REPRODUCIBILITY OF IEMG MEASUREMENTS ON THE M. TRICEPS BRACHII

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The muscular fibre type distribution within an individual is generally thought to be an important determinant for the ability of athletic performance. To determine fibre type distribution nowadays muscle biopsies are necessary. A less painful and simplified procedure would be helpful to determine fibre type distributions on large samples of athletes.

Electromyographic (EMG) measurements represent the electrical equivalent of several physiological phenomena. Therefore, the idea of determining muscle fibre types by EMG methods has intrigued various researchers. Studies from Viitasalo and Komi (1978) as well as Moritani, Nagata and Muro (1982) indicate that there may be a connection between muscular fibre type distribution and integrated EMG (IEMG) and/or the frequency spectrum shift during fatigue experiments. One of the well-known problems in EMG measurements is the variability in signal amplitude.

Reproducible EMG measurements are, however, essential for quantitative measurements. Although EMG equipment has improved considerably during recent years representative investigations date back more than ten years (Komi and Buskirk, 1970).

The present study introduces an automated system which allows the collection and a rapid evaluation of a great amount of EMG data. This system will be used in the future to examine EMG data of a large number of subjects, from whom biopsy samples will be taken simultaneously. As a first step the system was investigated, to examine the reproducibility of IEMG measurements.

Methods

A microcomputer based measuring station was built which collects force data and surface EMG data simultaneously. After preprocessing of the raw EMG signal, a threshold-reset integrated EMG was converted by an A/D unit and the data stored in the computer's memory (Figure 1). Similarly, the force signal from a 'Kistler' transducer was collected during the measurement period (Figure 2). For the evaluation the total sums of the processed

Figure 1

EMG and force were recorded from the biceps muscle. The EMG electrode was fixed to a flat contact which was pressed on uneven surface. A monopolar recording was made using an indifferent electrode on the back of the upper arm. The band was fixed to a flat contact which was pressed on uneven surface. The signals were amplified, filtered (0.2 to 10 kHz), processed (20 to 100 Hz) and stored on a microcomputer (Figure 1).
EMG and the force across the whole measurement period were used. The EMG electrodes (Stainless steel; size: 10 mm in diameter; 30 mm apart) were fixed to a flexible piece of silicon rubber, to guarantee an easy adjustment to uneven surfaces and to allow an accurate repositioning of the arrangement of different days. The electrodes were instrumented, using miniature impedance converters (input impedance > 100 Gigaohm) which were mounted directly onto the backside of both active electrodes (bandwidth of EMG unit: 20 to 650 Hz).

Surface EMG of the triceps brachii was collected on 9 sport students (3 females, 6 males) on 9 different days. Measurements were taken for isometric contractions at the levels of 10, 20, 40, 60, 80 and 100% of maximum voluntary contractions (MVC). All subjects performed in each condition 5 trials (5 seconds of contraction) in sequence with a rest of 30 seconds in between. While the EMG was recorded on the triceps the subjects pulled with their wrist on a chain, which was connected via force transducer to a wall.
Reproducibility of IEMG Measurements on the M. Triceps Brachii

between the upper arm and the
for each subject (Figure 3). The
feedback from an oscilloscope.
the data acquisition system the
mined during data evaluation.

2430 contractions, shows the
force for the triceps, as it was
determined as a mean from all trials per level of all subjects. The curve shows
slight deviations from linearity in the lower and upper MVC level regions.
The mean coefficient of correlation between integrated force and IEMG
from all individuals and all days was found to be 0.99 (N=81). Table 1 lists
the various coefficients of variability for intra- and interindividual compar-
isons. On all force levels the coefficients of variability were determined for
the 5 repetitions in a single force level condition (COV-rp), for the day to day
measurements within subjects (COV-dd), and for the interindividual meas-
urements (COV-ii). Whereas only little variations were observed in the 5
repetitions on single force levels (COV-rp = 4.6-8.7%) the day to day vari-
abilities (COV-dd = 15.6-28%) and the interindividual variabilities (COV-ii
= 23.5-32.2%) showed large values. It is interesting to note that for day to day
measurements the variability is decreased for the upper force levels.

Discussion

From a large sample of data it could be demonstrated that a high variability
must be taken into account if measurements are made on different days on
the same person or if measurements are made on different persons. These
results compare to findings from Komi and Buskirk (1970), who reported
reliability coefficients of only 0.69 for measurements on different days. A
surprisingly low variability has been found for repetitive measurements on
identical force levels within one session. A value of only 4.6% at a level of
80% MVC represents a high reliability. The high correlation coefficient of
0.99 between integrated force and IEMG suggests that similar physiological
events determine the development of force not only in single subjects but as a
general phenomenon for all subjects.

Therefore, the high variabilities from day to day and between subjects is
more likely to be caused by changes in conductivity phenomena of body
tissue rather than by physiological deviations. To be independent from
alterations in the electrical environment it is suggested to concentrate on
EMG parameters which are independent of the absolute recording level but
are relative measures.

Table 1—Coefficients of variability for EMG measurements.

<table>
<thead>
<tr>
<th>9 subjects</th>
<th>9 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 force levels</td>
<td>FORCE LEVELS (% mvc)</td>
</tr>
<tr>
<td>COV-rp (%)</td>
<td>10</td>
</tr>
<tr>
<td>COV-dd (%)</td>
<td>28.0</td>
</tr>
<tr>
<td>COV-ii (%)</td>
<td>23.5</td>
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</tbody>
</table>
Both, the elbow angle as well as the angle between the upper arm and the body were adjusted and fixed to 90 degrees for each subject (Figure 3). The force level was controlled through visual feedback from an oscilloscope. Because the force signal was collected with the data acquisition system the maintenance of the force level could be examined during data evaluation.

Results

Figure 4, comprising the data of a total of 2430 contractions, shows the relationship between integrated EMG and force for the triceps, as it was
References

