Abstract

Title: The objectivization of evaluation of the dynamics of self-defense instruments

Introduction: Strikes by the upper limb are key tools for the self-defense system. So far, mechanical properties have not been evaluated for a wider group of strikes without protective equipment with applications in training, injury risk assessment, forensic biomechanics and medical law.

Objectives: The aim of this work is to compile and objectify the evaluation of the dynamics of a wider group of strikes by the upper limb by specifying the size of the contact area and describing the damping properties of the foam of the detection apparatus. The aim is to evaluate the impact force, the probability of exceeding the bone tissue fracture threshold, the impulse, the size of the impact surfaces and the pressure for three impact techniques, both sexes and two experience levels.

Methods: The work consists of three projects. Two quasi-experiments were completed by 169 probands, men and women, experience levels beginner, advanced (n = 169, height 177.8±9.0; weight 81.6±17.8; age 27.3±8.1) within one period. Probands were measured on two devices (Kistler, Podokam), where the time, impact force of the blow was recorded and three segments of the upper limb were photographed. Probands performed 3 striking techniques, a total of 15 movement actions and 9 static simulations. The third experiment tested the cushioning foam with a drop test (126 tests), which was part of the measuring apparatus for describing the impact force.

Results: The Kruskal-Wallis test and the Wilcoxon rank sum test ($p < 0.01$) indicated the highest achieved F score in the order of elbows, palm strike, and clenched fist strike for the advanced level of experience. Male beginners did not confirm a statistically significant difference between elbow and palm techniques, while female beginners, on the contrary, pointed to the opposite order of palm and elbow techniques. The highest probability for exceeding the value of 5.1 kN (high risk of fracture) was confirmed by the elbow technique in men (25%). Pressure values were analyzed up to 50 MPa for the elbow and up to 10 MPa for the other two techniques. The description of the damping characteristics of the foam enabled recommendations for future experiments including the recalculation of the value of the damped impact force to the value of the undamped force, which represents points for computational models of injury risks on the human skull.

Keywords: punch, fist, palm, elbow, upper limb, dynamics, self-defense, injury, experiment