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Correlation between Body Composition and Regional Magnetic Induction Spectroscopy

Yazmin Hernandez-Alvarado, Laura Ortuño-Contreras, Eleazar Lara-Padilla, César A. González-Díaz*

Instituto Politécnico Nacional,
Escuela Superior de Medicina,
Mexico

cgonzalezd@ipn.mx

Abstract. Continuous monitoring of body composition is a relevant condition in monitoring sport people and essential in the training of high-performance athletes. Currently, there are no portable devices for personal use that allow athletes to track changes in their body composition as a result of their training program. Magnetic Induction Spectroscopy (MIS) allows non-invasive exploration of the electrical properties of biological tissues. The goal of this work was to explore regional measurements of MIS in the abdomen and arm to determine if they correlate with characteristic regional parameters for estimating body composition by electrical bioimpoedance The body composition of 25 volunteers was estimated through Electrical Bioimpedance Spectrocopy (EBIS), and its parameters in abdomen and arm segments were correlated with MIS measurements in the same segments. The results indicate a correlation of the MIS magnitude at 400 KHz with the water content in the arm segment (ρ =0.438, $p<0.05$), while the MIS phase at 99.4 KHz in the abdomen seems a potential correlation with body fat in the trunk but not statistical significance is evident (ρ =0.271, p=0.051). In principle, MIS measurements seem indicate sensitivity to water content and body fat in arm and trunk segments, respectively. However, the results so far are not conclusive to determine the technical feasibility of MIS to estimate no invasively body composition parameters.

Keywords. Bioimpedance, magnetic induction, body composition.

1 Introduction

EBiS is used to evaluate the six compartments (fat, skeletal muscle, visceral proteins, plasma proteins, extracellular space and skeleton) from which body composition is formed [1]. By applying sub sensory alternating current to the tissues and measuring the voltage drop, from which we can obtain two theoretical resistances at zero and infinite frequencies, by means of Cole's model (Cole 1928, Cole and Cole 1941) [2].

The EBiS advantage are multiple; instrumentation is portable, it is a non- invasive technique, safe andeasy to perform, the results are obtained immediately and the measurements can be repeated with a high reproducibility, in addition information can be obtained from healthy and pathological tissue [3]. It has application in almost allmedical areas, but in the area where it is most useful is in the sports field, as a way to monitor the body progress of each athlete.

Similar to EBiS, MIS has the ability to measure body composition indirectly. By inducing a magnetic field on a tissue and passing through it, it is possible to measure the resistance that the tissue in question has on the magnetic force provided.

One of the advantages of bioelectrical measurements by MIS with non-contact electrical coils is an inductive measurement that does not require galvanic coupling between the electrode and the skin or tissue under measurement, allowing more accurate results to be obtained [4].

This work focuses on the results obtained in a study conducted by Cesar A. Gonzalez [5] in the Intensive Care Unit (ICU) of the Mexican Army Military Hospital of the Mexican Army, where 6 healthy volunteers and eight patients with cerebral edema and cerebral hematoma confirmed by CT radiology, it was possible to obtain a classifier built from measurements in these two frequency ranges where an instant diagnosis of the medical condition

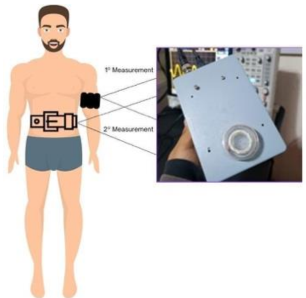

Fig. 1. Measurement locations with the magnetic induction device developed by the biomedical engineering laboratory of the IPN

Table 1. Distribution of age, weight, IMC (body mass index), FFM (free fat mass), FM (Fat mass) in average and standard deviation by gender

	Women (n=10)		Men (n=15)	
	Average+-DE	Range	Average+-DE	Range
Age	21.9 +-0.53	2	22.83+- 2.03	8
Weight	59.39+-7.88	24.4	75.24+16.06	60.6
IMC	23.20+-[illegible]	9.35	25.48+-4.78	20.19

of a patient's brain can be provided from a single set of measurements.

In this work we explore regional measurements of MIS in the abdomen and arm to determine if they correlate with characteristic regional parameters used for estimation of body composition by (EBIS).

2 Materials and Methods

A sample of 25 healthy volunteers between 20 and 29 years of age, under fasting conditions for 8 hours, was used. They were required not to have consumed water, not to have taken any medication and to not have done any strenuous exercise before. It was a requirement that they had no comorbidities, metallic prosthesis, pacemakers, hearing aids or major surgeries in the last 6 months.

Body composition was calculated by EBiS using the In Body 770, which provides measurements such as total and segmental body water, total and segmental body fat, obesity analysis, muscle, bone, phase angle and impedance at 1, 5, 50, 50, 250, 500 and 1000kHz.

In the IPN biomedical engineering laboratory, a prototype for regional MIS measurements was developed, the system estimates multifrequency magnitude and phase in the bandwidth up to 1.1 MHz. providing data such as magnitude and phase of the sample tissue, Showed in figure 1. Two measurements were made with the MIS prototype, the first one was placed on the external face of the non-dominant arm held by a spandex strap to avoid any noise as much as possible.

The second was placed 2 centimeters below the umbilical scar, also held by a lycra strap (Fig 1). Two measurements were taken from each region from which an average was obtained and compared with the gold standard. In order to reduce the bias between the measurements, both techniques were taken subsequent to each other.

Segmental body composition parameters and MISmeasurements were correlated trough a non-parametric correlation test by the use of the statistic software SPSS ver. 21.

The Pearson coefficient was estimated and a significance level $P<0.05$ was considered. The study was conducted according to the principles expressed in the Declaration of Helsinki. Volunteers were gently informed about the experimental protocol and signed an informed consent.

3 Results

The data obtained were inconclusive. Although there is a correlation between the magnitude of MIS at 400 KHz with the water content in the arm segment (ρ =0.438, $p<0.05$) (Fig. 2), on the other hand the MIS phase at 99.4 KHz (Fig. 3) in the abdomen it seems to have an approximate correlation with body fat in the trunk, but it is not evident since a statistical significance was obtained (ρ=0,271, $p>0.05$).

It means that although other studies carried out with the same principles satisfactory results have been obtained, this study was not entirely conclusive, so it is recommended that a larger population is performed in order to evaluate the results obtained in both segments.

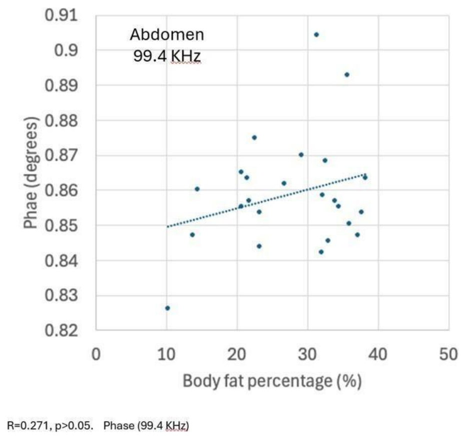

Fig. 2. Scatter plot of magnitude at 4KHz versuswater in left arm. Pearson's correlation was calculated (ρ = 0.438, P < 0.05)

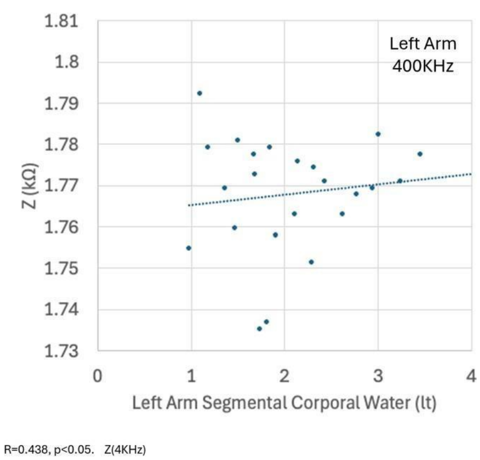

Fig. 3. Scatter plot of phase at 99.4KHz versus abdominal body fat percentage. Pearson's correlation was calculated (ρ = 0.271, P > 0.05)

4 Conclusions

In principle, MIS measurements seem correlate with water content, and potential correlation with body fat, such observations not allow us to determine if MIS is a useful technique for non-invasive determination of body composition parameters so far. It is suggested to perform a study with a larger population of volunteers to confirm or neglect the findings.

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References

1. **Garza, N. (2024).** Valoración nutricional mediante antropometría. McGraw Hill Medical. Vol. 14, No. 2, pp. 243–255.
2. **Mussnig, S., Krenn, S., Hecking, M., Wabel, P. (2024).** Assessment of Bioimpedance Spectroscopy Devices: A Comparative Study and Error Analysis of Gold-Plated Copper Electrodes. Physiological Meassurement. Vol. 45, No. 2, pp. 35. DOI: 10.1088/1361-6579/ad205b.
3. **Naranjo-Hernández, D., Reina-Tosina, J., Roa, L.M., Barbarov-Rostán, G., Aresté-Fosalba, N., Lara-Ruiz, A., et al. (2019).** Smart Bioimpedance Spectroscopy Device for Body Composition Estimation. Sensors, Vol. 20, No. 1, pp. 27. DOI:10.3390/s20010070.
4. **Tarjan, P.P., McFee, R. (1968).** Electrodeless Measurements of the Effective Resistivity of the Human Torso and Head by Magnetic Induction. IEEE Transactions on Biomedical Engineering, Vol. 15, No. 4, pp. 266–278. DOI: 10.1109/TBME.1968.4502577.
5. **Gonzalez, C., Valencia, J., Mora, A., Gonzalez, F., Velasco, B., et al. (2013).** Volumetric Electromagnetic Phase-Shift Spectroscopy of Brain Edema and Hematoma. PLOS ONE, Vol. 8, No. 5. DOI: 10.1371/journal.pone.0063223.

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**Corresponding author is César A. González-Díaz.*