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Case Report

How does long term exposure to base stations and mobile phones affect human hormone profiles?

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ABSTRACT

Objectives: This study is concerned with assessing the role of exposure to radio frequency radiation (RFR) emitted either from mobiles or base stations and its relations with human's hormone profiles.

Design and methods: All volunteers' samples were collected for hormonal analysis.

Results: This study showed significant decrease in volunteers' ACTH, cortisol, thyroid hormones, prolactin for young females, and testosterone levels.

Conclusion: The present study revealed that high RFR effects on pituitary–adrenal axis.

Introduction

Because of the increase in the usage of wireless communication devices of mobile phones in recent years, there is an anxious concern on the possible hazardous effects of prolonged exposure to radio frequency radiation (RFR) [1]. In considering the biological effects of RFR, the intensity and frequency of the radiation and exposure duration are important determinants of the responses.

It has been reported that exposure to RFR could affect the nervous system [2]. Hardell et al. found that cell phone users had an increased risk of malignant gliomas [3]. Subjecting human spermatozoa to RFR showed decrease in sperms motility and vitality and increase in DNA fragmentation [4]. The authors hypothesize that the high sporadic incidence of the clinical symptoms of the autoimmune multiple Sclerosis disease [5] may be a result of long exposure to RFR from mobiles.

This study is concerned with assessing the effect of RFR emitted from mobile phones and base stations on human hormone profiles, with anticipation to offer recommendations to assure health care and safety for humans continuously exposed to radio frequency radiation.

Design and methods

Study subjects

This study was conducted for 6 years on 82 mobile phone volunteers with age ranges 14–22 years ($n = 41$) and 25–60 years ($n = 41$). Those users were divided into three subgroups according to the time of their exposure to RFR: (weak $n = 19$), (moderate $n = 9$), and (strong $n = 13$) per day, in addition to 20 negative control subjects.

On the other hand, volunteers exposed to RFR emitted from base stations ($n = 34$) were selected with age ranges 14–22 years ($n = 17$), and 25–60 years ($n = 17$) and living at distances 20–100 m and 100–500 m apart from the base station. Additional 10 subjects of each age range living at a distance more than 500 m apart from the base station were considered as negative control group.

The source of the RFR (base stations or mobile phones) was GSM-950 MHz magnetic field and the ICNIRP-Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic field (up to 300 GHz) (International Commission on Non-Ionizing Radiation Protection). The present study was approved by the Ethics Committee of National Research Centre.

Volunteers inclusion criteria

Volunteers participated in the study fulfilled the following inclusion criteria: age 14–60 years, mobile phone users, or living at distances 20–100 m and 100–500 m apart from the base station.

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Blood samples collection

Blood samples of the volunteers were analyzed for estimation of the following hormones: plasma ACTH, serum cortisol, total T_3, T_4, prolactin, progesterone, and testosterone levels. All volunteers followed for 6 years and the blood samples were collected regularly from mobile phone users, volunteers exposed to RFR emitted from base stations, and the controls for time intervals after 1 year, 3 years and 6 years for hormonal analysis. The determination of the hormonal profile was performed on serum samples whereas ACTH was detected in EDTA plasma. The whole blood was collected in EDTA tube.

Blood samples were withdrawn from females to measure serum prolactin and progesterone levels. Whereas, blood samples were withdrawn from males to measure serum testosterone level. Blood samples were withdrawn from both males and females to measure plasma ACTH level, serum cortisol, total T_3 and T_4 levels.

Methods

Plasma ACTH, serum total T_3, and T_4 levels were determined quantitatively using DSL-ELISA Kits provided by (Diagnostic Systems Laboratories Inc.). Measurement of serum cortisol level was carried out using ELISA kit provided by Adaltis Italia SPA Company (Italy). Serum prolactin, progesterone, and testosterone concentrations were measured using ELISA kit supplied by (DRG International, Inc., USA).

Statistical analysis

The data were analyzed using SPSS program (Statistical Package for the Social Science; SPSS Inc., Chicago, IL, USA, 2001).

Results

Volunteers mean hormone values

Follow up data were available for all volunteers who were exposed to RFR either from mobiles or base stations. The clinical features of all individuals were summarized in tables.

Tables 1 and 2 illustrate that persons of ages 14–22 years or 25–60 years who were exposed, for time intervals extended to 6 years, to RFR either from mobile phones or from base stations suffered significant decreases in their plasma ACTH and serum cortisol levels as compared to the control group. High significant decrease ($P<0.01$) in plasma ACTH and serum cortisol levels was observed for persons exposed to RFR from base stations at distances extended from 20 to 500 m for a period of 6 years as compared to the control group.

Tables 1 and 2, also show that persons of ages 14–22 years and 25–60 years who were exposed, for time intervals extended to 6 years, to RFR either from mobile telephones or from base stations suffered high significant ($P<0.01$) decrease in their serum T_3 and T_4 levels.

Tables 1 and 2 show that young females (14–22 years) exposed to RFR from mobile phones or from base stations at distances 20–100 m and 100–500 m suffered decrease in their serum prolactin level and the rate of decrease significantly rose with increased time of exposure from 1 year up to 6 years. Conversely, the serum prolactin level for adult females (25–60 years) showed significant increase along the time of exposure 1 year up to 6 years.

Table 1 shows that serum progesterone levels in young and adult females exposed to RFR from mobile phones were non-significantly changed through exposure for 1 year up to 6 years as compared to healthy controls.

Table 2 shows that both young (14–22 years) and adult (25–60 years) females exposed to RFR from base stations did not suffer any change in their serum progesterone levels throughout the first year of exposure. However, with increasing exposure periods from 3 up to 6 years they suffered significant decrease in their serum progesterone levels.

Tables 1 and 2 illustrate that both young males (14–22 years) and adult males (25–60 years) exposed to RFR from mobile phones or from base stations experienced gradual decrease in their serum testosterone level with increasing the period of exposure.

Discussion

The intensity and frequency of RFR and exposure duration are important determinants of the cumulative effect that could occur and lead to an eventual breakdown of homeostasis and adverse health consequences. Therefore, greater commitment from policy makers, health care officials and providers is needed to raise public awareness about the hazardous outcomes of long term exposure to RFR.

As mentioned in our results, persons who were exposed to RFR suffered significant decreases in their ACTH and cortisol levels as compared to controls. This result is agreed with the previous study indicating that cortisol levels were decreased after exposure to RF [12]. The current result is in contradiction with a previous study indicating that electromagnetic fields have a slight elevation in human cortisol production [6] and with other previous study suggesting that cortisol concentration as a marker of adrenal gland function was not affected with RFR [11]. Djeridane et al. (2008) added that ACTH was not disrupted by RFR emitted by mobile phones [12].

Our results reveal that persons who were exposed to RFR either from mobile phones or base stations suffered highly significant decrease in their serum T_3 and T_4 levels which agree in case of low T_4 levels and disagree in case of low T_3 concentrations with previous study which suggested that serum T_3 remains in normal range [7].

In the present study, females exposed to RFR from mobile phones or base stations suffered change in their serum prolactin level and the rate of change significantly rose with increased time of exposure which is in converse with previous studies indicating that serum prolactin concentration remained within normal ranges after exposure to radiocellular phones [8,12]. Therefore, it is suggested that the menstrual cycle and the pregnancy will be affected by changing the level of serum prolactin which seems necessary to be optimized in these two processes.

Our study suggested that serum progesterone levels in young and adult females exposed to RFR from mobile phones non-significantly changed from 1 year up to 6 years as compared to healthy controls. So, the menstrual cycle and pregnancy may not be affected by serum progesterone concentration. Previous study revealed that microwaves produced significant increases in serum progesterone level only in pregnant rats [9].

In the present study, both young and adult males exposed to RFR from mobile phones or base stations experienced gradual decrease in their serum testosterone level with increasing the period of exposure which is almost the same as previously recent reported studies suggested that exposure to mobile radiation leads to reduction in serum testosterone and it possibly affects reproductive functions [10,11]. The present study is in converse with a previous study indicating that testosterone was not disrupted by RFR emitted by mobile phones [12].

In conclusion, the present study revealed that high RFR emitted from either mobile phone or base station has tangible effects on pituitary–adrenal axis represented in the reduction of ACTH and consequently cortisol levels. Also, exposure to RFR is associated with decrease in the release of thyroid hormones.

Moreover, our data suggested that each of serum prolactin in young females, and testosterone levels in males significantly dropped due to long-term exposure to RFR. Conversely, the serum prolactin levels for the adult females significantly rose with increasing exposure time. Finally, the degenerative effects of exposure to RFR were more pronounced for persons who used mobile phones for long periods of 6 years. Also, the effect of this type of radiation was more

Table 1
Plasma ACTH, serum cortisol, T3, T4, prolactin, progesterone, and testosterone of volunteers exposed to RFR from mobile phones.

Hormones (mean ± SE)	Groups											
	Controls						Mobile phone users					
	1 Year		3 Years		6 Years		1 Year					
	Age$_1$	Age$_2$	Age$_1$	Age$_2$	Age$_1$	Age$_2$	Age$_1$			Age$_2$		
							S	M	W	S	M	W
Plasma ACTH (pg/mL)	61.1 ± 1.1	63.2 ± 0.1	59.9 ± 0.2	62.3 ± 1.0	59.9 ± 0.3	60.2 ± 1.7	49.1 ± 0.3[b]	55.0 ± 1.1[b]	59.2 ± 0.1[NS]	53.2 ± 1.2[b]	58.3 ± 0.4[b]	62.1 ± 1.1[NS]
Serum cortisol (μg/mL)	30.0 ± 1.2	31.2 ± 0.1	30.0 ± 0.1	31.7 ± 0.3	29.9 ± 0.2	28.8 ± 2.3	20.3 ± 1.1[b]	27.3 ± 0.1[a]	30.1 ± 0.3[NS]	23.9 ± 1.0[b]	28.2 ± 0.9[b]	30.3 ± 1.1[NS]
Serum T_3 (ng/dL)	105.2 ± 1.3	102.0 ± 1.1	101.7 ± 1.2	98.6 ± 2.1	103.6 ± 1.1	99.0 ± 1.4	96.3 ± 1.2[b]	100.0 ± 0.6[b]	102.1 ± 1.3[NS]	93.9 ± 1.1[b]	98.1 ± 0.3[a]	99.0 ± 0.7[a]
Serum T_4 (μg/dL)	7.8 ± 0.6	6.9 ± 1.4	7.7 ± 1.1	6.5 ± 0.7	7.1 ± 0.3	6.6 ± 2.1	6.9 ± 0.1[NS]	7.0 ± 0.1[NS]	6.9 ± 0.1[NS]	6.3 0.8[b]	6.2 ± 1.2[NS]	6.0 ± 1.0[NS]
Serum prolactin (ng/mL)	17.8 ± 1.1	17.2 ± 1.2	17.3 ± 1.1	16.9 ± 1.3	17.0 ± 2.1	16.8 ± 0.5	14.9 ± 1.4[a]	14.7 ± 0.3[a]	17.3 ± 0.2[NS]	18.3 ± 0.1[a]	16.9 ± 0.3[a]	17.1 ± 0.2[NS]
Serum progesterone (pg/mL)	14.0 ± 1.3	17.1 ± 1.0	13.8 ± 1.2	16.9 ± 0.9	12.9 ± 1.3	16.8 ± 0.2	12.3 ± 1.1[NS]	12.2 ± 1.2[NS]	14.1 ± 0.7[NS]	16.1 ± 1.4[NS]	17.6 ± 0.3[NS]	16.5 ± 0.4[a]
Serum testosterone (pg/mL)	29.5 ± 1.2	25.2 ± 1.6	28.9 ± 1.8	24.3 ± 0.6	28.4 ± 0.3	24.0 ± 0.1	25.2 ± 0.2[a]	24.9 ± 0.1[a]	23.7 ± 0.4[a]	22.7 ± 1.2[a]	23.8 ± 0.4[NS]	19.9 ± 0.1[a]

Age$_1$: represents age from 14 to 22 years, Age$_2$: represents age from 25 to 60 years.S: represents Strong, M: represents Moderate, W: represents Weak.N Control = 10, N Strong = 13, N Moderate = 9, N Weak = 19.Strong use: more than 60 min/day, Moderate use: between 30–60 min/day, Weak use: less than 10 min/day.NS: non-significant change when comparing mobile phone users with controls.
[a] Significant difference at $P > 0.05$ when comparing mobile phone users with controls.
[b] Significant difference at $P > 0.01$ when comparing mobile phone users with controls.

Table 1 (*continued*)

Hormones (mean ± SE)	Groups											
	Mobile phone users											
	3 Years						6 Years					
	Age$_1$			Age$_2$			Age$_1$			Age$_2$		
	S	M	W	S	M	W	S	M	W	S	M	W
Plasma ACTH (pg/mL)	45.3 ± 0.6[b]	51.2 ± 1.3[b]	55.0 ± 1.1[b]	50.2 ± 0.4[b]	55.1 ± 1.1[b]	60.0 ± 0.3[b]	40.3 ± 0.4[b]	41.3 ± 1.1[b]	47.2 ± 0.2[b]	48.2 ± 0.4[b]	51.3 ± 1.3[b]	57.2 ± 1.1[b]
Serum cortisol (μg/mL)	18.3 ± 1.4[b]	20.2 ± 1.1[b]	25.1 ± 0.1[b]	20.3 ± 1.1[b]	25.9 ± 0.9[b]	20.3 ± 1.2[b]	18.0 ± 0.1[b]	17.3 ± 1.1[b]	20.3 ± 0.2[b]	17.0 ± 0.2[b]	22.0 ± 0.4[b]	24.1 ± 0.2[b]
Serum T_3 (ng/dL)	87.2 ± 1.3[b]	90.2 ± 1.6[b]	94.3 ± 1.1[b]	89.8 ± 1.1[b]	92.9 ± 1.3[b]	95.0 ± 1.1[b]	80.3 ± 1.1[b]	84.2 ± 0.5[b]	85.7 ± 1.1[b]	83.2 ± 1.3[b]	80.3 ± 1.1[b]	90.2 ± 0.7[b]
Serum T_4 (μg/dL)	7.9 ± 1.1[b]	7.6 ± 1.7[NS]	7.1 ± 1.3[NS]	6.4 ± 0.3[NS]	6.3 ± 0.8[NS]	6.1 ± 0.3[NS]	10.5 ± 0.1[b]	9.5 ± 1.1[NS]	8.9 ± 0.4[b]	7.4 ± 0.9[NS]	7.7 ± 1.3[NS]	8.0 ± 1.1[NS]
Serum prolactin (ng/mL)	17.4 ± 1.2[a]	9.8 ± 0.3[b]	9.7 ± 0.1[b]	23.5 ± 0.2[b]	19.2 ± 1.1[b]	18.7 ± 0.9[b]	10.1 ± 1.0[b]	8.7 ± 0.3[a]	8.7 ± 0.4[NS]	24.9 ± 0.1[b]	21.1 ± 0.3[b]	20.6 ± 0.1[b]
Serum progesterone (pg/mL)	13.9 ± 0.2[NS]	13.6 ± 0.7[NS]	13.4 ± 0.4[NS]	15.1 ± 0.3[a]	14.9 ± 0.1[a]	13.0 ± 0.5[b]	12.9 ± 0.2[a]	11.8 ± 0.1[a]	10.9 ± 0.3[a]	14.8 ± 1.1[b]	13.5 ± 1.3[NS]	12.8 ± 0.1[NS]
Serum testosterone (pg/mL)	19.8 ± 0.1[b]	18.7 ± 0.2[a]	16.5 ± 0.1[a]	17.5 ± 0.2[b]	16.9 ± 1.1[a]	16.1 ± 0.3[a]	13.1 ± 0.4[b]	12.7 ± 0.2[b]	12.3 ± 0.1[b]	11.1 ± 1.1[b]	11.4 ± 0.2[b]	9.8 ± 0.3[b]

Table 2
Plasma ACTH, serum cortisol, T3, T4, prolactin, progesterone, and testosterone of volunteers exposed to RFR from base stations.

Hormones (mean ± SE)	Groups								
	Controls (distance 500 m)						Volunteers exposed to RFR from base stations		
	1 Year		3 Years		6 Years		1 Year		
	Age_1	Age_2	Age_1	Age_2	Age_1	Age_2	Age_1		Age_2
							D_1	D_2	D_1
Plasma ACTH (pg/mL)	62.8 ± 1.2	58.3 ± 0.9	62.5 ± 0.3	58.4 ± 0.5	62.4 ± 0.7	58.9 ± 0.1	61.9 ± 0.2[NS]	62.3 ± 0.1[NS]	57.9 ± 1.3[NS]
Serum cortisol (μg/mL)	33.3 ± 2.6	30.1 ± 1.4	32.9 ± 1.1	30.3 ± 1.4	32.7 ± 1.1	29.9 ± 1.9	32.4 ± 1.2[NS]	32.9 ± 0.3[NS]	28.8 ± 1.6[NS]
Serum T3 (ng/ dl)	108.3 ± 1.6	100.0 ± 1.1	107.0 ± 1.9	100.0 ± 0.1	107.0 ± 0.1	99.9 ± 1.2	107.0 ± 1.1[NS]	107.9 ± 0.4[NS]	106.0 ± 1.1[NS]
Serum T4 (μg/dL)	7.2 ± 1.3	6.3 ± 0.3	6.8 ± 1.2	6.3 ± 0.1	6.7 ± 1.2	6.2 ± 2.4	6.9 ± 0.3[NS]	7.1 ± 1.1[NS]	5.9 ± 1.1[NS]
Serum prolactin (ng/mL)	18.3 ± 1.1	14.3 ± 1.6	18.0 ± 1.0	13.9 ± 1.2	18.0 ± 1.2	13.1 ± 0.2	17.6 ± 0.2[NS]	17.6 ± 1.3[NS]	19.1 ± 0.3[b]
Serum progesterone (pg/mL)	12.4 ± 1.1	10.0 ± 0.8	12.3 ± 1.6	10.0 ± 0.5	12.2 ± 1.9	9.8 ± 2.4	12.3 ± 1.1[NS]	12.3 ± 1.0[NS]	10.1 ± 0.9[NS]
Serum testosterone (pg/mL)	27.1 ± 0.3	24.2 ± 1.1	26.3 ± 1.1	23.2 ± 1.3	25.8 ± 1.4	22.9 ± 2.1	243 ± 1.1[b]	24.9 ± 1.9[NS]	20.1 ± 1.1[b]

Age_1: represents age from 14 to 22 years, Age_2: represents age from 25 to 60 years.D_1: represents distance from 20 to 100 m, D_2: represents distance from 100 to 500 m.N Control = 10, N Strong = 13, N Moderate = 9, N Weak = 19.NS: non-significant change when comparing persons exposed to base stations with controls.

[a] Significant difference at $P > 0.05$ when comparing persons exposed to base stations with controls.

[b] Significant difference at $P > 0.01$ when comparing persons exposed to base stations with controls.

Table 2 (*continued*)

Hormones (mean ± SE)	Groups								
	Volunteers exposed to RFR from base stations								
	1 Year	3 Years				6 Years			
	Age_2	Age_1		Age_2		Age_1		Age_2	
	D_2	D_1	D_2	D_1	D_2	D_1	D_2	D_1	D_2
Plasma ACTH (pg/mL)	58.0 ± 0.9[NS]	51.8 ± 1.7[b]	54.6 ± 1.1[b]	54.2 ± 0.6[b]	45.2 ± 1.8[NS]	47.3 ± 1.3[b]	48.3 ± 1.4[b]	40.7 ± 0.3[b]	43.1 ± 1.1[b]
Serum cortisol (μg/mL)	29.1 ± 1.3[NS]	27.2 ± 1.2[b]	27.4 ± 2.1[NS]	25.6 ± 0.1[b]	26.6 ± 1.1[NS]	21.2 ± 0.4[b]	22.4 ± 1.1[b]	22.9 ± 1.1[b]	24.2 ± 0.3[b]
Serum T3 (ng/ dl)	100.1 ± 0.2[NS]	97.3 ± 1.6[b]	98.1 ± 0.9[b]	97.4 ± 1.1[NS]	98.2 ± 1.9[NS]	78.0 ± 1.1[b]	82.3 ± 1.9[b]	91.3 ± 1.5[b]	93.4 ± 1.9[b]
Serum T4 (μg/dL)	6.1 ± 0.3[NS]	4.4 ± 1.8[NS]	4.9 ± 0.3[NS]	5.1 ± 0.3[b]	5.9 ± 0.8[NS]	2.7 ± 0.1[b]	2.8 ± 1.2[b]	3.8 ± 1.2[b]	3.9 ± 1.9[b]
Serum prolactin (ng/mL)	19.6 ± 1.1[b]	97.3 ± 1.6[b]	98.1 ± 0.9[b]	97.4 ± 1.1[NS]	98.2 ± 1.9[NS]	78.0 ± 1.1[b]	82.3 ± 1.9[b]	91.3 ± 1.5[b]	93.4 ± 1.9[b]
Serum progesterone (pg/mL)	10.5 ± 1.1[NS]	4.4 ± 1.8[NS]	4.9 ± 0.3[NS]	5.1 ± 0.3[b]	5.9 ± 0.8[NS]	2.7 ± 0.1[b]	2.8 ± 1.2[b]	3.8 ± 1.2[b]	3.9 ± 1.9[b]
Serum testosterone (pg/mL)	20.3 ± 1.6[NS]	20.2 ± 0.4[b]	20.9 ± 0.9[b]	18.1 ± 1.1[b]	18.6 ± 1.3[b]	11.8 ± 0.3[b]	10.9 ± 1.6[b]	15.3 ± 1.2[b]	16.1 ± 1.5[b]

obvious for persons living nearby base stations and exposed for a period of 6 years.

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