BIOMECHANICAL MEASURING STATIONS TO SOLVE PRACTICAL PROBLEMS IN KARATE SPORT

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The purpose of this study was to identify biomechanical details of the karate technique Gyaku-Zuki (reverse punch). For this a high speed camera was integrated in two different measuring stations. The results of six experienced in competition kumite athletes show new knowledge about the biomechanics in karate and the possibility of detecting of movement irregularities in order to avoid issues. Particularly the fist movement was quantified and the overstretchings in the elbow joint and in the wrist were observed. Furthermore it was confirmed that an athlete with a good intermuscular coordination the faster movements executed.

KEY WORDS: Karate, high-speed-analysis, biomechanical measuring station

INTRODUCTION:

Karate techniques are characterised by a high precision and high movement velocities. For instance Sforza et al. (2000) show a high repeatability of straight punches. But only a few biomechanical studies in relation to punches can be found (e.g. Nakayama, 1986, Zehr et al., 1997). One possible reason is the high measuring requirements. However the solution of practical problems demands the determination of movement details. One aspect is that in the competition the targeted precision is important for the win. Another problem we see in the imagine overloads in the joints because of the very short execution time of the arm stretching associated with high accelerations. For the Gyaku-Zuki two measuring systems (figures 1 and 2) with integrated high speed camera are represented which help to solve this problems. The Gyaku-Zuki is a reverse punch: the left or the right leg is moved forward and the reverse arm executes the fist punch (Lind, 1999). This karate technique is often used in the competition kumite and was characterised by Witte et al. (2005) and Emmermacher et al. (2005). This paper will presented two complexes: 1. Research of the precise achievement of the target and stability of the wrist, and 2. Estimations of the overstretchings of the elbow joint and the wrist in addition with records of surface electromyography.

METHOD:

Table 1 gives an overview of the subjects. In each complex the athletes executed the Gyaku-Zuki six times. Two measuring stations (figure 1 and 2) were designed in which a high speed camera was integrated: HCC 1000 (Vosskühler, 462 frames per second, 1024 x 1024 pixels, control mode by IEEE 1394 Interface). The high speed videos were automated analysed by Peak Motus software to calculate the interesting trajectories and angles (error estimation involved subjective error and pixel resolution of the camera amounts to 0.05°). Furthermore an acceleration sensor (2-dimensional, Kistler company) was used. One task of the complex 1 was the determination of the distance between fist and opponent (board). This was carried out by Peak-Motus-software. The other kinematic parameters were analysed by the AS200 (Infrared-motion-capture system, Lukotronic company, Innsbruck). The topic of the complex 2 was the determination of the joint overstretchings in relation to a neutral position (0°) and the record of the muscle activities (Biovision company, 1000 Hz). In contrast to the complex 1 the high speed camera was mounted over the athlete. So the angles are measured in the horizontal plane calculation by Peak-Motus-software). The following muscles were considered: m.tric. laterale, m. tric. longum, m. bic. brachii, m. deltoideus (pars clavicularis, pars acromialis, pars spinalis). A quantification of the muscle activity was not carried out.

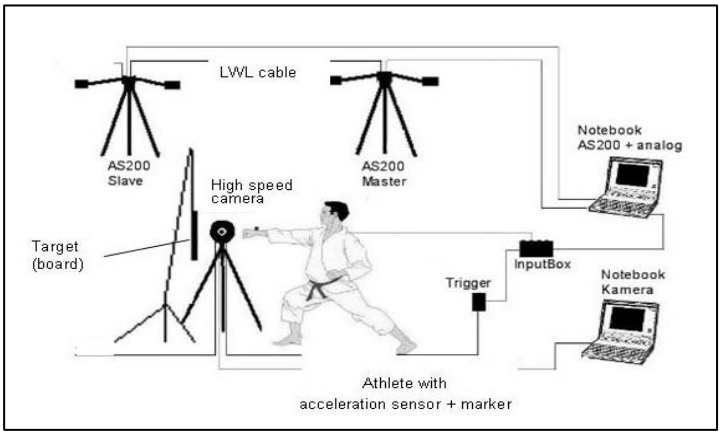
RESULTS:

Complex 1: Fig. 3 shows typical time courses of the displacement, velocity and acceleration of the fist, and the wrist angle. In addition it can be seen the distance between fist and board

in dependence on the time. In analogy to previous results (Emmermacher et al., 2005) for the acceleration the high negative values are noticeable. Another aspect is the movement in the wrist. This could be found in nearly all exercises. From the theoretical view point this movement should be minimal. Also surprisingly is the variability of the hit distance for each athlete (figure 4). In addition it seems that the values are higher than in the real competition. Statistical correlations (Pearson) between this distance and other parameters (movement time, length of fist trajectory) are not significant ($p>0.05$).

Table 1 Information about participated athletes

	Subject 1	Subject 2	Subject 3	Subject 4	Subject 5	Subject 6
Sex	m	m	m	m	f	f
Year of birth	1990	1989	1987	1974	1990	1989
Karate since	1995	1996	1993	1990	1996	1996
Body height [m]	1,81	1,78	1,72	1,77	1,56	1,68
Athlete of the national federation	yes	yes	yes	yes	yes	yes
Competition form	Kumite	Kumite	Kumite	Kumite	Kata	Kumite
Graduation	4th Kyu	3rd Kyu	1st Dan	1st Dan	1st Dan	3rd Kyu
Training hours per week	4.5	4.5	13.5	3	8.5	4.5



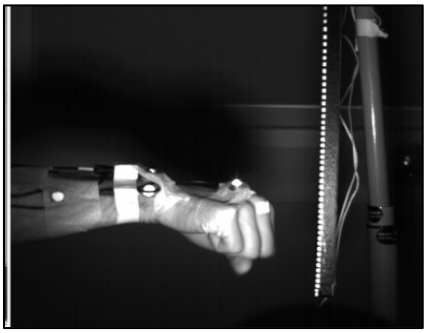
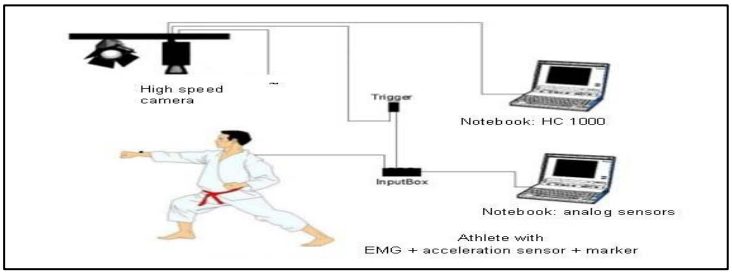


Figure 1: Scheme of the measuring station for complex 1 (left), high speed record of the hand with markers and acceleration sensor before reaching the target (board)



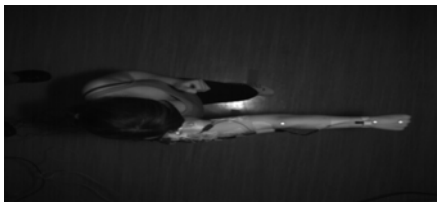


Figure 2: Scheme of the measuring station for complex 2 (left), high speed record of the arm with markers, acceleration sensor, and EMG sensors

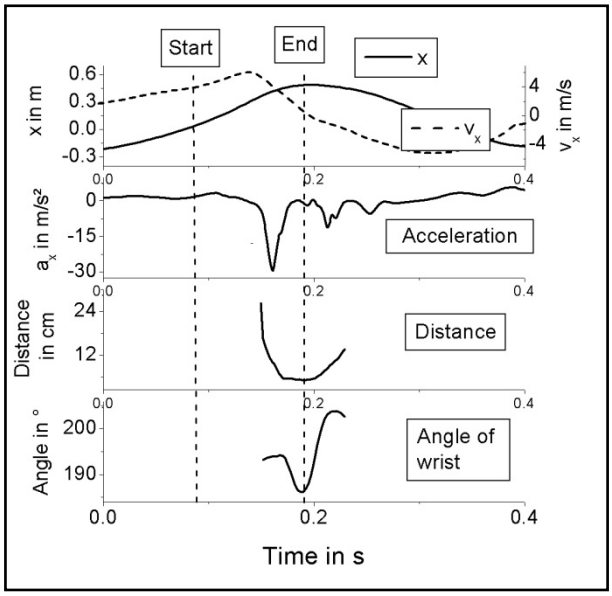


Figure 3: Kinematic analysis of the fist and the angle of the wrist for one exercise of subject 4 (complex 1)

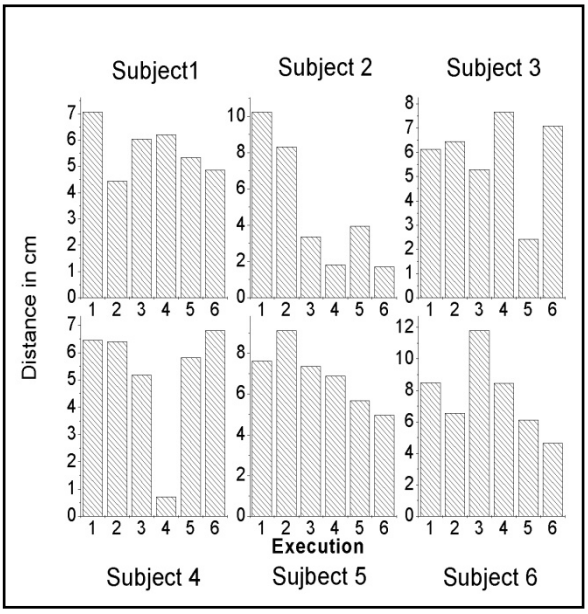


Figure 4: Hit distances between fist and board for all exercises (complex 1)

Complex 2: Overstretches in the elbow joint were observed for all subjects other than subject 1 (table 2). The mean values vary. The mean overstretches of the wrist are shown in the table 2. Expect for athlete 4 the other athletes exhibit overstretches in their wrist.

Table 2 Mean overstretches in elbow joint and wrist for all athletes (angle of the neutral position (0.00°, that means optimal stretching) (complex 2)

Subject	Mean overstretching Elbow angle	Mean overstretching Wrist	Subject	Mean overstretching Elbow angle	Mean overstretching Wrist
1	-0.4°	7.7°	4	7.4°	-1.9°
2	8.2°	15.8°	5	12.3°	13.7°
3	14.0°	18.7°	6	11.6°	8.5°

In order to realise a powerful karate technique, it is very important to have an optimal inter-muscular coordination. Figure 5 presents two examples of the electromyographical time courses during the punch of the Gyaku-Zuki for subjects 2 and 1. It can be seen that the m. triceps is activated over the arm stretching phase. Unlike subject 1 (right diagram) the m. biceps brachii as the antagonist has no activity. This can be interpreted as a better intermuscular coordination. Generally the subject 2 shows shorter and well-defined muscle activities than subject 1. It is possible that this lead to a better performance (mean duration of the stretching: subject 1: 147.5 ms and subject 2: 138.5 ms).

DISCUSSION:

The rules of competition request a distance between fist and opponent in the range between 2 cm and 5 cm. But some trials show distances between fist and board larger than 5 cm (complex 1, figure 4). In relation to these relative large hit distances the following influencing factors can be seen: consideration only the sagittal plane, using a hanged board instead of a real opponent, and no wear of hand protection. The overstretching of elbow joint and wrist could be illustrated by high speed video and by measuring of the angles. The movement in wrist should not be disregarded, because this instability in the joint can lead to issues when a contact occurs with the opponent. Referring to using the high speed camera the technical limits are the recording time duration of about 1.5 s and the format. This doesn't allow the film of the total body with a high space resolution. So we find that a high speed camera

should apply only for details of the movement, especially for the detecting of movement errors. Further investigations should be developed a complex performance analysis by a combination of both measuring stations with the aim to define standards of the karate technique in consideration of individual characteristics, to detect movement irregularities and to avoid issues in karate.

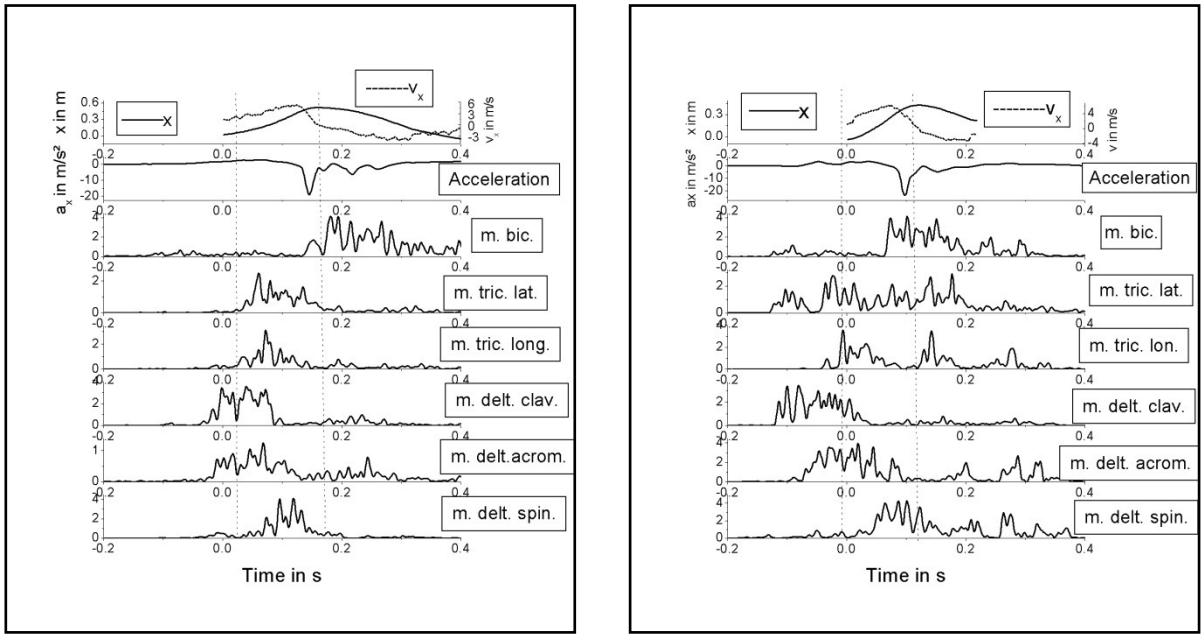


Figure 5: Kinematic and electromyographic time courses for subject 2 (left) and subject 1 (right), complex 2

CONCLUSION:

By means of the introduced measuring stations as a combination of different measuring systems (surface EMG, movement analysis by infrared system, high speed camera and acceleration sensor) it is possible to answer some practical questions in karate sport: analysing of technical details, estimation of the intermuscular coordination, detecting of movement irregularities in order to avoid issues.

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