SUMMARY
The aim of this study was to describe the motion pattern of the sound dog during walking using kinematic analysis and surface-electromyography. The use of an adaptive filter in surface-electromyography of the forelimb eliminated the crosstalk (ECG). This study has a potential clinical relevance not only for research in different kind of orthopedic or neurological diseases but also for the development of biomechanical models, for example artificial limbs. The results can also be used as a checkup in the sector of physiotherapy.

INTRODUCTION
Muscle activity can be measured by means of electromyography (EMG). Unfortunately this method is relatively unusual in canine motion analysis in contrast to the situation in horses, where numerous studies have proven it to be a useful and valid investigative method [1-3]. In a previous study, invasive needle EMG was used to investigate the activity pattern of several muscles of the dog [4] and two other studies employed non-invasive surface EMG to investigate the activity patterns of different hind limb muscles [5,6]. However, each of these studies focused on the muscle activity patterns of clinically sound dogs. However most studies are primarily concerned with the hind limb muscles, while only few studies deal with the fore limb [7].

METHODS
Seventeen sound private owned dogs with a mean body mass of 23.8 ± 5.3 kg, an age ranging from 1.0 – 8.0 years (mean 3.9 ± 2.4 years) and a shoulder height (measured from the ground to the dorsal edge of the scapula) of 52.9 ± 4.6 cm were included in this study. Ten of them were female and seven were male dogs.

For an objective exclusion of lameness ground reaction forces were measured after the dogs underwent a thorough orthopedic and neurological examination [8,9]. Animals were only included if there were not lame and showed no signs of pain during palpation of the joints and the back.

Light reflective markers were fixed on the skin above selected touchable bone points of the left forelimb. The surface electrodes were placed on the shaved and cleaned skin above the M. biceps brachii, M. brachialis, M. triceps brachii, and the left side of the thorax (applied over the apical impulse of the heart).

Synchronous measurements of kinematics, electromyography and electrocardiogram (altered Einthoven lead) in at least three motion cycles per dog have been recorded at individual walking speed.

The data was processed with EVaRT (Version 5.0.4, Motion Analysis Corp.), Microsoft Excel (Microsoft Office 2007 for Windows), MatLab (Version 7.4.0.287 (R2007a)) and SIMI Motion 6.5 (SIMI Reality Motions Systems, Unterschleißheim, Germany).

RESULTS AND DISCUSSION
Data of the muscle activity had to run through an adaptive filter which eliminated the crosstalk of the heart. Therefore QRS-complexes of the ECG were detected and removed from the EMG-data.

Joint kinematics was compared to the activity patterns of the biceps brachii, the triceps brachii and the brachialis muscle with joint motion (Figure 1). The results confirm our hypotheses that there is a correlation of joint motion and muscle activity during defined gait cycles.

Alterations of the joint angles:
For better understanding gait cycle was defined in early and late stance and swing phase. During the whole gait cycle carpal joint and elbow showed positive correlation which especially became noticeable in the early and late swing phase. The carpal joint extends in late stance phase (21.4° ± 4.0) while the shoulder flexes (-12.3° ± 2.7). Both joints go the same direction in the late swing phase.

Alterations of muscle activity:
Biceps brachii and brachialis muscle. Both muscles are flexors of the elbow. The activity was detected as one muscle group. They showed the activity pattern described with a high activity phase during the transition from stance to swing phase. This is in accordance with its functions as elbow flexor, supporter of shoulder flexion and flexor of the carpal joint during swing.

During the following late swing, the muscles slowly decreased activity (3.5 mV ± 2.0) and stayed nearly constant due to the middle of stance. Increased activity started in the late stance to reach a maximum in the early swing (99.6 mV ± 3.9).

Triceps brachii muscle acts as extensor of the elbow. The stance phase started in a maximal activity (94.4 mV ± 6.8), corresponding with the maximal extension of the shoulder and extension of the elbow and carpal joint during this period. Maximum decreased to the late stance phase (3.3 mV ± 1.7) and rested on a level until reached a second lower peak in the early swing phase (66.0 mV ± 14.6).

Evaluation of the muscle activity was possible because of the appropriate signal processing (elimination of ECG).

The muscle activity of extensor and flexors correlate at the transition from swing to stance phase can be seen as a
preparation of bearing the paw and stabilization of the fore limb. Muscle activity increases before flexion and extension of the joints.

CONCLUSIONS
An adaptive filter can be used to eliminate crosstalk of the electromyographic data. Range of motion, flexion and extension of the joints and muscle activity can be set in correlation between themselves and between each other. The muscles investigated correlate with the joint movements. Further studies in lame dogs could be helpful to describe and detect biomechanical changes.

REFERENCES

Figure 1: Joint angles and muscle activities during a motion cycle of a dog. Positive peaks show extension, negative flexion of the joint.