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Power breaking in taekwon-do – physical analysis

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Authors' contributions:
A Study design
B Data collection
C Statistical analysis
D Data interpretation
E Literature search
F Manuscript preparation
G Funds collection

Summary

The sight of a human breaking hard objects with his hands or feet is commonly associated with martial arts. A sight like that may often be perceived as a sign of super-human abilities. Power breaking is one of four sport competitions of Taekwon-do ITF. Therefore the search for new solutions will enable to achieve above average results. It is possible that the forces occurring during the power breaking tests may be ten times higher then the weight of the competitor. How is it possible that our body is able to withstand these forces? Where can we look for ways of breaking even more wooden boards? The thing that separates Taekwon-do from other martial arts is its Theory of Power, which consists of the fallowing factors: weight, speed, balance, concentration and breath. The two first of the mentioned factors are typically scientific but the following factors may also be described by scientific methods. Balance is the result of correctly set specific weight of the competitor. Concentration in other words the focus of a punch, this association with optics is justified due to the resemblance between the focus of light and the focus of force during the power breaking test. Breath can be described by the mechanics of gases. Every person that studies Taekwon-do will at some point of their carrier come across the problem of breaking hard objects. This thesis contains the scientific analyses of breaking hard objects and boards that are suspended.

Key words: **Taekwon-do • Power test • Taekwon-do strikes**

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Introduction

The sight of a human breaking hard objects with his hands or feet is commonly associated with martial arts. A sight like that may often be perceived as a sign of super-human abilities. Power breaking is one of four sport competitions of Taekwon-do ITF. This fact causes the search for new solutions that will enable the competitors to achieve the best possible results. It is possible that the forces occurring during the power breaking tests may be ten times higher then the weight of the competitor. How is it possible that our body is able to withstand these forces? Where can we look for ways of breaking even more wooden boards?

What influences the dynamic force of a human being from the scientific point of view?

The thing that separates Taekwon-do from other martial arts is its Theory of Power, which consists of the following factors: weight, speed, balance, concentration and breath. The two first of the mentioned factors are typically scientific but the following factors may also be described by scientific methods. Balance is the result of correctly set specific weight of the competitor. Concentration in other words the focus of a punch. This association with optics is justified due to the resemblance between the focus of light and the focus of force during the power breaking test. Breath can be described by the mechanics of gases.

Every person that studies Taekwon-do will at some point of their carrier come across the problem of breaking hard objects and will wonder where to gain the strength needed to successfully complete such a test [4]. As we all know, according to Newton's theory, the force of an object is directly proportional to its mass and acceleration.

$$F = m \cdot a \qquad (1)$$

While conducting an elementary analyses, we can observe the following relation between mass and acceleration. Starting with the formula for the distance constant accelerated motion:

$$s = v_0 t + \frac{at^2}{2} \text{ knowing that } a = \frac{\Delta v}{t} \rightarrow t = \frac{\Delta v}{a}$$

one can observe that $a = \frac{2\Delta v^2}{s}$

$$F = m \cdot \frac{2\Delta v^2}{s} \qquad (2)$$

Assuming that the distance of the fist for a particular human is constant and does not change in a significant way, velocity is the most important factor influencing the force.

One can observe the same results when analysing the formula for kinetic energy:

$$E_k = \frac{m \cdot v^2}{2} \qquad (3)$$

Why is it possible that a human is able to break concrete with his hands.

As we all know human bones have a very specific structure. Very similar structures have been used by engineers for hundreds of years.

The durability of human bones is shaped by the loads carried by the entire skeletal system, but the increase of the loads carried does not increase the durability. This conclusion is based on the analysis between the force of springiness and the durability.

The lack of activity and sufficient loads causes atrophy the of the skeletal system [2]. This resolves from the Wolf theory, the structure of the bone in the state of balance adjusts the structure of the bone to the way that the bone is tensed. During the changes of the tenses the bone structure changes, the speed of these changes is conditioned by the force of the tensions. Our skeletal system is constantly changing in order to fit the forces that it is forced to deal with, and the tenses forced on our bones influence their durability.

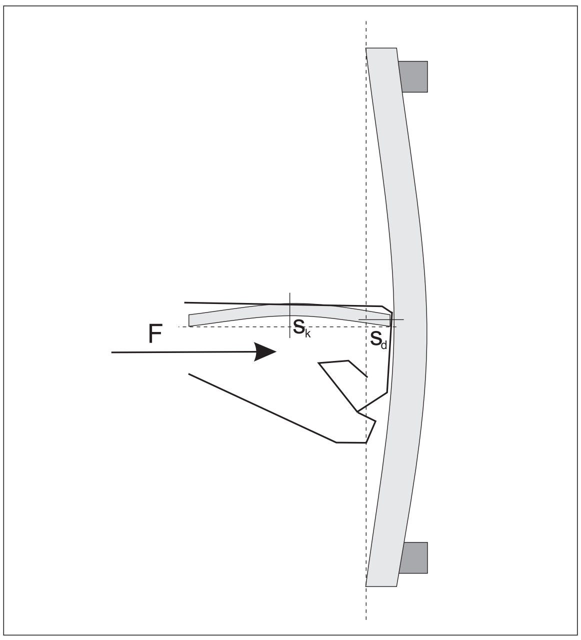

Figure 1. The breaking of a board, S_d – bending of the board, S_k – bending of the bone.

Table 1.

	Wood	Concrete	Bone
durability [MN/m^2]	36	45	139

The biomechanic durability of human bones depend mainly on our age. Our bones have the best durability when we are 30 to 40 years old, later that durability tends to decreases. [2] Our bones are most resistant to crushing and bending, for example our femoral bone resists the crushing force of 139 MN/m^2, for bending forces 160 MN/m^2 the resistance for stitching is smaller, but human bones show the smallest resistance for the process of twisting 53 MN/m^2. These results change depending on the studies bone up to 14-15%. The durability of human bones decreases with age showing that our bones become more fragile influenced by our ageing process (figure 1).

Table 1 shoves the resistance of:

– wood (pine board 30x15x2 cm),

– concrete (cement block 40x19x4 cm),

– bone (the resistance of femoral bone)

The energy used for the destruction of deformation of an object [3].

$$E = \frac{(1-e)^2}{2} \cdot \frac{mM}{m+M} \cdot v^2 \qquad (4)$$

e – coefficient describing the elasticity of the action, $e = \frac{v_1 - v_2}{v}$ – the velocity of the target having M mass, v_2 – the velocity of the fist having m mass, v – the velocity of the fist and the target after collision for perfectly elastic collisions e=1, for completely non elastic e=0.

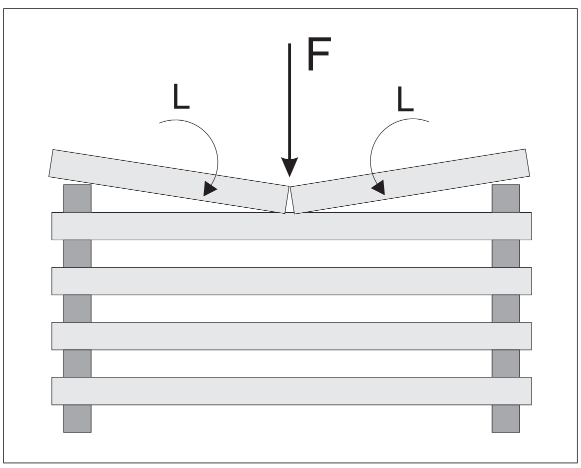

Figure 2.

Why is it easier to break boards that are divided?

Dividing the boards allows the effect of transferring the momentum[1]. When we break the top board we give each remaining half a angular momentum L where the rotation axes are the plaases where the board is supported.

$$L = \frac{d}{2} \cdot m \cdot v \Rightarrow \frac{2L}{d \cdot m}; \; F = \frac{m \cdot v}{t}; \; F = \frac{2L}{d \cdot t}; \text{ therefoure}$$

d – the length of the board, L – angular momentum, t – time of the break.

Therefoure the force of the punch is reinforced by the factor $2\frac{2L}{d \cdot t}$ (5) (figure 2)

Sketch 2.

A very important element of the art of breaking objects is the placing of the punch. If the punch is not precise and the competitor does not hit in the middle of the board the less energy will by transferred during the break. This is shown in sketch 3. A part of the energy initially transferred by the fist is lost by horizontal motion and at this moment there is not enough energy to destroy the next board.

The way the punch is performed is also very important. If we look at Hooke's theory:

$$\tau = \frac{F}{A} \qquad (6)$$

τ – tension; F – force, A – the surface

It is clearly viable that the tension of the object is proportional to the applied force and inversely proportional to the area of action. There four when the competitor allays the same force of the punch using a small attack area the tension that causes the boards to break will be bigger (figure 3).

How can we break an unsupported object?

During martial art shows sometimes the competitors demonstrate the breaking of objects only suspended with no device holding or supporting them. How is it possible that these objects can be broken.
Violent changes of the velocity are, according to the second Newton's principal of dynamics, accompanied by inertial force

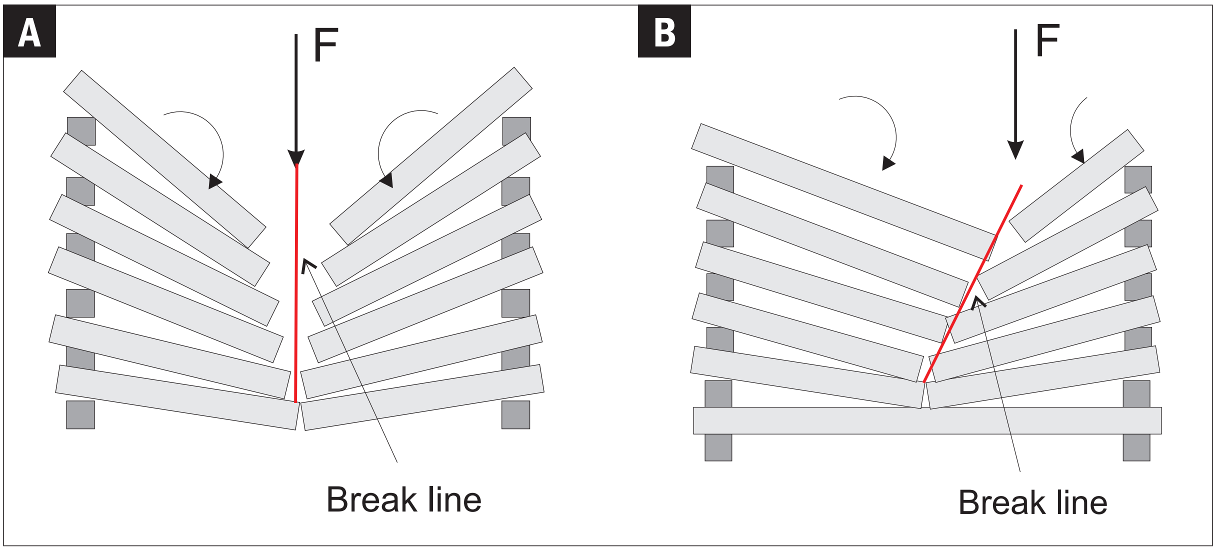

Figure 3 A, B.

$$F_b = -\frac{m(v_2 - v_1)}{t} \qquad (7)$$

m – mass of the object, v_2-v_1 – the difference of velocity, t – time in which the velocity changed.

Inertial force, will substitute the machine holding the object during the test. As one can observe, based on the formula nr 6, the bigger the velocity of the attack, the bigger the inertial force of the object. So the object will be destroyed if:

$$F_c - F_b > F_{min} \qquad (8)$$

F – Force of the attack, F – inertial force, F_{min} – the minimal force needed to destroy the object.

Conclusions

Different aspects of of Taekwon-do concerning the destruction of objects punches have been presented. Taekwon-do tradition assumes the stride for ethical and technical perfection. There are several ways of gaining respect and authority, one is the way of sport competition, another is breaking hard objects. Power breaking joins these both aspects. Therefoure the transfer of this theoretical considerations to the practical training may have effects in the form of gaining respect among the colleagues as well as achieving better sport results.

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