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Effect of Antioxidants Intake on Oxidative Stress Among Mobile Phone Users

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Abstract

The current study aimed to assess mobile phone usage intensity and evaluate potential oxidative stress exerted among mobile users then evaluate the effect of antioxidants supplement on oxidative stress status. Intervention study done on 150 students using mobile phones from both technical nursing institute and faculty of nursing, Cairo .University. Only (108) students completed to the post intervention phase. Questionnaire and assessment of electromagnetic field exposure from mobile phones was done. Malondialdyde, superoxide dismutase and catalase were measured pre and post supplementation. Mobile phones with two SIM cards, non-android mobiles and mobile phones owned by the medium users group had significant higher electromagnetic emissions. Malondialdyde was significant higher in high mobile users. Significant negative correlation between emissions from mobile phone and superoxide dismutase. After supplementation, significant improvement in superoxide dismutase and Catalase among both groups using mobiles (>5years and <5years), using one or two phones, using one or two SIM cards and in android mobile users. Moreover, Malondialdyde show significant reduction among non-android mobile users**.** It was concluded that exposure to low emissions from mobile phones could be fixed by dietary modification and increase antioxidant intake.

Key words: mobile phones; electromagnetic field; oxidative stress; antioxidants

Introduction

Oxidative stress is disturbance in the balance between the production of reactive oxygen species (ROS) and antioxidant defenses. It has been implicated in various pathological conditions [1].

Antioxidants are any substance that when present at low concentrations compared to that of an oxidizable substrate would significantly delay or prevent oxidation of that substrate. They protect the cells from the hazardous effects of free radicals and control their formation [2]. Superoxide Dismutase (SOD) is an important antioxidative enzyme which can convert superoxide into oxygen (O_2) and hydrogen peroxide (H_2O_2) for maintaining normal physiological conditions [3]. Catalase catalyzes the decomposition of H_2O_2 to O_2 and water (H_2O). H_2O_2 is a by-product of many normal metabolic processes, is a very powerful oxidizing agent and has the ability to destroy all cell components. So, it must be quickly converted into less dangerous substances [4].

Vitamins are organic compounds, which are not a direct source of energy but they act as a catalyst for various biochemical reactions and they facilitate energy metabolism. They can't be synthetized in the body so they must be obtained from diet. The vitamins with antioxidant effect are vitamin E, vitamin C, and β-carotene (pro-vitamin A) [5]. Vitamin C has direct antioxidant effects, as it can react with radicals and terminate their reaction before lipid peroxidation [6]. Vitamin E is the most potent radical-scavenging lipophilic antioxidant. It protects poly unsaturated fatty acids present in cell membrane and low density lipoprotein (LDL) from lipid peroxidation [7]. ß - Carotene is a pro-vitamin as it can be converted to retinol (vitamin A) by dioxygenase enzyme. It is stored in the kidney, liver and adipose tissues [8].

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Supplementation with antioxidants is widespread used aiming for maintenance of good health and prevention of progression of many age related diseases and some neurodegenerative disorders [9]. Sometimes the endogenous antioxidants are insufficient to counteract the harmful effects of free radicals. So, antioxidant supplementation may protect against the development of oxidative stress mediated diseases and maintain optimal body function [10].

The electromagnetic field (EMF) consists of electromagnetic waves, which are transverse oscillating waves of electric and magnetic fields that are perpendicular to each other and perpendicular to the direction of energy. The mobile phone technology is a source of EMF from the mobile phone base stations; and from the telephones themselves [11]. The third generation (3G), operates at frequencies between 1900 and 2200MHz [12]. Fourth generation (4G), provide ultra-broadband wireless internet access; they provide transmission rates up to 20Mb/s [13]. Egypt falls in the 15th place in the countries with the highest number of mobile phone subscriptions [14].

On exposure to EMF emitted from cell phones, the human body absorbs it and that might be associated with several health hazards. The radiofrequency radiations emitted from mobile phones increase free radicals which enhance lipid peroxidation and change the antioxidant activities in human blood, thus leading to oxidative stress which induces harmful effects on human health [15].

Lu et al., [16] reported that exposure to radiofrequency electromagnetic field of 900MHz for duration longer than two hours, induces reactive oxygen species (ROS) formation. Previous study [17] found increased MDA levels in endometrium of rats exposed to mobile phone emitted radiation (900-MHz) and on administration of vitamins E and C; the oxidative stress decreased and vitamins decreased the changes in endometrial tissue. Another study [18] results revealed increase in Malondialdyde (MDA) level, decrease in antioxidant enzymes activity (catalase and glutathione) in the blood of guinea pigs exposed to electromagnetic field emitted from cellular phone. Another authors [19] found in their experimental study that mobile phone electromagnetic waves induced oxidative stress and decreased antioxidant enzymes level. In their study, they found that supplementation with vitamin C and E had a role in reduction of oxidative stress and improvement of antioxidant enzymes. In her study Al-Damegh [20] found that vitamin C and E ameliorate the oxidative stress induced by mobile phone as they have important effects in prevention of lipid peroxidation and restoration of antioxidant enzymes.

The present study aimed to assess mobile phone usage intensity in a group of students and evaluate the potential oxidative stress exerted from such usage. Then give antioxidants supplement (combination of vitamin C and vitamin E) for two months' duration. After that, re-evaluate the effect of supplement on oxidative stress status of the studied population in relation to the intensity and duration of their mobile phone usage.

2. Subjects and methods

2.1. Study design:

Intervention study was done on 150 students aged from 18-22 years using mobile phones. Simple random sample was taken from students from both technical nursing institute and faculty of nursing.

Sample Size: It was planned to take all subjects who agreed to participate in the study. It was about only 25% from the population in faculty of nursing who agreed to participate in the study from total 200 students. While in technical institute (100) students agreed to participate in the study from total (150) students. So, the sample size was (150) student from both places.

- There were drop outs (42 students), so in the post intervention phase the studied group was (108).
- Sampling Type: - Convenient sample
- Exclusion criteria: Smokers, medical conditions (cancer, heart diseases, hypertension, bronchial asthma, chronic renal failure, diabetes mellitus, rheumatoid arthritis) and married females.

The study was approved by the Ethical Committee at Faculty of Nursing, Cairo University, and by the Ethical Committee at National Research Centre NO. (12122).

2.2. Methods:

Study phases:

1. Pre intervention Phase: aimed to
   - Data collection
   - Assessment of electromagnetic field exposure from mobile phones
   - Blood samples collection
2. Intervention Phase: aimed to

   Give the participants antioxidants (C- Retard 500mg and Extra 1000 Sedico) once daily for 2 months.
3. Post intervention Phase: aimed to

   Blood samples collection for re-evaluation of oxidative stress and detect any changes.

2.3. Data Collection:

Questionnaire:

Questionnaire was designed and filled by all participants [Sociodemographic data, medical, oxidative stress questionnaire (Abundant Life Wellness Center Oxidative Stress Questionnaire) and description of mobile phone usage {about the intensity of mobile phone usage, duration of mobile ownership, number of mobiles used by each participant, number of SIM (Subscriber Identification Module) cards within the mobile (single SIM or dual SIM mobile) and the operating system of mobiles}.

2.4. Assessment exposure to electromagnetic field from mobile phones
using non-invasive apparatus (RF-Analyser HF38B).

- ❖ The apparatus was hold by the researcher with a slightly outstretched arm, with hand behind it.
- ❖ Then it was pointed in all directions to establish the main direction of the incoming radiation.
- ❖ The instrument was rotated around its longitudinal axis by up to90°
- ❖ Each student was asked to talk from his mobile phone to assess the radiation emitted from his phone at rest and during ringing by holding the apparatus (by the researcher) in a distance from his mobile phone.

2.5. Blood sample

-Was collected by venipuncture with sterile 5 ml syringe from each subject. Each sample was divided into 2 separate sample tubes, one plain tube (without using an anticoagulant) was left to clot and then centrifuged (at 2000 for 10 minutes) and the separated serum was used for estimation of Oxidative stress (Lipid peroxidation) marker Malondialdyde (MDA). The second heparinized tube was centrifuged to separate the plasma from the erythrocyte. The erythrocyte was washed three times in cold normal saline (0.9% Na Cl). The hemolysate was used for the determination of antioxidant enzymes; superoxide dismutase (SOD) and catalase. Blood samples were kept at room temperature in fridge at temperature (-20°C) until fully examined for evaluation of oxidative stress enzymes.

-From each individual two samples were taken one pre intervention and the other after 2 months from taking antioxidants.

2.6. Laboratory investigations

MDA was estimated in serum by colorimetric end point procedure [21], SOD was estimated in plasma by kinetic procedure [22] and Catalase was estimated in plasma by colorimetric end point procedure [23].

3.<u>Statistical Analysis:</u>

- Data was statistically analysed using the Statistical Package for Social Sciences (SPSS) version 20for statistical analysis.
- Quantitative normally distributed data was analysed using independent t-test (comparison of two independent groups), paired t-test (comparison of two related groups), ANOVA (Analysis of Variance) for (comparison of more than two groups).
- Pearson correlation coefficient test was used to test association between variables.

4. <u>Results:</u>

Intervention study was done on 150 students; 104 (68.6%) of them were males, and 46 (31.4%) were females. With mean age (18.39±0.49 years).

Mean serum levels of the oxidative stress marker (MDA) is (5.9±2.9) U/L and antioxidant enzymes SOD and Catalase is (52.8±23.1) U/L and (685.1±123.5) U/L respectively among the studied group.

Measured parameters (MDA and antioxidant enzymes) did not differ statistically between males and females (P-value >0.05).

Table 1 shows that mobile phones with two SIM cards had statistically significant higher emissions than those with one SIM card (P<0.05). Non-Android mobiles had statistical significant higher emissions than android mobiles (P<0.01). Mobile phones owned by the medium users group showed the highest emission which is significantly difference from the other two groups (P<0.01)

Table (1): Differences in EMF emission levels of mobile phones according to number of SIM cards, mobile operating system, and duration of mobile phone use per day

	EMF emission	P-value
One SIM card No=114 (Mean ±SD)	**11.8±7.4**	**< 0.05***
Two SIM cards No=36 (Mean ±SD)	**15.3±4.6**	
Android No=89 (Mean ±SD)	**8.9±6.2**	**< 0.01****
Non Android No=61(Mean ±SD)	**18.2±3.9**	
(Low users) < 30 minutes No= 24 (Mean ±SD)	**11.1±7.5**	**<0.01****
(Medium users) 30-60 minutes No=47 (Mean ±SD)	**16.1±5.4***	
(High users) >60 minutes No=79 (Mean ±SD)	**11.1±7.1**	

*** P<0.05 (significant), ** P< 0.01 (highly significant)**

Table 2 shows that (MDA) level was statistically significant higher in high mobile users than the other two groups. Also, the antioxidant enzyme (Catalase) showed statistical significant difference in medium mobile users and low mobile users (P-value<0.05). Meanwhile, the antioxidant enzyme (SOD) showed no statistical significant difference in relation to duration of mobile use per day. -There is statistical significant negative correlation between emissions from mobile phone and the level of antioxidant enzyme (SOD) (P<0.01).

Table 3 shows that there is high statistically significant improvement in the level of antioxidant enzymes (SOD and Catalase) after supplementation (P < 0.01) While, the (MDA) level did not show statistical significant improvement (P > 0.05).

Table 4 shows that the (SOD and Catalase) levels show high statitical significant improvement after supplementation among both groups; those owing mobile (1-5 years) and those owing mobile (>5 years), (P< 0.01). Meanwhile, the (MDA) level did not show statistical significant improvement in both groups (P >0.05).

Table 5 shows that there is high statistical significant improvement after supplementation in antioxidant enzymes (SOD and Catalase) serum levels in both groups; owing one mobile phone and those owing two phones (P<0.01). MDA serum level did not show statistical significant improvement in both groups (P>0.05).

Table 6 shows that there is high statistical significant improvement in (SOD and Catalase) levels in both one and dual SIM mobile owners (P <0.01). MDA level shows statistical significant reduction only in dual SIM mobile users (P <0.05). In one SIM mobile users the reduction in (MDA) was not statistically significant (P >0.05).

Table 7 shows that in android mobile users, there is high statistical significant improvement in (SOD and Catalase) levels after supplementation (P <0.01).
While, the (MDA) did not show statistical significant reduction (P >0.05).

In Non-android mobile owners, after supplementation there is statistical significant improvement in (SOD and catalase) serum levels (P <0.01 and P <0.05 respectively). Moreover, (MDA) serum level show statistical significant reduction (P<0.05).

Table (2): Difference in levels of biomarkers in relation to duration of mobile phone use per day

	(Low users) < 30 minutes No= 24 Mean±SD	(Medium users) 30-60 minutes No= 47 Mean±SD	(High users) >60 minutes No=79 Mean±SD	ANOVA	P-value
MDA (U/L)	**5.2±2.6**	**5.2±3.3**	**6.7±2.7[a.]**	**4.5**	**<0.05***
SOD (U/L)	**52.2±24.1**	**49.7±25**	**55.3±21.1**	**0.9**	**>0.05**
Catalase(U/L)	**731.8±103.2**	**652.8±127.8[b.]**	**690±122.6**	**3.5**	**<0.05***

a. The MDA level is significantly higher than the other two groups LSD.

b.The catalase level showed high significant difference between those using mobile phone from (30-60 minutes) per day and those using mobile phone (<30 minutes) LSD.

* P-value< 0.05 (significant), (MDA): Malondialdyde, (SOD) : superoxide dismutase

Table (3): Mean serum levels of biomarkers before and after antioxidant supplementation

	Before supplementation (108) Mean ±SD	After supplementation (108) Mean ±SD	Paired t-test	P-value
MDA (U/L)	**6.1±2.9**	**5.1±4.4**	**1.9**	**>0.05**
SOD (U/L)	**52.8±23.4**	**65.8±26.9**	**6.3**	**<0.01****
Catalase (U/L)	**677.1±121.7**	**799.7±152.4**	**6.5.**	**<0.01****

** P< 0.01 (highly significant) (MDA): Malondialdyde, (SOD) : superoxide dismutase

Figure (1): Mobile phone usage in the studied group

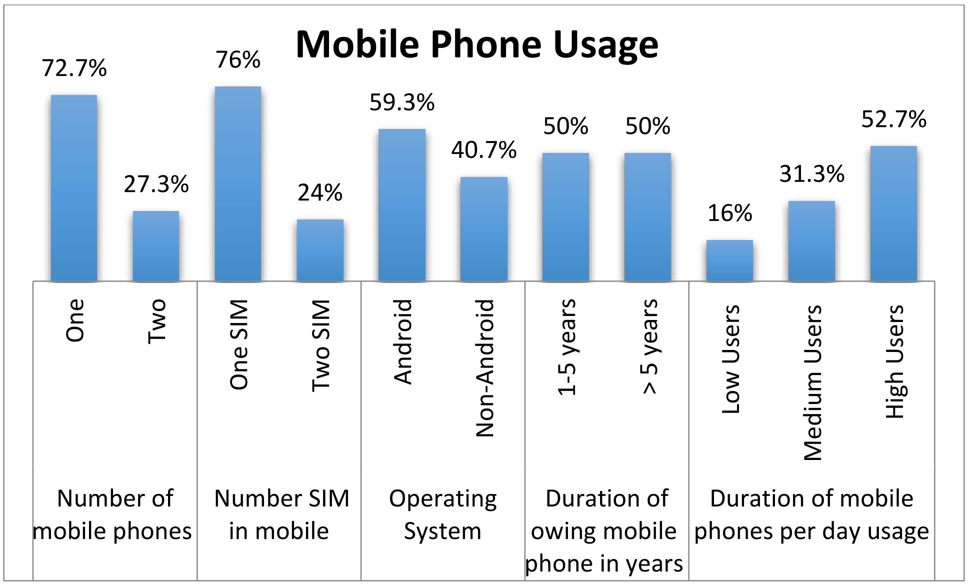

Fig (1): describes the mobile phone usage in the studied group. About (73%) of them owned one mobile phone and (76%) had one SIM (Subscriber Identification Module) card in the phone. For the duration of ownership of the mobile (50%) of the students owned mobile for duration (1-5 years) and for their usage, (52.7%) of them were high mobile users

Table (4): Changes in biomarkers mean serum levels after supplementation according to duration of mobile ownership

	Before supplementation (108) Mean ±SD	After supplementation (108) Mean ±SD	Paired t-test	P-value
Owing Mobile (1-5 years)				
MDA (U/L)	**5.4±2.7**	**4.9±4**	**0.61**	**>0.05**
SOD (U/L)	**55±22.7**	**68.2±22.1**	**4.5**	**<0.01****
Catalase (U/L)	**685.7±121.6**	**786.2±167.7**	**3.4**	**<0.01****
Owing Mobile (>5 years)				
MDA (U/L)	**6.8±2.9**	**5.2±4.7**	**1.9**	**>0.05**
SOD (U/L)	**50.7±23.9**	**63.4±31**	**4.2**	**<0.01****
Catalase (U/L)	**668.4±112.2**	**813.1±135.6**	**6.1**	**<0.01****

** P< 0.01 (highly significant) (MDA): Malondialdyde, (SOD) : superoxide dismutase

Table (5): Changes in biomarkers after supplementation according to number of Phones used

	Before supplementation (108) Mean ±SD	After supplementation (108) Mean ±SD	Paired t-test	P-value
One mobile phone				
MDA (U/L)	**6 ±2.9**	**5.1±4.7**	**1.4**	**>0.05**
SOD (U/L)	**54.9±23.3**	**64.3±28.2**	**4.2**	**<0.01****
Catalase (U/L)	**672.9±108.9**	**782.9±148.9**	**5.1**	**<0.01****
Two mobile phones				
MDA (U/L)	**6.4±2.9**	**4.8±3.5**	**1.8**	**>0.05**
SOD (U/L)	**46.6±22.7**	**70.3±22.4**	**5.8**	**<0.01****
Catalase (U/L)	**689.7±155.6**	**849.9±154.2**	**4.1**	**<0.01****

** P< 0.01 (highly significant) (MDA) : Malondialdyde, (SOD) : superoxide dismutase

Table (6): Biomarkers serum levels before &after supplementation according to number of SIM cards

	Before supplementation (108) Mean ±SD	After supplementation (108) Mean ±SD	Paired t-test	P-value
One SIM card				
MDA (U/L)	**6.1±2.9**	**5.3±4.6**	**1.1**	**>0.05**
SOD (U/L)	**56.2±22.3**	**66±27.3**	**4.9**	**<0.01****
Catalase (U/L)	**685.2±119.4**	**782.6±157.7**	**4.7**	**<0.01****
Dual SIM cards				
MDA (U/L)	**6.3±3.3**	**4.2±3.3**	**2.3**	**<0.05***
SOD (U/L)	**41.6±23.8**	**65±26.3**	**4.3**	**<0.01****
Catalase (U/L)	**650.2±127.7**	**856.4±119.3**	**4.9**	**<0.01****

* P< 0.05 (significant) ** P< 0.01 (highly significant)
(MDA): Malondialdyde, (SOD) : superoxide dismutase

Table (7): Change in Biomarkers after supplementation according to mobile operating system

	Before supplementation (108) Mean ±SD	After supplementation (108) Mean ±SD	Paired t-test	P-value
Android Mobiles				
MDA (U/L)	**5.9±2.9**	**5.6±4.2**	**0.36**	**>0.05**
SOD (U/L)	**54.2±23.5**	**66.4±25.8**	**3.9**	**<0.01****
Catalase (U/L)	**680.5±124.9**	**844.3±113.9**	**7.3**	**<0.01****
Non –Android Mobiles				
MDA (U/L)	**6.4±2.9**	**4.3±4.6**	**2.3**	**<0.05***
SOD (U/L)	**51.1±23.3**	**65±28.5**	**5.5**	**<0.01****
Catalase (U/L)	**672.7±118.5**	**741.7±176.1**	**2.2**	**<0.05***

* P< 0.05 (significant) ** P< 0.01 (highly significant)
(MDA): Malondialdyde, (SOD) : superoxide dismutase

5. Discussion:

Normally, ROS produced during physiological processes and play a role in defence against pathogens. But, they are unstable due to presence of unpaired electron which can be transferred to molecules as lipids, proteins and DNA, leading to their oxidation and damage with further production of ROS. Under normal conditions, ROS are counteracted by the antioxidant defense mechanisms. When, the ROS destroy the antioxidant defense, the oxidative stress occurs [24]. Many environmental pollutants might induce oxidative stress that could be prevented by antioxidants ingestion either naturally or as supplement [25].

Research on mobile phones included information about duration of ownership, duration of phone calls per day, and number of SIM cards. All of these parameters need to be evaluated, to determine if they are important determinant of exposure or not [26].

In the present study, the studied group was chosen non-smokers apparently free from medical diseases. As the gas phase of smoking contains free radicals and induces oxidative stress. Smokers show increased level of MDA and decreased levels of SOD and Catalase [27]. In addition, smokers show lower concentration of vitamin C [28].

Effect of EMF emitted from mobile phones on oxidant-antioxidant status was previously studied, results revealed the development of oxidative stress through increased level of (MDA) which is a marker of oxidative stress or decreased antioxidant enzymes (in order to scavenge the free radicals) [29].

In the current study, association between MDA and (SOD and catalase) in the studied group and the emissions from their mobile phones, revealed significant negative correlation between the emissions and SOD level. Similar results were reported by Moustafa et al. [30] who found an elevation in MDA level with reduction of SOD level among a studied group exposed to mobile phone radiofrequency with no change in catalase level. Also, Agarwal et al. [31] evaluated the effects of chronic exposure to EMF emitted from mobile phones. They found decreased SOD and catalase levels with elevation of MDA level. Moreover, another author [32] found increase in free radicals' concentration in the saliva of mobile phone users. They suggested that oxidative stress might be exerted in human cells on exposure to mobile emitted EMF.

Kesari et al. [33] explained the reduction of SOD level on exposure to mobile phone, that EMF emitted from mobile phones enhanced ROS production which was neutralized by antioxidant system. As the superoxide dismutase is responsible for intracellular dismutation of superoxide radical, generating hydrogen peroxide which has marked cytotoxic effect. This leads to decrease of SOD levels. Then hydrogen peroxide is detoxified by catalase enzyme, which is overproduced by cells so its level was not reduced. They suggested that use of mobile phone for long durations is not safe.

Previous study [34] reported that exposure to EMF emitted from mobile phones might increase hydroxyl free radical production and also lead to lipid peroxidation of cell membranes phospholipids with subsequent production of MDA. Also, exposure affected the antioxidant defense in the form of reduction of SOD levels. Reduction of SOD levels affected the dismutation of superoxide radical which will be accumulated. In their study they did not measure catalase level but they suggested that with SOD inhibition, the accumulated superoxide radical would be transformed to water and oxygen via catalase leading to its consumption and reduction of its level. Therefore, all the previous could explain our findings in the form significant inverse correlation of SOD with the emission rates, and the non-significant correlation between MDA catalase levels with the emission rates.

In our study, the studied group were categorized according to their usage of mobile phone per day into low users group (using mobile <30 minutes/day), medium users group (using mobile for 30-60 minutes/day) and high users group (using mobile>60 minutes/day). MDA level was significant higher in high users group than the other two groups. Catalase level was significant lower in medium users group than the other two groups. Those findings came in accordance with a previous study [35] who found increase MDA level and in contrary to our results they found significant decrease in salivary total antioxidant in group with high mobile usage (talking in mobile phone> 60 minutes/day) compared to other two groups with medium and low users (group talking <20 minutes/day and group talking from 20 – 60 minutes/day). In the present study when we assessed the EMF emitted from the mobile phones used by each group, we found that the mobile phones used by the medium users group emit high significant radiation than the mobile owned by the other two groups regardless to the duration of their usage per day. This might explain the significant reduction of the catalase level in medium users group in comparison to the other two groups.

Nowadays there is increasing in using natural antioxidants. With age, there is an increase in oxidative damage which gives rise to the increased need to exogenous antioxidant intake to enhance the endogenous antioxidant mechanism [36]. Natural antioxidant intake as vitamin C and vitamin E has protective role against electromagnetic field induced oxidative stress. That effect is induced either before or after exposure. Their antioxidant mechanism by chain breaking of lipid peroxidation via its suppression or free radicals scavenging [37]. Vitamin E antioxidant effect is via capture free radical forming a relatively stable free radical form of the vitamin and thus interrupt chain reaction. Also, it quenches free radicals, decreases lipid peroxidation and thus prevents cell injury. Vitamin E maintains immune cells integrity and thus enhances immunity [38].

In the present study, we gave supplement (Vitamin C in combination to Vitamin E) for two months. Then we re-evaluated the MDA and antioxidant enzymes levels after the end of supplementation course. Our results revealed that the MDA level did not show statistical significant difference after supplementation. On the other hand, SOD and catalase showed high statistical significant improvement.

Our results came in accordance to a previous study [39] results who found that exposure to EMF from mobile phones resulted in an increase in MDA level and decrease in antioxidant enzymes SOD and catalase activities. They reported that receiving vitamin C prior to exposure did not report such changes. They explained their results that vitamin C administration played a role in improvement of antioxidant enzymes activities and decrease lipid peroxidation (thus prevent oxidative stress). Results of another study [40] showed that exposure to cell phone generated EMF led to elevation of MDA level with subsequent reduction in SOD and catalase enzymes levels. They also found that vitamin C supplementation had prevented such effects. They explained the potential mechanisms of the antioxidant effect of vitamin C by: first, it had a reducing effect via scavenging of free radicals. Second, it helped in removal of hydrogen peroxide and other free radicals so having a role in improvement of antioxidant enzymes activities. And third, its ability to decrease lipid peroxidation via regeneration of α-tocopherol from α-tocopheroxyl radical (tocopherol free radical species). Also, another authors [41] found in their study that 50 days exposure to mobile phone emitted EMF led to lipid peroxidation with increase MDA level and subsequent reduction in SOD level. Their results revealed that pre-exposure treatment with vitamin E prevented oxidative stress.

Combination of vitamin C and E has synergistic and interactive effect in free radical scavenging and accelerate reaction with free radicals. Together with their antioxidant properties, they play an important role in neutralizing the effects of electromagnetic waves emitted from mobile phone [19].

In our study the non-significant reduction of (MDA) level could be explained by the continuous exposure to mobile phones (continuity of exposure to stressor) so the oxidative stress improved but not significant and that by itself is considered as positive effect of the supplementation. Also, that might be owed to the short duration of supplement which improved the antioxidant levels.

Regarding the mobile duration of ownership in the present study, both groups after supplementation showed high statistical significant improvement of SOD and catalase levels, while the MDA did not show statistical significant improvement. From those findings, we suppose that both vitamin C and E supplementation improves antioxidant enzymes levels regardless the duration of mobile ownership.

Considering the effect of supplementation on the oxidant antioxidant status among the studied groups having one phone and others have two phones. The level of SOD and catalase showed high significant improvement in both groups. However, the degree of improvement was more in those having two phones than others owned only one phone. On the other hand, the level of MDA showed reduction in its level but it did not show statistical significant difference.

In the current study, before supplement those having dual SIM mobiles showed lower levels of SOD and catalase enzymes and higher level of MDA. Then after supplement, there was significant elevation of both antioxidant enzymes. Also MDA levels showed significant reduction in dual SIM.

The above results indicate that the subjects exposed to higher emissions' mobiles, whether having two mobiles or mobiles with dual SIM, had lower levels of antioxidant enzymes (SOD and catalase) and higher levels of MDA. Moreover, after supplement administration the degree of improvement in antioxidant enzymes was more in the students exposed to higher emissions than in others exposed to lower emissions with subsequent less affection in antioxidant enzymes and MDA levels.

Similar to our findings, previous study [42] concluded in their study that low exposure to mobile phones induced lesser lipid peroxidation with lesser production of ROS. The lesser lipid peroxidation led to compensatory mechanism of endogenous antioxidant e.g. Nitric Oxide (which has much higher affinity to O^{2-} than SOD).so, it competes with SOD for O^{2-} removal. Therefore, the primary antioxidant enzymes as SOD are spared for other functions.

This finding might give an explanation to our results. As exposure to lower EMF emitted from mobile phone, induced less lipid peroxidation than highly EMF exposed. That might lead to subsequent less affection of antioxidant enzyme as they are spared for other functions. Supplementation with antioxidant vitamins improved the more affected subjects. Firstly, vitamin C and E improved (SOD and catalase) activities and then help to restore to depleted antioxidant enzymes in higher exposed persons. Second, the antioxidant enzymes are less affected in lower exposed subjects.

6.Conclusion:

EMF mobile phone emissions affect the oxidant-antioxidant status in mobile phone users and led to oxidative stress. The degree of affection differs according to intensity of use, duration of ownership, number of mobiles used, number of SIM cards in the same mobile and the mobile operating system. Antioxidant supplementation improved the oxidant-antioxidant status despite of continuity of the mobile usage pattern. But the degree of improvement was more in more affected subjects to restore the deficient stores and affected enzymes consumed by the continuous high exposure

So, in conclusion exposure to low emissions from mobile phones could be fixed by dietary modification and increase antioxidant intake.

Recommendation:

- Better exposure assessment should be considered in the future to have phones with low emissions.
- The dual SIM mobiles should be avoided as such devices induce high emissions, so they are considered dangerous to human health.
- Reduction the intensity of mobile usage generally and talking particularly to be less than 30 minutes per day.
- Lifestyle and dietary modification by increase natural antioxidant intake especially vitamin C and E containing diet for mobile phone users.
- Encourage to use speaker mode or headset in order to keep a distance between the head and mobile phone.
- Encourage people to keep the mobile away or shut down during sleep.

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Study Limitations:

At the beginning of the study, the studied group was (150). There were drop outs (42 students), so in the post intervention phase the studied group was (108).

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Ethical consideration :

The study was approved by the Ethical Committee at Faculty of Nursing, Cairo University, and by the Ethical Committee at National Research Centre NO. (12122).

Conflict of interest

All authors declared no conflict of interest

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