Traditional karate in a modern world:
"Physics of an effective technique with traditional kime".

Physics of Karate
Marc Boismenu, Rokudan, IKD
Outline

- Purpose of Research Paper
- Traditional Karate
- Principles of Physics
- How Physics Principles explain effectiveness of karate techniques
- Summary
TO EXPLAIN TRADITIONAL KARATE EFFECTIVENESS WITH SCIENTIFIC PRINCIPLES

2. Nakayama M. Best Karate Comprehensive, 1978
5. Tipler P.A., Physics, Oakland University, Worth Publisher inc., 1976
I - TRADITIONAL KARATE

KIME (Explosive Attack)

- CORRECT APPLICATION OF POWER
  - Correct Posture & Stance
  - Seika Tanden (vibration, rotation, thrust, down, up, pendulum)

- SPEED OF TECHNIQUE
  - SPEED
  - MOMENTUM
  - KINETIC ENERGY

- BODY EXPANSION AND CONTRACTION

- KI (ENERGY, FOCUS)
  - Mind – mental clarity, mental concentration
  - Feeling – punch, strike, block and kick
  - Spirit – of the samurai. Kiai is the loud expression of your internal energy in conjunction with quick exhalation from your hara (lower stomach). It is the union of body and mind.
I - TRADITIONAL KARATE

“THE ESSENCE OF A KARATE TECHNIQUE”  M. Nakayama

KIME (Explosive Attack)

- CORRECT APPLICATION OF POWER
- SPEED OF TECHNIQUE
- BODY EXPANSION AND CONTRACTION
- KI (ENERGY, FOCUS)
Outline

- Purpose of Research Paper
- Traditional Karate
- Principles of Physics
- How Physics Principles explain effectiveness of karate techniques
- Summary
II – PHYSICS FUNDAMENTALS

1. LAWS OF MOTION – Isaac Newton (circa 1686)

1. If there are no external forces acting on a body, it remains at rest or in motion with constant velocity – Law of Motion

2. The time rate of change of the momentum of a body is equal to the resultant external force acting on the body; where \( p \) is momentum, \( m \) is mass and \( v \) is velocity

\[
p = m \times v
\]

Momentum

2. The resultant force on a body is the sum of all forces

\[
F_R = F_x + F_y
\]

Resultant Force

3. To every action, there is always an equal but opposite reaction. In other word if a body A (punch) exerts a force \( F_A \) on body B (board), body B will exert an equal but opposite force \( F_B \) on body A.

4. The work done from the resulting force is the kinetic energy of that body

\[
E = \frac{1}{2} mv^2
\]

m is the mass and \( v \) the velocity

5. Force (F) is acceleration (a) times mass (m) \( F = m \times a \), where \( a = \frac{\Delta v}{\Delta t} \)
II – PHYSICS FUNDAMENTALS

To every action, there is always an equal but opposite reaction
II – PHYSICS FUNDAMENTALS

- **LAWS OF MOTION – Isaac Newton**
  - The time rate of change of the momentum of a body is equal to the resultant external force acting on the body:
    \[ p = m \times v \]  
    *Momentum*
  - The resultant force on a body is the sum of all forces
    \[ F_R = F_x + F_y \]  
    *Resultant Force*
  - To every action, there is always an equal but opposite reaction.

if a body A (punch) exerts a force \( F_A \) on body B (board), body B will exert an equal but opposite force \( F_B \) on body A.
II - PHYSICS

- SYSTEM IN EQUILIBRIUM
  - Energy is not created nor destroyed (without work input)
  - Energy is thus transformed or dissipated from work input

- MOMENTUM (P) IS A CONSERVED QUANTITY (P=MV, F=P/t)
  - Large force in a small amount of time will equate same momentum as a small force over long time but sudden energy transfer (large F) can yield to deformation

- LAWS OF PHYSICS DESCRIBE FORCE, MOMENTUM AND DEFORMATION

- ENERGY PER UNIT AREA
  - Therefore the smallest target area yields the biggest impact

- LAW OF MOTION
  - For every action there is an equal and opposite reaction.
Outline

- Purpose of Research Paper
- Traditional Karate
- Principles of Physics
- How Physics Principles explain effectiveness of karate techniques
- Summary
Applying the law of conservation shows momentum is a conserved quantity. "It can be neither created nor destroyed. It is passed from one object (the hand) to another (the board)".

Momentum is thus transferred.

With $\Delta p$ a fixed quantity, $F$ and $t$ are necessarily inversely proportional ($F = \frac{p}{t}$).

Momentum can be transferred with a large force for a short time or with a small amount of force continuously for a longer time.

This explains why the amount of time involved in the transfer of momentum needs to be small.

✓ We now know Force must be transferred over a small amount of time to have a more significant impact.

Walker describes momentum during a karate technique as follows: Acceleration measures change in velocity over time ($t$)

$$a = \frac{\Delta v}{\Delta t} \quad \text{(Changes in velocity over time)}$$  \hspace{1cm} (5)

And similarly, change in momentum is measured by change in velocity

$$\frac{p}{t} = m \cdot \frac{\Delta v}{\Delta t} \quad \text{(Mass is constant)}$$  \hspace{1cm} (6)

Force times time equals change in momentum, or impulse:

$$\Delta p = F \times t \quad \Rightarrow \quad (F = \frac{p}{t})$$  \hspace{1cm} (7)
Force is proportional to both mass and acceleration. How does one optimize force?

- Mass of a Chudan Zuki is affected by how much mass moves with the punch
- Smith and Hamill studied karatekas punching a bag and identified the following
  - Fist velocities were approximately the same for all skill levels
  - The bag momentum was greatest for the highest skilled karateka
  - The authors hypothesized that the increase in bag momentum was due to the subject’s ability to generate a greater effective mass during the impact.
  - With [fist velocity] = 11.5 m/s just before impact and [bag momentum] = 47.4 Ns, the effective mass of the striking fist was estimated to be 4.1 kg.

✓ Straight wrist and locked elbow allows the punch to “carry” a bigger mass and deliver more energy
SPEED FACTOR

- The other factor in the force is acceleration or changes in speed over time.
- A typical measure of time to execute a straight punch by a black belt is about 0.2 sec.
- Maximum speed is ~ 7 m/sec. at approximately 75% of the full technique extension.
- Past ~75% extension, deceleration occurs and speed goes to zero.

 ✓ In order to achieve maximum speed, it is important to apply kime and in a real attack, target a point behind the opponent in order to strike at 75% of the arm’s full extension.
Chananie examined collision mechanics of a hand strike to a board.

- Energy is defined as $E = \frac{1}{2}mv^2$ where $m$ is mass and $v$ velocity.
- Mass and Speed were covered previously, what else can improve Energy?
- Karateka’s punch energy must be greater than deformation energy for rupture.
- He notes that formulas for force, momentum & deformation energy are for a given unit area.
- He measured punch energy at ~190 Joules.
- If applied using four knuckles (1"X4")sq.in. = 190/4 = 47.5 J/sq.in. vs using two knuckles 95 J/sq.in.

Smaller surface area with a given amount of energy will yield a greater impact (rupture vs not).
Outline

- Purpose of Research Paper
- Traditional Karate
- Principles of Physics
- How Physics Principles explain effectiveness of karate techniques
- Summary
III - OPTIMAL ENERGY TRANSFER IN KARATE

- Execute technique with kime leads to the highest energy level.
- High force transferred over a small amount of time yields the most significant impact.
- Body connection increases mass of strike – include part of the arm by locking both wrist and elbow to + mass.
- Weight of karateka is not as critical as that of the effective mass of the punch or strike.
- Two knuckle punch yields higher impact to given area (N/SQ M).
- Speed is critical, square of speed affects energy yield.
- Highest speed is at 75% of arm extension => must focus fist past target.
Gitustu yori shinjutsu

“Spirit and mind are more important than technique”

Master Funakoshi believed the focus on skill development was misplaced. In a kata competition with opponents of equivalent skill levels, the person with more Ki and controlled emotions will most likely be victorious.

Technical skills and effective techniques are merely the means to this end.
Thank You

Marc Boismenu