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Effects of Radiofrequency (Cell Phones and Television) on Migraine and Headache Symptoms in Children and Adolescents

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Abstract

Background: The present study aimed to assess the possible effects of using mobile phones during pregnancy on headaches and migraines in children and adolescents.

Objectives: Migraine and Headache Symptoms are attributed to Radiofrequency (Cell Phones and Television) in Children. It is worth noting that recent studies have not been able to indicate a convincing causal relationship with Radiofrequency.

Methods: The current meta-analysis, organized based on the PRISMA statement, was performed by searching the relevant articles published in PubMed, Cochrane Library, Web of Science, and Scopus. Original articles published in English from inception until April 1, 2023, were retrieved in this study. The quality of the articles included in the systematic review was scored based on the Newcastle-Ottawa Scale.

Results: A heterogeneity test was performed for headaches (children, adolescents, and both groups) and migraine. Considering that the chi-square test result was insignificant (P>0.05), the results of the fixed model were reported. Based on the reported results, the odds ratio estimate of the meta-analysis of children's headaches in the Fixed model was equal to 1.51. Furthermore, the meta-analysis results demonstrated that the odds ratio of headache in adolescents was 1.48; in both groups (children and adolescents), it was 1.51. The meta-analysis on migraine, with only two studies in this field, was equal to 1.52.

Conclusion: As evidenced by the obtained results, exposure to radiofrequency was related to migraine and headache symptoms. There are no high-quality randomized control trials (RCTs) and/ or multiple consistent non-RCTs without methodological flaws.

Keywords: Adolescents, Cell phones, Children, Headache, Migraine, Radiofrequency

1. Background

The majority of families today have access to television, video devices, computers, and the Internet. Listening to the radio or music is common among almost all adolescents, and almost all have cell phones (1). Nowadays, it is impossible to imagine a

modern social person who does not use a cell phone or Wi-Fi, and these technologies have increased significantly in recent decades (2,3). Currently, there are more than 700 million cell phone users across the globe. These cell phones produce various frequencies in different countries and continents. Exposure to radiofrequency (RF) energy depends on the frequency of cell phones. Analog telephones produce 450-900 MHz, digital telephones 1900-850 MHz, and third-generation telephones approximately 2000 MHz (4). Cell phones are also devices that emit low levels of RF in the microwave range during use (5). Children and adolescents are an important age group due to the high use of cell phones. The potential for higher vulnerability is arguable due to greater lifetime exposure, a still-developing nervous system, and greater conductivity of brain tissue. They use cell phones at a younger age and more than today's adults (6). Nonspecific symptoms, such as headaches, sleep problems, or concentration problems, are consistently attributed to cell phone use and exposure to cell phone stations (7, 8). Headache is one of the most serious health problems worldwide (1).

2. Objectives

In epidemiological studies, headache has been reported as one of the most common symptoms; nonetheless, it is worth noting that recent studies have not indicated a convincing causal relationship with cell phones (9). In light of the aforementioned issues, the present study aimed to assess the effect of RF on migraine and headaches in children and adolescents.

3. Methods

The current meta-analysis, organized based on the PRISMA statement, was performed by searching the relevant articles published in PubMed, Cochrane Library, Web of Science, and Scopus. Original articles published in English from inception until April 1, s2023, were retrieved in this study (10). The combination of keywords used in the search was based on Mesh, as well as the keywords listed in related articles, including "Mobile," "Prenatal period," "Radiofrequency exposure," "Cell phone," "electromagnetic field," "Cellular phone," "Migraine," "Child." We also hand-searched the gray literature and reference lists of identified papers. We also sent an email request to ask about missing data and full-text availability.

Inclusion criteria: The original studies and those investigating childhood migraine due to RF electromagnetic field radiation exposure during pregnancy and after birth were included.

Exclusion criteria: Publication of an article in several sources, articles published in a source with low credibility, studies examining barriers to sexual dialogue in Western and European countries, non-English language articles, unpublished studies, letters to the editor entered into the review.

Data extraction: The Cochrane data extraction tool was modified and utilized to collect the data from each study. Two authors separately reviewed and extracted the information below from the selected studies and reached a consensus after exchanging opinions. Extracted information included the author's name, year of publication, country, study population, exposure characteristics, exposure severity scale, and study outcomes. The data extracted from each of the articles are presented in Table 1. Two independent reviewers performed Data extraction, and discussion was used in case of controversy.

Table 1. Results of data extraction

First author/ year/ country	Study design	Study population	Duration of study	Type of exposure	The scale of exposure intensity	Outcomes/results
Heinrich et al. /2010 /Germany (11)	Population-Based Cross-Sectional Study	1484 children and 1508 adolescents aged 8-10 years and 13-15 years, respectively	2006-2007	Cell phones (based on wireless and WLAN phones)	Dosimetry/self-reported exposure	Greater severity of headache, agitation, and concentration problems in adolescents exposed
Milde-Busch et al./2010 /Germany (12)	Population-Based Cross-Sectional Study	1025 adolescents aged 13-17 years	2010	Cell phones	Self-reported exposure	Greater intensity of headache in adolescents with daily listening to music
Sudan et al. / 2010 / USA (13)	Population-Based Cross-Sectional Study	52,680 pregnant women and children	1996-2002	Prenatal cell phone exposure	Self-reported exposure	The likelihood of migraine and headache-related symptoms in children who were exposed to cell phones was higher than in children who were not exposed to contact.
Söderqvist et al. / 2008 / USA (14)	Cross-Sectional Study	2000 Swedish adolescents aged 15-19 years	2005-2006	Cordless phones	Self-reported exposure	Greater severity of headache, agitation, and concentration problems in adolescents exposed Greater intensity of headache in adolescents with daily listening to music The likelihood of migraine and headache-related symptoms in children who were exposed to cell phones was higher than in children who were not exposed to contact. Health complaints include fatigue, stress, headaches, anxiety, concentration problems, and sleep disturbances among regular wireless phone users.

Quality assessment: Newcastle-Ottawa Scale (NOS) was applied to evaluate the quality of cohort and case-control studies. NOS has three major domains: comparability, observed outcome, and patient selection. Based on this criterion, the articles that scored six and above were included in the study. The scores of 4-5 were considered a moderate risk of bias, and scores below four were regarded as a high risk of bias. The minimum score in this criterion was 0, and the maximum score was 9 (Table 2, 3). Based on this criterion, the articles scored six or above were classified as good quality (11). Two independent reviewers performed the quality assessment, and if there were any differences in opinion, it was resolved by discussion.

Data were analyzed using Stata software (version 13.1). Finally, the I2 and Q Cochran test determined the heterogeneity index between studies. Heterogeneity is interpreted as mild if the I2 value is < 25%, moderate if the I2 ranges from 25% to 50%, severe if the I2 is between 50% and 75%, and highly severe if the I2 is >75%. The

significance level was considered to be less than 0.05. A random or fixed effect model was used to report data based on heterogeneity level.

Table 2. The quality score of the cohort studies included in the systematic review based on the Newcastle Ottawa Scale

Assessment items	Heinrich et al. (11)	Milde-Busch et al. (12)	Sudan et a1. (13)	Söderqvist et al. (14)
The exposed cohort is genuinely representative of the average condition of the exposed population	1	1	1	1
The non-exposed cohort is taken from the same population as the exposed cohort.	?	?	1	1
Confirmation of exposure using a reliable file/structured interview	1	1	1	1
Comparability of cohorts based on gender and age	1	1	1	1
Comparability of cohorts based on other factors	1	1	1	1
independent and blind assessment of outcomes/ reliable data	1	1	1	1
Adequacy of the follow-up period for the occurrence of consequences	1	1	1	1
Complete follow-up of all samples	1	1	1	1
The improbability of creating bias with the origin of missing samples	-	-	-	-
Total score	7	7	8	8

Table 3. Estimated ORs of Headache and Migraines and their 95% confidence intervals for each study

ID	The first author (publication date)	Subjects	Exposure	Method of detection	OR	95% CI
1	Heinrich et al. (2010)	Children	mobile phone	Headache	2.33	(0.98 -5.54)
2	Heinrich et al. (2010)	Adolescents	mobile phone	Headache	1.55	(1.05-2.29)
3	Fredrik Söderqvist et al. (2008)	Adolescents	wireless telephones such as phones (DECT)mobile and cordless	Headache	1.5	(1.2-2.1)
4	Sudan et al. (2012)	Children	Cell Phone	Headache	1.51	(1.42–1.60)
5	Sudan et al. (2012)	Children	Cell Phone	migraines	1.51	(1.20–1.91)
6	Milde-Busch et al. (2010)	Adolescents	Mobile phone	Headache	1.2	(0.7-2.0)
7	Milde-Busch et al. (2010)	Adolescents	Mobile phone	migraines	1.7	(0.4-7.0)

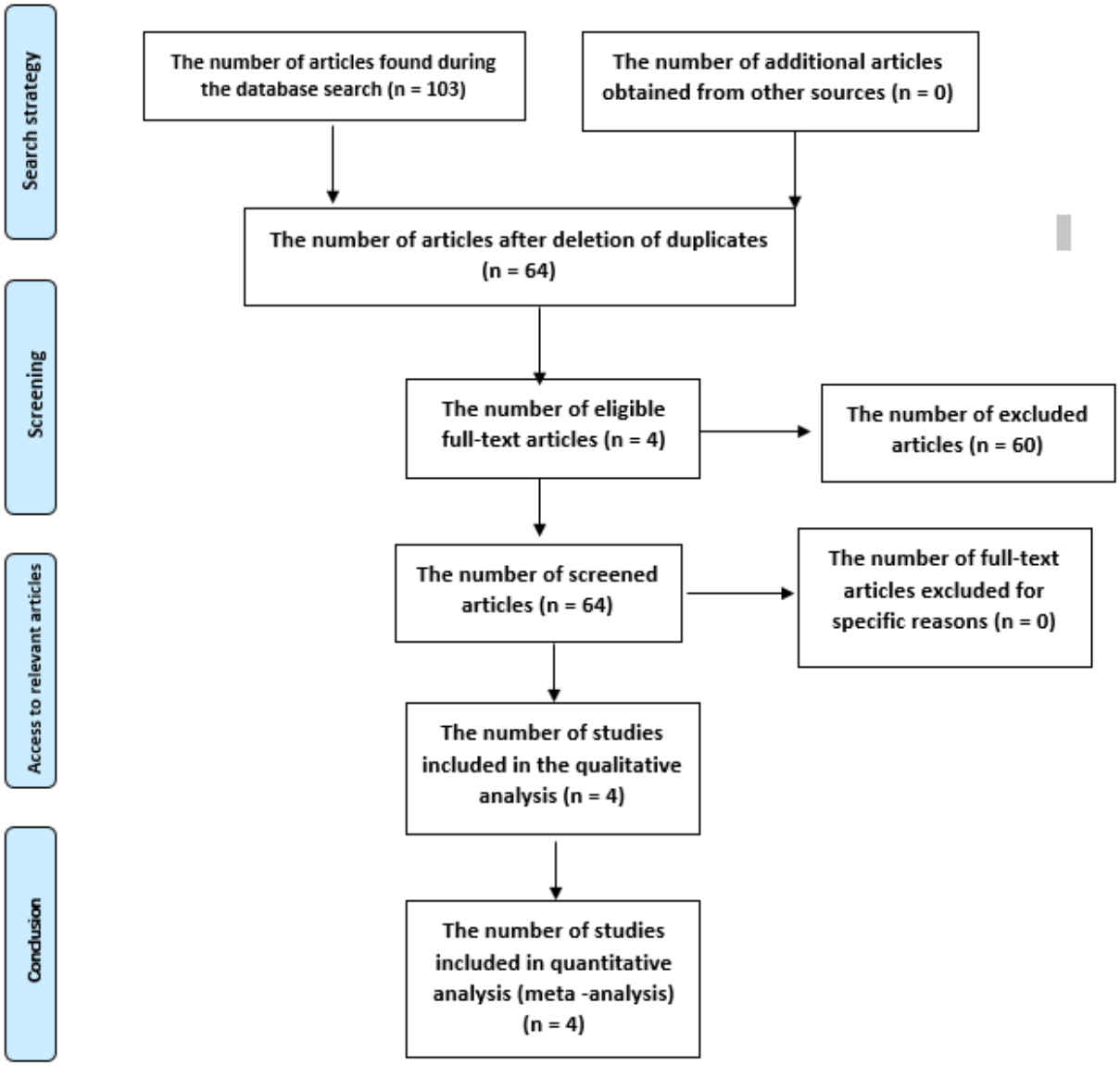

Figure 1. Flowchart of the Search Process

4. Results

The detailed PRISMA flow chart is shown in Figure. 1. A heterogeneity test was performed for headaches (children, adolescents, and both groups) and migraine. Considering that the chi-square test result was insignificant (P>0.05), the results of the fixed model were reported. Based on the reported results (Table 4), the odds ratio estimate of the meta-analysis of children's headaches in the Fixed model was equal to 1.51. Furthermore, the meta-analysis results illustrated that the odds ratio of headache in adolescents was 1.48; in both groups (children and adolescents), it was 1.51. The meta-analysis on migraine, with only two studies in this field, was equal to 1.52.

Figure 2 (left side) displays the information of all five studies and their weights based on the fixed model for the odds ratio. Meta-analysis estimate of odds ratio for headache in children and adolescents was plotted separately. The highest weight (89.78%) was assigned to the study of Sudan (2012) et al., and the lowest

weight (0.42%) pertained to the study by Heinrich et al. (2010).

Figure 3 depicts the information of all two studies and their weights based on the fixed model for the odds ratio of migraine. The highest weight (97.44%) was assigned to the study of Sudan et al. (2012).

Table 4. Estimated ORs of headache and migraines and their 95% confidence intervals; estimation was performed based on a fixed effect model

Symptoms	Subjects	N	Fixed- effect model (95% CI)	P-value of Heterogeneity test[1]
Headache	Children	2	1.51 (1.42, 1.60)	0.318
	Adolescents	3	1.48 (1.24, 1.77)	0.705
	Children+ Adolescents	5	1.51 (1.43, 1.59)	0.782
Migraines	Children+ Adolescents	2	1.52 (1.20, 1.91)	0.873

[1]Chi-squared test

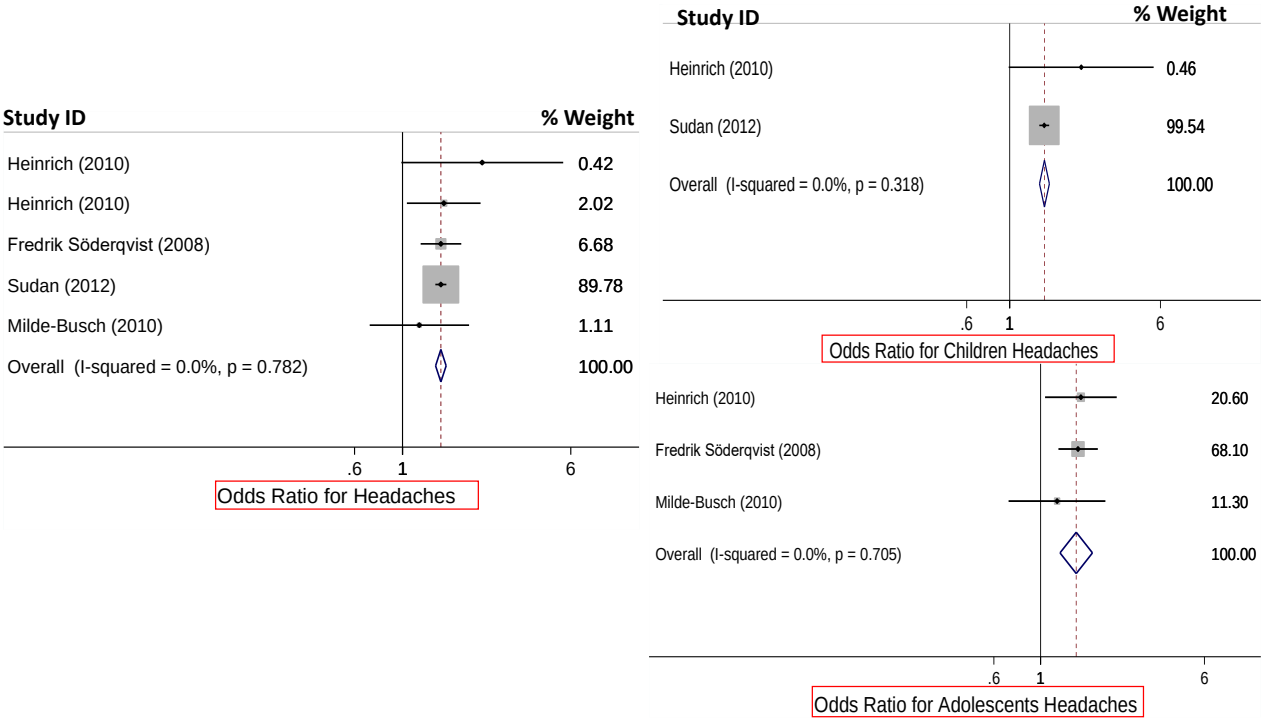

Figure 2. Forest plot showing weights (%) for each of five studies of headaches (left-hand side), two studies of children's headaches (on the top of right-hand side), and three studies of adolescents' headaches (on the bottom of right-hand side), with pooled OR (fixed-effects model)

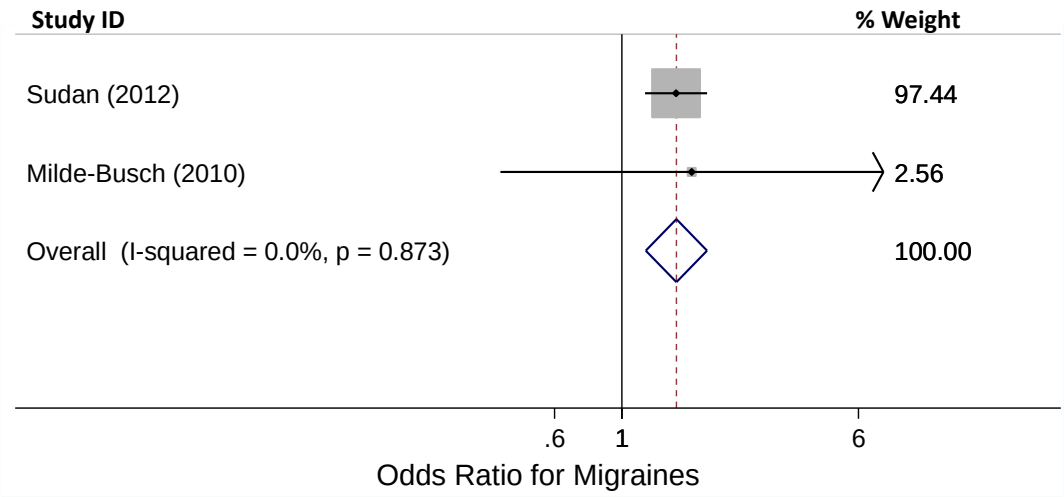

Figure 3. Forest plot showing weights (%) for each of two studies of Migraines, with pooled OR (fixed-effects model)

Charts related to publication bias

Begg's test and funnel plot can be employed to check publication bias. This test interprets the funnel plot statistically. If the funnel plot is symmetrical and the p-value is not significant, it can be concluded that there is no publication bias.

As illustrated in Figure 4, considering that the funnel plot is symmetrical, it can be concluded that there is no heterogeneity between studies. Moreover, the p-value for the OR index for headache symptoms using Begg's test was equal to 0.822, indicating the absence of publication bias.

Sensitivity analysis

In sensitivity analysis, it is possible to evaluate the impact of each study on the final result. Sensitivity analysis can make it possible to know how much each study contributes to the overall outcome of the studied index.

Based on the last row of Table 5, the odds ratio for headache and migraine equals 1.51. The upper lines demonstrate the total if each study were removed. The exclusion of individual studies caused the headache odds ratio to change slightly.

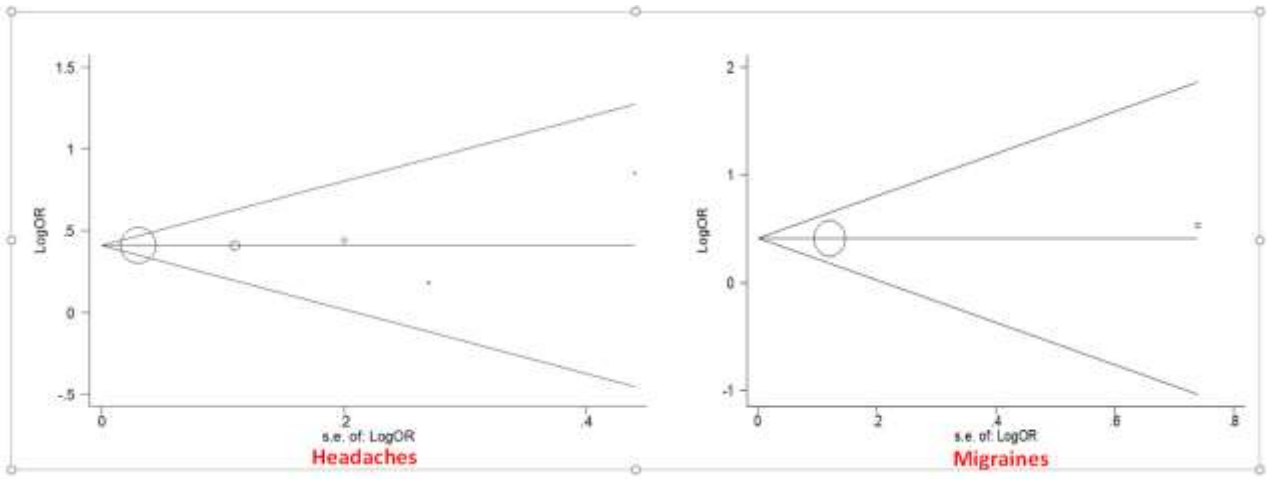

Figure 4. Begg's Funnel plot of OR with 95% confidence limits for Headaches (left-hand side) and Migraines (right-hand side)

Table 5. Sensitivity analysis of OR for each of the five studies

Study omitted	Coefficient (95%CI)	
	Headache	Migraine
Heinrich (2010)	**1.50 (1.42, 1.59)**	-
Heinrich (2010)	**1.51 (1.42, 1.59)**	-
Fredrik Söderqvist (2008)	**1.51 (1.42, 1.60)**	-
Sudan (2012)	**1.50 (1.26, 1.79)**	**1.70 (0.40, 7.24)**
Milde-Busch (2010)	**1.51 (1.43, 1.60)**	**1.51 (1.19, 1.91)**
Combined	**1.51 (1.43, 1.59)**	**1.51 (1.20, 1.91)**

Fixed-effect model

5. Discussion

In recent years, the frequency of cell phone use in families has increased drastically; therefore, children are also exposed to waves. The use of social media for children's health has benefits and risks. The notable benefits include exposure to vast knowledge and sources of new ideas, social support, and increased opportunities to access health promotion messages and information. On the other hand, the potential risks include adverse health effects (such as exposure to microwave radiation, child weight, eye damage/eye irritation, loneliness, ear suffers damage, type of cancers, and sleep problems) and exposure to incorrect, inappropriate, or unsafe content and contacts which threaten a person's privacy

and confidentiality (15, 16). Since children's nervous system is growing, and for anatomical reasons, children have smaller heads and thinner skulls, their brain tissues absorb more waves than adults (17, 18). This research indicated that using television and cell phones in the vicinity of children or themselves harms their health, such as headaches.

One of the most common symptoms reported in this study was the occurrence of headaches in children or adolescents following the use of television and cell phones. The prevalence of headaches in children and students is one of the most serious health problems in the world (19). A study by Zheng et al. (2014) in China pointed out a significant relationship between headaches and the use of cell phones in children. Moreover, they reported that daily use of cell phones by children elevated the risk of headaches up to 2.8 times per person. Chiu et al. (2015) demonstrated that children who regularly use mobile phones have 1.42 times the odds ratio of headaches and migraines than other children (20). Another study conducted by de Vitta et al. (2020) in Brazil on factors affecting the occurrence of headaches in students revealed that the initial prevalence of headaches in these people was around 60.7%, which could be caused by the use of electronic devices, such as television and cell phone (19). In line with the results of our study, Cho et al. (2016) in South Korea illustrated that increasing the duration of phone calls was the cause of aggravating and increasing headaches and reducing the duration of calls to less than 5 minutes was associated with a decrease in the incidence of headaches (21). In another study, a significant relationship was observed between listening to music on headphones and headaches in 13-17-year-old adolescents (12). Another study documented that all types of screen-based activities increase the incidence of headaches with the increase in the number of hours spent using the screen (22). Research has also demonstrated that the high prevalence of this phenomenon is directly related to the decrease in people's socioeconomic conditions since low-income groups may have less access to a healthy diet, optimal stress management, health, and job services (19, 23).

Social technology use brings various advantages and disadvantages for mental and /or physical health. Another common problem in the target group is tension headaches after exposure to electronic screens (15, 24). Oksanen et al. (2005) found that children with migraine tend to use computers more frequently compared to those with migraine (25). The duration of contact and the type of body position when using electronic devices are directly related to the occurrence of stress headaches, and the effect of thermal sensation can cause this due to exposure to radiofrequency-electromagnetic field (RF-EMF) (21). Using the mentioned devices for more than three hours a day is associated with the occurrence of stress headaches (19). A study revealed that this type of headache can be caused by sleep problems and the feeling of heat in the ears, and these symptoms are also dependent on the dose and the number of hours of using these devices during the day (26). It has been proven that behavioral interventions are very effective, especially in treating pediatric headaches, and can replace drug therapy by eliminating or reducing the use of electronic devices (15). In addition, the use of television in the public space of the home, not only in the bedroom, and eliminating the use of digital devices (in the morning, while eating and sleeping) and using them for up to two hours a day in school-aged children can significantly help reduce migraines in children.

Different studies reported a wide range of results investigating prenatal cell phone exposure and its effect on the child and neurodevelopment, depending on the child's development. Haghani et al. investigated the possible effects of prenatal exposure to cell phone waves (about six hours a day) on male and female rats. They found that prenatal

exposure to electromagnetic fields (EMF) led to marked changes in the electrophysiological properties of Purkinje neurons. Nonetheless, these changes may not be severe enough to alter cerebellar-dependent functional tasks. Birks et al. (2017), in a multinational cohort study of 83,884 mother-child pairs regarding the effects of prenatal cell phone use, demonstrated that maternal cell phone use during pregnancy may be associated with an increased risk of behavioral problems, especially attention-deficit/hyperactivity disorder (27). Most studies were conducted retrospectively; however, the potential problems of retrospective studies are recall bias and overexpression of exposure. The small sample size and small number of studies were the notable limitations of this meta-analysis.

6. Conclusion

The findings of this study confirmed that exposure to radiofrequency was related to migraine and headache symptoms. There are no high-quality randomized control trials without methodological problem flaws.

Availability of data and materials: The dataset analyzed during the current study is available upon reasonable request from the corresponding author.

Conflicts of interests: The authors have no relevant conflict of interests to declare.

Consent for publication: All authors agree to publish the article in the present form.

Ethics approval and consent to participate: Not applicable.

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Author contributions: Conceptualization, project administration, and funding acquisition: Masumeh Ghazanfarpour, Mohammad Hasan and Mohammadi, Hashem Lashgari Kalat; Methodology: Roya Nikbakht, Elnaz Askaripour, Raziye Najafabadipour, Omolbanin Heydari, Mohammad Hasan Mohammadi and Hashem Lashgari Kalat; Software: Hashem Lashgari Kalat, Masumeh Ghazanfarpour and Elnaz Askaripour, Raziye Najafabadipour; Validation and supervision: Elnaz Askaripour, Raziye Najafabadipour, Hashem Lashgari Kalat and Mohammad Hasan Mohammadi; Formal analysis: Roya Nikbakht5, Omolbanin Heydari and Masumeh Ghazanfarpour; Investigation: Hashem Lashgari Kalat, Masumeh Ghazanfarpour and Mohammad Hasan Mohammadi; Resources: Elnaz Askaripour, Raziye Najafabadipour, Omolbanin Heydari and Hashem Lashgari Kalat; Data curation, Elnaz Askaripour, Raziye Najafabadipour, Omolbanin Heydari and Hashem, Mohammad Hasan Mohammadi Lashgari Kalat; Writing the original draft: Hashem Lashgari Kalat, Elnaz Askaripour, Raziye Najafabadipour and Mohammad Hasan Mohammadi; Review and editing: All authors

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