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Magnetic Resonance Imaging - A Technique for Studies of Anthropometric Internal Data

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1. Introduction

The number of people with musculoskeletal disorders is increasing. Biomechanical models are very useful in estimating the exposure and the connection between exposure and disorders. However, internal anthropometric data required for modelling are often missing or are based on cadaver studies of only a few bodies (Demster (1955), Finsen (1995)). Thus the models are incomplete and give rough approximations only.

Magnetic Resonance Imaging (MRI) is a rapidly growing technique, which allows high-resolution images of an arbitrary section of the human body. MRI is now a well-established tomographic method, which gives information about water content as well as biochemical and molecular structure of soft tissue. Three types of MR images are normally recognised: proton density-, T2- and T1- weighted. In the first image type, proton concentration (content of unbound water) is shown, while in the other two, the relaxation properties of the protons are displayed (Edelman (1996)). The relaxation properties are reflecting the ability of the protons to maintain and transmit imposed radiofrequency energy. Adequately weighted MR images can distinguish between compact bone, porous bone, bone marrow and different types of soft tissue. The technique is therefore also suitable for achieving anthropometric measurements, and has been applied in ergonomic studies such as those by Tracy (1989) and Pierre-Jerome (1996).

This paper presents our experiences using the MRI technique to study internal anthropometric measurements of the neck and shoulder region. Both the potential and limitation of the method are discussed.

2. Method

Twenty women equally distributed between the ages of 18 and 65 years were selected for the experiment. People with chronic pains in the neck or shoulder region, with metal objects in their body or suffering from claustrophobia were not allowed to participate. The study was carried out on a modern MRI-system (Siemens Magnetom Vision 1.5 T) at the University Hospital in Lund. A total of seven T1- and T2-weighted measurement sequences of the neck and shoulder region were acquired during one hour examination of each subject.

The MRI-system has a cylinder opening with a 60 cm diameter in which the subject lies in a neutral supine position. A transmit and receive system is built into the magnet for body examinations with large fields of view. However, special transmitting and receiving radio-frequency coils can also be placed tightly around the subject to improve signal-to-noise-ratio. Positions other than supine can also be used for shorter periods of time depending upon the choice of coil. Within 3-5 minutes, two-dimensional images of 10-20 sections with a section thickness of 3-5 mm are registered (resolution ≈1 mm). If a special coil is used, the resolution obtained can be better than 0.5 mm. Another method to improve the resolution is to increase the measurement time. A three-dimensional image of a body region can also be created. The geometrical accuracy of the MRI system varies with the distance from the absolute centre of the magnet. Imaging can be performed within a 50 cm diameter sphere from the centre point, but in an antrophometric study, the variation of accuracy with distance from the centre has to be evaluated. In this study, such an evaluation was made using a water-filled perspex phantom.

Movements can also be studied using the MRI-system. For dynamic studies, rapid imaging (<0.1 s) of a chosen segment must be used, however, the resolution is reduced (>2 mm). In this study, the dynamic features of the system have not been used.

3. Results and conclusions

The MRI-technique has many advantages (table 1). It is a fast non-invasive method and due to its extensive clinical use, the effects of exposure to the magnetic field are well documented and not considered harmful. However, the narrow space within the magnet represents an inconvenience for the subject, the postures during the experiment may be uncomfortable and some people experience claustrophobia. During our experiment two people terminated the experiment before the last measurements were completed. It is our opinion that, for this type of study, the total measurement time on any occasion should not exceed one hour.

The narrow experimental space of course limits the range of postures and movements, which can be studied. The supine position also affects the results - a sitting or standing position would be a realistic simulation of work positions. This kind of MRI-system is, however not commercially available today for whole-body scanning.

Table 1. Properties of a MRI-experiment

	Advantages	**Disadvantages**
The MRI-system	A clinical standard method in many hospitals.	High investment and operative costs. Normally limited accessibility for non-clinical research projects.
The experiment	Fast (minutes). Non-invasive.	Lack of space in the magnet. The subject is in a supine position.
The results	High quality image of an arbitrary part of the body.	Artefacts in the image if the subject moves during the examination.
	Images of soft tissues.	Contraindications: Certain metallic implants, claustrophobia etc.
	The images can be re-analysed. In a tree dimensional image, an arbitrary section can be observed.	

The main advantage of this method is that high quality images of an arbitrary section of the human body can be analysed. With a properly chosen examination sequence, soft tissues, such as muscles, tendons and ligaments, which are of special interest to ergonomic studies, can be easily identified. In our experiment, we obtained a spatial resolution of 0.6-0.9 mm which was adequate to estimate the load on different tissues and muscles to get a more accurate knowledge of the effect of external exposure from different work situations. In some cases a higher resolution could be used to distinguish more detail. However, the number of experiments would have to be reduced due to the limitation of the total measurement time.

For the evaluation of the images, special computer programmes are used. Inexpensive and efficient programmes dedicated to anthropometric evaluation for the Intel/Windows platform are obviously difficult to find but more general image analysis programs can be used to measure, for example, distances and areas of interest. It is important for the quality of the measurements that artefactual errors are minimised by choosing suitable parameters, for instance, sequence weighting and field of view. In our case, artefacts due to blood circulation, breathing and other movements of the subject have caused some problems.

In summary, the MRI method is very useful for studying internal anthropometric measurements. However, a multidisciplinary research group including anatomists and MRI experts is required to ensure a high quality anthropometric study. Unfortunately, the limited accessibility and the high investment and operative cost still restrict the use of the MRI-technique as a standard method for achieving anthropometric data.

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