Effects of 7 Tesla MRI examination on postural stability

J. M. Theysohn[1,2], A. K. Bitz[1], O. Kraff[1,2], S. Maderwald[1,2], M. Gerwig[3], O. Kastrup[3], D. Timmann[3], F. Schmitt[4], H. H. Quick[1,2], E. R. Gizewski[1,2], M. Forsting[1,2], M. E. Ladd[1,2], and S. C. Ladd[1,2]

[1]Erwin L. Hahn Institute for Magnetic Resonance Imaging, University Duisburg-Essen, Essen, Germany, [2]Department of Diagnostic and Interventional Radiology and Neuroradiology, University Hospital Essen, Essen, Germany, [3]Department of Neurology, University Hospital Essen, Essen, Germany, [4]Siemens Healthcare, Erlangen, Germany

Introduction:

Magnetic resonance imaging [MRI] is known as a safe diagnostic imaging procedure without harmful long-term effects for personnel or subjects when conducted in accordance with safety regulations (IEC, FDA). As far as is currently known, this also applies to ultra high-field MRI with static magnetic field strengths of 7 Tesla and above, which are currently only used in research. Nevertheless, transient side-effects are reported more frequently at higher field strengths, and are often associated with the insertion into and movement of the human body through the magnetic field. Dizziness is among the most often reported sensations, with the most probable mechanism being the induction of electrical currents inside the inner ear due to the movement of the electrically conducting tissue of the head inside the spatially varying magnetic field [1]. Furthermore, subjects often report a subjective postural instability after the examination, even outside the scanner room, which until now has not been fully explained or investigated. The current study aims at quantitatively assessing this subjective effect by measuring postural instability before and after a 7 Tesla examination.

Methods:

Twenty neurologically healthy volunteers (16m, 9f) underwent a Romberg's test before, 5 minutes after, and 15 minutes after a 7 Tesla examination. The MR examination lasted 45 minutes and was performed with a whole-body 7T MRI (Magnetom 7T, Siemens Healthcare, Erlangen, Germany) and an eight-channel transmit/receive head coil (Rapid Biomed, Wurzburg, Germany). Additionally, five of these volunteers were included in a control study performed on a separate day. In the control study, the subjects were not exposed to the electromagnetic fields produced by the MR system; instead they rested on a gurney in a quiet room for 45 minutes. Results of the control group were used to exclude physiological effects by orthostatic regulation. The Romberg's test was performed while standing on a 20 cm thick foam cushion with feet close together and with open or closed eyes. When standing on the cushion with eyes closed, stability of the stance is heavily dependent on vestibular system function [2]. Analysis of the body motion was performed by an ultrasound real-time measuring system (Zebris Medical Systems, Germany), recording 3D positions of sensors fixated to the lumbar spine, head, both shoulders, and both thighs. After initial calibration of the system, each condition was measured for 30 seconds. Data were evaluated to determine the sway area and the sway path length, as well as various speeds and accelerations. Mean values of the twenty volunteers were compared for the different time points and regarding the different eye states using one-way ANOVA for repeated measurements and post-hoc Bonferroni correction for statistical evaluation.

Results and discussion:

In Fig 1 the sway path length is shown as a measure for postural stability for all 20 volunteers. Results for tests with eyes open show no significant differences in postural stability between experiments before and after MR examination. However, for closed eyes the sway path was significantly increased 5 min after MRI examination, indicating a postural instability which was normalized after 15 min. The different outcome between the results with eyes closed compared to eyes open indicates that the instability can be attributed to the vestibular system. Since no significant effects were measured for the control group without MRI exposure, the measured reduction of the postural stability appears to be caused by the MR examination rather than by physiological effects due to orthostatic regulation after returning to the upright position.

Conclusion:

The results show that exposure to magnetic and/or electromagnetic fields produced by a 7 Tesla MR system during examination of the head only temporarily cause a dysfunction or over-compensation of the vestibular system. Further investigation of the individual physiological effects on the vestibular system of static magnetic fields, magnetic field gradients, and radio-frequency fields will be the aim of further studies.

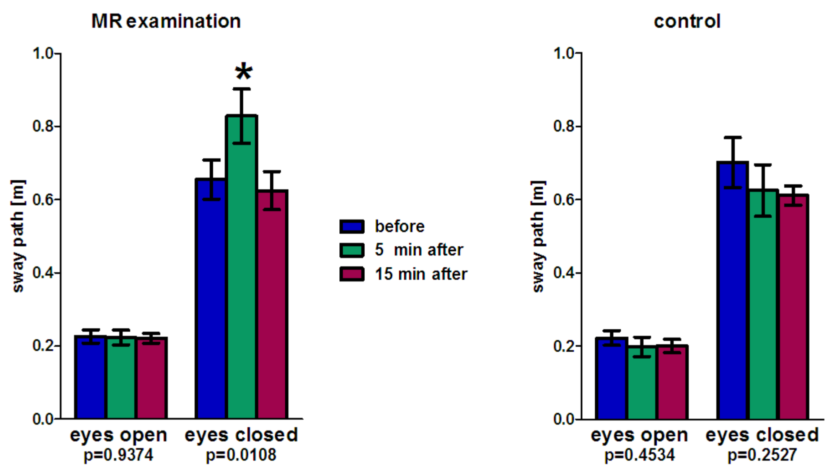

Fig 1: Statistical evaluation of sway path length as indicator of postural stability: mean ± SEM; one-way ANOVA for repeated measurements; post-hoc Bonferroni (* $p<0.05$).

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