

# Differentiation of fast and slow muscle fibers by bioimpedance

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**Abstract.** The differentiation of fast and slow muscle fibers in vivo still requires heavy equipment (ergometer, biopsy ...). These fibers conduct the electrical current differently. Therefore the aim of this study is to see if it is possible to differentiate quickly, by bioimpedance, fast and slow fibers, and firstly muscles which are typical composed by slow or fast fibers. To do this, we used a multifrequency impedancemeter Z-Metrix® (BioparHom Company, France). We collected the electrical characteristics (Longitudinal and Transversal, from 1 to 1000 kHz) for a population of 20 rats aged 70 days, on Soleus muscles (composed principally of slow fibers) and Extensor Digitorum Longus (EDL) muscles (composed principally of fast fibers). We compared the means of alpha (L/T) and R=f(X) with Wilcoxon tests. We obtained none significantly differences between electrical data obtained on EDL and Soleus muscles, but we could see clearly differences on graphics representation and with the example of a rat. Therefore, we can think that differentiation, by bioimpedance, of muscles typed slow and fast fibers, could be possible.

## 1. Introduction

Localized impedance measurements can provide useful approaches for assessing neuromuscular disease [1] and more generally characteristics of muscle. In 2006, Nie showed that it's possible to transfer Electrical Impedance Myography (EIM) from human to animal, especially rats [2]. Recently, Ahad presented a study which indicated that it seems possible to link electrical characteristics of rat muscle and fiber size [3].

Thus, the differentiation of fast and slow muscle fibers in vivo still requires heavy equipment (ergometer, biopsy...). Then it's difficult to use this information in clinical or sportive routine.

Therefore, the aim of this study was to see if it's possible to use bioimpedance to differentiate quickly fast and slow fibers, firstly in rats, before transferring to human.

## 2. Material and method

To do this, we used a multifrequency impedancemeter Z-Metrix<sup>®</sup> (BioparHom<sup>®</sup> Company, France) showed figure 1. This device operates on six 1.5 volt batteries with an injection current low with 77  $\mu$ A.



Figure 1: multifrequency (1 to 1000 kHz) impedancemeter Z-Métrix<sup>®</sup>.

Figure 2 indicate the 4 needles-electrodes we used for our experimentation. We took care that the distance between the needles was always constant.



Figure 2: description of our needles-electrodes.

We collected some electrical characteristics (resistances R and reactances X from 1 to 1000 kHz) and we calculated the phase angle Alpha, in degree, with equation 1:

$$Alpha = ATan(X / R) * \frac{180}{2\pi} \quad (1)$$

Where X and R are respectively the reactance and the resistance in ohm.

We did that in longitudinal way of fibers of muscles (L) and in transversal way of fibers of muscles (T).

We explored muscles of a population of 20 rats aged 70 days, on Soleus muscles (composed principally of slow fibers) and Extensor Digitorum Longus (EDL) muscles (composed principally of fast fibers).

Table 1 indicates the composition of each type of muscles obtained with histological cuts.

**Table 1:** mean and standard deviation (SD) of numbers of slow and fast fibers in each type of muscles explored.

		Number of slow fibers		Number of fast fibers		Total number of fibers
			%		%	
Soleus	Mean $\pm$ SD	1905,42 $\pm$ 409,46	93,81	125,26 $\pm$ 26,22	6,19	2030,68 $\pm$ 426,47
EDL	Mean $\pm$ SD	100,47 $\pm$ 28,67	4,30	2215,16 $\pm$ 319,73	95,70	2315,63 $\pm$ 339,80

We used non parametric paired test (Wilcoxon) for our statistic tests because of our small sample and non Gaussian distribution.

## 3. Results and discussion

We see in table 1 that Soleus muscle have about 94% of slow fibers in compare with EDL muscle witch have 95,7% of fast fibers. Then we can consider, that differentiating Soleus and EDL muscle, for a first step, is about the same that differentiating slow and fast fibers.

**Table 2:** mean and standard deviation of differences of alpha L/T between Soleus and EDL in percent, for various frequencies.

Frequency (KHz)	Mean $\pm$ SD	Wilcoxon Tests
10	-33,1 $\pm$ 77,4	Ns
50	-46,9 $\pm$ 111,8	Ns
100	-56,7 $\pm$ 143,2	Ns
200	-42,2 $\pm$ 110,8	Ns
304	-32,6 $\pm$ 81,6	Ns
500	-2,9 $\pm$ 60,5	Ns
1000	12,1 $\pm$ 56,7	Ns

As we can see on figure 3, we observe a clearly difference between Soleus and EDL alpha L/T. Despite those observations, especially for frequencies from 50 to 350 kHz, there is none significantly difference between the alpha L/T of our two types of muscle, as shown in table 2.

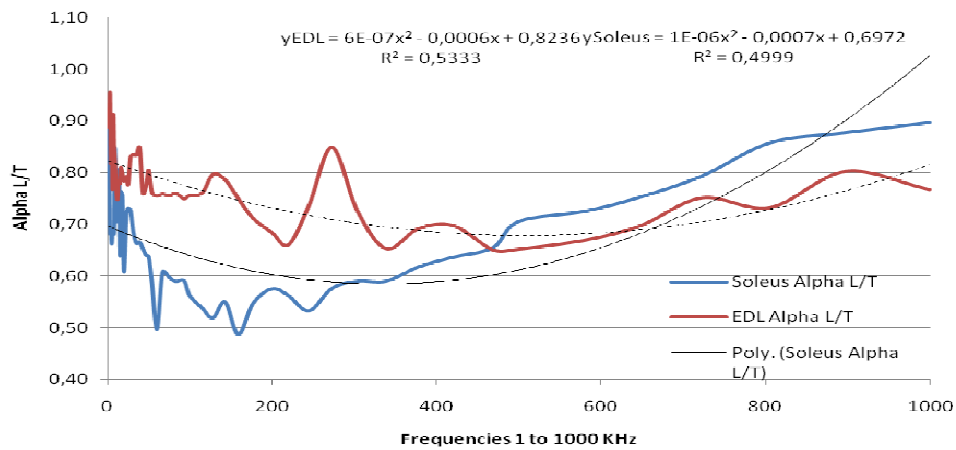


Figure 3: variation of means of alpha (L/T), for 1 to 1000 kHz, for Soleus and EDL.

Then we wanted to explore with more details the electricals characteristics of our two types of muscles. Table 3 lists mean and SD of resistances (L/T) and reactances (L/T) for various frequencies.

**Table 3:** mean and standard deviation of differences of Resistances and Reactances (L/T) between Soleus and EDL in percent, for various frequencies.

Frequency (KHz)	MeanR $\pm$ SD	Wilcoxon Test	MeanX $\pm$ SD	Wilcoxon Test
10	58,2 $\pm$ 52,5	Ns	121,8 $\pm$ 172,5	Ns
50	48,8 $\pm$ 112,9	Ns	100,1 $\pm$ 221,7	Ns
100	42,6 $\pm$ 108,5	Ns	92,7 $\pm$ 217,6	Ns
200	31,6 $\pm$ 77,8	Ns	98,2 $\pm$ 195,8	Ns
304	20,4 $\pm$ 77,15	Ns	76,6 $\pm$ 196,4	Ns
500	17,9 $\pm$ 65,8	Ns	51,6 $\pm$ 181,6	Ns
1000	10,4 $\pm$ 31,4	Ns	54,5 $\pm$ 156,3	Ns

As the first approach with alpha (L/T), we observe on figure 4 a different dispersion of mean  $R=f(X)$  (L/T) between Soleus and EDL but as lists in table 3, those differences in resistance and reactance are not significant.

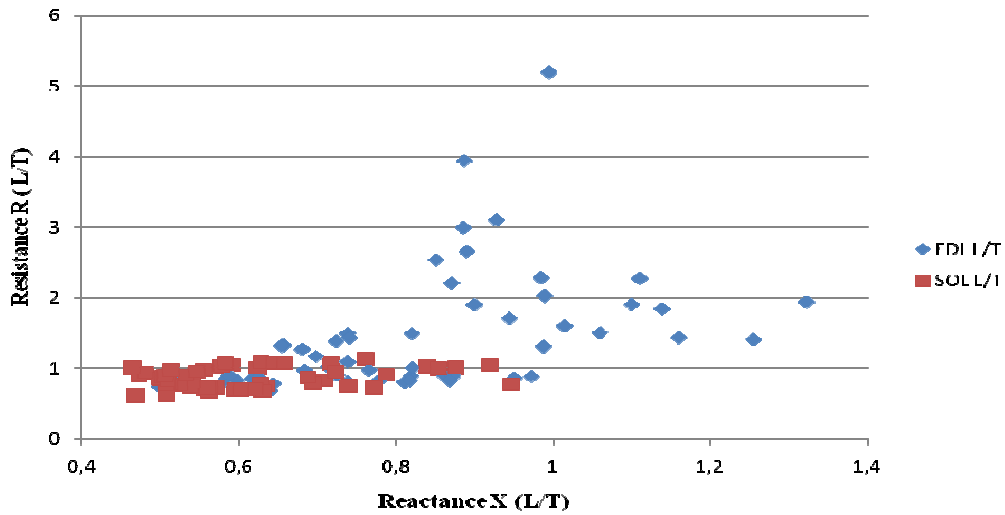


Figure 4: dispersion of means of  $R=f(X)$  (L/T), for 1 to 1000 kHz, for Soleus and EDL.

As we see differences but not significant, we wanted to try to apply those methods for differentiating EDL and Soleus on a rat, taken with hazard. Figure 5 and 6 show clearly the difference in the electrical characteristics, alpha and  $R=f(X)$  (L/T), between EDL and Soleus.

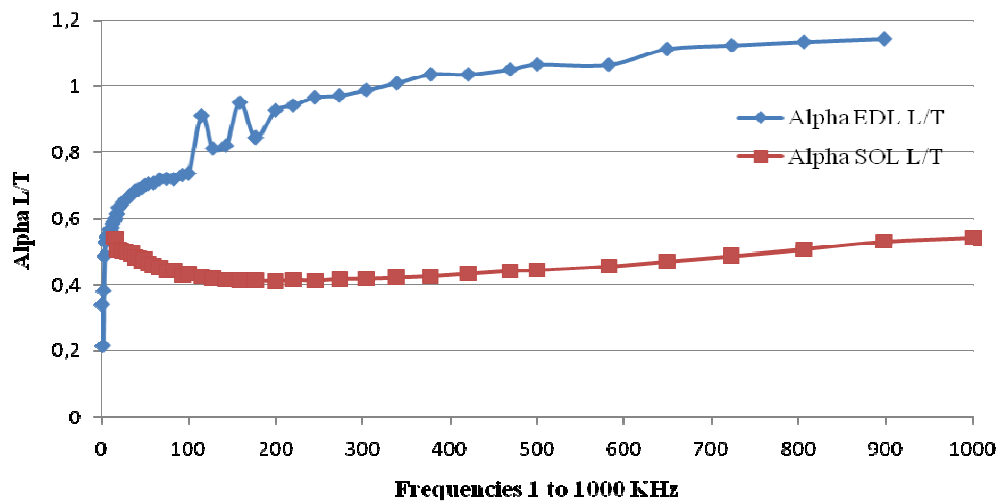


Figure 5: example for a rat, of variations of alpha (L/T), from 1 to 1000 kHz, for EDL and Soleus.

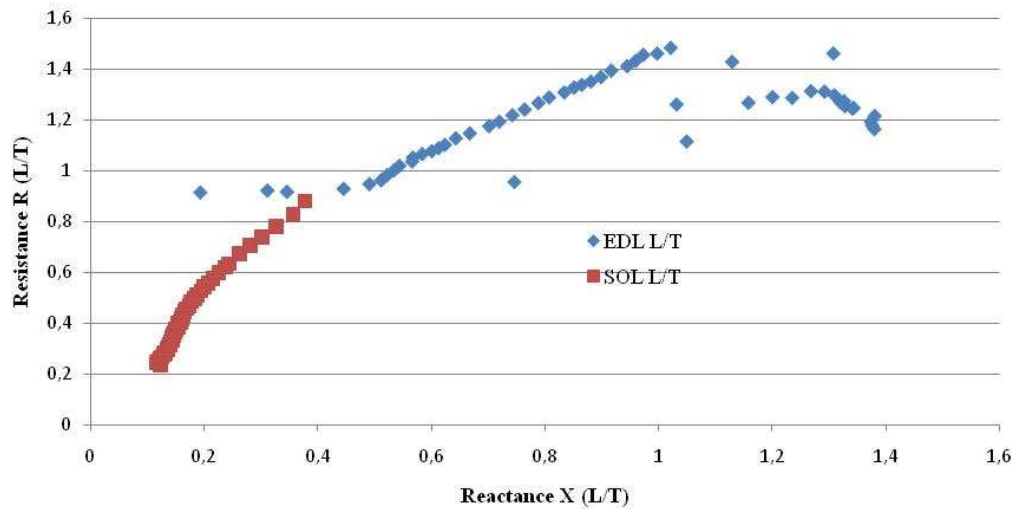


Figure 6: example for a rat, of variations of  $R=f(X)$  (L/T), from 1 to 1000 kHz, for EDL and Soleus.

Then, in that rat, we could differentiate EDL and Soleus muscle by bioimpedance. Therefore, we dissociated fast and slow fibers by bioimpedance.

#### 4. Conclusion

We tried two methods to characterized electrical data of muscles:  $\alpha$  (L/T) and  $R=f(X)$  (L/T). For the two approaches, we could see differences between Soleus and EDL, but not significant. Maybe we haven't significant differences because our sample is too small (with important SD), or we used the inappropriate statistics tests. We're going to do a new validation, with a new bigger sample.

When we applied those two methods on a rat, to have an example, we could dissociate EDL and Soleus electrical characteristics. Then, we can think that bioimpedance could permit to differentiate, by extension, fast and slow fibers, quickly, with a non-invasive and low cost tool, ideal for clinical and sportive routine.

#### References

- [1] Esper GJ, November 2009 *Muscle Nerve* **34** 595-602.
- [2] Nie R, August 2006 *Clinical Neurophysiology* **117(8)** 1844-9.
- [3] Ahad MA, December 2009 *Physiology Measurement* **30(12)** 1415-27.