ELECTROMYOGRAPHIC RESEARCHES OF GYAKU-ZUKI IN KARATE KUMITE

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The purpose of this study is the presentation of electromyographic analyses of Gyaku-Zuki. Dependent on the degree of the karteka different levels of intermuscular coordination could be observed. On the basis of the adaptive AR model spectral parameters of the EMG signals were determined. These different EMG parameters prove that during the pushing arm extension under equal conditions several frequency bands appear.

KEY WORDS: karate, electromyography, adaptive AR modeling

INTRODUCTION: Little work has been done concerning the biomechanical study of karate techniques. Particularly with regard to electromyographic analyses very few investigations (Nakayama, 1986) are known. However, in order to realize a powerful karate technique, it is very important to have an optimal inter- and intramuscular coordination. The aim of this study is the presentation of an electromyographic pilot study relating to the arm muscles during the push of the Gyaku-Zuki. The Figure 1 documents the technique of Gyaku-Zuki.

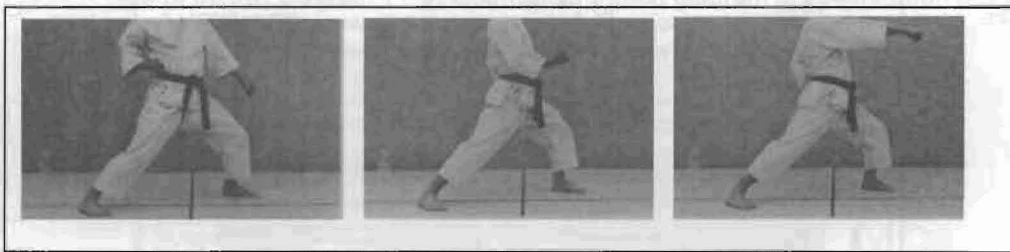

Figure 1 Technique of the reverse push Gyaku-Zuki (source: Nakayama, 1986).

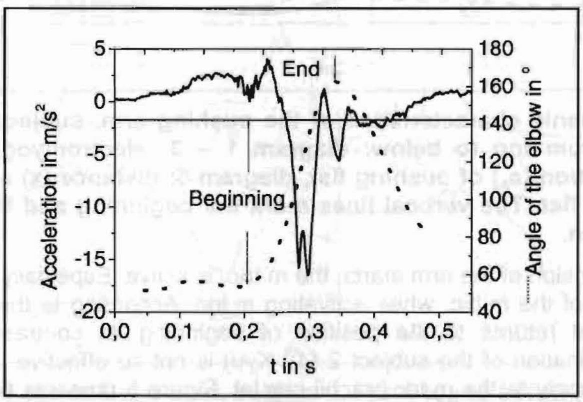

Figure 2 Time course of the fist acceleration in pushing direction and time course of the elbow angle. Beginning and end of the arm extension are marked.

According to Figure 2 exclusively the extension of the arm in the elbow is considered. The beginning of the considered movement is defined as the minimal value of the acceleration of the fist. At this point of time the angle of the elbow increases as well. The end of the extension is located at the moment of the maximal amount of the elbow angle. At this point of time the sign of the pushing velocity changes (see also Figure 3). The duration of the movements is something more than 100 ms. But even shorter movement times were noticed too. For achieving these high positive and especially negative accelerations, which are necessary in today's world of karate Kumite, optimal inter- and intramuscular coordination are essential. Because the extension of the pushing arm is mainly realised by the m.tric.brachii, the topic of this study is the spectral analysis of its electromyographic signals.

METHOD: Four competitive karateka participated in this study. For each athlet nine performances of the Gyaku-Zuki were analysed. The electromyographic signals of m.tric.brachii caput laterale and caput longum as well as m.bic.brachii were recorded. The accelaration of the pushing fist was detected in two dimensions synchronously. Both, the electromyographic signals as well as the acceleration data of the fist, were sampled with a rate of 1000 Hertz. Simultaneous a three-dimensional videometric analysis (200 Hz) and a kinemetric analysis using an IR-system (200 Hz) were carried out. Based on the elctromyograms the signal power could be estimated. The adaptive AR-method by Arnold et al. (1998) was used to get the spectral parameters (Schwab, 2004).

RESULTS AND DISCUSSION: Figure 3 shows the electromyograms of the muscles compared to the acceleration, distance and velocity of fist in pushing direction.

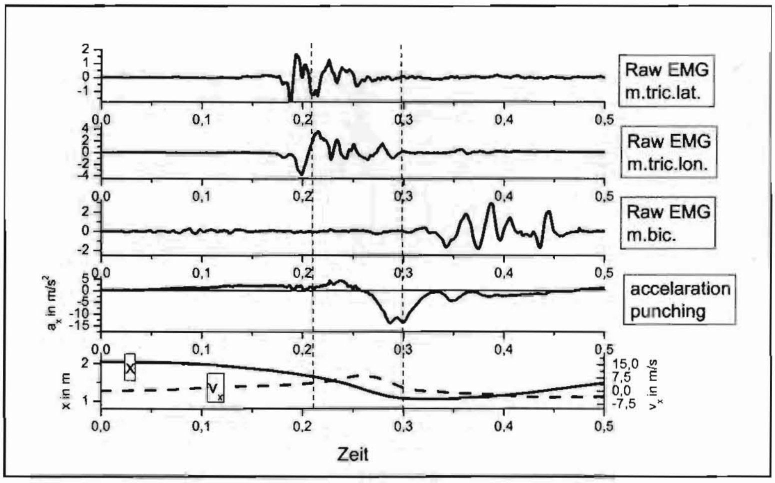

Figure 3: Biomechanic characteristics of the pushing arm, subject 1 (black belt, 3th Dan). From top to below: diagram 1 – 3: electromyograms, diagram 4: acceleration (a_x) of pushing fist, diagram 5: distance (x) and velocity (v_x) of pushing fist. The vertical lines mark the beginning and the end of the arm extension.

Just before the extension of the arm starts, the m.tric. is active. Especially subject 1 is able to realize a disactivity of the m.bic. while activating m.tric. According to that the m.bic. is only active when the fist returns to the position of beginning. In contrast to subject 1 the intermuscular coordination of the subject 2 (4^{th} Kyu) is not so effective (see Figure 4). The following analyses apply to the m.tric.brachii cap.lat. Figure 5 presents two examples of the frequency analysis for subject 1.
The frequency spectra (Figure 5) seem to demonstrate that with the beginning of the muscle activity several wave bands are emerged within shortest time. These persist during the pushing, although the fist is positive and negative accelerated. The reduced muscle activity can be seen in the middle diagram (EMG power). These findings would suggest the following interpretation. The changing power of muscle results from a modification of recruitment of motor units. Important frequency effects are not observed. The frequency analyses of subject

2 having an intermuscular coordination, which is not so optimal, exhibit unclear and small frequency waves (s. Figure 6). In addition the momentary median frequency is not constant.

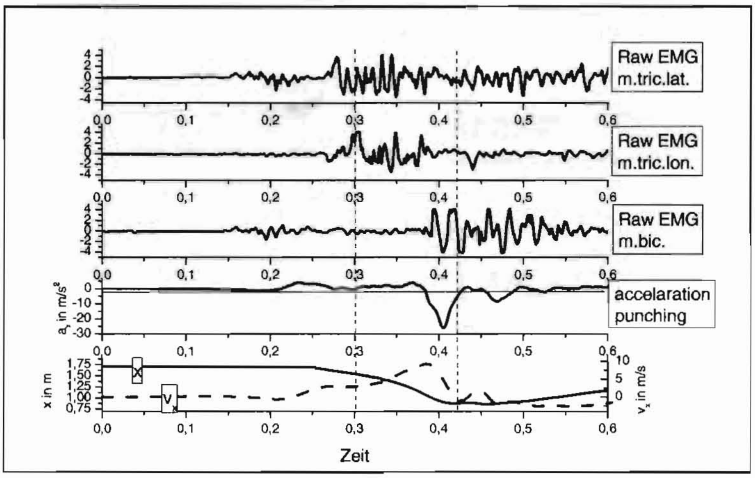

Figure 4 Biomechanic characteristics of the pushing arm, subject 2 (4th Kyu). (From top to below: diagram 1 – 3: electromyograms, diagram 4: accelaration (a_x) of pushing fist, diagram 5: distance (x) and velocity (v_x) of pushing fist.). The vertical lines mark the begin and the end of the arm extension.

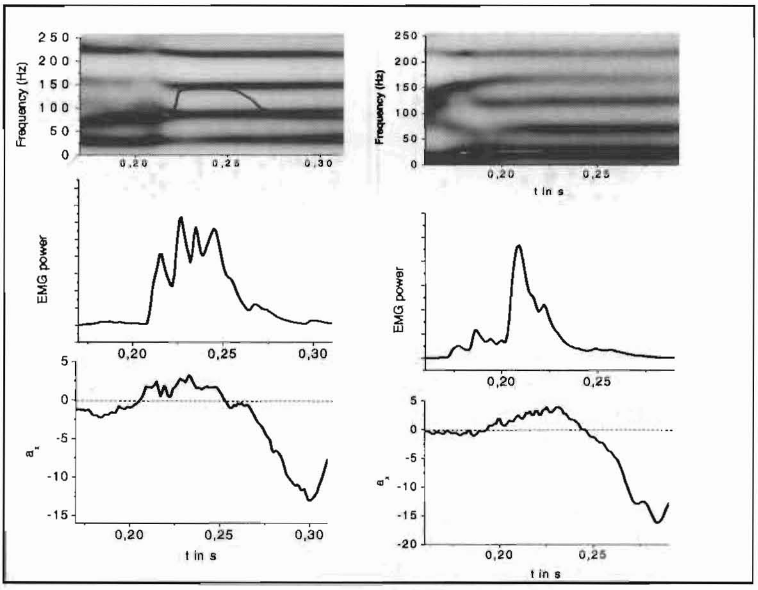

Figure 5 Two exercises of Gyku-Zuki, subject 1. From top to below: time-dependent frequency spec-trum (m.tric.cap.lat.) with median frequency, power of EMG, accele-ration (a_x) of pushing fist.

A further interesting aspect is, whether there are interrelationships between the mean median fequency and the movement time or the maximal positive accelaration. The diagrams in Figure 7 show that there are no correlations between the kinematical quantities and the mean median frequency. These findings can be interpreted that for each push different frequencies or rather frequency bands appear independent on the movement performance. It can be concluded that neither recruitments nor frequency effects in spite of the high degree of automation of the movement are fixed, but the organism is able to realize over and over new schemata of muscle activation.

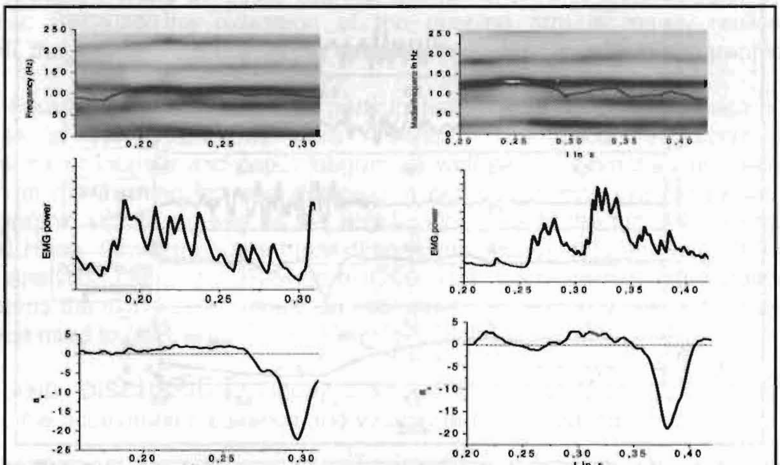

Figure 6 Two exercises of Gyku-Zuki, subject 2. From top to below: time-depndent frequency spectrum (m.tric.cap.lat.) with median frequency, power of EMG, acceleration (a_x) of pushing fist.

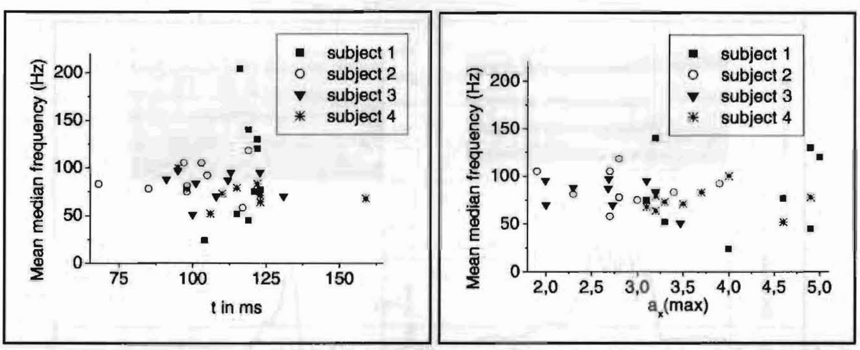

Figure 7 Mean momentary median frequency in dependence on the movement time (left) and the maximal positive acceleration (right). Drawn are all pushings of each subject.

CONCLUSION: The rapid occurrence of the frequency bands can be explained on the basis of Henneman principle (Henneman, 1974): switching on the single motor units with different frequencies. The optimal intramuscular coordination which is necessary for karate techniques can be recognised by using an adaptive frequency analysis in small and parallel frequency bands and in a constant median frequency. To agree with other powerful sports, an optimal intermuscular coordination appears in the elimination of the activity of the antagonist. In conclusion the results suggest that the fast pushing of the Gyaku-Zuki is characterised by a high variability of the m. tric. activity.

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