

Subjective Assessment of Sensations Experienced by 7 Tesla Magnetic Resonance Imaging

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TARGET AUDIENCE: All researchers who use ultra-high field MRI

PURPOSE: To perform safe and appropriate examinations at 7 Tesla (T), it is crucial to understand potential physiological effects and risks caused by exposing to the high static magnetic field and high radio frequency. Although MRI scanners with the magnetic field of less than 8T are classified as “non-significant risk devices” except for neonates by FDA, some transient sensations such as vertigo and metallic taste are said to be frequently experienced at 7T. Previous studies performed with large European cohorts and 7T scanners of two vendors demonstrated that the most frequent and unpleasant sensation at 7T was the vertigo or dizziness during moving table into or out of the scanner bore, which were more severe than those at 1.5 T [1–3]. However, it remains unknown whether severities and characteristics of these sensations are comparable to the previous reports in other countries and scanners. Hence, we investigated the unpleasant sensations experienced by large number of the Japanese subjects during MRI examination using another 7T scanner that has a slow table-feed speed, and then compared these sensations to the previous reports.

METHODS: 279 healthy volunteers and 229 patients included in the study (316 men and 192 women; age range 9–85 years [median, 33 years]). We used a 7T MRI scanner (Discovery MR950; GE Healthcare) with a bore diameter of 60 cm and a length of 333 m and with a maximum gradient amplitude of 50 mT/m and slew rate of 200 mT/m/ms. All examinations were performed using quadrature transmission and 32-channel receive head coils. The scanner table moves automatically into and out of the scanner bore at a constant table-feed speed of 2 cm/s which is slower than those introduced in the previous studies regarding 7T scanners. A questionnaire regarding potential sensations and symptoms during table-moving and scanning was newly created based on the previous studies. After MRI examination at 7T, the subjects filled out each questionnaire item by using an 11-point scale. The level of the sensations was categorized as follows: 0–1, minimal; 2–4, weak; 5–7, moderate; and 8–10, severe. The scores during table moving and those during scanning were compared by Wilcoxon’s matched-pairs signed-ranks test ($p < 0.05$).

RESULTS: Of the 508 subjects, 3 patients could not reply to the questionnaire and 1 volunteer refused MRI examination when moving into the bore mainly due to claustrophobic complaints. The remaining 504 subjects (99.2%) (278 volunteers and 226 patients) were eligible for further analyses. Among the various sensations experienced in examination at 7T, vertigo and feeling of curving/leaning during table moving were most frequently observed (weak, 18.5% and 21.6%; moderate, 8.9% and 8.9%; severe, 1.6% and 2.0%, respectively) and were significantly more frequent than those during stationary position (weak, 11.9 % and 7.7%; moderate, 4.2% and 2.0%; severe, 0% and 0.2%, respectively) ($p < 0.001$) (Figure 1). In contrast, the metallic taste, nausea, and light flashes were rarely experienced (moving table, 1.0%, 1.8%, and 0.8%, respectively; stationary table, 1.0%, 1.6%, and 1.4%, respectively). Other sensations were found in 3–11% in moving and/or stationary table positions. The mean scores of the sensations such as vertigo, metallic taste, nausea, sweating, headache, and light flashes in this study were apparently smaller than those in the previous study particularly during the table movement (Table 1).

DISCUSSION: Previous studies reported that subjective discomforts, particularly vertigo, are experienced mainly during the table movement in approximately one fourth of the subjects, suggesting the sensations can be mainly caused by gradual increase/decrease of the magnetic field strength, i.e. dB/dt. In this study, however, the substantial discomforts occurred in approximately one eighth and the severities were apparently milder when compared with the previous studies. These discrepancies can be mainly attributed to the table feed speed of the scanners. A slow speed setting of the table feed in the scanner we are using can diminish dB/dt-related stimulations of cranial and peripheral nerves. Hence, slowing down the table-feed speed is considered to be a crucial technique to minimize unpleasant sensations such as vertigo at 7T.

CONCLUSION: Unpleasant sensations such as vertigo were experienced at 7T especially when the table is moving, but were infrequent and weak, when compared with the previous studies, presumably do to the slow table-feed speed, indicating that the degree of subjective discomforts at 7T is tolerable and may be acceptable in the usage of the clinical practice.

REFERENCES: [1] Theysohn JM, et al. *MAGMA* 2008;21:63-72. [2] Heilmaier C, et al. *Bioelectromagnetics* 2011;32:610-619. [3] Versluis MJ, et al. *JMRI* 2012;38:722-725.

Table 1 Mean scores of various sensations experienced during the table movement (first number) and stationary position (second number).

	Present study (n = 504)	Heilmaier, et al.[2] (n = 573)
Vertigo	1.25/0.58**	2.2/0.5*
Curving to left or right	1.36/0.39**	n.a.
Metallic taste	0.06/0.04	0.4/0.3
Nausea	0.06/0.07	0.5/0.3
Sweating	0.13/0.42**	0.4/0.4
Headache	0.11/0.29**	0.5/0.6
Fear	0.44/0.34	0.4/0.4
Light flashes	0.06/0.05	0.3/0.2
Tachycardia	0.35/0.32	0.4/0.3
Feeling of unreality	0.31/0.32	0.3/0.3

* $p < 0.05$, ** $p < 0.001$; n.a., not applicable.

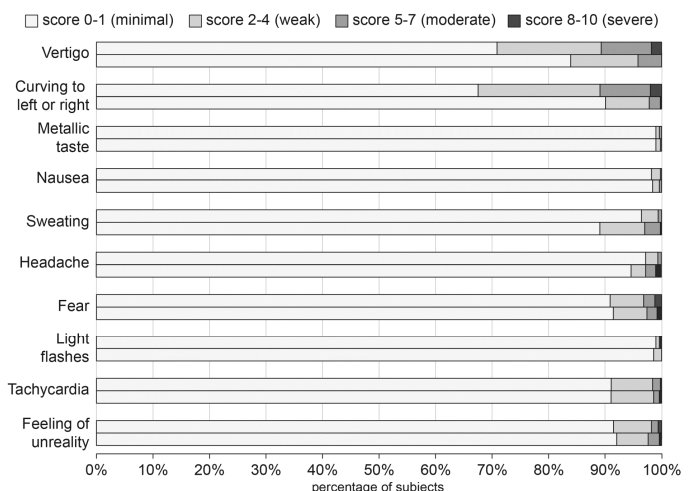


Figure 1 Scores of sensations experienced during the table movement (upper bar) and stationary position (lower bar) at 7T.