

Subjective symptoms in Magnetic Resonance Imaging operators: prevalence, short-term evolution and possible related factors

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KEY WORDS

Electromagnetic fields; short-term symptoms; occupational stress

PAROLE CHIAVE

Campi elettromagnetici; effetti sulla salute; stress lavoro correlato

SUMMARY

Background: *The number of Magnetic Resonance Imaging (MRI) operators is rapidly increasing. In these workers, a high prevalence of certain subjective symptoms has been described but until now scant research is available on this topic.* **Objectives:** *To assess the prevalence and the evolution of symptoms over time in a group of operators recently engaged in MRI, also considering the possible role played by factors such as age, gender and occupational stress.* **Methods:** *In 17 physicians exclusively engaged in MRI - 6 working with 1.5 T scanners only and 11 with both 1.5 and 3T - subjective symptoms were evaluated at the beginning of MRI activity and after 2 months by using an ad hoc questionnaire. The questionnaire also included items on occupational stress.* **Results:** *At the start of MRI activity, 81% of the subjects reported at least one of the investigated symptoms; after 2 months, 85% of the symptomatic operators reported the regression of one or more symptoms. In operators with high exposure (1.5 and 3 T scanners), the mean number of symptoms tended to be higher compared with those with lower exposure (1.5 T only), and the reduction after 2 months was significantly greater. In the whole group, occupational stress was significantly correlated with the total number of symptoms and to some of the symptoms more specifically. As stress did not differ between highly- and lowly- exposed, there is no reason to assume an influence on the observed differences in the prevalence and reduction of symptoms.* **Conclusions:** *Our data suggest that MRI operators may experience various symptoms at the beginning of activity, rapidly reversible in a few weeks. The trend over longer periods deserves further study. Occupational stress may play a role in symptoms. The duration of previous MRI work (particularly short-term) as well as work-related stress should be adequately addressed in future studies on subjective symptoms in operators.*

RIASSUNTO

«*Sintomatologia soggettiva in operatori di Risonanza Magnetica: prevalenza ed andamento a breve termine e possibili fattori correlati*». **Introduzione:** *Il numero di operatori addetti alla Risonanza Magnetica (RM) sta rapidamente aumentando. In questi lavoratori un aumento della prevalenza di alcuni sintomi è stato segnalato ma*

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ad oggi pochi dati sono disponibili su questa tematica. **Obiettivi:** Valutare la prevalenza e l'evoluzione dei sintomi in un gruppo di operatori recentemente assunti in RM considerando anche il possibile ruolo di fattori come: età, genere e stress lavoro correlato. **Metodi:** Sono stati valutati i sintomi soggettivi in 17 medici addetti esclusivamente a RM, 6 impegnati esclusivamente in attività con scanner da 1.5 T, gli altri 11 anche con macchinari da 3 T. I sintomi soggettivi sono stati valutati all'inizio dell'attività di RM e dopo 2 mesi mediante un questionario ad hoc che comprendeva anche alcune domande riguardanti lo stress lavoro correlato. **Risultati:** All'inizio dell'attività in RM, 81% dei soggetti riferivano almeno uno dei sintomi indagati. Dopo 2 mesi l'85% degli operatori sintomatici aveva riferito la regressione di uno o più sintomi. Negli operatori esposti anche a 3 T il numero medio di sintomi tendeva ad essere maggiore rispetto a quelli esposti solo a 1.5 T e anche la loro riduzione dopo 2 mesi era significativamente più grande. Lo stress è risultato significativamente correlato con alcuni sintomi specifici e col numero totale di sintomi. Dal momento che la valutazione dello stress non differiva tra questi due gruppi, non ci sono motivi per ritenere che questo abbia potuto incidere sulle differenze osservate. **Conclusioni:** I nostri dati suggeriscono che gli operatori possano riferire alcuni sintomi all'inizio della loro attività in RM, la maggior parte dei quali reversibili però in poche settimane. L'eventuale sviluppo di questi per periodi più lunghi merita ulteriori approfondimenti. Lo stress lavoro correlato potrebbe essere implicato nella comparsa dei sintomi. La durata della precedente attività in RM (specialmente a breve termine), così come l'influenza dello stress lavoro correlato, necessita di essere adeguatamente valutata in studi futuri.

INTRODUCTION

Magnetic Resonance Imaging (MRI) is a rapidly expanding technology (5). Operators working with MRI scanners are exposed to high levels of static magnetic fields (SMF), as well as time-varying magnetic field (TVMF), while moving through the non-uniform static magnetic field that surrounds the scanner (7). The number of operators exposed to MRI-related electromagnetic fields is increasing rapidly. In a recent study, Schaap et al. estimated about 7,000 workers in the Netherlands (6). In Italy, no reliable data are currently available, but a number exceeding 25,000 can be estimated.

In these workers, an increased prevalence of general symptoms such as headache, concentration problems, tiredness or sleepiness, as well as 'sensory' symptoms such as a sensation of dizziness or vertigo, feelings of instability and nausea were reported (10). Most of these symptoms were non-specific, while some – e.g., magnetophosphenes and metal taste – were considered specific and related to MRI magnetic field (9). All symptoms are currently considered transitory (2, 8). The influence of work-related stress on the prevalence of these disorders is disputed (2, 10).

The problem is that, until now, scant research is available on this topic, different methods were ap-

plied, and results are not easily comparable. Furthermore, no data are currently available on the evolution of symptoms over time.

For these reasons we studied the prevalence and the evolution of symptoms over time in a group of operators engaged for the first time in MRI, also considering the possible role played by a number of occupational stress factors.

METHODS

Seventeen residents in Radiology and Medical Imaging (9 males and 8 females, mean age 32.9 years -3.7 SD-) were included in the study. As MRI is part of their curriculum, all participants spent 1 year working every day exclusively in MRI rooms; none of them was engaged in night shifts. Six of the subjects (3 males and 3 females, mean age 33.2 years -3.1 SD-) were working only with 1.5 Tesla (T) MRI scanners, while the other 11 (6 males and 5 females, mean age 32.8 years -4.2 SD-) were working with either 1.5 T or 3 T MRI systems; the difference in gender and age between these groups was not significant. During the whole period considered, in none of the cases was there any need to induce anesthesia in the patients, so no exposure to anes-

Table 1 - Main features of the examined subjects

| | Number | Gender | Age (Mean±SD) | MRI activity months (Mean±SD) |
|--------------------------|--------|----------|------------------|----------------------------------|
| Total | 17 | 9 M, 8 F | 32.9±3.7 | (8.8±3.6 SD) |
| Working only with 1.5T | 6 | 3 M, 3 F | 33.2±3.1 | / |
| Working with 1.5T and 3T | 11 | 6 M, 5 F | 32.8±4.2 | / |

thetics occurred in the residents under study. Table 1 describes the main features of the subjects.

In each subject, the occurrence of symptoms at the beginning of MRI activity was studied by one of the authors (G.Z.), using a specific questionnaire based on previous literature and individually administered (10). More specifically, the investigated symptoms were dizziness or vertigo, nausea, tinnitus or ringing in the ears, metal taste, magnetophosphenes, headache, tiredness or sleepiness, concentration problems, feeling of instability, memory loss and sleep disorders (10). The possible occurrence of other symptoms was also considered: an open question on the presence of any other symptom experienced during the period of work with MRI was included in the questionnaire. Nobody refused to answer the questionnaire.

In subjects reporting the occurrence of symptoms, subjective relationship with MRI activity was explored, along with the time of appearance of symptoms after entering the scanning room/disappearance after leaving.

Subjects were required to report the frequency of symptoms, which was classified as “never” “less than once a week”, “at least once a week”, “daily”. Furthermore, they were instructed to report whether symptoms were subjectively related to MRI activity.

Only symptoms appearing “at least once a week” and “daily” were considered relevant to this part of the study and used for further analysis. In contrast, symptoms appearing less frequently were discarded as occasional.

Diseases or use of ototoxic drugs possibly causing the investigated symptoms, such as benign paroxysmal positional vertigo (BPPV), migrainous vertigo (vestibular migraine), Meniere’s disease, vestibular neuritis, vertebrobasilar insufficiency, cerebellar

problems, inner or middle ear surgery and other ear diseases – congenital or acquired – were screened and excluded in the examined group.

To analyse the possible role of work-related stress on symptoms, 6 questions related to job interest, work adaptability, help from colleagues, personal health status perception, excessive workload and subjective stress level were also included in the questionnaire. The subjects gave an evaluation on a 4-point scale. The sum of the results of the scale was calculated (values ranging 6-24) to obtain a subjective “occupational stress score” (OSS). The OSS was then related to the results of the questionnaire on symptoms to evaluate a possible relationship.

Based on some preliminary observations suggesting a progressive reduction of symptoms after a few weeks of work with MRI scanners, we re-evaluated the prevalence of symptoms in the same operators after two months of work, by using the same questionnaire.

The sample of 17 physicians presented here is part of a larger multicenter study performed throughout Italy on various health care workers including medical doctors, technicians, nurses and researchers. Due to the peculiarity of this group composed only of physicians recently engaged for the first time and exclusively in MRI, the incidence and the short-term evolution of the symptoms, the results are presented separately for the sake of clarity.

Statistical analysis

All data were analysed using the statistical software SPSS 16 package (Statistical Package for the Social Sciences).

A Friedman rank test was carried out to analyse the differences between the prevalence of each symptom and the mean number in these physicians

exposed to MRI at the beginning of their activity and after two months.

A P-value less than 0.05 was considered statistically significant.

Student's t-test was used to compare the values of the "occupational stress score" between operators working with 1.5 T scanners only and operators working with 1.5 T and 3 T.

A multiple linear regression model was applied to evaluate the relationship between the total number of symptoms, the prevalence of each of the symptoms and the values of the OSS.

RESULTS

Thirteen physicians out of 17 (81%) reported the occurrence of at least one of the investigated symptoms in the first weeks. The mean number of symptoms was 2.5 (1.71 SD). The most frequently reported were tiredness or sleepiness, headache and concentration problems. In our group, no operators reported 2 symptoms usually considered typical in MRI workers, such as magnetophosphenes or metallic taste.

Among the considered symptoms, headache and tiredness or sleepiness were the most frequently deemed subjectively related to activity in MRI rooms; respectively 6 (46.1%) and 5 (38.5%) of the operators specifically referred the symptoms to occupational activity. In the vast majority of the 13 operators (92%), however, at least one of the symptoms was subjectively attributed to MRI activity.

All subjects reported the appearance of the symptoms within 15 minutes after entering the scanning room, and regression within 30 minutes of the end of work in the scanner area.

The prevalence of symptoms was compared between the 6 operators working with 1.5 T scanners only (low exposure) and those working with both 1.5 T and 3 T (high exposure). The former had a slightly lower number of symptoms: 1.8 (1.9 SD) as opposed to 2 (1.9 SD) in the latter, even if the difference was not significant (p=n.s.).

After two months of work with MRI, 11 out of the 13 symptomatic operators (85%) reported a regression of one or more symptoms and the mean

number of symptoms in subjects working with 1.5 T scanners dropped from 1.8 to 0.67, while that in 1.5 and 3 T operators decreased from 2 to 0.82. In the latter group but not in operators with low exposure, the reduction of the mean number of symptoms was statistically significant at Friedman's Test (p=0.005) (table 2).

Considering the specific symptoms, a greater reduction occurred in the most frequent, i.e. tiredness or sleepiness, headache and concentration problems. The difference was significant for tiredness or sleepiness and headache (Friedman's Test: p-values respectively 0.025 and 0.014, table 3).

Subsequently, we compared the results of the "occupational stress score" with the complaints reported by the physicians during the first weeks. Accordingly, we applied the multiple linear regression test using age and gender, the total number of

Table 2 - Mean number of symptoms in 1.5 T scanner vs. 1.5 and 3 T scanner operators at beginning and after at least two months. () Standard Deviation. *Differences were considered significant for P<0.05

| | Subjects exposed to 1.5 T | Subjects exposed to 1.5 T and 3 T * |
|---------------------------|---------------------------|-------------------------------------|
| During the first weeks | 1.8 (0.92 SD) | 2 (1.90 SD) |
| After at least two months | 0.67 (0.81 SD) | 0.82 (0.98 SD) |

Table 3 - Prevalence of symptoms at the beginning of activity in MRI rooms and after at least two months. Only symptoms reported at least once a week or more frequently are considered. Number of subjects in brackets. * Differences were considered significant for P<0.05

| Symptoms | During the first weeks | After at least 2 months |
|-----------------------------------|------------------------|-------------------------|
| Sensation of dizziness or vertigo | 12% (2) | 6% (1) |
| Nausea | 6% (1) | 6% (1) |
| Concentration problems | 24% (4) | 18% (3) |
| Tiredness or sleepiness | 59%* (10) | 29%* (5) |
| Headache | 41%* (7) | 6%* (1) |
| Feeling of instability | 12% (2) | 6% (1) |
| Sleep disorders | 6% (1) | 6% (1) |

symptoms and each specific symptom as covariates. The total number of symptoms was significantly related directly to the stress score ($p=0.008$) (table 4); considering the specific symptoms, only tiredness ($p=0.009$) and sleep disorders ($p=0.014$) were related (table 5).

No difference was observed in the results of the occupational stress evaluation between operators working with 1.5 T scanners only as against 1.5 and 3 T scanners. The OSS values were respectively 9.8 ± 1.9 (SD) and 10.4 ± 2.8 ($p>0.05$).

DISCUSSION

We examined a group of physicians engaged for less than 1 year exclusively in MRI during the considered period (i.e. working for most of the day in the MRI room). To the best of our knowledge, no comparable studies are available so far. Six operators were working exclusively with 1.5 T scanners, while 11 worked with both 1.5 T and 3 T. The groups differed neither in terms of age nor in gender. This aspect is of interest, considering that Heinrich et al.

Table 4 - Multiple Linear Regression using Occupational Stress Score as dependent variable and age, gender and total number of symptoms reported as independent variables. Predictors in the Model: (Constant), total number of symptoms. * Differences were considered significant for $P < 0.05$

| Model | Unstandardized Coefficients | | Standardized Coefficients Beta | t | Sig. |
|---------------------------|-----------------------------|------------|-----------------------------------|--------|-------|
| | B | Std. Error | | | |
| (Constant) | 8.602 | .727 | / | 11.839 | .000 |
| Total number of symptoms | .842 | .275 | .620 | 3.064 | *.008 |
| Excluded Variables | | | | / | / |
| Gender | / | | / | -1.139 | .274 |
| Age | / | | / | .866 | .401 |

Table 5 - Multiple Linear Regression using Occupational Stress Score as dependent variable and age, gender and each of the symptoms reported as independent variables. Predictors in the Model: (Constant), tiredness, sleep disorders. Tinnitus and metal taste were automatically excluded from the analysis because nobody had reported them. * Differences were considered significant for $P<0.05$

| Model | Unstandardized Coefficients | | Standardized Coefficients Beta | t | Sig. |
|-----------------------------------|-----------------------------|------------|-----------------------------------|--------|-------|
| | B | Std. Error | | | |
| (Constant) | 8.429 | .637 | / | 13.240 | .000 |
| Tiredness | 2.571 | .849 | .519 | 3.030 | *.009 |
| Sleep disorders | 5.000 | 1.775 | .483 | 2.816 | *.014 |
| Excluded Variables | | | | / | / |
| Gender | / | | / | -.499 | .626 |
| Age | / | | / | .636 | .536 |
| Sensation of dizziness or vertigo | / | | / | -.462 | .651 |
| Nausea | / | | / | 1.289 | .220 |
| Concentration problems | / | | / | .000 | .000 |
| Memory loss | / | | / | / | / |
| Headache | / | | / | .514 | .616 |
| Feeling of instability | / | | / | -.462 | .651 |

(3) detected a difference in symptoms prevalence between males and females.

At the beginning of work with MRI, 81% of the subjects reported at least one of the symptoms. In a study by Wilén et al. (10), in experienced MRI operators the proportion was 92%. In our workers, the specific symptoms most frequently reported were tiredness or sleepiness, headache and concentration problems (table 3). No operator complained of magnetophosphenes or metal taste. However, these symptoms are not usually frequent in operators working with MRI systems up to 3 T (1).

The operators noted the occurrence of symptoms within 15 min of entering the MRI scanning room. Similar results were reported in a previous study (10). In all cases, symptoms disappeared within 30 minutes after the end of work in the MRI room.

What is most interesting in our results and is unreported in previous studies is that the majority of the operators (85%) observed a regression of at least one of the symptoms within 2 months of activity in the MRI room. The mean number of symptoms also diminished, although only in operators with high

exposure (1.5 and 3 T) the difference was statistically significant (Friedman Test=0.005). Apparently, the highest reduction occurred in the symptoms with the highest prevalence at the beginning of MRI work (tiredness, headache and concentration problems) (table 3).

The comparison of our results with previous studies is difficult, since only one study appeared directly comparable, i.e. that by Wilén et al. (10) on 59 Radiology nurses in Sweden, where a similar method to collect symptoms was used, but no data were available on the trend of symptoms over time. The prevalence of symptoms observed in our study and that in Wilén et al. (10) are presented in figure 1: compared to this study, at the beginning of MRI activity, the prevalence of some of the symptoms (tiredness or sleepiness, headache and dizziness, vertigo and possibly concentration problems) was higher in our operators, while at the second evaluation the prevalence of the same symptoms was more homogeneous.

The prevalence of symptoms was related to stress level, as suggested by the significant relationship

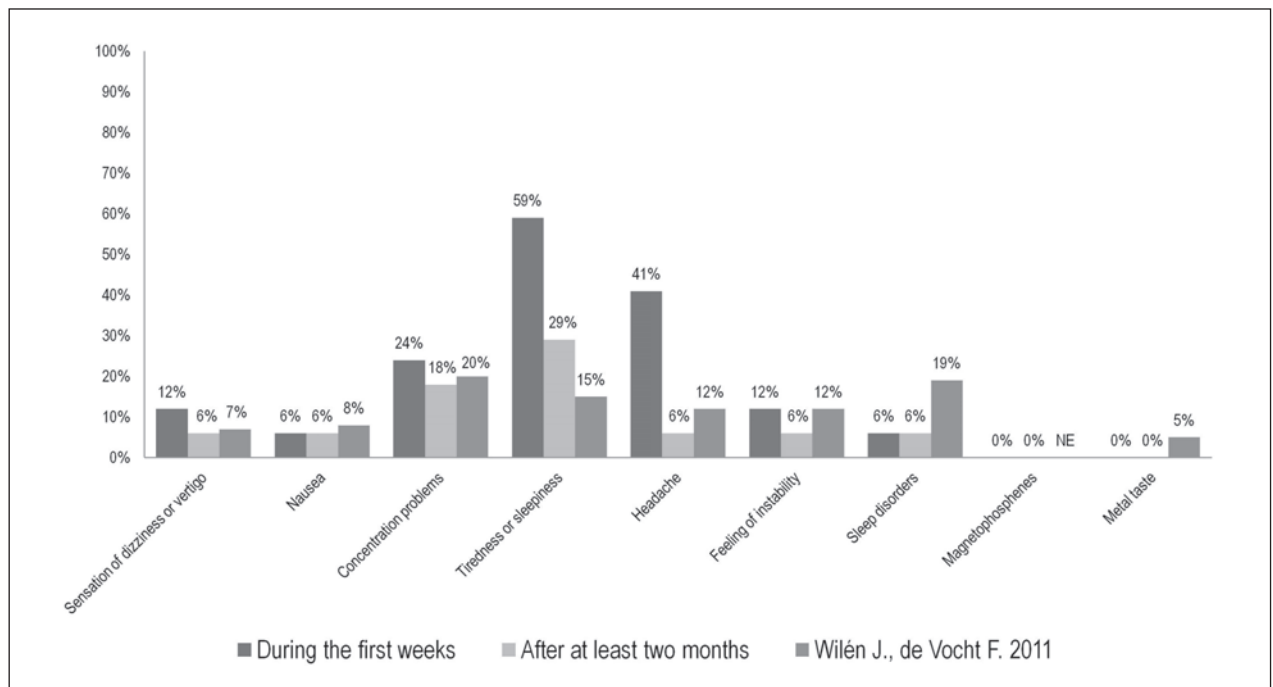


Figure 1 - Prevalence of symptoms observed in MRI operators (during the first weeks/after two months) and by the Swedish study (10). *NE (not evaluated)

found between the values of the “occupational stress score” and both the total number of symptoms and some specific symptoms such as tiredness and sleep disorders. These results are consistent with those recently reported by De Vocht et al (2), whereas Wilén et al. (10) observed no association.

In any case, 1.5 and 1.5-3T operators did not differ with regard to OSS. Accordingly, there is no reason to assume that the prevalence of symptoms observed in these 2 groups and the variation after 2 months were influenced by differences in perceived stress.

Our data indicate a tendency to a higher prevalence of symptoms – however not significant – and to a greater (significant) reduction in workers with high exposure compared to those with low exposure.

Because no differences were observed in the principal factors known to influence symptoms (such as age, gender and stress), the results support the hypothesis that the observed reduction after 2 months is related to an adaptation of operators to the EMF field exposure induced by work in MRI rooms. Nonetheless, no data are currently available to explain the possible mechanisms of such an adaptation.

Some obvious limitations in our study are the relatively small number of subjects included and the fact that no other researchers observed similar results. Furthermore, the potential role of other factors such as noise (4), or indoor pollutants, cannot be totally ruled out. Another aspect worth mentioning is that in our group it was not possible to study the trend of symptoms over longer periods. Arguably, this topic deserves further research.

Accordingly, results need replication in larger groups of operators, possibly including control groups. At the same time, the evaluation of symptoms should be improved, e.g. with repeated collections of the questionnaire over time and by including other contributing factors.

Our results show a high prevalence of subjective symptoms, rapidly reversible at the end of exposure, in newly engaged MRI operators. The data emphasise a tendency to an increase in those working with 1.5 and 3T compared to 1.5T only, and a reduction of the symptoms within 2 months, which was significant in the former group only. Work-related

stress proved related to the prevalence of symptoms but, as stress did not differ between high and low exposure, there is no reason to assume an influence on the differences in symptom prevalence and reduction observed in the two groups. The number of subjects included in this preliminary study is small, and results certainly require further replication and clarification. Nevertheless, the data support a potential role of MRI-related electromagnetic fields exposure in symptom appearance and regression. This suggests the hypothesis of a short-term adaptation, even if the possible mechanism(s) should be elucidated, and the role of other factors such as noise cannot be ruled out. The trend of symptoms over longer periods certainly warrants further study. Notwithstanding the limitations, our data show that duration of previous MRI work (particularly short-term) as well as work-related stress should be adequately addressed in future studies on subjective symptoms in operators.

NO POTENTIAL CONFLICT OF INTEREST RELEVANT TO THIS ARTICLE WAS REPORTED

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