AN EXPERIMENTAL METHODOLOGY FOR ANALYSIS AND IMPROVEMENT OF THE MOST COMMONLY USED PUNCHING AND KICKING TECHNIQUES WITH THE UPPER AND LOWER LIMBS IN KYOKUSHIN KARATE

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ABSTRACT

Presenting the most frequently used punching techniques with the upper and lower limbs in Kiokushin karate style based on the video analysis of the performance in leading international karate competitions. An experimental method is approbated for measuring the simple and the complex motional reaction to a signal of light and sound, the speed of movement of the punching limb and the power of the punch (the energy value of the punches) in training environment that is providing short-term information and possibility to correct and improve the punching technique. A specially designed instrument is used for psychophysiological tests with an implemented three-dimensional accelerometer, a pulsemeter and a specialized apparatus assembly; all these instruments make possible the measurement of the time period for a simple and a complex motional reaction, the reaction to signal of light and sound – red and green lightdio and programmed sound signals as well as the speed of movement of the punching limb. The average values of the time for reaction, the time of attack and the speed of the combating arm in the gyaku-zuki attack technique are established for a simple and a complex motional reaction with a light and sound signal and are compared with the results of similar investigations. Conclusions are made regarding the importance rate of the particular attack components in relation to time duration of the attack. The weaknesses of the approbated equipment are counted as well as the possibilites for the correction of those weaknesses.

Key words: karate, energy value of the karate punch

INTRODUCTION

Efficient management of the training process in any sport requires not only compliance with the existing postulates of the theory and methodology of sports training, but also knowing and using the latest ideas, discoveries and introductions of various contemporary scientific works and especially the ones that provide opportunities for acquiring quick information. Considering all of the above, we tested an experimental methodology for measuring simple and complex reactions to a sound signal, the speed of the punching (kicking) limb, and the force of the punch or kick in terms of energy value in training conditions. The most commonly used punches and kicks were analyzed: Gyaku-Tsuki (a straight punch with the rear hand) and Mawashi Gery Gedan (a lower-level hook kick) respectively. The methodology and the apparatus especially organized for this purpose had been tested earlier with stuntmen (Videv, Petrov, 2014; Videv, 2016b) and boxers and we had indications that this set-up could successfully be used in other sports because it

gives long-term information and allows for refining and improving technique performance.

A variety of equipment set-ups is used internationally, and it relies on tensiometric, accelerometric, cinematic, dynamometric and other methods of study. The most commonly used one, however, is video observation in combination with cinematic analysis of individual techniques. By means of using computer programs, video-recording the athlete's motions with several cameras at the same time and from different angles while the athlete is wearing markers on his or her joints allows for creating 3D models, which are an excellent tool for analyzing the videotaped material. Even without having the 3D animation at hand, video-analysis is widely applied while learning techniques and detecting errors in their execution.

A similar analysis of techniques: Seiken Oi Tsuki and Seiken Gyaku Tsuki, focusing on studying the physical laws applied in Karate was carried out in 2007/2008 in "Q. Cataudella" high school in cooperation with Antonio Gianni, a Karate instructor.

This project was awarded a certificate of the European Association STELLA (Science Teaching in a Lifelong Learning Approach) in 2009. In this case the techniques were recorded by means of digital video-recording. Later on, the techniques were analyzed by means of single frames as cinematic characteristics were listed, such as the average acceleration and the speed of the punches [<http://fisicadelkarate.altervista.org/>].

Ten years earlier, Chananie, (Chananie, 1999) analyzed cinemographs made by means of a digital camera shooting at 25 frames per second, that illustrated the motions in the case of a straight hand punch from still position. The results reported in this study regarding Seiken Gyaku Tsuki were the following: acceleration – 63 m/s², speed – 13 m/s. and regarding Seiken Oi Tsuki they were acceleration – 49 m/s², speed – 10 m/s.

An attempt to determine the power of a Seiken Gyaku Tsuki was made by means of using Arduino Platform. This apparatus includes a micro-computer, a mains switchboard, and compilation and upload software. It functions by using one and the same axis of the accelerometer, which produces an analogue signal indicating the sum of the positive and the negative accelerations. Then the signal is digitized by means of a fast A/D converter and is read by a microcontroller. This device is connected to a makiwara, and when a punch is delivered, the device reads its acceleration (Robertson, 2002).

A similar experiment was conducted by Denis Kim and David Thiel at St. Augustin University of Applied Science in 2015. They studied the speed of a Karat straight pinch (Seiken Gyaku Tsuki) and a boxing cross punch. The motion was recorded by means of an inertia monitoring accelerometer mounted on the wrist of the athlete, under the glove. The accelerometer was used in order to collect data about the wrist's acceleration. The data received was processed by RMS's profile for acceleration, a software program. The sensor of the device in question was developed by SABEL labs at Griffith University. This accelerometer can be used under normal conditions during training time, and it does not create any difficulty while punching. Among men, the speed of the straight punch varied at 8.1 ± 1.4 m/s. Among women, the speed of the straight punch varied at 6.6 ± 1.6 m/s. (Kim, Thiel, 2015).

Such well-designed and precisely performed lab studies that view the physical laws describing the technique execution in Karate and give a wide range of opportunities to improve the training pro-

cess. They allow trainees to improve the visualization of individual techniques, and thus they speed up the process of reducing technical errors. Similar projects allow athletes to figure out the difference between the theoretical model of performance and its practical application (Landry, 2009).

METHODOLOGY

Unlike the surveys we studied, the methodology we propose requires that athletes deliver the blows not at their own will, but upon receiving a sound or a light signal. This makes our experiment much closer to real circumstances where athletes need to respond in an instant to finding an opening or a crack in the opponent's defense.

The goal of this article is not to present the results of our experiment, whose aim was to determine the speed and the power of the most commonly used punching and kicking techniques performed with the upper and the lower limbs respectively in Kyokushin Karate, but to introduce the methodology by means of which we achieved this goal, and therefore proved its applicability.

To accomplish the goal of the experiment, we needed to solve the following problems:

1. Video analysis of the final matches of important national and international championships in order to estimate the most commonly used kicks and punches.
2. Studying existing written sources that provide information about various methodologies used to measure the speed and the power of these kicks and the punches.
3. Approbation of the method used to measure the latent period of reaction in the case of a simple and a complex motoric reaction to a light and a sound signal, the speed of the limb delivering the kick or punch, and the power of the kick or punch (the energy value of the blow).
4. Selection of a suitable experimental group and performing the survey using our methodology.
5. Analyzing and systematizing the results from the survey upon completion.

The survey participants were chosen among the Vassil Levski National Sports Academy students studying Kyokushin Karate, and qualification levels varying from 4th kyu to 1st dan.

In addition to literature overview, the survey methods included discussion, video-analysis, accelerometry (a combined methodology used for studying psycho-physiological characteristics) and mathematical and statistical analysis.

The theoretical analysis of the literary sources, interviews with athletes held in a free format for the purpose of generalizing information, and above all, the video analysis of international matches and domestic championships has convinced us that the most commonly used punches and kicks in Kyokushin Karate are Seiken Gyaku Tsuki and Mawashi Geri. Therefore, relying on this conclusion, our survey focused on these pinches and licks.

Two experiments were videotaped by means of combined methodology aiming to record psycho-physiological characteristics, and the video recordings were analyzed.

For the needs of the study, we used the apparatus approbated for the doctoral work of chief associate professor Emil Videv (Videv, 2016a), which was adapted for the survey we conveyed (Figure 1 and Figure 2).

Figure 1 and 2. Apparatus used

The apparatus used included a combined psycho-physiological measurement device with an in-built accelerometer, a heartrate meter, and a specialized apparatus that measures the simple and complex motoric reaction times to sound and light signals – a red and green light indicator, and programmable sound signals, as well as a speedometer for the motion of the punching or kicking limbs. We only used the equipment's features that concerned our survey. The electronic devices used were placed in synthetic plastic boxes sized 80 x 55 x 20 mm equipped, as mentioned, with a three-dimensional accelerometer and a signal receiver with

standard pulse-testers. The accelerations along the three axes (X-vertical, Y-horizontal, Z-sagittal) were recorded once in 20 ms. (Figure 3). The devices are equipped with buttons for time marker input indicating the beginning and the end of each experiment of each respective stage. One of these devices was mounted onto the back of the punching bag in the vicinity of its center of mass and the other device was mounted on the athlete's attacking wrist and on or the kicking ankle, respectively. The data recorded was received through a USB port by means of specialized software.

Figure 3. The accelerations along the three axes of the pinching bag measured by the mounted accelerometer for the Gyaku Tsuki Punch.

Fig. 4. The apparatus in action.

We used a standard target of the equipment set, on whose back we attached an electronic board that

produced sound signals, and, on the front, we mounted three light indicators in various colors in order to produce light signals (Figure 4).

In order to provide identical conditions for all participants in the experiment, the target's construction allowed for height adjustments so that it was at each participant's eye level. The target was placed in the immediate vicinity of punching bag, slightly behind

it, so that it would be easy to see by the participant and was used only to pass the signals.

In order to adapt the apparatus to the requirements of our survey, we mounted a metal net connected by an electric conductor to the electric switch on the post of the target. The activation mechanism of the switch was connected to the protector of the attacking hand by means of a metal cord. (Figure 5)

Figure 5. *A participant ready for action*

In the simple motoric reaction experiment the attack signal (a green light on the light indicator or a sound of 2500 Hz) was given by the electronic

board mounted to the target, which in turn was controlled by a personal computer and the software (Figure 6 and Figure 7).

Figure 6 and 7. *The front and the back side of the target with the electronic board mounted on it.*

The signal was produced only in the case when the metal cord was stretched enough to pull the switch's

button which in turn opened the electric circuit with the electronic board of the target (Figure 8).

Figure 8. *A stretched trigger mechanism
(a closed electric circuit)*

Once the sound or light signal was produced, the athlete had to attack the target at full power as quickly as possible. At the attack's initiation, the cord was released, and the switch automatically came to its initial position, thus opening the electric circuit (Figure 9). At this moment the software measured the latent period of each participant, from giving the signal to the initiation of the attack (breaking the circuit). The time elapsed be-

Figure 9. *A released trigger mechanism
(an open electric circuit)*

tween this moment and moment of impact with the punching bag (Figure 10), when the circuit closed again, gave information about the speed of the motion performed. The sum of these times is the time needed to produce the complete attack on behalf of the athlete when a break in the opponent's defense is spotted. The average duration of this time that we measured was 716,69 ms.

Figure 10. *An impact on the punching bag closes the circuit again.*

The intervals between producing the signals were uneven. The experiment measured independently the speed of motoric reaction to light and sound signals, as twelve signals of each kind were given.

Likewise, we measured the speed of complex motoric reaction. The difference between the two measurements was that among the signals demanding response were others that did not demand a reaction (a different color light in the case of visual reaction and a lower tone signal – 300 Hz for the auditory signal).

The accelerations along the three axes and the maximum speed achieved by the attacking limb, as well as the quantity of energy delivered onto the

punching bag, were measured by the accelerometers mounted. The accelerations, reaching almost 9G, indicate that measuring techniques in combat sports requires 15-20G accelerometers.

DISCUSSION

The apparatus used and tested in this experiment for combat sports needs gives unique and reliable results that could be used rationally, especially if the apparatus is completely adapted to this purpose. In particular, we consider the following aspects:

1. The electronic board could be built into the punching bag or the makiwara, so that the light signals could appear frontally, right in front of the athlete.

2. The metal net could be replaced with another type of conductor (a rubber one).
3. If a tablet-size monitor is attached to, or even built in, the punching bag, the light signals could be replaced with video images of an opponent performing various punches or combinations of such. Then the athlete would need to decipher the opponent's intentions and strike first, overtaking the opponent, or produce an adequate counterattack. If a potential future opponent is studied in detail by means of video analysis, a demonstrator could be videotaped in front view as performing the commonly used techniques by this opponent in his typical style. The athlete in question could study the opponent's weak points and develop and master an efficient counterstrategy, which could in turn become an advantageous move. If a competitor used this kind of training, he or she would not need to adapt to the opponent's actions because they would have already practiced their counterattacks, the moment of their initiation, and the speed that would make them successful.

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