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ORIGINAL ARTICLE

Body mass index as a risk prediction and prevention factor for professional mixed low-intensity EMF burden

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Abstract

The exposure conditions in the physiotherapy are characterized with various sources emitting electromagnetic fields (EMF) in different frequency ranges. Very little is known about the exposure modalities' influence on the operators. In this article, we present the effects of EMF on personnel morbidity profile dependent on the body mass index (BMI) increase. By cross-tabulation, the role of higher BMI on enhancing the EMF vulnerability potential is confirmed. The correlation of the higher BMI with some serious diseases and conditions' development has been evidenced statistically significant. By the whole-studied group, a general tendency for allergy, cardiovascular diseases, sleep disruption and age-shortened menopause, as well as allergy and leiomyoma in the expositional criteria subgroups (ESG), formed for the purposes of this study, is evidenced. The three ESGs are formed on work residence duration in the electrolight therapy section. The first – up to four working hour daily, the second – the entire working day (7 h) and the third group is not residenced in the electrolight therapy section. We hypothesize two signaling ways of interaction of the chronically low-intensity EMF and the higher BMI as the most likely: hormonal – by melatonin levels decrease due to estrogen levels increasing and endocrine – mast-cells auto replication and degranulation stimulation. Based on the results of the study, the BMI increase as an observed control factor in the prediction of the professional risk can be recommended.

Keywords

EMF-BMI causality, mixed low-intensity EMFs, morbidity aggravation, BMI – burden predictor, overweight control

History

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Introduction

In the modern lifestyle, electromagnetic fields (EMF) are a pandemic factor with high biological activity. Its mechanism of interaction with the living structures is hypothesized in different signaling ways – cell, tissue and organism level (Markov, 2011). Mostly, it is dependent on the physical parameters of the field that are as follows: frequency, incident power density duration of exposure, intensity, distance, the constructive and micro/macro climate components of the environment.

On the other hand, the body acceptance and absorption depends on the momentary psychosomatic status. Yet, recognized biological aggravating factors of the EMF burden are body exhaustion, immaturity, pregnancy, hyper-hydration and individual hyper-electrosensibility. The BMI is a popular way of primary metabolic assessment. The simple practical use of the WHO classification often is a reliable means to define the obesity level and the following possible risk of cardiovascular, cerebrovascular, endocrine dysfunctions and/or disorders. In the last 10 years, obesity is one of the scourges of modern society because of the unhealthy food, sedentary lifestyle and stress (WHO factsheets 311). The influence of the body mass index (BMI) as a factor-enhancing body EMF vulnerability and its deleterious effects has been discussed as an exception until now (Levallois et al., 2001) and not to the physiotherapy EMF-exposed/overexposed personnel. Only separate observations such as the underestimation of the field strength decreasing from BMI (Neubauer et al., 2010; Röösli, 2014), or histological description of mast-cells changes in EMF conditions (Berg et al., 1990; Johansson, 2009) could be indirectly referenced.

In the recent research provided in native mixed low-intensity EMFs, professional background, alongside with the specific somatic and neuro-behavioral morbidity profile estimation, we try to elucidate the causal relations, in particular, the BMI interference (Vesselinova, 2013b). So far, the occupational EMF background in physiotherapy is a familiar question with a poorly recognized reflection on personnel health, studied by very few researchers in recent years (Cromie et al., 2001, 2002; Rubtzova et al., 2012; Vesselinova, 2013a).

BMI results analysis

The assessment of BMI impact on the specific morbidity in the physiotherapy professional group was made due to the unstudied, and for this reason, unknown causal relation of

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the features of the electromagnetic exposition background for the development of various morbidity and disturbances by chronically low-intensity variable expositions.

Material and methods

A cohort group of 270 people from 30 physiotherapy facilities from different levels of the National Healthcare System (NHCS) in Bulgaria was studied: multiprofile hospitals for active treatment, diagnostic-consultative centers, specialized hospitals of final and long-term treatment and rehabilitation, the National Hospital of Physical Therapy and Rehabilitation, situated in 5 cities and 10 resorts. An indirect ambispective survey approach with an anonymity option has been preferred. A complex original survey card with 102 questions on the EMF recently recognized and some additional in our own observations targets systems and conditions, e.g. periodontitis, osteoporosis, photosensibilization is created and validated. The results show an interesting dynamic and some very important new tendencies of influence – bone density reduction, circulatory, immune and reproductive system involving, estrogen levels rising (indirectly assessed), stomatological status worsening with periodontitis prevalence (Vesselinova, 2012, 2013a,b), which is highly socially significant.

Statistical methods used

- Parametric – independent samples *T*-test, disperse analysis.
- Non-parametric – Kolmogorov–Smirnov Method, chi-squared test (Fisher's exact test).
- Regress analysis.

Parameters dissection analysis

Demographic

The studied professional subgroups working in the physiotherapies are as follows: physiatrists (physicians with specialty in physical and rehabilitation medicine (PRM)), physiotherapists (academy and professional bachelors), kinesitherapists (academy bachelors or masters) and hospital attendance (with primary and secondary education after a training course for some thermo- and hydro-procedures application) (Figure 1).

By gender: female – 90%, male – 10%.

Professional

The biggest group – 76% is with long-term work experience of >10 years, and is nearly homogenously presented in all professional subgroups (Figure 2).

Factorial and anthropometric

The summary of the results shows that the investigated group is of young age (45.3 years), with long work experience (13.8 years) and in majority residenced in the electrolight therapy sections with EMF emitting sources. The average BMI of the whole-studied group is present in the normal ranges – 24.2, shown in the bottom of Table 1 (bold font).

Daily source contact

Apparatuses emitting various EMFs (including optic radiation) in different frequency ranges and intensities (Table 2) are displaced for providing the prescribed procedure applications in the electrolight therapy section which is a common hall with cabins. This heterogeneous non-ionizing background was precisely analyzed and we define it as the main problem in physiotherapy. The procedure application is performed by physiotherapists whose residence's work place is present in the section. In some complicated cases, PRM physicians (physiatrists) provide the procedure application or supervise it/them but their resident work place is out of the section, so they get intermittently in the close and the intermediate zone of the emitted EMFs in the section.

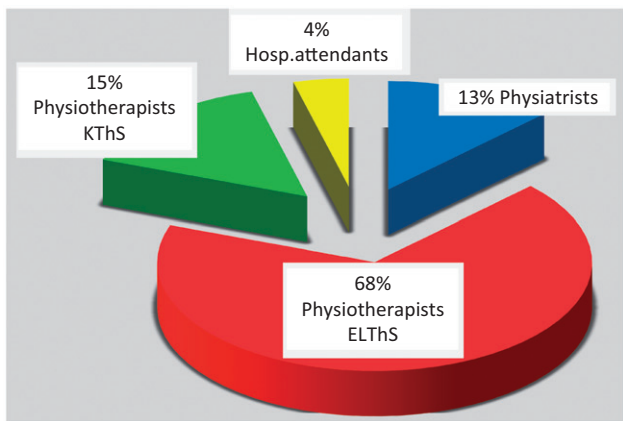
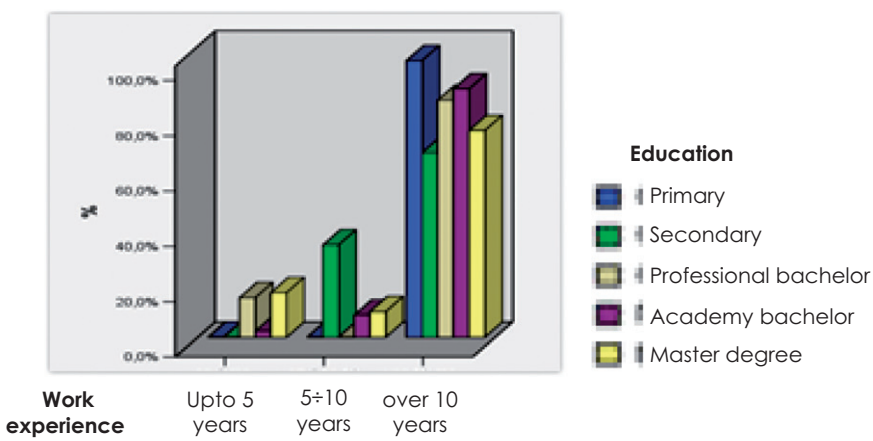


Figure 2. Professional subgroups.

Figure 1. Distribution of the personnel by work experience and education.



Expositional criteria

The physiotherapy wards studied are highly case-load burdened (69%) as an indirect index of exposition overload (we define the point of many >50 provided procedures per day). By the residence in the EMF, exposition background of the personnel is divided into three subgroups.

Detailed information

I EG constitutes 19% from the personnel working intermittently in the ELThS – physiatrists, hospital attendances
II EG constitutes 58% from the personnel–residential working in the ELThS (physiotherapists)
III EG 0 working hours (wh) in the ELThS – 23%, its working sections are without electrical physiotherapeutic factor – kinesitherapists, physiotherapists.

Group morbidity profile

Our results of group general morbidity profile are presented in Figure 3:

> The dispersion of the morbidity among the expositional criteria subgroups (ESGs) clearly shows the enhanced morbidity risk in the II ESG – 15 consequential signs (79%) from the studied 19. For the I ESG, they are 9 (47%) and for the III ESG, they are only 2 (10%) (Vesselinova, 2013b).

Table 1. Average values of some factorial and anthropometric indices.

Index	Abs. No	Average
Age (years)	263	45.3 (22–71)
Work experience extension	256	13.8
Work extension in EMF background (h)	203	5.8 (1–8)
Absence from work (months)	48	15.7 (2–48)
Annual leave (days)	240	35 (12–48)
High (cm)	236	**165.27 (155–190)**
Weight (kg)	237	**65.71 (48–115)**

Table 2. Medical devices and personnel in contact (%).

√ Magnet	72.25
√ Therapeutic ultrasound	72.25
√ for UV and IR optic light (UV, IR)	68.52
√ for RF, MW therapy	66.67
√ for diathermy	65.87
√ for high-frequency current (D'Arsonval)	51.34
√ for monochromatic light (LASER)	23.22

Body mass index correlations

For the purpose of the study the deviations with a cross-tabulation by ANOVA test with Fisher's exact test for the significant of the physiotherapy group health status were studied. The critical level of significance is $\alpha = 0.05$.

The BMI is one of the nine factorial signs (FS) which we find as most causal related and on this reason have been studied in more detail. The other eight are work experience, age, case-load burden of the of ELThS, predominant RF sources application, daily residence in the ELThS, work with sources in different EMF ranges, rotation absence, external co-factor. The causal searching and the establishments related to the BMI are presented in Tables 3 and 4.

By the parametrical *T*-test (ANOVA), the BMI increase is statistically significant for:

(1) Allergies in the II ESG – $p = 0.005$.
Other FS which is significant for the general group – the predominant RF source work.
(2) Aggravating the uterine myoma development risk for II ESG – $p = 0.022$.
Other FS which show significance for promoting: the long-term work experience of the II ESG, the 1st age group (up to 40 years) of the II ESG and an external co-factor existing.
(3) Hysterectomy as operative resolving an uterine myoma – $p = 0.003$ for I ESG and for the III – $p = 0.005$.
Other FS as a reason of surgical case resolving shown significance as a means of choice in myoma treatment: by work experience in the 2nd (5–10 years) age group of the II ESG and for the 1st (up to 40 years) age group both for I and II ESGs.
(4) Menopause praecox – $p = 0.040$.
Other FS which is significant: work experience for the 2nd group (5–10 years) of the II ESG.
(5) Anxiety in general – $p = 0.034$.
Other FS which shows significance: work experience for the 3rd (over 10 years) group in the II ESG.
(6) Sleep disturbances in the quality – $p = 0.029$.

Figure 3. Group general morbidity profile.

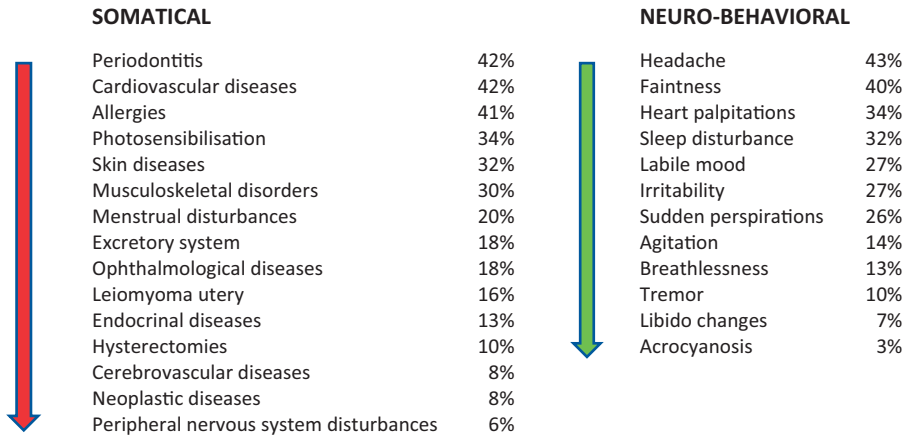


Table 3. Statistical significance of cross-tabulation.

Index	Photo sensibilization	Allergy	Leyomyoma uteri	Menopause praecox	Hysterectomy	Offspring with malformations	Cancerogenesis	Breast cancer	Ovarian cancer
BMI	NS	II ESG $p = 0.005$	II ESG $p = 0.033$	$p = 0.040$	I ESG $p = 0.003$ III ESG $p = 0.005$	NS	NS	NS	NS

Table 4. Statistical significance of cross-tabulation.

Index	Endocrinal disturbances	Cardio-circulatory diseases	Herpes labialis	Misscarriages	Sleep disruption	Libido changes	Agitation	Anxiety
BMI	NS	$p = 0.012$	NS	NS	(3)*$p = 0.029$	NS	NS	$p = 0.034$

Agenda: Sleep disruptions – (1) by falling asleep, (2) in the sleep duration and (3)* in the quality.

Other FS which are significant: case-load burden in the ELThS, predominant work with RF sources and external co-factor existing.

(7) Cardiovasculatory diseases – $p = 0.012$.
Other FS which are significant: by age – for the 2nd (40–50 years) of the I ESG, by caseload burden in the ELThS for both – in general and for the II ESG; by RF sources work prevailing.

This strongly defined palette by the studied index has been shown as significant factorial signs of the work conditions what undoubtedly reveals the causal relation of the BMI with the specific work background and EMF expositions. Thus, the BMI can be treated as a new confirmed EMF burden aggravating fact alongside with the popular fact of cardio-circulatory system risk rising by obesity.

One more detail from the results of our study is supporting other way this statement. The highest BMI in the group is 26.34 which on the WHO classification is a preobese status (which should be treated with attention only by two or more risk factors in addition) and is a moderate risk of the obesity related diseases. So their manifestation in such EMF work conditions is due to the exposure situation.

Per se acute or long-term non-ionizing exposures (ELF EMFs or RFR) at levels below the actual exposure standards, have been defined as a not obvious cardiovascular-related hazard in the summary of such investigations (Jauchem, 1997).

Significance of BMI for the health of the group studied

The evidenced agravation of higher BMI could serve a crucial role in the prevention of allergy, cardiovascular disease and myoma, evidenced by the high enough optimistic ranges proved by the confidence intervals method (confidence 95%) – Table 5.

Discussion

The increasing of the number of mast cells (MC) – so-called unicellular glands in the subcutaneous adipose tissue is the main index of overweight and obesity, respectively, of enhanced BMI. We could relate the convincingly established dependence of the BMI rising and the severity of the bioeffect of the low-intensity various EMFs in present study to the findings of mast-cell histological changes. They are observed in electrohypersensitive people facial skin cells' populations, obtained in very close background conditions. This phenomenon, described as a skin alteration from UV light or ionizing radiation, is known as UVB irradiation induced mast-cell degranulation with TNF-α release (Johansson, 2009). Mast cells (MCs) belong to the innate compartment of the immune system and their role in allergic reactions via IgE receptor binding are widely known (Zierau et al., 2012). In terms of the results obtained in our study, this can be correlated as confirmed in two directions:

Higher BMI and the uncontrolled background conditions (stochastic superposition of various EMF ranges and optical sources in the work area) in the ELThS increased the field absorption aptitude which leads to

Auto replication by the potentiated increasing of the mast-cells number effect of low- and super low-frequency EMFs (Berg et al., 1990; Hilliges et al., 1995).

An interesting finding what could explain the sleep disturbances significance by cases with higher BMI in EMF background conditions us observed is the urinary concentration decrease of excreted main melatonin metabolite 6-sulfatoxymelatonin (6-OHMS). It is cited and discussed in the study by Levallois et al. (2001) of settlements in the vicinity of power lines and is associated with aging, BMI increasing and medication use.

Having in mind that overweight and obese status characterized by expansion of adipose tissue, respectively, mast cells, the interrelations the mastocites and the estrogen levels established in some studies are very important for right explanation the found indirectly estrogen increase by BMI raising in present study (leyomioma, cardiovascular diseases and sleep disturbances) and its role in the allergy reaction substitution. While Kim et al. (2001) was showing the negative feedback between estrogens and mast-cells cytokine production (TNFα and IL 6). Lucan et al. (2013) are associating alterations in rats mainly with the hormonal deprivation due to prior ovarectomy, represented by growth in number of the bladder mast cells, atrophy of the urothelium and amplification of the expression of estrogen receptors-α

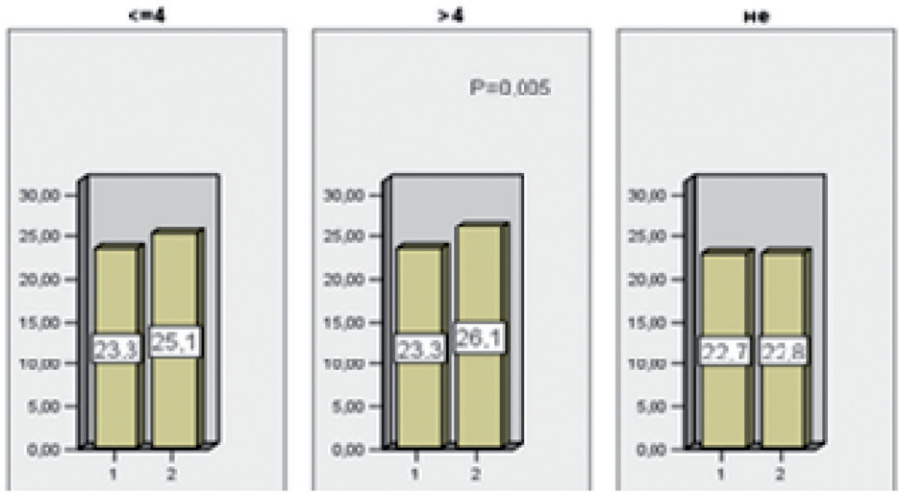


Figure 4. Dependence of the BMI and the allergy aggravations by ESG.

Table 5. Confidence intervals.

	Optimistic (>*p*)	(*p*<) Pessimistic
Cardiovascular diseases (including hypertension, hypotension and dystonia)	35.7	47.5
Allergic manifestations	34.9	46.7
Leiomyoma utery	11.2	20.5

from the urothelium. Other authors, cited in an actual review of the current bibliography, maintain the controversy: mast-cells estrogen activation. In the conclusions of this review, these statements of MC behavior – activation by several factors, including female sex hormones, estradiol and progesterone have been fully accepted (Zierau et al., 2012).

In the point of view of our results, we can assume – endocrine and hormonal ways are in the basis of the relation between various long-term low-intensity EMFs and the higher BMI. The potential mechanisms on such relation are mast-cells number auto replication, mast-cells degranulation, and melatonin level decrease as a consequence of estrogen level enhancement.

The presented data give us reason to conclude that the higher BMI aggravates the individual EMF exposure/overexposure risk. The severity of the expression of some diseases, symptoms and conditions is statistically and biologically confirmed.

Conclusions

BMI is an important indicator of possible EMF overload. Although the group studied has a normal BMI (24.2), our study was the first to our knowledge which evidenced its causation with EMF exposure in physiotherapy to morbidity hazard aggravation by proposed up most likely ways. Personnel with some form of overweight/obesity seems to be more acceptable/vulnerable to EMF. It may consist even when the BMI increase is not exceeding the pre-obese ranges.

The manifestation of diseases and conditions with big social meaning and consequences dependent on BMI is unambiguously statistically confirmed for allergies ($p = 0.010$), cardiovascular diseases ($p = 0.012$), sleep disruptions ($p = 0.029$), leiomyoma ($p = 0.022$) and age-shortened menopause ($p = 0.040$). That, assessed by the aspect of non-ionizing exposures in physiotherapy revealed a side of its mechanisms of interaction and the influence in this process of some individual factors (BMI).

Recommendations

Based on the results, it can be recommended:

- To treat the BMI as an important EMF absorption index.
- To measure the BMI as a marker for professional risk prediction.
- To involve the BMI control in main prevention measures.

The medical personnel with higher BMI have to be on special observation, prevention and prophylaxis. The EMF over-load burden can be avoided such physiological way as BMI control and its health uncertainties, as well as the aggravation of severe diseases can be reduced without additional financial load and administrative efforts.

Declaration of interest

The author reports no conflicts of interest. This study was conducted with the approval of the Ministry of Health Committee for therapy services and ethics and was supported by the President of the Association of Physical and Rehabilitation Medicine, Asst Prof M. Marinkev, MD, and by the Executive Director of the National Complex of the Specialized Hospitals of Rehabilitation Ch. Chalukov, MD. The author alone is responsible for the content and writing of the article.

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