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Short communication

Occupational exposure to MRI-related magnetic stray fields and sleep quality among MRI – Technicians - A cross-sectional study in the Netherlands

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ABSTRACT

We investigated the association between occupational exposure to MRI-related magnetic stray fields with sleep quality in a cross-sectional study among 490 imaging technicians in the Netherlands. Imaging technicians filled in questionnaires about MRI exposure, lifestyle, work practices and sleep quality and quantity (Medical Outcomes Study sleep scale). Of six sleep domains, exposure to MRI-related magnetic stray fields appeared to be associated with increased sleep disturbance (OR 1.93, 95% CI 1.00–3.70) and non-optimal sleep duration (OR 1.95, 95% CI 1.11–3.44). Given earlier findings of possible increased accident risks among exposed imaging technicians, these findings merit follow-up.

1. Introduction

Magnetic Resonance Imaging (MRI) has seen a steep increase in the number of MRI units, number of scanning procedures, and in scanner field strength over the past decades (OECD health statistics database (OECD.Stat), 2020; Schaap et al., 2013). This has led to an increase in occupational exposure to MRI-related magnetic stray fields, with increases in the number of exposed staff and increased exposure levels (Schaap et al., 2013, 2016). Occupational exposure to MRI-related magnetic fields has been related to acute symptoms such as vertigo, and neurocognitive effects (Van Nierop et al., 2015; Schaap et al., 2014). Few studies have investigated potential long-term effects of occupational exposure to MRI-related magnetic fields, but increased risks of commuting accidents was observed among MRI system testers and technicians who were exposed to the magnetic stray fields of MRI scanners (Bongers et al., 2016; Huss et al., 2017). In addition, sleeping disorders and tiredness were frequently reported among personnel who worked with or near MRI scanners (Zanotti et al., 2015). The objective of our analysis was to investigate the association between exposure to MRI-related magnetic stray fields and sleep quality in imaging technicians in The Netherlands.

2. Methods

In 2013, members of the Dutch Association of Medical Imaging and Radiotherapy (Nederlandse Vereniging Medische Beeldvorming en Radiotherapie, NVMBR) who worked in the field of Medical Imaging were invited to fill in an online questionnaire. The questionnaire inquired about lifestyle, work practices and health, including sleep quality and quantity. Of the 1637 invited imaging technicians, 490 filled in the questionnaire (response rate 30%).

We used proxies to assess occupational exposure to MRI-related magnetic stray fields: we asked participants if they had worked in an MRI-scanner room in the past 12 months or past 4 weeks prior to the survey. We also asked on how many days they had worked in an MRI-scanner room during the past 4 weeks. Furthermore, we tried to disentangle possible exposure to switched gradient stray fields and radiofrequency pulses (RF) from exposure to only static magnetic fields (SF) and time-varying magnetic fields (TvMF), by asking if the participants had been present in an MRI-scanner room during actual image acquisition in the 12 months and 4 weeks prior to the survey.

The 12-item Medical Outcomes Study sleep scale was used to assess the sleep quality in the four weeks prior to the survey (Hays and Stewart, 1992). Sleep items were scored and grouped according to the manual. This resulted in the following sleep domains: 1) sleep disturbance (ability to fall asleep and maintain restful sleep), 2) somnolence

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(daytime drowsiness or sleepiness), 3) sleep adequacy (sufficiency of sleep in terms of wakefulness), 4) snoring, 5) non-optimal sleep duration (non-optimal amount of sleep) and 6) respiratory problems (shortness of breath). The overall sleep problem index II was created by grouping the items from sleep disturbance, sleep adequacy and somnolence domains (Hays and Stewart, 1992).

We used linear regression to study associations between exposure proxies and the overall sleep problem score. Logistic regression was used for the six sleep domains by dichotomizing these domains into 'less affected' and 'more affected' sleep because data were not normally distributed. For sleep domains: sleep disturbance, somnolence, sleep adequacy, snoring and respiratory problems, the 75th percentile was used as the cut-off point to categorize participants as having less or more affected sleep. The 75th percentile was chosen *a priori* to identify stronger affected persons while retaining enough statistical power for the analysis. We grouped participants as having non-optimal sleep duration if they slept, on average, less than 7 h or more than 8 h a day in the past 4 weeks (Hays and Stewart, 1992) and additionally evaluated the group <7 vs 7–8 h as well as >8 vs 7–8 h, so excluding the respective other group from the analysis. We adjusted for *a priori* selected confounders age, sex, current smoking- and alcohol consumption status, current medication use, ever used sleep medication in the past 4 weeks, work-related stress in the past 4 weeks (in tertiles), working on evening- and night shifts in the past 4 weeks (using medians as cut-offs, with categories 0, 1–2, 3–12 evening shifts; 0, 1–2, 3–8 night shifts), and body-mass index categories.

3. Results

Characteristics of participants enrolled in this study can be found in Table 1. The study population consisted of 381 women (78%) and 109 men (22%), the average age was 44 years. Of the 490 participants, 216 (44%) reported entering an MRI room in the past 4 weeks and 62 (13%) reported to be present during image acquisition. Adjusted risk estimates did not indicate associations between MRI-related magnetic stray field exposures and the sleep problem summary (sleep problem index II), somnolence, adequacy of sleep, snoring or respiratory problems (Table 2).

We observed increased sleep disturbance among participants who were present in an MRI room during image acquisition in the past 4 weeks (OR 1.93, 95% CI 1.00–3.70). More non-optimal sleep duration was observed among participants who entered an MRI room more often (7–20 days) in the past 4 weeks (OR 1.95, 95% CI 1.11–3.44) than who entered the MRI room sometimes (1–6 days). Most participants with non-optimal sleep duration (n = 108) reported sleeping <7 h (n = 93, 86%). Removing 15 participants reporting to sleep >8 h from the analysis resulted in an adjusted OR of 1.92 (95%CI 1.04–3.51). Reversely, removing participants sleeping <7 h resulted in an OR of 2.33 (95%CI 0.62–8.82). Adjusting for potential confounding had no material effect on the risk estimates.

Table 1
Characteristics of study population.

	Unexposed to MRI-related stray fields[a]	Past exposure to MRI-related stray fields[a]	Recent exposure to MRI-related stray fields[a]	P[b]
Age (in years) [a]	46.58 (9.9)	42.24 (11.4)	42.56 (10.6)	<0.001
Sex				0.519
Female	186 (79.8)	30 (73.2)	165 (76.4)	
Male	47 (20.2)	11 (26.8)	51 (23.6)	
Smoking status				0.314
Never	151 (64.8)	32 (78.0)	154 (71.3)	
Former	65 (27.9)	8 (19.5)	52 (24.1)	
Current	17 (7.3)	1 (2.4)	10 (4.6)	
Alcohol use				0.835
Never	55 (23.6)	8 (19.5)	46 (21.3)	
Former	10 (4.3)	1 (2.4)	12 (5.6)	
Current	168 (72.1)	32 (78.0)	158 (73.1)	
Medication use[c]				0.322
No	136 (58.6)	25 (61.0)	125 (58.1)	
Yes	39 (16.8)	9 (22.0)	50 (23.2)	
Past 4 weeks	57 (24.6)	7 (17.1)	40 (18.6)	
Sleep medication use				0.854
No	216 (92.7)	39 (95.1)	201 (93.1)	
Yes	17 (7.3)	2 (4.9)	15 (6.9)	
Work-related stress				0.098
Low	91 (39.1)	20 (48.8)	64 (29.6)	
Medium	75 (32.2)	12 (29.3)	83 (38.4)	
High	67 (28.8)	9 (22.0)	69 (31.9)	
Evening shifts				<0.001
0 days	119 (51.1)	24 (58.5)	62 (61.6)	
1–2 days	74 (31.8)	9 (22.0)	75 (24.1)	
3–12 days	40 (17.2)	8 (19.5)	79 (14.4)	
Night shifts				0.125
0 days	161 (69.1)	28 (68.3)	133 (61.6)	
1–2 days	53 (22.7)	6 (14.6)	52 (24.1)	
3–8 days	19 (8.2)	7 (17.1)	31 (14.4)	
BMI				0.344
<25	142 (60.9)	30 (73.2)	144 (66.7)	
25–29.9	68 (29.2)	10 (24.4)	57 (26.4)	
≥30	23 (9.9)	1 (2.4)	15 (6.9)	

[a] All numbers are n (%) with the exception of age, which is shown as mean (SD). Total N = 490.
[b] P values of group differences, based on a one-way ANOVA for age and chi-square tests for the other covariates.
[c] There was missing information on medication use (N = 2).

4. Discussion

In our study, occupational MRI exposure was not associated with (overall) sleep quality and most of the evaluated sleep domains. However, imaging technicians who had worked with or near MRI scanners often (7–20 days) during the four weeks prior to the survey reported more often non-optimal sleep duration. Imaging technicians who were present in an MRI room during image acquisition reported more often sleep disturbance.

To the best of our knowledge, this is the first study that evaluated workers' sleep quality and their association with exposure to MRI-related magnetic stray fields. Strength of our study is the inclusion of information on potential confounders. Limitations pertain to the low response rate (30%). It is possible, although unlikely, that study participants were aware of potential detrimental effects of working with or near MRI scanners on their sleep, but the study was not focusing on sleep quality per se. Also, no previous study has attributed decreased sleep quality to working with or near MRI scanners to date.

Exposure measures were correlated to some degree: 29% of imaging technicians who entered an MRI room in the four weeks prior to the survey also reported being present in an MRI room during image acquisition. Imaging technicians who were present in an MRI room during image acquisition could stand in close proximity to the bore, for example when guiding anxious patients. As a consequence, these imaging technicians could be exposed to switched gradient stray fields, but also have a higher SMF peak exposure. Motion-induced TvMF exposure levels depend on body-velocity and positioning relative to the magnet (Crozier and Liu, 2005). As we did not have information on movement patterns and/or speed of our study participants, we were limited in our ability to make a clear distinction between the different MRI-related exposures. We also have no biological explanation for the possible associations between MRI-related magnetic stray field exposures and affected sleep.

We performed a large number of tests, which could have resulted in observing associations by chance, and results should be seen as hypothesis generating. Future studies could be improved by objectively quantifying workers' exposure and sleep, e.g. with dosimetry and sleep actigraphy. Reduced sleep quality affects health, and given previous

Table 2
Associations between entering an MRI room, presence during image acquisition, scanner strength and the seven sleep domains.[a,b,c,d,e]

	Sleep problem index II	Sleep disturbance	Somnolence	Sleep adequacy	Snoring	Non-optimal sleep duration	Respiratory problems
	β adjusted (95% CI)	OR adjusted (95% CI)	OR adjusted (95% CI)	OR adjusted (95% CI)	OR adjusted (95% CI)	OR adjusted (95% CI)	OR adjusted (95% CI)
Unexposed	referent	referent	referent	referent	referent	referent	referent
Entered MRI room past 12 months, not past 4 weeks	1.61 (−2.50–5.72)	1.35 (0.56–3.03)	1.52 (0.66–3.33)	0.71 (0.26–1.69)	0.41 (0.06–1.56)	2.14 (0.94–4.69)	0.76 (0.21–2.14)
Entered MRI room past 4 weeks	0.61 (−1.76–2.99)	1.23 (0.76–1.98)	1.11 (0.68–1.80)	1.17 (0.73–1.88)	1.44 (0.79–2.63)	1.28 (0.78–2.10)	0.89 (0.48–1.64)
Unexposed	referent	referent	referent	referent	referent	referent	referent
Entered MRI room past 12 months, not past 4 weeks	1.62 (−2.50–5.73)	1.35 (0.56–3.05)	1.52 (0.66–3.34)	0.71 (0.26–1.69)	0.41 (0.06–1.57)	2.14 (0.94–4.69)	0.76 (0.21–2.14)
Entered MRI room past 4 weeks, 1–6 days	1.28 (−1.65–4.20)	1.52 (0.85–2.69)	1.25 (0.69–2.25)	1.15 (0.64–2.04)	1.69 (0.80–3.49)	0.68 (0.33–1.34)	0.91 (0.42–1.90)
Entered MRI room past 4 weeks, 7–20 days	−0.01 (−2.87–2.85)	1.00 (0.55–1.77)	0.98 (0.54–1.76)	1.19 (0.68–2.07)	1.25 (0.59–2.55)	**1.95 (1.11–3.44)**	0.86 (0.39–1.80)
Unexposed	referent	referent	referent	referent	referent	referent	referent
Entered MRI room past 12 months (no acquisition)	−0.01 (−4.54–4.52)	0.94 (0.32–2.41)	1.21 (0.46–2.91)	0.79 (0.27–2.02)	0.60 (0.09–2.37)	2.37 (0.96–5.59)	0.67 (0.15–2.13)
Entered MRI room past 4 weeks (no acquisition)	−0.58 (−3.55–2.38)	0.90 (0.48–1.67)	0.81 (0.42–1.53)	1.59 (0.90–2.80)	1.11 (0.49–2.40)	0.86 (0.43–1.65)	0.58 (0.23–1.32)
Presence during acquisition past 12 months, not past 4 weeks	1.78 (−1.75–5.31)	1.34 (0.67–2.63)	1.52 (0.76–2.97)	0.68 (0.31–1.42)	1.30 (0.51–3.07)	1.72 (0.85–3.40)	1.49 (0.64–3.27)
Presence during acquisition past 4 weeks	2.32 (−1.18–5.82)	**1.93 (1.00–3.70)**	1.43 (0.70–2.81)	1.02 (0.50–2.01)	1.70 (0.72–3.82)	1.60 (0.78–3.20)	0.86 (0.30–2.14)

[a] Adjusted for age, sex, current smoking- and alcohol consumption status, medication use, sleep medication use, (work-related) stress, evening- and night shifts, and BMI.
[b] Non-optimal sleep duration = on average < 7 h or >8 h of daily sleep in the past 4 weeks.
[c] Sleep problem index II = overall sleep problem summary.
[d] No acquisition = not present during image acquisition.
[e] Increased odds ratios indicate decreased sleep quality.

reports of increased risks of commuting accidents when working with or near MRI scanners, the observation merits follow-up.

Contributors

HK conceived of the study. EÖ analysed data and drafted a first version of the manuscript. KS was responsible for the data collection. All authors were involved in interpretation of the data and provided input in the consecutive iterations of the manuscript. All authors read and approved of the final version of the manuscript. AH is the guarantor for this work.

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Ethics board

The ethics committee of the University Medical Centre Utrecht declared that ethical approval was not necessary for this survey (protocol number 13–066/C).

Declaration of competing interest

All authors declare that they have no conflicts of interest.

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