Age related changes in EMG profiles and muscle length patterns during gait in healthy growing children and adults.

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Introduction

There is still much inconsistency in the results of different studies on muscle acftivity in walking adults.

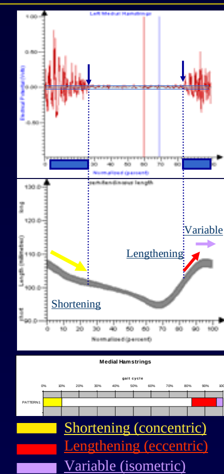
Little information has been published about normal pediatric EMG profiles.

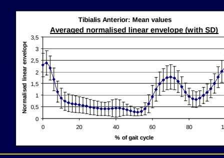
There is a lack of studies evaluating muscle length patterns or contraction modalities (concentric, eccentric, isometric) of activated muscles during gait, in adults as well as in children.

The purpose of the study was to delineate significant EMG and muscle length differences during gait, between age groups, in children and adults.

Patients, Materials and Methods

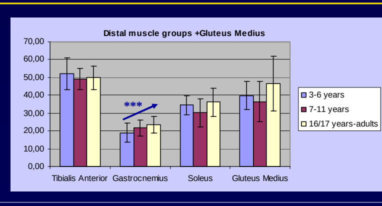
- Subjects:
  - 63 healthy children, divided in 5 age groups
    - 3-4 years => N=12
    - 5-5 years => N=10
    - 7-8 years => N=14
    - 9-11 years => N=14
    - 16-17 years => N=13
  - 13 adults
- Data collection: Full body 3D gait analysis:
  - Kinematic and kinetic data were collected using an 8 camera VICON system and 3 AMTI forceplates
  - Muscle activity of 8 lower extremity muscle groups were obtained bilaterally using a surface EMG system (K-Lab, high pass filter, cut-off at 20 Hz, 18 dB/oct)
- EMG on/offset determination:
  - Visual evaluation of EMG traces
  - Definition of detectible rise in EMG activity above the steady state (2 SD from rest phase signal as a reference for steady state)
  - 3 trials bilaterally, at self selected speed
  - Activity patterns were averaged per limb
- Muscle length of 8 muscles:
  - 4 segment musculoskeletal model *(Delp et al. 1990, IEEE trans of biomed eng 37: 757-767)*
  - Muscle length expressed as a % of the length that the muscle would have if the subjects were in the anatomical position (= all joint angles were 0).
- Activity and muscle lenth patterns:
  - Timing and duration of on and off phases
  - Shortening, lengthening or isometric condition
  - Linear envelopes (window of 20 ms), normalised to the mean of the subject ensemble average

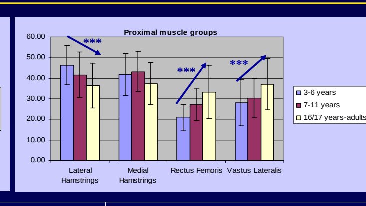




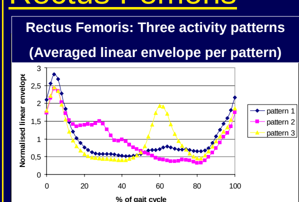
Total duration of activity

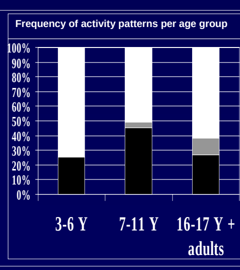
- Decreased with increasing age for Lateral Hamstrings (p<0.001)
- Increased with increasing age for Rectus Femoris, Vastus Lateralis and Gastrocnemius (p<0.001)





Rectus Femoris

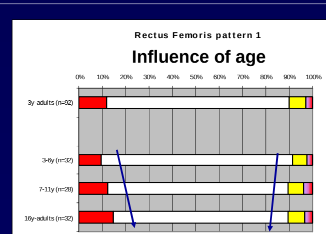




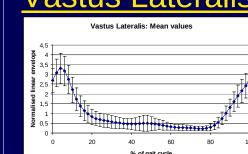
Pattern 1
Pattern 2
Pattern 3

Pattern three was typically seen for subjects walking at a high non-dimensional walking velocity

(Non-dimensional velocity according to Hof 1996, Velocity = Velocity / SQRT(g.l_0))

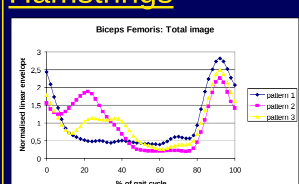


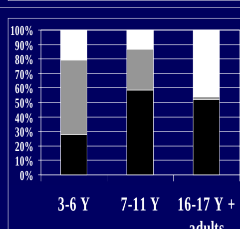
Vastus Lateralis



Only minor differences between age groups

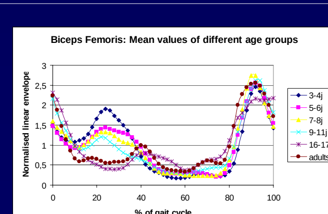
Hamstrings





Pattern 1
Pattern 2
Pattern 3

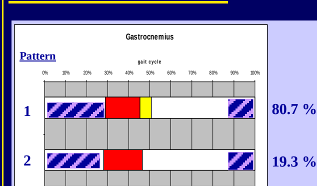
For the youngest children (3-11Y) an extra activity peak around 22% of the gait cycle was recognised

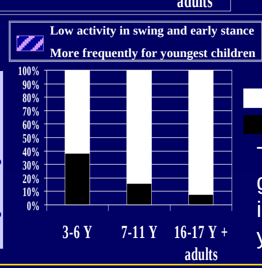


Large similarity between medial and lateral hamstrings

Terminal swing showed isometric co-contraction patterns for Rectus Femoris and Hamstrings

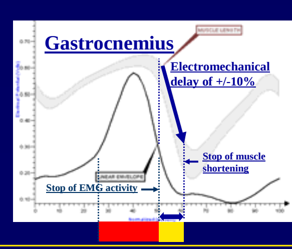
Gastrocnemius





Pattern 1
Pattern 2

The onset of activity gradually delayed with increasing age until 16 years of age (p<0.005)



Tibialis anterior

Young children more frequently showed prolonged eccentric activity in stance (p<0.001)

Activity in swing and muscle length patterns were similar for all ages

Discussion and conclusion

Different EMG profiles were recognized for each muscle group. Differences between age groups were mainly found in stance. The contraction modalities (lengthening, shortening, isometric) were mature at 3 years of age. In the clinical decision making process based on gait analysis, individual pathological EMG profiles should be compared to different EMG patterns per muscle of age related normal subjects.