Surface Electromyography and Movement Analysis
During Swimming of Disabled Athletes

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Introduction
For many years, the application of motion analysis and electromyography as well as their simultaneous coupling are used in the swimming sport, successfully. Unfortunately, only few experiences are situated in the application of both investigation procedures so far for the swimming of disabled (de Witte et al., 1988; Schega et al., 2000; Mühlbauer & Schega, 2000). An useful application of these methods is to be aimed, regarding to the increasing development in the elite-sport of disabled swimmers. Results of motion and training-scientific recommendations and notes for the Functional Classification System of the International Paralympic Committee (IPC) could developed for coaches as well as for sportsmen as a baseline.

Methods
 Altogether 14 (9 male and 5 female) national and international top-level swimmers were examined. The results are represented exemplary on a competitive swimmer (age 20 years, mass 62 kg, height 178 cm) with dysmelia (upper arm left) while swimming breaststroke. The athlete was tested in a swimming flume with constant speed ($v_K = 0.7$ m/s) during a step test (duration of the step test: 3 min, duration of the break between the test steps: 1 min).

Motion analysis: A video camera was used for the lateral recording of the swimming movement. The data evaluation (velocity-, distance-, angle-, time values) of marked body points (hand-, hip-, footjoint) took place using the software SIMI Motion®. The swimming movement was characterized using the swim-phases-model by Jähnig, Wünsch & Wiegand (1973).

Surface electromyography: For the electromyographical registration of 6 muscles in pairs a telemetric and a stationary measuring system (Noraxon®) was used. The activities of the EMG were recorded with special waterproof electrodes. The digital signals were rectified, filtered and smoothed. The evaluation of signal amplitudes (iEMG in mV) took place using the software MyoResearch®.

Results & Discussion
Due the specific disabled feature of the examined athlete the emphasis of the result representation is aligned to the propulsion effectiveness of the arm movement (Table 1). Regarding to the main phase of the arms we have found movement average values of 0.84 m/s for the velocity of the hip, 25.32° at the beginning and 23.75° at the end for the hip-shoulder-watersurface angle and a temporal duration of 0.47 s. The horizontal distance of the hip in the cycle of the arms amounts on the average 1.35 m.
The simultaneous coupling of both research methods enables a characterisation of the muscular activity in the phases while swimming breaststroke. All derived muscles show a higher neuromuscular activity on the right part of the body in comparison to the left (Fig. 1-6).

The M. biceps brachii (Fig. 1) and the M. pectoralis major left (Fig. 3) achieves their highest neuromuscular activity in the main phase of the arm movement. In the initiating phase of the arm movement we measured for the M. triceps brachii (Fig. 2) and for the M. deltoideus pars acromialis (Fig. 4) the highest values.
The M. latissimus dorsi (Fig. 5) and the M. erector spinae lumbalis (Fig. 6) are approximately equally strongly activated in all swimming phases.

**Summary**

The simultaneous registration and evaluation of movement-analytic and electromyographic function parameters permits the indication of disabled- and function specific features while swimming. With consideration of the disability individual variations of the swimming techniques are provable as a sign for the adaptation and compensation of the athlete. On the basis of a common (coach, athlete, examiner) interpretation of the individual swimming technique and the accurately orientation on the neuromuscular coordination in spatial and time, training-methodical emphasis are derivable. The determination of the active musculature while swimming could supply important notes and the application of a fair Functional Classification System.

**References**


