

Association between Mobile Phone Use and Physical Wellbeing

Md. Nurul Amin,¹ Md. Sultan-Ul-Islam,² Md. Jawadul Haque³

ABSTRACT

Background & objective: Mobile phones transmit information using radio waves through a network of fixed antennas. Radiofrequency waves are electromagnetic fields, and unlike ionizing radiation such as X-rays or gamma rays, can neither break chemical bonds nor cause ionization in the human body. However, a large number of studies performed over the last two decades claimed that exposure to radiofrequency electromagnetic fields (RF-EMF) from mobile phone have been linked with symptoms ill-health. But the studies were studded with shortcomings and their findings were inconsistent. The present study was therefore intended to see the status of physical health of cell-phone users and the potential effect of talk-time on haemodynamic stability, as an indirect evidence of impact of RF-EMF on haemodynamic variables.

Methods: A cross-sectional analytical design was considered suitable for assessing physical symptoms associated with mobile phone use, while for assessing changes in haemodynamic state before and after a certain duration of phone call were studied with the help of within sample pre-test post-test design. The study was conducted in the Institute of Environmental Science (IES), Rajshahi University (RU), Rajshahi between July 2017 to June 2022. Data for the study were collected from medical students of Rajshahi Medical College (n = 118) and students from RU (n = 195). Having obtained written approval from the IES, Rajshahi University, Rajshahi and verbal approval from the Supervisor and the Co-supervisor, data were collected from the respondents with their consent, over a period of three months from October to December 2021 using a semi-structured questionnaire containing the variables of interest. However, respondents suffering from any serious illnesses (like fever on the day of interview) or had a history of hypertension were excluded. We used questionnaires to obtain self-reported information on headache, tinnitus, hotness or earache during call, hearing deficit, vertigo, irritability, sleeplessness or digital eye syndrome like dry eye, red-eye, blurred vision, lacrimation, eye strain, neck pain etc. Whether radiofrequency radiation emitted from the mobile phone cause rise of local temperature and changes in haemodynamic variables like pulse, systolic and diastolic blood pressures of respondents data were taken before and immediately after a phone call and the differences between the two data-set were analyzed.

Result: The study demonstrated that respondents were invariably used to using Smartphone with mean duration of use being 6.8 ± 2.7 years. Investigating about profile of mobile use revealed that the median number of calls made and received daily (on an average) was 5 (range: 1-55), the median of average duration of per call was 4 (range: 1-60) minutes with median duration of longest call daily being 10 (range: 1-180) minutes. Overall, the users spent on an average 4.3 ± 2.3 hours' time daily on mobile. A considerable proportion of mobile users experienced irritability (38.7%), sleeplessness (30.7%), weekly headache (30.3%), hotness in the ear during call (22.4%), earache (19.5%), occasional vertigo (13.4%) and tinnitus (12.1%). The symptoms of computer vision syndrome or digital eye syndrome reported were blurred vision (37.1%), eye-strain or irritation (32.3%), lacrimation (28.8%), dry-eye (15%), red-eye (18.2%) and neck pain (17.5%). The local temperature was observed to be significantly increased by 0.6 OF after a median duration of 20 (range: 4 - 32) minutes talk ($p < 0.001$) with consequent increase in heart rate by 3 beats/min ($p = 0.009$). However, neither local temperature nor pulse immediately after quitting the call was found to bear any significant correlations with talk-time.

Conclusion: The study concluded that a reasonable number of mobile users experienced irritability, sleeplessness, weekly headache, hotness in the ear during call, earache, occasional vertigo and tinnitus. The symptoms of computer vision or digital eye syndrome like blurred vision, eye-strain or irritation, lacrimation, dry-eye, red-eye and neck pain are also not unusual. The local temperature and heart rate are significantly increased with prolonged talk-time.

Key words: Mobile phone use, physical wellbeing, haemodynamic variables etc.

Authors' information:

¹ **Dr. Md. Nurul Amin**, Associate Professor (Research & Development) & Executive Editor, Ibrahim Cardiac Medical Journal, Ibrahim Cardiac Hospital & Research Institute, Shahbag, Dhaka-1000, Bangladesh

² **Dr. Md. Sultan-Ul-Islam**, Pro-Vice Chancellor, Professor, Department of Geology Mining, Ex-Director, Institute of Environmental Science, University of Rajshahi, Rajshahi.

³ **Dr. Md. Jawadul Haque**, Professor & Head, Department Community Medicine, Rajshahi Medical College, Rajshahi

Correspondence: Dr. Md. Nurul Amin, Mobile: 01753178452, E-mail: mdamin01@yahoo.com

INTRODUCTION:

Last two decades have witnessed tremendous growth in communication technology. With the advent of digital technology, we can now communicate to any parts of the world by just touching on the screen of smartphone. Keeping pace with the communication technology, the world's economy is growing faster. People's adoption of mobile phone devices and internet-based services added an impetus in 2020 following the outbreak of CoVid19.¹ Bangladesh Telecommunication Regulatory Commission data reported that the number of active mobile phone users has increased to 18.1 crore at the end of December 2021, nearly equal to the total population of the country. From making phone calls to participating in meetings, mobile phones have now become an indispensable tool of communication. Mobile phone connections have enabled tech-savvy users to do everything of their day-to-day activities using mobile phone services. Scientists working on the impact of mobile technology on human health and environment are of the opinion that these digital devices are not without side-effects, although, to date, there is an inadequate knowledge on what biological systems could be affected by the use of these devices.

International Agency for Research on Cancer (IARC) published cancer risks from Radiofrequency (RF) radiation. Human epidemiological studies gave evidence of increased risk for glioma and acoustic neuroma. RF radiation was classified as Group 2B, a possible human carcinogen. Further epidemiological, animal and mechanistic studies have strengthened the association. Besides, the carcinogenic effect of non-ionizing radiation emitted from cordless digital devices, numerous health effects have already been claimed to occur. Sensations of burning or warmth around the ear,² headache³, disturbance of sleep⁴, alteration of cognitive functions and neural activity^{5,6}, as well as alteration of the blood-brain barrier and a relative decrease in regional cerebral blood flow have been reported as effects resulting from mobile phone use.^{7,8} Individuals sensitive to electromagnetic fields often experience cognitive impairments & complaint of headache, and perceive that such symptoms could be caused by the RF-EMF exposure.⁹ Headache is an

important warning sign that body temperature is rising to a risky level suggesting that when RF heats body tissues, body temperature and other vital physiological parameters such as heart rate and blood pressure may change.¹⁰ The heating effects arise when radiation is so high that it warms up the whole body by 1°C or more after 30 min exposure at 4 W/kg specific absorption rate.¹¹

With the increasing use of new technology of 3rd generation (3G) or universal mobile telecommunication system (UMTS), using the 1.9–2.1 GHz frequency band has been introduced, followed by the 4th generation, social concerns have been raised concerning the possible health effects of radio frequency-electromagnetic fields (RF-EMFs) emitted by mobile phones in humans.^{12,13} Quite a good number of studies have investigated whether RF-EMF has adverse health effects. But the results, in general, are conflicting and inconclusive.^{14–16} While a number of studies demonstrated influence of radiation on health, others could not replicate these findings. Moreover, the studies have shortcomings and their findings are inconsistent. The present study was therefore, intended to 1) assess the prevalence of physical symptoms of ill-health like headache, tinnitus, hearing loss sleeplessness etc. among mobile users and 2) see the effect of mobile use (talk-time and duration of mobile phone use) on haemodynamic variables (blood pressure, heart rate and local temperature).

METHODS:

For assessing physical symptoms associated with mobile phone use, a cross-sectional analytical design was used, while for assessing changes in haemodynamic stability between baseline and after a certain duration of phone call were studied with the help of within sample pre-test post-test design. The study was conducted in the Institute of Environmental Science (IES), Rajshahi University (RU), Rajshahi between July 2017 to June 2022. The data for the study were collected from the 3rd year medical students of Rajshahi Medical College (n=118) and from the 2nd year students of Statistics and Accounting Departments of RU (n=195). As this study was a part of PhD thesis, conducted in the

Institute of Environmental Science (IES), Rajshahi University, Rajshahi, we obtained written approval from the IES, Rajshahi University, Rajshahi. Data were collected from the respondents on verbal approval from the Supervisor and the Co-supervisor and written consent from the respondents, over a period of three months from October to December 2021 using a semi-structured questionnaire addressing the variables of interest. However, respondents suffering from any serious illnesses (like fever on the day of interview) or had history of hypertension or were unwilling to give voluntary consent to participate in the study were excluded.

We used questionnaires to obtain self-reported information on headache, tinnitus, hotness or earache during call and hearing deficit (presumed to be caused by radiofrequency radiation) vertigo, irritability, sleeplessness or digital eye syndrome (a group of eye and vision problems resulting from extended computer or digital device use) like, dry eye, red-eye, blurred vision, lacrimation, eye strain or irritation, neck pain etc. Data on self-reported perceived mental problem (depression, stress and mental wellbeing), personal, familial and social problems (like study pressure, financial constraint, mobile addiction and love-affairs complex) were also assessed. Whether radiofrequency radiation emitted from the mobile phones cause rise of local temperature and changes in haemodynamic variables (like pulse and blood pressure), all the medical students were asked to make a call to their near and dear ones as long as they like. Before making a call their baseline pulse, systolic and diastolic blood pressures were measured (by a rechargeable digital blood pressure measuring instrument) and local temperature over parotid gland was recorded using an infrared temperature sensor. The data on these haemodynamic variables were again recorded as soon as they gave up calling and the differences between the two data-set were statistically analyzed to observe the changes in haemodynamic state and to find their association and correlation with talk-time. Data were analyzed using SPSS (Statistical Package for Social Sciences), version 25.0. The test statistics used to analyze the data were descriptive statistics, Chi-squared (χ^2)

Test, Paired-sample t-Test and Pearson's correlation with level of significance being set at 5%.

RESULT:

The demographic characteristics show that median age of the respondents was 22.2 ± 1.1 (range: 20-24) years. A male preponderance was observed among the respondents, although respondents from medical colleges were predominantly female and those from university were predominantly male. Over 70% of the respondents came from urban area and economically belonged to middle socioeconomic class (Table I). Profile of mobile use is illustrated in table II. All the respondents were used to using Smart phone. The mean duration of mobile phone use was 6.8 ± 2.7 years. While the median number of calls made and received daily (on an average) was 5 ± 1 (range: 1-55), the median of average duration of per call was 4.0 ± 0.4 (range: 1-60) minutes. The median duration of longest call made daily was 10 ± 1.4 (range: 1-180) minutes. The median of average time spent daily on mobile was 4.3 ± 2.3 (range: 1-12) hours.

Asked about the reasons of using smart phone, majority of the respondents informed that they used the device for transmission and reception of both calls and messages using net (94.9%), keeping connected with the social media like Facebook, YouTube, WhatsApp etc. (97.4%), maintaining academic relationship with teachers and students (96.5%) & viewing and enjoying socially acceptable contents (95.5%). However, some respondents were used to viewing socially unacceptable/erotic contents (28.4%) & playing video games (27.8%) (Table III). The symptoms of ill-health complained by the mobile phone users were irritability (38.7%), followed by sleeplessness (30.7%), headache (mild to severe) at least once in a week (30.3%), hotness in the ear during call (22.4%), earache (19.5%), occasional vertigo (13.4%) & tinnitus (12.1%). The symptoms of computer vision or digital eye syndrome reported were blurred vision (37.1%), eye-strain or irritation (32.3%), lacrimation (28.8%), dry-eye (15%), red-eye (18.2%), neck pain (17.5%) etc. Some non-specific symptoms like indigestion/ IBS were complained by 7.9% of the respondents (Table IV).

Investigating about mental, personal/familial/social problems felt by the respondents revealed that 136(69.7%) of them perceived mental problem further stratified as depression (61.7%), anxiety (58.8%) and stress (76.5%). Probed about the reasons of perceived mental problem, predominant reason reported was study pressure (69.8%), followed by familial problem (57.3%), financial constraint (50%), mobile addiction (48.5%) and love-affair complex (33.1%) (Table V). Phone-call intervention showed that the local temperature was observed to be significantly increased from 97.4 ± 0.7 OF at baseline to 98.0 ± 0.8 OF immediately after a median duration 20(range: 4 – 32) minutes call ($p < 0.001$) with consequent increase of pulse from 89 ± 17 at baseline to 92 ± 17 beats/min ($p = 0.009$) (Table VI). Fig. 1-4 show the correlation between talk-time and haemodynamic variables. None of the haemodynamic variables (local temperature, pulse, systolic and diastolic pressures) just after quitting the call were found to bear any significant correlations with talk-time ($r=0.007$, $p=0.940$, $r=0.002$, $p=0.981$, $r=0.008$, $p=0.931$ and $r=-0.017$, $p=0.857$ respectively).

Table I. Distribution of subjects by their demographic characteristics (n= 313)

Demographic characteristics	Frequency	Percentage	Mean ± SD (range)
Age (years)	---	---	22.2 ± 1.1 (20-24)
Sex			
Male	180	57.5	---
Female	133	42.5	---
Residence			
Urban	220	70.3	---
Rural	93	29.7	---
Socioeconomic status			
Poor	5	1.6	---
Lower middle class	59	18.8	---
Middle class	222	70.9	---
Upper middle class	24	7.7	---
Rich	3	1.0	---

Table II. Distribution of subjects by their profile of mobile use (n= 313)

Profile of mobile use	Median ± SEM	Range	IQR*
Duration of mobile use (years)	6.8 ± 2.7	14(2-16)	4
Number of calls made and received daily	5 ± 1	54(1-55)	4
Average duration of per call (minutes)	4.0 ± 0.4	59(1-60)	5
Longest duration of the call daily (minutes)	10.0 ± 1.4	179(5-180)	15
Average time spent on mobile phone daily (hrs.)	4.3 ± 2.3	11(1-12)	2

* IQR = Interquartile range

Table III. Distribution of subjects by their Purposes of using smart phone (n= 313*)

Purposes of using smart phone	Frequency	Percentage
Transmission and reception of both calls and messages using net	297	94.9
Keeping connected with the social media like FB, YT, WA etc.	305	97.4
Maintaining academic/official relationships	302	96.5
Viewing & enjoying socially acceptable contents	299	95.5
Viewing & enjoying socially unacceptable/erotic contents	89	28.4
Playing and enjoying video games	87	27.8

*Total will not correspond to 100%, for multiple response

Table IV. Distribution of subjects by their symptoms or problems (n = 313*)

Symptoms or problems	Frequency	Percentage
Irritability	121	38.7
Sleeplessness	96	30.7
Weekly headache (mild to severe)	95	30.3
Hotness in the ear during call	70	22.4
Earache during call	61	19.5
Occasional vertigo	42	13.4
Tinnitus (a buzzing sound in the ear)	38	12.1
Hearing deficit	20	6.4
Blurred vision	116	37.1
Eye strain/irritation	101	32.3
Lacrimation	90	28.8
Dry eye	47	15.0
Red-eye	57	18.2
Neck pain	55	17.5
Indigestion/IBS	25	7.9

*Total will not correspond to 100%, for multiple response

Table V. Distribution of subjects by their suffering from mental problems (n= 195*)

Perceived mental, personal/familial/social problems	Frequency	Percentage
Mental problem	136	69.7
Depression (n = 136)	84	61.7
Anxiety (n = 136)	80	58.8
Stress (n = 136)	104	76.5
Personal/familial/social problems (n = 136*)		
Study pressure	95	69.8
Familial problem	78	57.3
Financial constraint	68	50.0
Mobile addiction	66	48.5
Love-affairs complex	45	33.1

*Total will not correspond to 100%, for multiple response

Table VI. Changes in haemodynamic variables before and after call

Haemodynamic variables	Measure		*p-value
	Before call (n = 118)	After call (n = 118)	
Pulse (beats/min)	89 ± 17	92 ± 17	0.009
Systolic blood pressure (mmHg)	120.6 ± 12.5	119.3 ± 13.6	0.185
Diastolic blood pressure (mmHg)	74.1 ± 9.4	73.2 ± 9.9	0.777
Local temperature over parotid gland (°F)	97.4 ± 0.7	98.0 ± 0.8	< 0.001

*Data were analyzed using Paired-sample t-Test and were presented as mean ± SD.

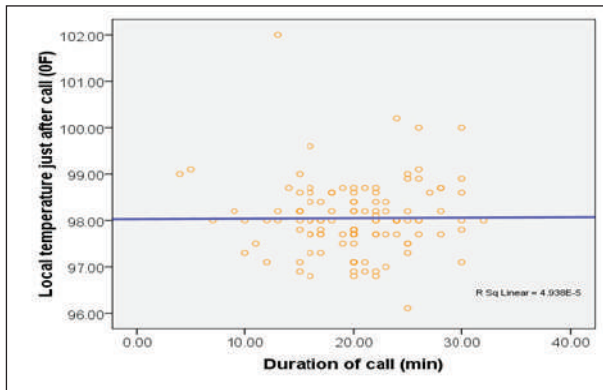


Fig. 1 showing correlation between talk-time and local temperature

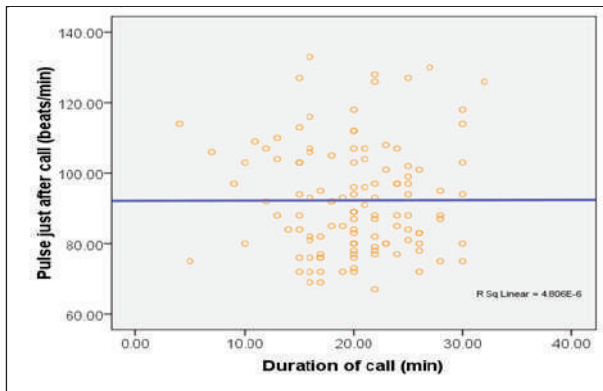


Fig. 2 showing correlation between talk-time and pulse (heart rate)

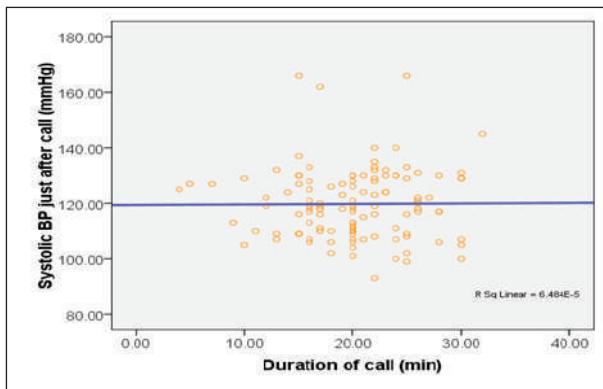


Fig. 3 showing correlation between talk-time and systolic blood pressure

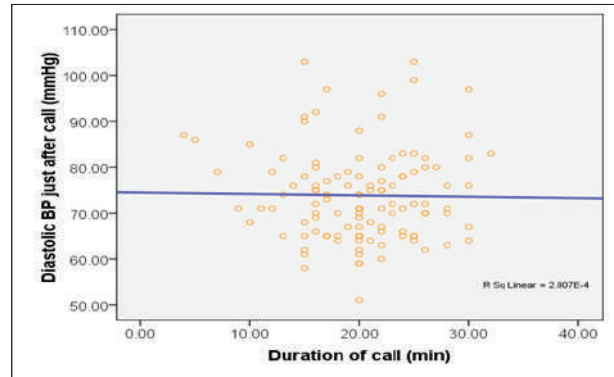


Fig. 4 illustrating the correlation between talk-time and diastolic blood pressure

DISCUSSION:

Some of the findings presented in the result section needs further explanation/interpretation to come to a conclusion. The present study was intended to see the status of physical health of mobile phone users and the impact of talk-time on haemodynamic stability (as an indirect evidence of impact of RF-EMF on haemodynamic variables). The study demonstrated that all the respondents were young (varying from 20-24 years with mean age being 22 years) and invariably using Smartphone with median duration of use being 6 years. Investigating about profile of mobile use revealed that the median number of calls made and received daily (on an average) was 5(range: 1-35), the median of average duration of per call was 4 (range: 1-60) minutes. Overall, the users spent on an average 4(range: 0.5-12.0) hours' time daily on mobile (including the time spent of internet). A sizable proportion of the respondents (around 28%) used smartphone to view socially unacceptable or erotic contents (28.4%) and playing and enjoying video games (27.8%) which raises concern.

A considerable proportion of the mobile users experienced irritability, sleeplessness, weekly headache, hotness in the ear during call, earache, occasional vertigo and tinnitus, which are believed to be due to RF radiation from the digital devices used by the respondents. The symptoms of computer vision or digital eye syndrome like blurred vision, eye-strain or irritation, lacrimation, dry-eye, red-eye, neck pain reported were no less and inappreciable from health perspective. Studies of various designs have looked into the consequences of mobile phone exposure on

various symptoms. Acute impacts (i.e., immediate responses to the exposure) have been studied in controlled settings, with outcomes including headache, wellbeing, and physiological responses. Some cross-sectional population studies have linked mobile phone use to an increased prevalence of headaches, sleeping problems, attention problems, and a decreased sense of well-being, however biases in the cross-sectional design restrict their interpretation.^{17,18} Few studies have looked at the occurrence of symptoms including headaches, tinnitus, and other somatic complaints in relation to data on RF-EMF exposure that was obtained prospectively.^{19,20} A Swiss study found no link between mobile phone use and tinnitus or total symptom score, probably because of a small sample size and just one year of follow-up time. Besides, it had insufficient statistical power to detect the occurrence of outcomes among those who were free of the symptoms at baseline.¹⁹ A Dutch study did not find any associations with sleep disorders or other symptoms and studied on exposure from base stations rather than mobile phone use.²⁰ A large Danish prospective study demonstrated higher rates of hospitalizations for migraine headache and vertigo among mobile phone users, but the study did not provide any information on amount of mobile phone use and confounders were limited to age, sex and calendar period only.²¹

Whether radiofrequency radiation emitted from the smartphone cause rise of local temperature and changes in haemodynamic variables, data on pulse, systolic and diastolic blood pressures and local temperature over parotid gland of respondents from medical students were taken before and immediately after a phone call. Analysis showed that the local temperature was significantly increased from by 0.6 °F after a median duration of 20(range: 4-32) minutes call with consequent increase of heart rate by 3 beats/min. However, neither local temperature nor pulse immediately after quitting the call was found to exhibit any significant correlations with talk-time indicating that not all individuals are equally sensitive to radiofrequency electromagnetic fields (RF-EMF). Besides, radiofrequency emitting

rate, measured in terms specific absorption rate (W/kg), from different brands of mobile is not the same, which may also be considered to explain such orthodox findings. Had all individuals been equally sensitive to RF-EMF and all the mobiles used the same RF, we probably would have got a linear correlation between talk-time and local temperature as well as between talk-time and heart rate.

Health effects of RF-EMF emitted from mobile phones have been the topic of research for over two decades, primarily prompted by a widespread concern that rampantly used novel technology could have unusual health consequences, rather than any firmly grounded hypothesis. Although people have been exposed to RF-EMF for decades, mostly from radio and television broadcasts and from industries using RF-EMF generating equipments, the rapid adoption of mobile phone technology has exponentially increased RF-EMF exposure, especially to the head. A wide array of health outcomes such as, different types of carcinomas (especially intracranial tumours), neurodegenerative ailments, sleep disturbance, & other health-related problems have all been investigated. Several expert groups have reviewed the scientific evidences generated from the studies²²⁻²⁴ but have not found convincing data of adverse health effects at exposure levels encountered in the general population, although International Agency for Research on Cancer classified RF-EMF as possibly carcinogenic to humans (class 2B). A large European collaborative prospective cohort study of mobile phone use was started in Sweden, Finland, Denmark, the UK and The Netherlands in 2007–2014 to provide improved scientific evidence on potential health hazards due to RF-EMF from mobile phone use.²⁵ The preliminary findings of the study (based on Swedish and Finish data only) demonstrated that the participants at highest decile of recorded call-time (average call-time >276 min per week) at baseline reported a weak, relative risk of increased frequency of weekly headaches after a 4-year follow-up (adjusted OR = 1.13, 95% CI = 0.95–1.34). But this finding largely seemed to be spurious after adjustment for confounders. There was no distinct gradient of

weekly headache with increasing call-time (P trend 0.06). Tinnitus and hearing loss were not at all associated with call-time.

Right now, we would like to conclude the findings of our study. But before concluding, the strengths and limitations of the study deserve mention. The study was conducted on an adequate sample to draw a valid conclusion, but lack of a control group in the study limits generalization of the findings. Another strength of this study is that when we assessed the haemodynamic state (local temperature, pulse and blood pressures) of the respondents and asked them to make a call, we told them to talk sitting on a chair in a cool room, avoid going under the sun and hot /exciting talk while communicating. The respondents were also instructed to ask us before quitting the call so that changes in haemodynamic state of the respondents could be measured as soon as they finish talking.

CONCLUSION:

Summarizing the findings of the study, it appears that a considerable proportion of mobile users experience irritability, sleeplessness, weekly headache, hotness in the ear during call, earache, occasional vertigo and tinnitus. The symptoms of computer vision syndrome or digital eye syndrome like blurred vision, eye-strain or irritation, lacrimation, dry-eye, red-eye and neck pain are also not unusual. The local temperature and heart rate are significantly increased with prolonged talk-time. However, neither local temperature nor heart rate just after the call does bear any correlations with talk-time.

REFERENCES:

1. <https://www.newagebd.net/article/162209/mobile-phone-connection-growth-3-year-high-in-2021>
2. Oftedal G, Wilen J, Sandstrom M, Mild KH. Symptoms experienced in connection with mobile phone use. *Occup Med (Lond)* 2000;50:237-45.
3. Frey AH. Headaches from cellular telephones: are they real and what are the implications? *Environ Health Perspect* 1998;106:101-03.
4. Borbely AA, Huber R, Graf T, Fuchs B, Gallmann E, Achermann P. Pulsed high-frequency electromagnetic field affects human sleep and sleep electroencephalogram. *Neurosci Lett* 1999;275:207-10. doi: 10.1016/S0304-3940(99)00770-3.
5. Preece AW, Iwi G, Davies-Smith A. Effect of a 915-MHz simulated mobile phone signal on cognitive function in man. *Int J Radiat Biol* 1999;75:447-56. doi: 10.1080/095530099140375.
6. Hamblin DL, Wood AW, Croft RJ, Stough C. Examining the effects of electromagnetic fields emitted by GSM mobile phones on human event-related potentials & performance during an auditory task. *Clin Neurophysiol* 2004;115:171-78. doi:10.1016/S1388-2457(03) 00313-4.
7. Fritze K, Sommer C, Schmitz B. Effect of global system for mobile communication (GSM) microwave exposure on blood-brain barrier permeability in rat. *Acta Neuropathol (Berl)* 1997;94:465-470. doi: 10.1007/s0040 10050734.
8. Haarala C, Aalto S, Hautzel H, Julkunen L, Rinne JO, Laine M, et al., Effects of a 902 MHz mobile phone on cerebral blood flow in humans: a PET study. *Neuroreport* 2003;14: 2019-23. doi: 10.1097/ 00001756-200311140- 00003.
9. Rösli M, Moser M, Baldinini Y, Meier M, Braun-Fahrländer C. Symptoms of ill health ascribed to electromagnetic field exposure-a questionnaire survey. *International Journal of Hygiene Environmental Health* 2004;207:141-150.
10. McKinlay AF, Allen SG, Cox R, Dimbylow PJ, Mann SM, Muirhead CR, et al. Review of the scientific evidence for limiting exposure to electromagnetic fields (0-300GHz). *Docs NRPB* 2004;15:83.
11. <http://www.who.int/peh-emf/about/WhatisEMF/en/index4.html>.
12. Heinrich S, Thomas S, Heumann C, vonKries R, Radon K. Association between exposure to radiofrequency electromagnetic fields assessed by dosimetry and acute symptoms in children and adolescents: a population based cross-sectional study. *Environ Health* 2010;9:75. doi: 10.1186/1476-069X-9-75;
13. Baan R, Grosse Y, Lauby-Secretan B, El Ghissassi F, Bouvard V, Benbrahim-Tallaa L, et al. Carcinogenicity of radiofrequency electromagnetic fields. *The Lancet Oncology* 2011;12:624-626. pmid:21845765
14. Marino AA, Carrubba S. The effects of mobile-phone electromagnetic fields on brain electrical activity: a critical analysis of the literature. *Electromagnetic biology and medicine* 2009;28:250-274. pmid:20001702.
15. Kwon MS, Hamalainen H. Effects of mobile phone electromagnetic fields: critical evaluation of behavioral & neurophysiological studies. *Bioelectromagnetics* 2011;32: 253-272. pmid:21452356.
16. Regel SJ, Achermann P. Cognitive performance measures in bioelectromagnetic research—critical evaluation and recommendations. *Environmental health: a global access science source* 2011;10:10. pmid:21266038

17. Thomas S, Ku"hnlein A, Heinrich S, Praml G, Nowak D, von Kries R et al. Personal exposure to mobile phone frequencies and well-being in adults. *Bioelectromagnetics* 2008;29:463-70.
18. Heinrich S, Thomas S, Heumann C, von Kries R, Radon K. Association between exposure to radiofrequency electromagnetic fields assessed by dosimetry and acute symptoms in children and adolescents. *Environ Health* 2010;9:75.
19. Frei P, Mohler E, Braun-Fahrl"nder C, Fro"hlich J, Neubauer G, Ro"o"sli M. Cohort study on the effects of everyday life radiofrequency electromagnetic field exposure on non-specific symptoms and tinnitus. *Environ Int* 2012;38:29-36.
20. Martens AL. Modeled & perceived exposure to radiofrequency electromagnetic fields from mobile phone base stations and the development of symptoms over time in a general population cohort. *Am J Epidemiol* 2017;186:210-19. DOI: 10.1093/aje/kwx315
21. Schu"z P, Waldemar G, Olsen JH, Johansen C. Risks for central nervous system diseases among mobile phone subscribers. *PLoS One* 2009;4:e4389.
22. AGNIR 2012. Advisory Group on Non-Ionising Radiation. Health Effects of Radiofrequency Electromagnetic Fields. http://webarchive.nationalarchives.gov.uk/20140629102627/http://www.hpa.org.uk/webw/HPAweb&HPAwebStandard/HPAweb_C/1317133826368
23. Non-Ionizing Radiation, Part 2. Radiofrequency Electromagnetic Fields. IARC Monograph 102. Lyon: International Agency for Research on Cancer, 2013.
24. SCENIHR. Scientific Committee on Emerging and Newly Identified Health Risks. Potential Health Effects of Exposure to Electromagnetic Fields. European Commission, 2015. http://ec.europa.eu/health/scientific_committees/emerging/docs/scenihr_o_041.pdf
25. Schu"z J, Elliott P, Auvinen A, Kromhout H, Poulsen AH, Johansen C et al. An international prospective cohort study of mobile phone users. *Cancer Epidemiol* 2011; 35:37-43.