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Whole-body NMR spectroscopy as a tool to assess human body composition

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Introduction

Methods for evaluating the content of fatty tissue in the human body are described. They are based on the analysis of MR images and recording the NMR spectra of the whole body. Particular attention is paid to the spectroscopic method, where the evaluation is made by analysis of the intensities ratio of water and fat peaks. Early measurements were performed on mice by a high field NMR spectrometer [1]. Interest in such measurements is due to the fact that they are easy to implement and take little time. But the main thing is that there is correlation between the intensity ratio of peaks and the content of fat in the body of an animal. The aim of our work was to adapt the method used on small laboratory animals to human studies.

Materials and methods

The measurements were performed on a standard (horizontal bore magnet) 0.5 Tesla MR scanner (Bruker Tomikon S50). NMR spectra were recorded from all parts of the body, and then summed. In the total spectrum, peaks of water and fat were defined - figure 1. The analysis of peak intensities (I_W and I_F) gave information about the content of fat in the human body.

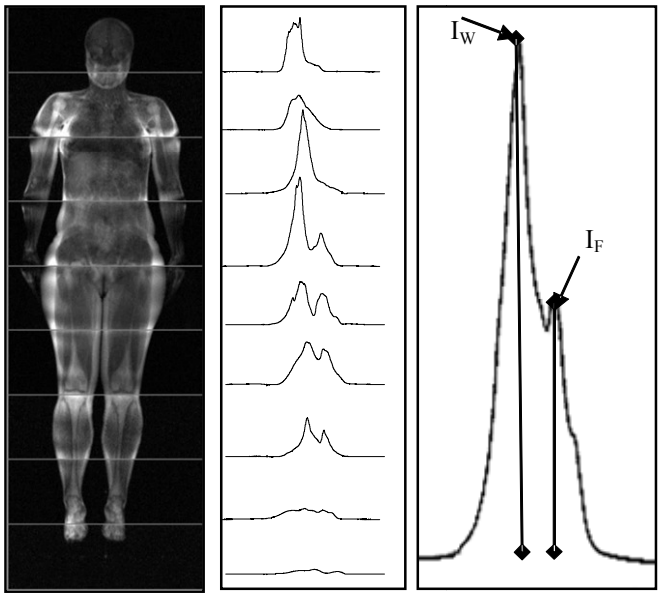

Figure 1: Left: arrangement of scanned slices; Center: NMR spectra from each slice; Right: total (whole-body) NMR spectrum

Registration of the NMR spectra from all parts of the human body was carried out in a homogeneous magnetic field. To do this, the patient's body was moved stepwise along the horizontal axis of the magnet. Scanning area was limited by slice thickness of 20 cm. Slice direction was perpendicular to the mentioned axis. Local NMR spectroscopy scanning methods were used to fix the slice location and its thickness. These methods use inhomogeneous (gradient) fields which are applied synchronous with exciting RF pulses [2].

NMR data were compared with the average density of the body $\rho=m/V$, where m and V are body mass (kg) and volume (m^3) for each object of research accordingly, as well as the volume of fat V_F determined by MR images. There were T1 and T2-FSE weighted images (in-plane resolution 0.23 mm, slice thickness 10 mm). Abdominal and subcutaneous fat areas were determined visually by anatomical landmarks [3]. Segmentation of these areas and areas inside hypodermic fat was carried out [4]. It gave possibility to count the volume of body fat and the volume of whole body respectively.

Results

The measurement results for the 8 test subjects (6 females and 2 males) are presented in the table below.

Table 1

	f1	f2	f3	f4	f5	f6	m7	m8
ρ	960	985	997	1000	1014	1016	1045	1175
I_F/I_W	0.97	0.84	0.93	0.77	0.63	0.61	0.31	0.42*
V_F/V	-	0.46	0.42	-	0.32	-	-	0.27

One can notice that both parameters I_F/I_W and V_F/V are approximately linearly dependent on average density of the body. In particular it indicates to correlation between fat content in human body and intensity of fat peak in the whole body NMR spectrum.

The problem connected with low magnetic field (0.5 T) was revealed. Width of the lines appeared to be comparable with the distance between them. It leads to the difficulties not only of measuring integrals of spectral lines but also the differentiation of peaks. Because of this in low field one can obtain a doubtful result for a very lean subject – see value I_F/I_W for m8 (marked with an asterix) in the table.

Conclusion

Measurements indicate a correlation between the average density of body and fat in it. It is consistent with the results of work [1]. It is preferable to perform spectroscopic measurements at a stronger magnetic field (1.5 T and more) to obtain whole body high resolution NMR spectra.

References

[1] P. Mystkowski, et al. - *Int J Obes Relat Metab Disord*, 2000, **24** (6), 719-724.
[2] A. N. Garroway, P. K. Grannell, P. Mansfield - *J Phys C7*, 1974, 457-462.
[3] E. L. Thomas, et al. - *J Appl Physiol*, 1998, **85**, 1778-85.
[4] N. V. Anisimov, et al. - *Proc. EUROMAR-2008*, 254.