



Research Article

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Effects of ELF-EMF Treatment on Depression

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Abstract

Introduction: Depression is an extremely widespread disorder that is also highly impactful on the quality of life and general health of individuals, on a global scale.

The aim of this study was a preliminary assessment of a potential non-pharmacological treatment, based on extremely low frequency and intensity electromagnetic fields (ELF-EMF), which could potentially reduce the impact of depression on the lives of sufferers.

Materials and methods: A preliminary case-control study based in 2 centres was conducted during the second half of 2020.

The recruited participants were subject either to ELF-EMF treatment (Group α) or to a placebo treatment (Group β) for a total of 5 sessions. Treatment involved non-focused exposure using a radiant mat associated with focused exposure in the cranial area using the same ELF-EMF parameters. Each individual session lasted 36 min and the same ELF-EMF program was used for all 5 therapeutic sessions.

The effects of treatment were evaluated by giving the subjects the following self-administration tests: Zung Self-Rating Depression Scale (SDS), Beck Depression Inventory Scale (BDI), and Short-Form 12 (SF12). The tests were administered before starting the treatment cycle (T0), after the 5 sessions (T1), and at a 2 month follow-up (FU).

Results: Statistical significance indicating an improvement in the depressed state perceived by the participants was achieved with both the SDS and the BDI, at T1 (T1: SDS $_{\alpha}$ 37.8, SDS $_{\beta}$ 46.6, $p = 0.012$; BDI $_{\alpha}$ 8.7, BDI $_{\beta}$ 20.4, $p = 0.004$) and persisting at FU (T1: SDS $_{\alpha}$ 39.1, SDS $_{\beta}$ 49, $p = 0.037$; BDI $_{\alpha}$ 10, BDI $_{\beta}$ 19.9, $p = 0.04$).

As regards SF12, the mental part of the test (MCS12) exhibited a significant improvement at T1 in the treated group compared to the placebo (MCS12 $_{\alpha}$ 47.40, MCS12 $_{\beta}$ 40.48, $p = 0.048$), but this was not confirmed at FU.

During the treatment period there were no drop-outs from the 2 groups and no adverse events were reported in the treatment group.

Conclusions: Treatment with ELF-EMF demonstrated safety and efficacy for reducing the gravity of perceived depressed state.

Introduction

Depression is possibly the most widespread psychiatric disorder in the world, affecting more than 264 million people, according to an online report by the WHO in January 2020 (<https://www.who.int/news-room/fact-sheets/detail/depression>).

Electromagnetic fields are widely used today in psychiatry, based on transcranial magnetic stimulation technology (TMS) [1-3]. This is also applicable in the treatment of depression [4,5].

However, the use of extremely low frequency and intensity electromagnetic fields, so-called ELF-EMF, in psychology and psychiatry has been little studied. These could reduce the risk of undesirable effects associated with the higher intensities administered during TMS.

It is known that depression involves an alteration in serotonin metabolism (5-HT) and of the serotonergic circuits [6-8]. Recent observations have demonstrated how these alterations are strongly linked to inflammation [9], thus defining depression as a systemic disorder.

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It is equally well known that depressed subject's present altered brain electrical activity [10].

Current knowledge of the application of ELF-EMF in biology, though limited, includes a well documented systemic anti-inflammatory effect [11-19]. The effects of ELF-EMF on the 5-HT metabolism [20,21] are also well known. Finally, it has been demonstrated that brain electrical activity can be influenced by the application of ELF-EMF [22], with frequency dependent effects [23].

Starting from this state-of-art, the authors wanted to investigate whether the abovementioned effects of ELF-EMF might have a positive impact on depressed subjects.

Materials and Methods

This double-blind case-control study was carried out at two distinct centres: The *Poliambulatorio* C.F.M. medical physiotherapy centre located in Treviglio (BG, Italy), and an integrated medicine day clinic at the Public Agency for Personal Health Services (APSP, old age home) "Santa Maria", located in Cles (TN, Italy).

Twenty participants were recruited for the study with diagnoses of depression, evaluated on 2 dedicated scales: Zung's Self-Rating Depression Scale (ZSDS), and Beck's Depression Inventory (BDI). In addition to these scales, a more generic self-assessment was included using the SF-12. The scales were measured before start (T0), and at termination (T1), of the treatment cycle, which included 5 sessions. Four weeks after completion of treatment the scales were measured again as a follow-up evaluation (FU).

The 20 subjects were divided equally between the two centres cited above: 10 in Group α (treated) and 10 in Group β (placebo). The results were then analysed statistically applying Student's t-distribution analysis at 95% confidence.

Zung's self-rating depression scale (ZSDS) [24-26]

The ZSDS is a questionnaire designed to assess the quantitative aspects of depression. It comprises 20 items that investigate physiological symptoms and concomitant psychological symptoms of the depressive syndrome. This widely used questionnaire was first published in 1965 and revised in 1974 as an auxiliary instrument in clinical diagnosis, as well as an epidemiological research instrument, and for measuring the efficacy of psychotherapeutic and/or pharmacological treatments.

Beck's depression inventory (BDI) [27-29]

This scale was created to measure the behavioural expression of depression. Its main characteristic is that the quantification criteria are clearly defined for every item: Each level of seriousness has a specific definition, from which patients choose the one best describing their own condition.

SF-12 Quality of life assessment [30-32]

The SF-12 questionnaire is an abridged version of the Short-Form Health Survey 36 (SF-36). It uses 12 of the 36 questions of the original questionnaire to investigate just the 2 summary indices rather than the original 8 scales. The

two indices are the PCS (Physical Component Summary) for physical state, and the MCS (Mental Component Summary) for mental state. The main strong points of this questionnaire are its conciseness and relative ease of use.

SEQEX devices

This study involved the use of a SEQEX[®] device, produced and distributed by the Italian company S.I.S.S.T.E.M.I. Srl (Trento, Italy), certified CSQ ISO-13485. This device implements an analogue mechanism to generate complex electromagnetic fields in a frequency range from 1 to 124 Hz, of variable intensity from 1 to 20 μ T. The field parameters are tested by the manufacturing company using specialized instrumentation: A GM08 Gauss meter produced by the company Hirst.

The electromagnetic fields produced by the control unit of the treatment device (on which the electromagnetic field parameters are set) are administered from a mat containing Helmholtz coils that generate the ELF-EMF. Patients lie on the mat and receive non-focused total-body treatment with weak electromagnetic fields.

This study made use of two device variants, one fully functional and the other modified so that no form of electromagnetic field was emitted. One device was located in each of the two centres taking part in the study (Table 1).

"Time on" represents the period in seconds during which the device effectively emits ELF-EMF. "Time off" represents the period in seconds during which the device does not emit anything. During each step time (indicated as "Total time") the ELF-EMF is administered following the time on/time off cycle.

The ELF-EMF as described in the table was administered to patients simultaneously in two different ways: Using a radiant mat for non-focused total-body treatment, and using a band accessory positioned on each patient's cranium.

Results

ZSDS

The results at T0 for both Group α and Group β were substantially equivalent (average α = 48.6, average β = 48) (Table 2).

At T1, Group α showed a significant reduction in test-score compared to Group β (average α = 37.8, average β = 46.6, p = 0.0121).

At FU, the difference in scores between the two groups remained statistically significant (average α = 39.1, average β = 49, p = 0.0374).

BDI

The results at T0 for both Group α and Group β were substantially equivalent (average α = 21.3, average β = 22) (Table 3).

At T1, Group α showed a significant reduction in test-score compared to Group β (average α = 8.7, average β = 20.4, p = 0.0039).

At FU, the difference in scores between the two groups remained statistically significant (average $\alpha = 10$, average $\beta = 19.9$, $p = 0.0429$).

SF-12

The results at T0 for both Group α and Group β were substantially equivalent (average $\alpha = 41.28$, average $\beta = 41.21$) (Table 4 and Table 5).

At T1, Group α showed a significant increase in test-score compared to Group β (average $\alpha = 47.40$, average $\beta = 40.48$, $p = 0.0486$).

At FU, the difference in scores between the two groups had lost the statistical significance observed at end of treatment (average $\alpha = 42.81$, average $\beta = 41.73$).

Discussion

The effect of ELF-EMF on the central nervous system (CNS) and in particular on the psycho affective component has been widely documented in literature [1-5].

Table 1: The following electromagnetic set-up parameters were used for the present study.

Step	Frequency (Hz)	Intensity (μT)	Time on (sec)	Time off (sec)	Total time (min)
1	10	20	5	2	4
2	11	20	5	2	4
3	12	20	5	2	4
4	10	20	5	2	4
5	11	20	5	2	4
6	12	20	5	2	4
7	10	20	5	2	4
8	11	20	5	2	4
9	12	20	5	2	4

Table 2: The results of the ZSDS questionnaire are reported below, divided by group.

ZSDS		T0	T1	FU
α	P1	39	36	36
	P2	58	37	57
	P3	66	45	56
	P4	50	28	31
	P5	44	33	30
	P6	38	34	26
	P7	46	48	40
	P8	51	46	42
	P9	48	39	46
	P10	46	32	27
β	P1	40	45	43
	P2	55	55	60
	P3	62	60	63
	P4	56	40	44
	P5	38	41	40
	P6	40	34	38
	P7	44	48	50
	P8	51	50	54
	P9	50	47	48
	P10	44	46	50

Table 3: The results of the BDI questionnaire are reported below, divided by group.

BDI		T0	T1	FU
α	P1	41	16	32
	P2	15	3	0
	P3	18	2	4
	P4	19	15	11
	P5	20	7	10
	P6	10	4	0
	P7	34	20	22
	P8	31	3	0
	P9	8	11	13
	P10	17	6	8
β	P1	38	35	33
	P2	20	24	22
	P3	15	12	13
	P4	18	15	11
	P5	23	25	22
	P6	10	7	8
	P7	30	26	32
	P8	39	30	33
	P9	12	10	11
	P10	15	20	14

Table 4: The results of the SF-12 questionnaire are reported below, divided by group, for the two sections PCS12 and MCS12 in turn.

PCS12		T0	T1	FU
α	P1	41.46239	46.78601	49.16947
	P2	46.11789	42.42185	50.72182
	P3	38.62963	46.78136	34.6083
	P4	48.04361	54.82927	54.84756
	P5	35.84375	42.31675	39.7151
	P6	51.07483	43.57383	43.7025
	P7	39.7867	37.82537	46.08084
	P8	35.50401	29.94468	38.54841
	P9	43.48506	45.83761	43.07318
	P10	55.93816	45.91775	47.22844
β	P1	36.47399	39.57486	41.99556
	P2	51.18816	50.69097	45.42115
	P3	47.6555	45.71049	42.61094
	P4	38.80282	38.80282	39.56581
	P5	35.84375	38.21008	37.0226
	P6	48.33926	46.3567	48.39052
	P7	42.52227	43.28526	45.92794
	P8	31.99561	31.78931	32.5523
	P9	37.80582	40.23851	40.95987
	P10	49.74384	47.85478	45.94254

Two independent studies conducted using the same devices as the present study observed a positive effect of non-focused ELF-EMF treatment:

- Betti, et al. [33] verified an absence of adverse effects and concomitant positive response (measured on the BPRS scale) for psychiatric patients.
- Greco and Garoli [23] conducted electroencephalographic analysis of healthy subjects undergoing non-focused ELF-EMF treatment that simulated cerebral frequencies and

Table 5: No significant differences were observed between the two groups for any of the scores (T0, T1, and FU).

MCS12		T0	T1	FU
α	P1	42.46502	40.37163	27.03285
	P2	34.25315	49.81612	30.33617
	P3	38.04454	34.45856	36.09519
	P4	31.33555	46.08507	46.0165
	P5	47.78295	50.03071	47.84809
	P6	45.72286	47.57126	44.36373
	P7	33.43375	44.46482	42.31775
	P8	43.22885	48.8951	45.6412
	P9	55.23103	60.61005	57.19037
	P10	41.31043	51.71104	51.26325
β	P1	43.21023	33.12128	39.89929
	P2	30.50399	29.15824	33.65645
	P3	35.12307	39.89091	38.64582
	P4	34.26042	34.26042	36.88822
	P5	47.78295	48.63252	49.71858
	P6	47.15389	48.4751	49.193
	P7	32.00272	34.63052	29.26379
	P8	44.48064	41.51913	44.20757
	P9	55.60507	52.08508	52.81629
	P10	42.07308	43.01617	43.07238

rhythms, obtaining an initial observation of the adaptive behaviour of the CNS in response to electromagnetic stimulation.

In addition, a study by Greco and Destefani [34] verified the effects of non-focused electromagnetic fields on heart rate variability (and so indirectly on the autonomic nervous system).

Starting from these premises, the present authors adopted a hybrid set-up that combined non-focused total-body treatment, with direct stimulation on the cranium of patients. Both electromagnetic irradiation sources administered the same extremely low frequency and intensity electromagnetic field, as described in the “Materials and Methods”.

The frequencies selected for this trial were based on one of the set-ups used in the study by Greco and Garoli [23], specifically called the “Alpha” set-up.

In this study the authors decided to focus on two specific scales for depression, together with a test specific to quality of life.

The 10 subjects exposed to ELF-EMF treatment (Group α) experienced an objective improvement in depressed state compared to the control (Group β), with an improved outcome on both the ZDS scale (p = 0.0121) and BDI scale (p = 0.0039) at the end of the treatment cycle, with statistically significant scores persisting at FU (ZDS p = 0.0374, BDI p = 0.0429).

The results from the generic SF-12 test were somewhat different. As predicted at T0, the homogeneity of the 2 test groups resulted in the PCS12 component showing no significant variations on the measurement scales. MCS12 instead showed a significant difference in favour of the treatment group at T1 (p = 0.0486), but this was not

confirmed at FU. This final detail does not compromise the results obtained for the two depression specific tests, since the MCS12 is highly generic in nature, causing it to vary (also in a negative sense) for reasons extraneous to the object of study in this paper (for example, a wrist fracture, or a week of flu, can alter an MCS12 score enough to change in outcome, but without influencing other tests so strongly).

Depression is among the diseases that most negatively affect quality of life [35-38], also acting as an unfavourable prognostic factor for cardiac diseases [39-42] and chronic diseases [43-45] if not effectively treated. Consequently, acting to mitigate this disability is a priority for sufferers, therapists, and from the perspective of public health.

Starting from the etiogenesis of depressive disorders [6-10] and the effects of pharmaceuticals like selective serotonin reuptake inhibitors (SSRIs) [46-48] and considering the effects of ELF-EMF studied to date on the 5-HT metabolism [20,21], on the 5-HT receptors (5-HTRs) [49], and brain electrical activity [22,23], the authors propose the following hypothesis for the action of ELF-EMF on depression:

- The combination of focused and non-focused ELF-EMF irradiation stimulates production of 5-HT in the encephalic trunk, a component that plays an important role in the pathophysiology of depression [50].
- The 5-HTRs most likely involved in the antidepressant effect associated with ELF-EMF are the 5HT1 (supporting the previous point) and cortical 5HT2 receptors, with the effect of enhanced receptor density.
- The induction of specific frequency dependent electrical activity [23] within the 10-12Hz range also induces an increase of 5-HT production in the cortex.
- Considering the action on the metabolism of dopamine [20], the involvement of the dopaminergic circuits linked to depression can also not be excluded.
- The effects described in the previous points appear to stabilize after a brief treatment cycle, inducing effects that endure for as long as several weeks. This could be explained with a direct action on the HRV [34], a biomarker for potential response to antidepressant therapy [51].
- The anti-inflammatory and neuroprotective effects of ELF-EMF [52] could further explain the effect, especially with such rapid treatment response times, bearing in mind the pathophysiological gravity of neuroinflammation on the genesis of depression.

Since the administration of ELF-EMF was not focused on a single cranial target, it is difficult to establish the robustness of the above hypotheses. It is possible that multiple phenomena occur in combination, with enhanced induction under specific frequencies and a summation effect.

Conclusions

While the study presented here is conditioned by some obvious limitations (among others, the small number of recruited participants), the authors nevertheless sustain

that the approach presented for the treatment of depressive disorders, in addition to being safe, may prove to be valid both as a stand-alone approach, and as a support for pharmacological antidepressant therapies and psychotherapy within integrated medicine protocols.

The authors are convinced that the hypotheses formulated here deserve further investigation, including an amplification of the breadth of enquiry into the effects of ELF-EMF on the central nervous system.

Statement of Conflict of Interest

Dr. Alessandro Greco declares that he is an external consultant for the company S.I.S.T.E.M.I. srl, acting in the roles of: Medical and scientific director for training professional therapists in the use of the device adopted for the present study, development of new technologies, and researching new therapeutic applications for the technologies applied in the present paper.

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