MUSCLE ACTIVITY OF THREE SUBJECTS DIFFERING IN WEIGHT AND HEIGHT DURING A VERTICAL JUMP

Uli Bräuning, Jörg Subke, Thomas Horstmann, Stefan Grau, Hans-Hermann Dickhuth,
Eberhard-Karls-Universität, Tübingen, Germany

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INTRODUCTION: This work is part of a project to determine the internal forces of the human motional apparatus with an anatomical model of muscles (Bergmann et al., 1993; Soest, A.J., 1992). The first measurement was done to evaluate changes of potentials of surface electromyography with different locations of electrode sites and different resistors between the electrodes. The objective of the second was to investigate the activity of muscles in their stimulation sequence, the quantitative participation of the single muscle and cinematic study during vertical jumps.

METHODS: Noraxon EMG and Medicotest ECG electrodes were used and the electrodes were placed following the description of Winter. M. gastro. med., M.

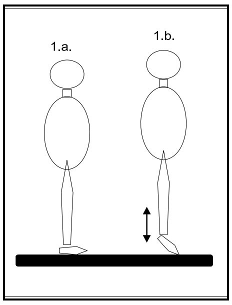

figure 1: sketch a.: starting position; sketch b.: movement;

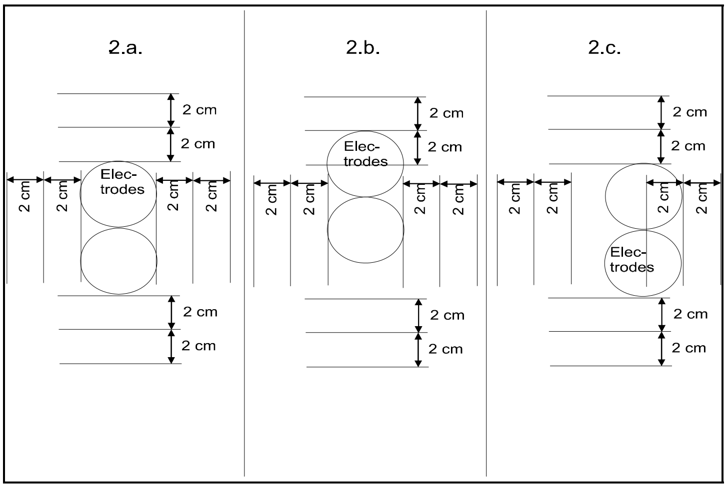

figure 2.a.-c.: 2.a.: placement of Winter (zero measurement); 2.b.: movement of 2 cm in cranial direction; 2.c.: movement of 2 cm in lateral direction;

gastro. lat., and M. soleus of a 32 year old male subject (*Height: 186 cm; Weight: 78 kg*) were evaluated first while the subject moved ten times from a "standing at attention" posture to standing on the tips of his toes (*see Figure 1)* with a resistor between the electrodes higher than 60 Ω and lower than 5 Ω (called the 5 Ω zero measurement). Then we moved the electrodes 2 cm and 4 cm in the vertical and horizontal directions (resistor of lower than 5 Ω) *(see Figure 2.a.-c.)*. Data processing was done with the myosoft 1.0. software for windows by rectifying and smoothing with root mean square = 32. The mean value and standard deviation of every ten movements were calculated. Every measurement was expressed as a percentage of the zero measurement. The results of the M. gastro. lat. are shown to the 5 Ω measurement with displacement of the electrodes and 60 Ω measurement without displacement of the electrodes *(see Table 2)*. The results of the M. gastro. med. are equal and of the M. sol. are poorer.

Movement of electrodes	cranial		caudal		lateral		medial		60 Ω
	2cm	4cm	2cm	4cm	2cm	4cm	2cm	4cm	0 cm
Percentage of zero measurement	84%	74%	98%	75%	85%	83%	74%	74%	72%

Table 2

Secondly, the signals of eight muscles (M. glut. max., M. semitend., M. biceps femoris, M. rectus femoris, M. vastus lat., M. vastus med., M. gastro. med., M. soleus were derived during a maximum voluntary contraction (mvc)) of three male subjects differing in weight and height *(see Table 3)* with a frequency of 1000 Hz.

Subject	Height	Weight	Age
a.	192 cm	90 kg	28 years
b.	178 cm	66 kg	26 years
c.	176 cm	58 kg	25 years

Table 3

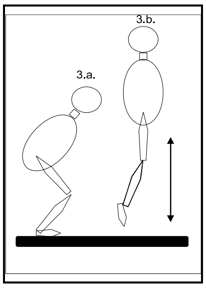

Figure 3: sketch a.: starting position (the subjects folded their arms behind their backs); sketch b.: movement (they started and landed on the same spot);

The subjects were then asked to jump ten times from a squatting position in the vertical direction *(see Figure 3)*. The data were processed (rectification, rms=32, normalisation to mvc) and the mean value and standard deviation of ten jumps for every muscle was calculated.

RESULTS: The measurements with a 60 Ω resistor differed as well as the measurements with the different locations of electrode sites and a resistor lower than 5 Ω. In T*able 2* it is possible to see the relation between the 60 Ω measurement of the M. gas. lat. and the zero measurement of the same muscle according to 72 %. This means that the signal of the measurement with the higher resistor is 28 % lower than the signal of the measurement with the lower resistor. The signals of the moved electrodes are about 25 % lower than the signal of the zero measurement.

The results of the squat jumps are shown in Figure 4. a. Subject a. had the highest activity for the M. vas. med., followed by M. gas. med./ rec. fem., M. vas. lat., M. sol. The M. bic. fem., M. semit. and M. glut. max. showed almost no reaction. The M. vas. med./gastr. med. and M. sol. started at first and nearly at the same time with their reaction followed by M. vas. lat. and M. rec. fem.

The M. sol. and M. vas. lat. of subject b were the muscles with the highest response, followed by M. rec. fem./vas. med./glut. max. and M. semit./bic. fem. The M. vas. lat. and M. semit. started at first with their reaction followed by M. glut. max./bic. fem., M. sol. and M. gastr. med./rec. fem./vas. med.
The M. vas. med. of subject c. had the highest response, followed by M. vas. lat., M. sol., M. gastr. med. and M. glut. max. The M. semit. and M. bic. fem. showed nearly no reaction. The M. vas. med started at first with its activity followed by M. vas.lat., M. sol., M. glut. max., M. rec. fem. and M. gastr. med.
By comparing the muscle activity of the subjects with each other it can be seen that the muscles of the tallest and heaviest subject started their activity earlier than the muscles of the shortest and lightest subject.

CONCLUSIONS: Firstly, it is possible to see how important the placement and resistor of the electrodes is. Secondly, there is a possible relationship between the beginning of the activity of the muscles and the size of the subjects. This effect should be considered in using such calculations of the internal forces of the human motion apparatus in the development of prostheses and sports science.

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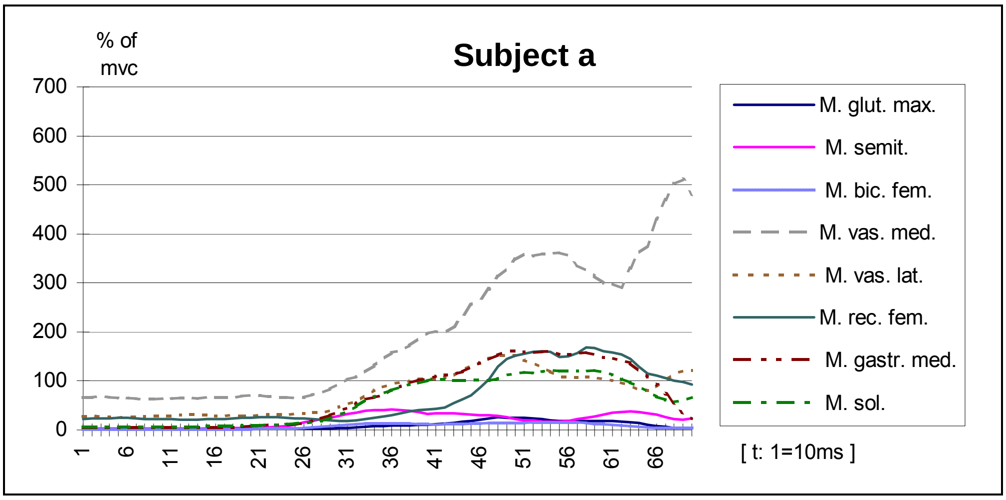

Figure 4.a.-c.

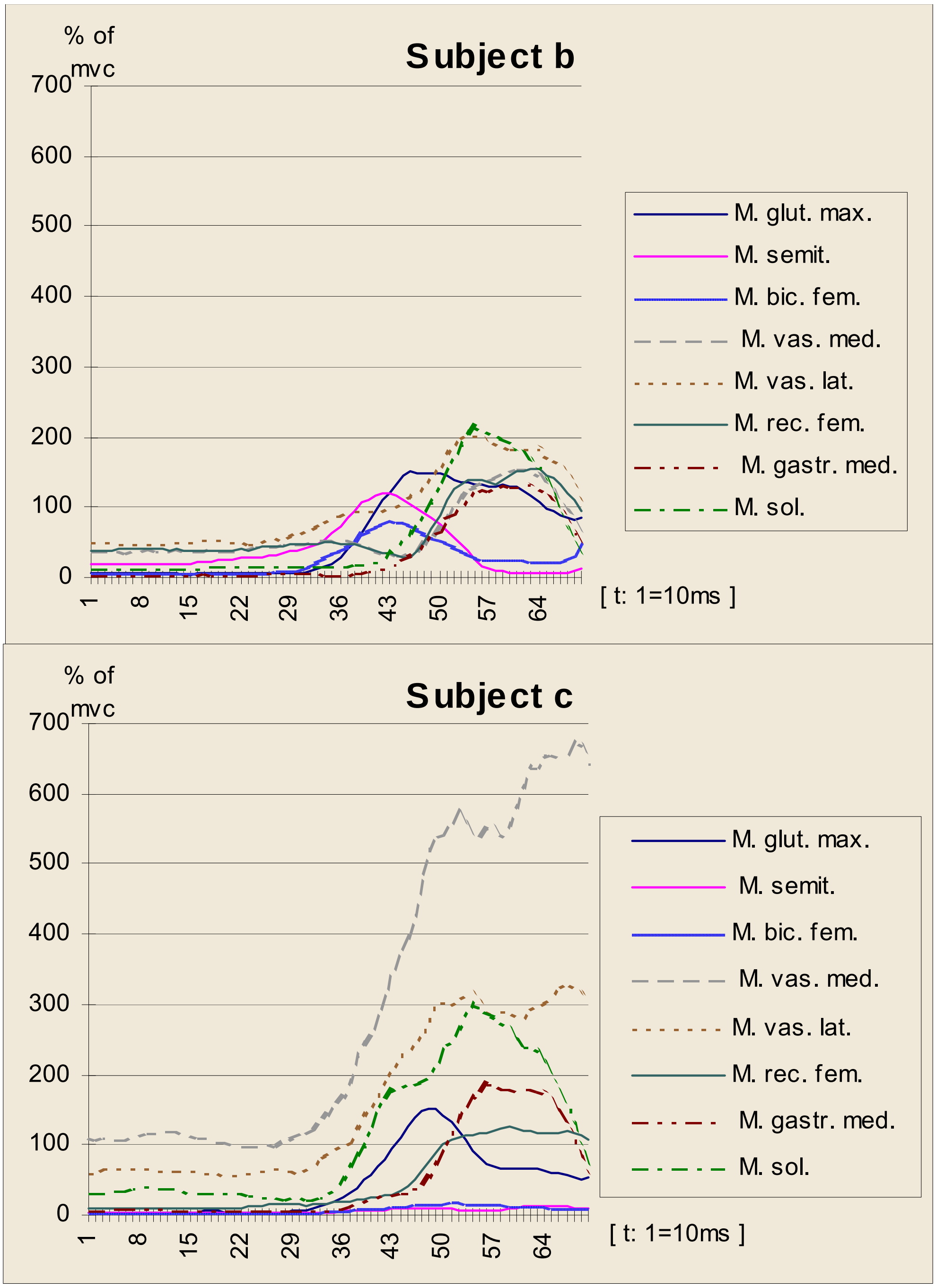
% of mvc
Subject b
700
600
500
400
300
200
100
0
1
8
15
22
29
36
43
50
57
64
[t: 1=10ms]
M. glut. max.
M. semit.
M. bic. fem.
M. vas. med.
M. vas. lat.
M. rec. fem.
M. gastr. med.
M. sol.
% of mvc
Subject c
700
600
500
400
300
200
100
0
1
8
15
22
29
36
43
50
57
64
[t: 1=10ms]
M. glut. max.
M. semit.
M. bic. fem.
M. vas. med.
M. vas. lat.
M. rec. fem.
M. gastr. med.
M. sol.

*Figure 4.a.-c.**