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Measurement of force impact Taekwondo athletes, assessing the possibility of injury of human head

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Abstract

The article presents the results of measurements impact taekwondo athletes to the board which opens after hitting stroke. Measured values are compared with the results of scientific studies that dealt with human head injuries due to the impacts of various kinds. Most often, these results were determined using cadavers bodies. Force action of the athletes on board was realized by direct punches which are combat sport led to facial parts of opponent. In their own measurement was determined time course of forces impinging on the dynamometer plate including size and direction of the force. Dynamometer measured forces to 10000 N. The frequency was set to 1000 Hz. Estimate of accuracy was 0.5% of measured value. A composite plate was attached to a dynamometer using special steel structures. When comparing the results was found that the combat sport of taekwondo strikes, including other power effects (eg. others combat sports, falls, blows to the head in accidents, etc.) can cause fractures of the facial bones and even other human head trauma or cervical vertebrae.

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1. Introduction

One of the problems solving mechanism of biomechanics is head trauma. This solution is performed using FEM and experiments. The aim of this work is to find solutions to protect your head which reduce the risks associated with head injuries. For example, there may be a crash injury, occupational accidents, falls or sports (especially combat sports). Everywhere where there is a strong impact to the head [1–5].

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The reduction in force action on the head can be achieved by using protective gear head. Increasing the active and passive safety in automobiles, etc. Strong impact to the head are exposed for example the combat sports athletes. This is an area in which it is relatively easy to carry out investigations.

For example, when analyzing injuries in professional boxers in Australia between 1986 and 2001 [1] found that of 427 matches have been 107 injuries, of which 89.9% (= 96 injuries) were head injuries and neck (of which 45.8% were eye injuries 15.9% concussions) [6].

The exact determination of force action on the head is quite complicated and is done experimentally embalmment or non-embalmment heads cadavers or measuring direct blow to the Taekwondo Board Breaking. In this article we compared these two methods.

2. Determination of power effect on the head

2.1. The impact force of punch

Measurement of power effect of impact carried out by hand was performed in the laboratories of the Faculty of Physical Education and Sport. For testing was used preparation used in taekwondo competitions – Taekwondo Board Breaking consisting of two composite plates joined grooved "lock". It was measured dissipated energy of punch the open of board. Punch was scanned by dynamometric plate Kistler 9281 and high-speed camera Redlake HG 100, kinematics of impact were measured by Qualisys system. Was measured as the maximum force applied to the plate, impact velocity of limb on the plate, duration and impact the total energy imparted by shock. Force acting on the plate was carried out by a direct blow. Direkt punch is in the combat sport led to the facial region of opponent.

During the actual measurement was determined the time course of force on board Dynamometric including size, direction of the force. By the dynamometer were scanned the forces up to size 10000 N size, frequency was set at 1000 Hz, accuracy was 0.5% of the measured value. Composite plate was attached to the dynamometer thanks special steel structures.

From the time course of force was determined by its maximum size, duration and impact work done. The maximum impact force is the maximum of the vector sum of all forces acting on the plate at the time of impact. The impact speed was calculated by numerical differentiation (by time) of the kinematic data measured by the Qualisys system. The duration of impacts has been deducted from the graphs of force dependent on time.

Impact was performed using a punch of taekwondo sportsman. It was done a 10 punches. Valid were evaluated only three punches (was not effected more strikes – indisposition of sportsmen. Valid punches were those in which no opening "lock" composite plates.

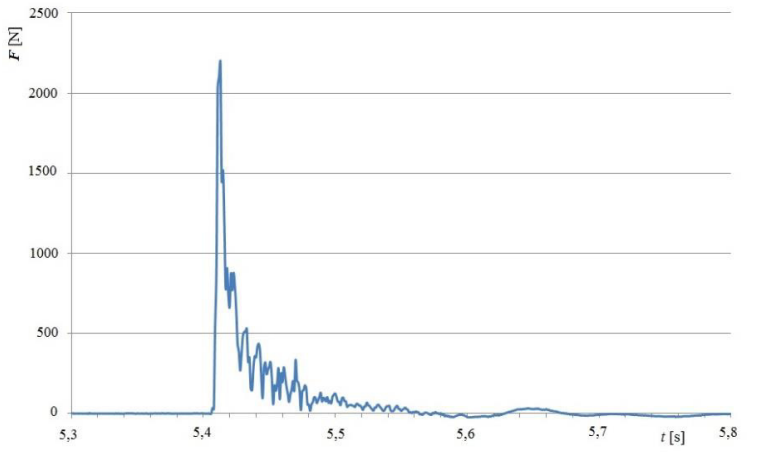

Fig. 1. The time course of the total force of impact measured using the dynamometer – 2rd attempt.

In Fig. 1 is the waveform of forces of valid experiments. In Fig. 2 is a sample shots from the high speed camera. Absolute force exerted by an athlete was obtained the vector sum of forces in axes *x*, *y*, *z*:

$$F = \sqrt{F_x{}^2 + F_y{}^2 + F_z{}^2} \tag{1}$$

Measured parameters of valid experiments are in Table 1. Scattering of acting force is 322 N (acceptable value). The area of impact was estimated at 6.5 cm^2.

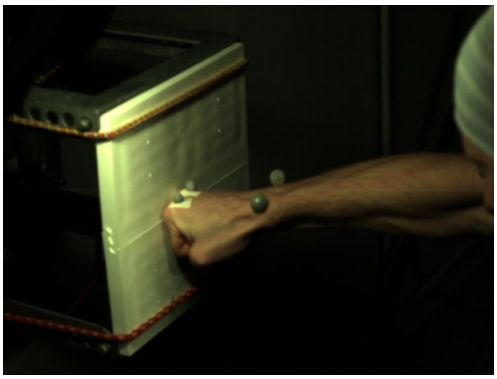

Fig. 2. Sample of high speed camera Redlake HG 100th.

Table 1. Measured parameters of valid experiments.

Number of measurement	Max. impal force F_{max} (N)	Impact velocity v (m.s^{-1})	Duration of impact t (s)	Transmitted energy E (kJ)
1	1 970	8.4	0.0109	13.1
2	2 192	7.7	0.0129	14.7
3	2 292	8.0	0.0119	15.7
Average	2 151	8.0	0.0119	14.5

3. Power effects leading to fractures of the cranial bones

Results of works by different authors which dealt force effects that can cause fractures of skull bones are listed in Table 2 [7–13].

For example in the work of Nahum, Gattse, Gadda and Danforth (1968) were solved to the impacts of facial and cranial part of the cadavers. The sample was used only once. Impact always worked at a specific location. The area of the body impactor was 6.45 cm^2 and the contact surface was protected with a nickel plate.

In the work of Schneider and Nahum (1972) was impactor a circle with size of 6.5 cm^2. All experiments were always performed on one sample including soft tissues. They used cadaver heads. Impact was realized they fall on a horizontal surface.

Additional experiments revealed that the force that causes the fracture grows with increasing dimensions of the contact area impactor. Whether the bone at impact broken or not can be detected using an accelerometer located on the rear side of the impactor.

Recalculating force effects in other sizes impact areas on area the size of 6.5 cm^2 will be great variance values.

More precise details are not known impactor. For this reason, we were used to compare the values obtained impactor of 6.5 cm^2 (see Table 2 – row 1 and rows 4–7). It is a same area such as area of punch.

Table 2. Sizes forces for facial bone fractures (selected values) [7–13].

No.	Bone	Range (N)	Average (N)	Number of samples	Impact area (cm^2)	Recalculated on 6,5 cm^2 (N)
1	Lower jaw	1980–4110	2840	6	6.5	2480
2	Lower jaw	818–2600	1570	6	25.8	396
3	Lower jaw	4460–6740	5390	5	127	276
4	Upper jaw	623–1980	1150	11	6.5	1150
5	Facial	970–2850	1680	6	6.5	1680
6	Facial	910–3470	1770	18	6.5	1770
7	Facial	1120–1660	1360	4	6.5	1360
8	Facial	1600–3360	2320	6	33.2	454
9	Nasal	1875–3760	2630	5	ø25mm	684

4. Conclusion

Impact area of proband wasn't measured. It was estimated on the basis of experience. When properly maintained punch is targeted object affected knuckles of the index finger and middle finger. The estimated impact area with consideration of deformation of soft tissue is 6.5 cm^2.

Values of the Table 1 and 2 corresponding to the size of the impact area were compared (i.e. the values from Table 1 and rows 1, 4–7 in Table 2).

Values from Table 1 a 2 were compared. They were compared to the corresponding size of the impact area (values 1–3 from Table 1 and a value of 1, 4–7 from Table 2).

The comparison it is evident that taekwondo punches and force effects of other combat sports can cause fractures of the facial bones and even other human head trauma or cervical vertebrae.

The intensity of the blow to the head of a live opponent may vary depending on different conditions impact (stiffness of tissues, inertia opponent's responses, volitional control, and motivation of the attacker, etc.). All these corrections but rather reduce our impact possible intensity measured, thus the probability of head injuries (fractured skull bones).

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