Muscle Coordination and Energy Cost in Voluntary Crouch Gait

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Introduction

Crouch gait is a well known pathological gait pattern that is often present in diplegic children with a cerebral palsy, eg. [1]. Though the effect of crouch gait on muscle length and interventions at the muscular level on the crouch position are well studied [2,3], it is not known how changes in muscle kinetics are related to the changed posture and mechanisms of propulsion. However, quantitative electromyography can be used to compare muscle kinetics [4]. This study aimed to describe the change in muscle co-ordination and energy consumption, as the result of walking in crouch.

Statement of Clinical Significance

In order to provide a baseline reference for clinical interpretation of crouch walking, the energy cost as well as compensatory adaptations of muscle co-ordination of voluntary crouch walking in healthy subjects, must be known.

Methodology

Five healthy young students (3 male; 2 female, age 20-24, body mass 63-84 kg., height 1.70-1.91) participated in the study. Each subject walked on the treadmill at a speed of 1.11 m/sec. (4 km/h). After some accommodation, subjects walked for at least 5 minutes. Three conditions were imposed: normal walking; walking in mild crouch; walking in deep crouch. The depth of crouch was controlled by a rope that was hanging in front of the eyes of the subject, respectively 5 and 10 cm below eye-height (in upright standing position). Oxygen consumption was measured with a VmaxST telemetric ambulant system of monitoring pulmonary gas exchanges resulting in an output of VO2, VCO2 and VE. Online the data was inspected for steady state and results from the last minute were averaged. Data was processed into energy consumption, and energy cost, normalized for bodyweight.
A surface EMG signal was recorded from six muscles of the left leg: m.gluteus maximus (GM), m.rectus femoris (RF), m.biceps femoris caput longum (BF), m.vastus medialis (VM), m.tibialis anterior (TA) en m.gastrocnemius medialis (GA). Electrode-placement was according to SENIAM recommendations [4]. Footswitches were taped to the heel and first metatarsal. Off line all EMG signals were processed into the envelope signal, i.e. the smoothed rectified EMG at 2 Hz. Ensemble average was performed over 10 strides per subject. The ensemble average of all 5 subjects was calculated.

Results

Energy cost for normal walking was 4.1 ± 0.5 J/(m*kg) , while walking in mild crouch cost 4.5 ± 0.5 J/(m*kg), and deep crouch took 5.9 ± 1.2 J/(m*kg). All values are significantly different at p=0.05. Envelopes of EMG are presented in figure 1. It is clear that all EMG levels are higher at deeper crouch (but just slightly higher for TA and BF), except for the gastrocnemius, which is less active at deeper crouch.

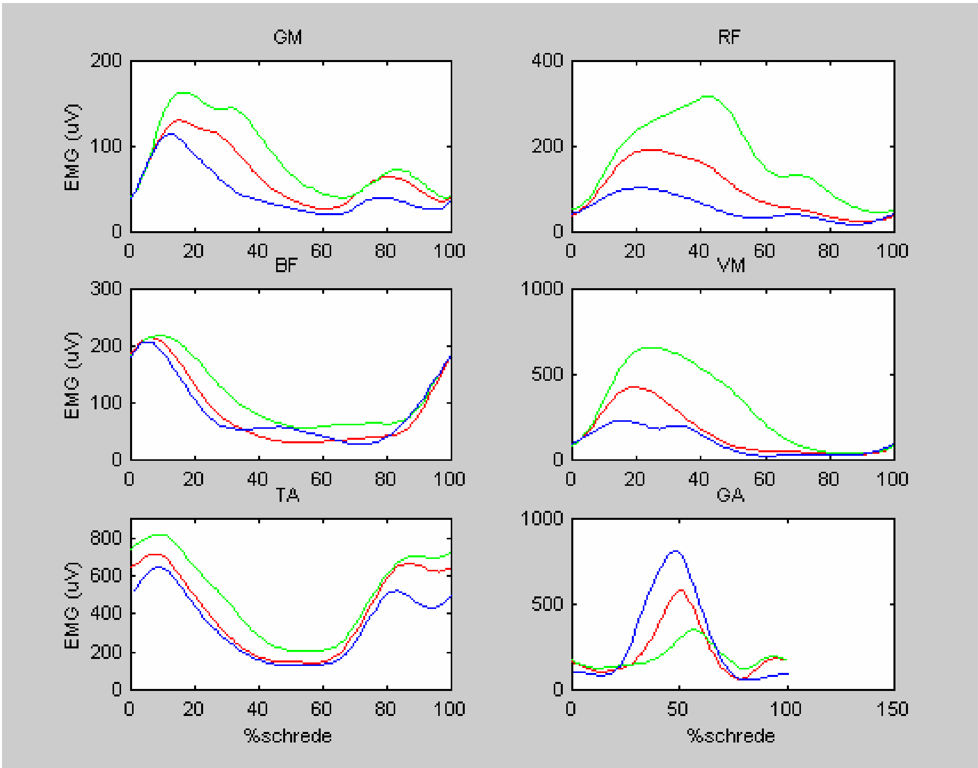

Figure 1. Blue=normal walking (4 km/h), red=mild crouch, green=deep crouch

Discussion

The study of crouch gait in healthy subjects, provides insight to the non-pathological responses of muscle coordination and energy cost to this task. These knowledge might assist clinicians to assess the changes that present themselves in pathological crouch gait in a patient. It is clear that walking in crouch increases energy cost. Energy losses as compared to normal walking are spent to prevent from collapsing and a less effective propulsion. [5]
This is also reflected in the envelopes of the EMG signals. Typical anti-gravity muscles as GM and VM are increased in amplitude and become active throughout stance phase. Also RF becomes very active as crouch increases, especially at the end of the stance phase to assist hip flexion. BF increases only a little, in contrast to findings in patients [1]. The GA activity in terminal stance, related to forward push-off disappears as crouch increases.
It is concluded that in voluntary crouch gait, significant energy gets lost in maintaining posture against gravity and that the power source for propulsion is shifted to the hip.

References

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