time is defined as the high velocity of Carol's strike. Carol's high velocity Kenpo Karate punch allowed her to gain an advantage over her larger attacker.

Just how does a strike inflict damage? A strike inflicts damage through the transmission of energy into a target—specifically, kinetic energy. Kinetic energy is defined as "the content of energy that an object with momentum possesses." The equation for kinetic energy is $KE= \frac{1}{2}mv^2$. An analysis of kinetic energy reveals that if a martial artist can double the velocity of a strike, they can quadruple the kinetic energy generated.(Lampkin 2 p. 2) The kinetic energy of Carol's punch can be determined by calculating ½ 50kg (5 $m/s)^2$ = 625 joules.

However, it is the transfer of energy into a target that causes damage. To quantify the potential damage of a Kenpo Karate strike, we need to evaluate how much deformation energy is delivered by the blow. The amount of energy that a leg bone may absorb before breaking is represented by about 350 joules. This result is proportional to the cross-sectional area of the bone. If we consider a smaller bone, like an arm bone or a rib, then a proportionately smaller amount of energy will be required to break the bone. An arm bone has a diameter of about half that of a leg bone, so the energy it may absorb will be a quarter as much as that of a leg bone, or about 88 joules. This amount was greatly exceeded by Carol's punch, which totaled 625 joules. Therefore, the strike had a massive amount of potential to cause deformation.

Therein lies the advantage of having been formally trained in Kenpo Karate in lieu of solely relying on size and strength for powerful strikes. Ed Parker applied his knowledge of physics when he was developing his modern system of Kenpo Karate which has been proven to assist a smaller person in defending themselves against a larger attacker. To reemphasize the indisputable fact that velocity and focused power are much more effective than mass alone, take the case of a bullet, which contains very little mass and will cause negligible damage when thrown by hand at a target. However, when fired from a gun, the same bullet becomes incredible powerful just as the focused power of a correctly executed Kenpo Karate punch.