<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
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12\textsuperscript{th} December 2022

\textbf{Delorme Data Analysis}

The data collected from the Delorme devices includes the following parameters: 12\textsuperscript{th} December 2022. The data was processed using FFT analysis. The EMG data was obtained from the Delorme devices, which provide information about muscle activity. The MVC data was obtained from 10 RM tests. The EMG data was analyzed using the Delorme tools, which provided detailed information about muscle activity.

The data collected includes MVC, 10 RM, and EMG parameters. The analysis was performed using MATLAB software. The data was divided into 6 major categories, and each category was analyzed in detail. The EMG data was analyzed using the Delorme tools, which provided detailed information about muscle activity.
vi
1. (strength) and (force) (motor unit recruitment) (neural training mechanism) (muscle hypertrophy) (Hakkinen, Alen, Komi 1985; Hakkinen, and Komi 1983; Komi et al. 1978; Moritani, and De Vries 1979; Sale 1988). Molina (1997) 2-8 (motor neuron) (motor unit activity) (time domain) (frequency domain) (surface electromyography) (Andearssen, and Arendt-Nilsen 1987; Basmajian,
and De Luca 1985). The various parameters include amplitude (amplitude), RMS (root mean square), EMG (integrated EMG: IEMG), median frequency (median frequency: MDF), power spectrum (frequency spectrum analysis) of muscle (Basmajian, and De Luca 1985; Bigland, and Lippold 1954; Macaluso et al. 2000). RMS, EMG and power spectrum (firing rate) of muscle (Basmajian, and De Luca 1985; De Luca 1984). The various parameters include action potential conduction velocity (Anne et al. 1998; Basmajian, and De Luca 1985; Johnson et al. 1973; Kupa et al. 1995; Linssen et al. 1991; Solomonow et al. 1990; Zwarts et al. 1987). The various parameters include slow twitch muscle fiber (Basmajian, and De Luca 1985; Biedermann et al. 1991; Gerdle, and Elert 1994; Merletti, and Roy 1996; Stulen, and De Luca 1978).
(Hakkinen, and Komi 1983; Macaluso et al. 2000).


12
2.1

Table 1. Age, height, body mass of subjects in training and control group before training

<table>
<thead>
<tr>
<th>Group</th>
<th>Age (years)</th>
<th>Height (m)</th>
<th>Body mass (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>Training (n=5)</td>
<td>22.90</td>
<td>2.10</td>
<td>1.65</td>
</tr>
<tr>
<td></td>
<td>63.60</td>
<td>5.00</td>
<td></td>
</tr>
<tr>
<td>Control (n=5)</td>
<td>26.30</td>
<td>3.60</td>
<td>1.66</td>
</tr>
<tr>
<td></td>
<td>65.80</td>
<td>6.03</td>
<td></td>
</tr>
</tbody>
</table>

(p>0.05).
2.2 นั้น ๆ

ถ้าเราจัดการ 3 นาที หรือ 12 นาที แล้วจะเห็นผลต่างๆ.

ถ้าเราจัดการ 3 นาที ยังไม่ได้ดี เราจะต้องจัดการ 10 นาที หรือ 12 นาที.

ถ้าเราจัดการ (0, 3, 6, 9, 12) นาที แล้วจะเห็นผลต่างๆ (dominant side).

ถ้าเราจัดการ 0 หรือ 12 นาที แล้วจะเห็นผลต่างๆ.

2.3 นั้น ๆ
2.4 攫有助取

digital tensiometer] TSD121C (BIOPAC System Inc., CA. USA) [ tapping a 91 cm long MVC [cylindrical] and MP100 [BIOPAC System Inc., CA. USA] [fall time] 500 ms (filtering) for MVC [sensing] 125 Hz. A low pass filter (low pass filter) 100 Hz. TSD121C [memoris] 110° (biceps brachii) [memoris] 90° (forearm) [memoris] 90° (supination) [memoris] MVC [memoris] 30°, 60°, 100° (maximal peak force) 100° MVC [memoris] 10% MVC, 10% MVC [memoris] 30° MVC [memoris].
2.5 Materials and Methods

2.5.1 Participants

Volunteers were recruited from the local community and were asked to complete a questionnaire regarding their health history. Participants were excluded if they had any history of cardiovascular disease, neurological disorders, or recent injuries. The study was approved by the institutional review board.

The measurements were taken at the rectus femoris (RF) and vastus medialis (VM) muscles, with the RF being at the anterior superior iliac spine and the VM being at the patella. The RF muscle was marked using dermographic ink (3M), and the VM was marked using electrolyte gel (electrode). The RF and VM were marked with a consistent amount of pressure to ensure consistent muscle performance.

The participants were asked to perform isometric contractions at 90°, 135°, and 180° muscle angles, with the RF muscle being marked at 1/3 of the muscle length, and the VM muscle being marked at the patella. The contractions were performed in a randomized order to minimize bias.

The 1RM was calculated as follows:

\[
1RM = W0 + W1, \quad W1 = W0 \times 0.025 \times R \quad \text{equation (1)}
\]
2.5.2 理論的・実験的解析

12. TSD121Cの最大筋力最大筋力（MVC）は80 ± 5%である（Macaluso et al. 2000; Lindeman et al. 1999）。このため、筋力の測定においてはTSD121Cを用いる必要がある。筋力の測定においては、1RMの80%を基準として、10RMの10cmを実施する。
A. Isometric exercise

B. Isotonic exercise

Fig 1. Instrument setting.
2.6 データ処理

2.6.1 データ処理の設定

LabView でデータ処理を行いました。FFT および Hanning windowing を使用し、データの処理を行いました。FFT のパラメータ（epoch）は 0.5 を設定し、サンプル数は 1/8、128 の場合、サンプル数を 75、384 の場合、サンプル数を 75% に設定しました。データをランダムノイズとし、LabView を使用してデータを処理しました。データの処理は以下の式 (2) を使用しました。

\[ \text{データ} = \frac{\text{初期値} - \text{最終値}}{\text{最終値}} \]  

\[ \text{最終値} = \text{データ} \pm 1 \text{ MSE (mean square error)} \]
2.6.2 EMG

8 of the 10 signals from the EMG were analyzed using Labview software.
2.7 Data Analysis

2.7.1 Measurement

Data were collected on a 12-month cycle using a computerized system to measure the normalized mean (normalization) of EMG activity (Ann 2001; Clancy 2001).

The EMG data were measured at 0°, 20°, 40°, 60°, 80°, and 100° of elbow flexion and extension, with 1RM, MVC, and 0° of elbow flexion and extension serving as the reference points for normalization. The EMG was sampled at 8 Hz and analyzed with a 2–10 Hz bandpass filter. The EMG was integrated over 100 ms epochs.

The EMG data were then normalized to the EMG at 0°, with a coefficient of 1.0 for EMG, and a coefficient of 2–3 for EMG at 20°, 40°, 60°, 80°, and 100° of elbow flexion and extension.
2.7.2 Repeated ANOVA

The (repeated ANOVA test) was performed. The analysis was done for 12 t-tests (paired t-test) and 12 independent t-tests (independent t-test). The significance level was set at \( \alpha = 0.05 \). The statistical analyses were conducted using SPSS (Statistical Package for the Social Science) 10.0.
3.1 Study Results

Table 2. Changes of limb circumference

<table>
<thead>
<tr>
<th>Group</th>
<th>Muscle circumference</th>
<th>Pre-training</th>
<th>Post-training</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean  SD</td>
<td>Mean  SD</td>
<td></td>
</tr>
<tr>
<td>Training (n=5)</td>
<td>Upper arm</td>
<td>28.90 2.26</td>
<td>29.82 2.17</td>
<td>6.98*</td>
</tr>
<tr>
<td></td>
<td>Lower leg</td>
<td>46.24 2.14</td>
<td>48.30 1.31</td>
<td>4.83*</td>
</tr>
<tr>
<td>Control (n=5)</td>
<td>Upper arm</td>
<td>28.44 1.57</td>
<td>28.54 1.47</td>
<td>0.85</td>
</tr>
<tr>
<td></td>
<td>Upper leg</td>
<td>46.50 2.41</td>
<td>45.76 2.34</td>
<td>0.65</td>
</tr>
</tbody>
</table>

* p<0.05.
3.2 .GetData from EMG

3.2.1 GetData

GetData 0, 3, 6, 9, 12 to EMGGetData 12, 15, to EMGGetData 18, 21, to EMGGetData (p<0.05)(Table 3, Fig 2). 8GetData to EMGGetData 0, 12 to EMGGetData 8 to EMGGetData.
Table 3. ANOVA for relative IEMG with two repeated factors

<table>
<thead>
<tr>
<th>Exercise type</th>
<th>Muscle</th>
<th>Repeated factor</th>
<th>Sum of square</th>
<th>Degree of freedom</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Biceps brachii</td>
<td>Week</td>
<td>29.32</td>
<td>4.00</td>
<td>11.27*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Second</td>
<td>0.78</td>
<td>7.00</td>
<td>3.83*</td>
</tr>
<tr>
<td>a IM</td>
<td></td>
<td>Week*second</td>
<td>0.46</td>
<td>28.00</td>
<td>1.48</td>
</tr>
<tr>
<td></td>
<td>Rectus femoris</td>
<td>Week</td>
<td>102.39</td>
<td>1.32</td>
<td>10.39*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Second</td>
<td>1.93</td>
<td>1.69</td>
<td>2.75</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Week*second</td>
<td>2.20</td>
<td>3.13</td>
<td>1.74</td>
</tr>
</tbody>
</table>

|               | Biceps brachii | Week            | 41.29         | 4.00              | 3.69*  |
|               |                | Second          | 4.15          | 7.00              | 9.85*  |
| b IT          |                | Week*second     | 1.02          | 28.00             | 0.47   |
|               | Rectus femoris | Week            | 10.26         | 4.00              | 17.45* |
|               |                | Second          | 0.20          | 7.00              | 1.23   |
|               |                | Week* second    | 0.54          | 28.00             | 1.31   |

a IM: Isometric exercise.
b IT: Isotonic exercise.
* p<0.05.
Fig 2. Changes of relative IEMG during isometric exercise in the training group.
3.2.2  

0, 3, 6, 9, 12  

EMG  

Table 3, Fig 3.  

p<0.05.  

0, 12  

EMG.
Fig 3. Changes of relative IEMG during isotonic exercise in the training group.
3.2.3 12\textsuperscript{th} Day of Training on EMG

EMG is increased by MVC at the 12\textsuperscript{th} day of training, whereas EMG is decreased by MVC at the 6\textsuperscript{th} day of training (Fig 4).

The EMG of 1RM is increased by MVC at the 12\textsuperscript{th} day of training, whereas EMG of 1RM is decreased by MVC at the 6\textsuperscript{th} day of training (Fig 5).

EMG of 12\textsuperscript{th} day of training is decreased by MVC (p<0.05) (Fig 4-5).
Fig 4. Comparison of changes in relative IEMG and relative MVC of isometric exercise during training of 12 weeks.
Fig 5. Comparison of changes in relative IEMG and relative MVC of isotonic exercise during training of 12 weeks.

* p<0.05.
3.3 材料と方法

12\% の特定の条件下において、特定の条件が特定の結果を導き出すことを示しました (p<0.05)(Table 4, Fig 6). さらに、特定の条件下において、特定の条件が特定の結果を導き出すことを示しました (p<0.05).

12\% の特定の条件下において、特定の条件が特定の結果を導き出すことを示しました (p<0.05)(Fig 6).
Table 4. ANOVA for three relative parameters of MDF regression line with two repeated factors

<table>
<thead>
<tr>
<th>Exercise type</th>
<th>Repeated factor</th>
<th>Sum of square</th>
<th>Degree of freedom</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>IMDF</td>
<td>IT a</td>
<td>Muscle</td>
<td>0.01</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Week</td>
<td>0.30</td>
<td>4.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Muscle*week</td>
<td>0.03</td>
<td>4.00</td>
</tr>
<tr>
<td></td>
<td>IM b</td>
<td>Muscle</td>
<td>0.02</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Week</td>
<td>0.28</td>
<td>4.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Muscle*week</td>
<td>0.01</td>
<td>4.00</td>
</tr>
<tr>
<td>Fatigue</td>
<td>IT</td>
<td>Muscle</td>
<td>1.69</td>
<td>1.00</td>
</tr>
<tr>
<td>index</td>
<td></td>
<td>Week</td>
<td>1.46</td>
<td>4.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Muscle*week</td>
<td>1.36</td>
<td>4.00</td>
</tr>
<tr>
<td></td>
<td>IM</td>
<td>Muscle</td>
<td>0.33</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Week</td>
<td>0.44</td>
<td>4.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Muscle*week</td>
<td>0.40</td>
<td>4.00</td>
</tr>
<tr>
<td>Slope</td>
<td>IM</td>
<td>Muscle</td>
<td>1.03</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Week</td>
<td>1.95</td>
<td>1.83</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Muscle*week</td>
<td>0.47</td>
<td>1.41</td>
</tr>
<tr>
<td></td>
<td>IT</td>
<td>Muscle</td>
<td>0.42</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Week</td>
<td>0.56</td>
<td>4.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Muscle*week</td>
<td>0.37</td>
<td>4.00</td>
</tr>
</tbody>
</table>

a IM: Isometric exercise.
b IT: Isotonic exercise.
c IMDF: Initial median frequency.
* p<0.05.
Fig 6. Changes of relative IMDF during training of 12 weeks.
3.4 یافته‌ها

12 درصد از تعداد مصرف کنندگان در این ارائه تا انتهای آزمون (p>0.05) (Table 4, Fig 7). در حالی که 12 درصد از مصرف کنندگان در ارائه دیگر، تا انتهای آزمون (p<0.05) از میان می‌آیند. در نهایت، 12 درصد از مصرف کنندگان در این ارائه باعث تغییرات 6 درصدی در نتایج 2 می‌شوند.

- 26 -
Fig 7. Changes of relative fatigue index during training of 12 weeks.

* p<0.05.
3.5 Results and Discussion

The results of the analysis indicate that there is a significant difference in the performance of the two groups (p>0.05) (Table 4, Fig 8). As can be seen from the table, the mean performance of the experimental group is higher than the control group (p<0.05), indicating that the experimental intervention had a positive effect.

Further analysis of the data reveals that the improvement in performance is not uniform across all participants. For instance, 6 participants showed a significant increase in performance, while only 2 participants showed a decrease. This suggests that the intervention was effective for some but not for all.
Fig 8. Changes of relative regression slope during training of 12 weeks.

* p<0.05.
12 [EMG, (% EMG) (training-induced adaptation)]

DeLorme [maximal peak force] MVC, [1RM (concentric 1RM strength)]

specificity] [Brunner 1967].

Pincivero et al. 2000; Kankaanpaa 1997].

FFT 75% [1-8] (intraclass correlation coefficients)

3 [0.92, 0.80] [
EMG 8, MVC 1.59, MVC 1.78, 1RM 1.70, 1RM 1.98. (Hakkinen, and Komi 1983; Lindeman et al.
1999; Moritani, and De Vries 1979).
Fig. 9. Hypothetical changes of MDF during training of 12 weeks
5

12

12

MVC, 1RM, EMG, FFT

6

6


electromyographic measurement of distal upper extremity”. *Clinic Biomech*, 16: 576- 585.


Edwards RH, and Hyde S. 1977. "Methods of measuring muscle strength and

- 37 -


Moritani T, and devVries HA. 1979. "Neural factors versus hypertrophy in the


ABSTRACT

Characteristics of Surface Electromyography During Strength Training of 12 weeks

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Dept. of Rehabilitation Therapy
(Physical Therapy Major)
The Graduate School
Yonsei University

This study tested whether repeated measurement of median frequency (MDF)-related variables could express the muscle power changes during a 12-week DeLorme strengthening program, by using consecutive overlapping FFT (fast Fourier transformation) and integrated EMG (IEMG) from surface EMG data for isometric and isotonic exercise. To evaluate the effect of training, the following were recorded every 3 weeks for the elbow flexors and knee extensors of 5 healthy male volunteers: MVC, 1RM, limb circumference, and surface EMG during isometric MVC or isotonic contraction at 10RM load. From the EMG data, IEMG and variables from a regression analysis between MDF and time were obtained.

MVC, 1RM, IEMG, and initial MDF increased linearly over the training period.
The fatigue index and slope of the regression line increased temporarily until the 6th week and decreased thereafter. From these results, there appeared to be enhanced neural recruitment of fast twitch fibers in the first 6 weeks and continued enhancement in the recruitment and hypertrophy of fast twitch fibers, which led to increased fatigue resistance, over the last 6 weeks.

Accordingly, the MDF and IEMG analysis technique could demonstrate the effect of the program detected significant changes in both isometric and isotonic contractions. EMG analysis methods can be used to estimate the electrophysiological and histological changes in skeletal muscles during a strengthening program.

Key Words: Surface EMG; FFT; IEMG; MDF; Strengthening.