GENERAL DENTISTRY

The effect of smartphones on daytime sleepiness, temporomandibular disorders, and bruxism among young adults

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Objectives: Effects of modern cellular technology on our lives is a relatively new topic of interest. The aim of the present study was to investigate the effect of smartphone use on daytime sleepiness, temporomandibular disorders (TMD), and bruxism (sleep and awake) among young adults in Israel. **Method and materials:** Questionnaires on demographic variables, mobile phone use characteristics, anxiety, depression, daytime sleepiness, bruxism (sleep and awake), and diagnosis of TMD were filled in by ultra-Orthodox young adults (18 to 35 years of age) using a simple mobile device with no internet connection, religious young adults who use an internet-connected smartphone solely for work purposes, and secular young adults with an internet-connected smartphone for unlimited use. **Results:** Various aspects of smartphone use, including being awakened at night by the phone, stress caused by information delivered by the phone, and stress from phone overuse increased the risks of daytime sleepiness, TMD, and bruxism. Those sequelae are associated with substantial negative effects on both the individual and society. High risks of motor vehicle accidents, chronic orofacial pain, and irreversible damage to hard dental tissue structures are some of those negative consequences. **Conclusions:** The adverse effects of smartphone use on daytime sleepiness, TMD, and bruxism are substantial. Their influence on public health and health care costs are causes of concern.
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Key words: awake bruxism, daytime sleepiness, sleep bruxism, smartphone use, temporomandibular disorders (TMD)

The last decade has witnessed tremendous changes in the way we communicate and use our mobile phones. More and more technologies are incorporated into the device commonly referred to as a “smartphone,” as it has become the main computer used in everyday life. It is no longer used exclusively for telephone calls, but also for networking, chatting, communicating, and gaming. People study, read, work, socialize, and practically “live” through their mobile phones, some with a constant need to be available and able to react instantly. This new lifestyle carries with it some negative mental and physical health consequences, such as daytime stress, difficulty in falling asleep, and repeated awakening at night or early morning in order to check the phone.[1] New behavioral addictions have been described, such as fear of missing out (FOMO)[2] and phobia of losing or forgetting the phone and being disconnected (NOMO).[3] Chronic exposure to the smartphones’ light emission at night can lead to disruption in melatonin secretion and have further deleterious effects, such as daytime sleepiness, impaired memory, and decreased stress management.[4-8] In addition to the immediate effect of smartphone use on stress and sleep, it may also have indirect influence on a group of disorders that are directly affected by stress and anxiety, such as temporomandibular disorders (TMD) and bruxism.

TMD is a collective term for a variety of disorders affecting the temporomandibular joints, the masticatory muscles, and the associated structures.[9] The etiology is multifactorial, with the possibility of one or more anatomical, physiologic, psychosocial (ie, stress, anxiety), behavioral (ie, bruxism, poor sleep), and genetic factors interacting or contributing to their onset.[10,11] By having negative outcomes on stress management, poor sleep quality can further serve as a perpetuating factor for TMD.

Bruxism is an umbrella term for several jaw muscle activities. The motor activity during sleep is referred to as sleep bruxism (SB), and as awake bruxism (AB) during wakefulness.[12] Psychosocial factors, such as stress and anxiety, can lead to exacerbation of SB, which, in turn, is positively associated with insomnia and high levels of daytime fatigue and sleepiness.[13-17]

A global survey ranks Israel as the second highest in smartphone usage.[18] Recent findings indicate the important role played by smartphones in the lives of young Israeli adults.[19]

However, Israeli society is not a homogenous one. It includes sectors that differ from each other in their level of religiousness, from the ultra-Orthodox to the completely secular. The level of religiousness has obvious explicit and implicit influences on everyday lifestyles, including the use of cellular phones.

The ultra-Orthodox sector forbids connection to the internet and, as such, the use of smartphones that have internet connection is avoided. This avoidance stems from an ideology that limits exposure to the modern world to a minimum. Instead, the ultra-Orthodox use mobile phones that enable only voice communication and simple text messages. Their types of mobile phones must receive the approval of the Rabbinical Committee for Communication, and are referred to as "kosher" phones (KP).

There are sectors in the Orthodox community that are somewhat less strict. Those followers conduct an Orthodox way of life, recommend the use of a KP for everyday use, but allow a limited use of smartphones with internet access for work purposes ("combined use" [CU]).

The fact that there are two Orthodox communities with distinct patterns of mobile phone use (KP versus CU) enables the exploration of the effects of smartphone use on young adults with an otherwise very similar cultural background and lifestyle. A third group, that of secular young adults, use smartphones with internet access and social networking, exactly as in other unrestricted lifestyles (SP).

The aim of this study was to investigate the effect of mobile phone use on datime sleepiness, TMD, and bruxism (sleep and awake) among young adults from secular and religious sectors in Israel.

Method and materials

Population

Three groups of young adults aged 18 to 35 years were eligible for study recruitment. The age of participants was defined according to a definition of "young adults" as accepted in the literature.[20]

Group 1 included ultra-Orthodox subjects who use a KP (the KP group). Inclusion criteria were good health, age as specified above, leading an Orthodox way of life, and using exclusively a kosher and/or a hardwired phone for remote communication.

Group 2 included Orthodox subjects who use a kosher and/or hardwired phone for everyday use (calls, simple text messages) and a smartphone with internet connection exclusively for work purposes (the CU group). Inclusion criteria were good health, age as specified above, leading an Orthodox way of life, and using a KP and/or smartphone as specified above.

Group 3 included secular subjects who used smartphones (the SP group). Inclusion criteria were good health, age as specified above, leading a secular way of life, using internet freely, and using a smartphone with internet connection for calls, social networking, news, gaming, etc.

Exclusion criteria for all three groups were self-report of any neurologic or rheumatologic pathologies or dysfunctions.

Subjects were approached at their schooling institutions (eg, University, Talmudic/religious College, etc) or at their places of work or residence (Orthodox or secular neighborhoods). Subjects completed the questionnaire on the spot or returned it on the next day.

The study was conducted in full accordance with the World Medical Association Declaration of Helsinki. The Ethics Committee of the Tel Aviv University approved all study procedures (permit no. 13423869).

Instruments and study variables

The survey was conducted with the use of self-report questionnaires.

Demographic information

Questions referring to the following parameters: sex, age, education, working (yes/no), type of work (daytime, nighttime, shifts), average hours of sleep in 24 hours, personal status (single, married, in significant relationship, divorced), number of children, and age of youngest child.

Mobile phone use

The mobile phone questionnaire developed in 2001 by Thomée et al[8] was used to evaluate the extent of mobile phone use. The questionnaire consists of seven items referring to the following variables:

- Average number of mobile phone calls per day during the last month (0, 1 to 5, 6 to 10, 11 to 20, more than 20)
- Average number of connections to social media (eg, Facebook, Twitter, WhatsApp) per day during the last month (scored as above)
- Number of waking incidents at night to check the mobile phone during last month (ranging from "never" to "almost every night")
- Needing to be available (ranging from "never" to "24 hours")
- Level of stress caused by the need to be available (ranging from "none" to "extremely stressed")
- Awareness of mobile phone overuse (yes/no)
- Attempts to limit mobile phone use (yes/no).

The questionnaire enables the definition of the following variables (graded as low, medium, and high):

- Level of mobile phone use (Phone – Use)
- Night wakefulness (Phone – Night)
- Demand for availability (Availability)
- Stress due to mobile phone (Stress – Phone)
- Mobile phone overuse (Overuse).

Daytime sleepiness ("Sleepiness")

Daytime sleepiness was assessed through the Epworth Sleepiness Scale.[21] This is a simple, self-administered questionnaire which provides a measurement of the subject's general level of daytime sleepiness. The scale is widely used to evaluate daytime sleepiness, particularly among patients with sleep disordered breathing. The questionnaire consists of eight items scored on a scale of 1 to 4. It evaluates daytime sleepiness through questions regarding subjects' likelihood of dozing off or falling asleep in common daily life daytime situations (eg, reading, watching TV, talking, etc).

The final scores of daytime sleepiness are as follows:

- 0–5, low normal
- 6–10, high normal
- 11–12, mildly excessive
- 13–15, moderately excessive
- 16–24, severely excessive.

Trait anxiety (TraitA)

The well-established and widely used trait anxiety scale from the Spielberger state-trait anxiety questionnaire was used to assess the subjects' levels of trait anxiety.[22] The trait anxiety scale (TraitA) contains 20 statements with a four-point response format varying from 1 (not at all) to 4 (very much so).

The levels of trait anxiety are scored as follows:

- ≤ 30, low
- 31–45, moderate
- ≥ 45, high.

Diagnostic criteria for TMD (DC/TMD)

The 2014 updated manual of DC/TMD is a widely used and well-established tool to study TMD.[23] It is a dual axis diagnostic algorithm for diagnosing different subtypes of TMD: Axis I assesses clinical signs and symptoms, and Axis II evaluates associated psychosocial factors, such as anxiety and depression. The following Axis I and Axis II variables were evaluated.

Anxiety (Anx)

Axis II employs the GAD-7 questionnaire to assess generalized anxiety disorders (GAD).[24] This is a self-administered tool containing seven questions with a four-point response format varying from 0 (not at all) to 3 (nearly every day). Total scores of 5, 10, and 15 are generally used as cut-off points for mild, moderate, and severe anxiety. In the present study, the levels of anxiety were scored as follows:

- 0–4, minimal anxiety
- 5–9, mild anxiety
- 10–14, moderate anxiety
- 15–21, severe anxiety.

Depression (Dep)

Axis II employs the patient health questionnaire (PHQ-9) to evaluate depression. This is a self-administered tool containing nine questions aimed at screening for the presence and severity of depression. The final score ranges from 0 to 27, with scores of 5,10, and 15 indicating mild, moderate, and severe depression.[25] In the present study levels of depression were scored as follows:

- 0–4, minimal depression
- 5–9, mild depression
- 10–14, moderate depression
- 15–19, moderate to severe depression
- 20–27, severe depression.

Table 1 Demographic variables of the study groups

Variable	KP Group (n = 202)	CU Group (n = 104)	SP Group (n = 272)	*P*	Test
Female (%)	44%	60%	61%	.001*, KP < CU = SP	Chi-square
Age, y (mean ± SD)	25.5 ± 7.6	27.5 ± 6.8	28.2 ± 5.3	.000*, KP < CU = SP	Kruskal-Wallis
Personal status (% single)	51%	32%	44%	.013, CU < SP < KP	Chi-square
Children, n (mean ± SD)	2.00 ± 2.8	1.85 ± 2.0	0.65 ± 1.2	.000*, SP < CU = KP	Kruskal-Wallis
Age of youngest child, y (mean ± SD)	1.67 ± 1.1	2.25 ± 2.0	3.3 ± 3.3	.001*, SP < CU = KP	Kruskal-Wallis
> 6 sleep hours†	56%	55%	52%	.49	Chi-square

CU, combined use; KP, kosher phone; SD, standard deviation; SP, smartphone.
*Statistically significant (*P* < .05).
†The 6-hour cut-off point is based on the recommendations of the National Sleep Association, who define it as "appropriate" for young adults.[29]

Facial pain symptoms and/or masticatory system disturbances (TMD)

Axis I employs a symptom questionnaire that refers to the presence of pain in the area of the jaws, front of ears, and temples, and to the type of pain (eg, continuous, increasing with function) during the previous month.[23] Subjects who reported at least one of the pain symptoms typical to TMD (area of pain, type of pain), are referred to as TMD positive. This is an acceptable method for screening of TMD among large populations.[26]

Sleep bruxism

Sleep bruxism (SB) was evaluated by questions such as "Are you aware, or have you been told, that you grind or clench your teeth when you are asleep?" (yes/no). Awake bruxism (AB) was evaluated through questions such as "Are you aware, or have you been told, that you are clenching or grinding your teeth while you are awake?" (yes/no). This methodology is valid for screening for bruxism among large populations.[26-28] It adheres to the definition of "possible" bruxism, as graded by the consensus papers on bruxism.[12,13]

Statistical analysis

Data were analyzed using SPSS software (IBM). Power analyses using independent proportions showed that 100 subjects per group will yield a minimal difference of 15%, with 80% power and significance level of .05.

The data were tested for normality using one-sample Kolmogorov-Smirnov test. The following datasets were found to be skewed: age, number of children, age of youngest child, Sleepiness, TraitA, Anx, and Dep. Therefore nonparametric analysis (eg, Kruskal-Wallis) was used.

In the first step, chi-square and Kruskal-Wallis analyses were used to compare among groups with regard to the following variables: demographic information, mobile phone characteristics, daytime sleepiness, anxiety, depression, and presence of TMD, SB, and/or AB symptoms.

In the second step, multivariate analyses were performed as follows:

- Logistic regression to evaluate the effect of demographics (sex, age, education, working yes/no, type of work, average hours of sleep in 24 hours, personal status, number of children, and age of youngest child), anxiety (trait anxiety and anxiety according to GAD-7), depression (minimal, mild, moderate, moderate to severe, severe), and mobile phone characteristics (mobile phone use, night wakefulness, demand for availability, stress due to mobile phone, mobile phone overuse) on daytime sleepiness.
- Logistic regression to evaluate the effect of demographics, anxiety, depression, and mobile phone characteristics (as specified above) on TMD.
- Logistic regression to evaluate the effect of demographics, anxiety, depression, and mobile phone characteristics (as specified above) on AB.
- Logistic regression to evaluate the effect of demographics, anxiety, depression, and mobile phone characteristics (as specified above) on SB.

Table 2 Mobile phone use characteristics (% of subjects from each study group)

Characteristic		KP Group	CU Group	SP Group	*P*	Test
Level of phone use	Low	13%	3%	1%	.000*, KP < CU < SP	Chi-square
	Medium	27%	12%	1%		
	High	61%	86%	95%		
Night wakefulness	Low	80%	60%	46%	.000*, KP < CU = SP	Chi-square
	Medium	18%	27%	39%		
	High	3%	13%	15%		
Availability	Low	76%	62%	59%	.002*, KP < CU = SP	Chi-square
	Medium	21%	33%	38%		
	High	3%	5%	3%		
Stress due to phone	Low	78%	61%	50%	.000*, KP < CU < SP	Chi-square
	Medium	21%	34%	43%		
	High	1%	5%	7%		
Phone overuse	Low	80%	66%	55%	.000*, KP < CU < SP	Chi-square
	Medium	12%	19%	26%		
	High	8%	15%	19%		

CU, combined use; KP, kosher phone; SD, standard deviation; SP, smartphone.
*Statistically significant ($P < .05$).

Table 3 Daytime sleepiness among study groups (% of subjects from each study groups)

Daytime sleepiness	KP Group	CU Group	SP Group	*P*	Test
Low-normal	50%	51%	41%	.005, KP = CU < SP	Kruskal-Wallis
High-normal	41%	39%	41%		
Mildly excessive	6%	7%	8%	.019, KP = CU < SP	Chi-square
Moderately excessive	2%	3%	7%		
Severely excessive	1%	0%	4%		

CU, combined use; KP, kosher phone; SD, standard deviation; SP, smartphone.
*Statistically significant ($P < .05$).

Results

In total, 850 subjects were approached. The response rate was 73% for the SP group, 75% for the CU group, and 64% for the KP group. The reasons for noncompliance were mostly due to lack of time, length of questionnaire, and/or privacy concerns.

Comparisons among groups

Demographics

The final number of fully completed questionnaires was 578. Details about participants' demographic variables are presented in Table 1. The KP and CU groups were similar in the number of children and age of youngest child. The KP subjects were slightly younger and fewer of them were females. In spite of the differences in personal status and age of youngest child, there were no differences among groups in the percentage of subjects who reported sleeping more than 6 hours per night.[29]

Mobile phone use

As expected, there were significant differences among groups in patterns of mobile phone use (Table 2). While only 2.5% of the KP group reported high levels of waking up at night to check their mobile phones, the percentages among the CU and SP

Table 4 Anxiety and depression levels among the study groups (% of subjects from each study group)

Domain	Level	KP Group	CU Group	SP Group	*P*	Test
Trait anxiety	Low to moderate	62%	59%	48%	.000*, KP = CU < SP	Kruskal Wallis
	Severe	38%	41%	52%	.006, KP = CU < SP	Chi-square
Anxiety (GAD-7)	Minimal	90%	76%	68%	.000*, KP < CU < SP	Kruskal-Wallis
	Mild	8%	19%	20%		
	Moderate	2%	4%	7%	.000*, KP < CU < SP	Chi-square
	Severe	1%	1%	5%		
Depression	Minimal	80%	71%	67%	.006*, KP < CU < SP	Kruskal-Wallis
	Mild	16%	22%	20%		
	Moderate	3%	7%	9%		
	Moderately severe	1%	0%	4%	.0128, KP < CU < SP	Chi-square
	Severe	1%	0%	1%		

CU, combined use; KP, kosher phone; SD, standard deviation; SP, smartphone.
*Statistically significant ($P < .05$).

Table 5 Presence of temporomandibular disorder symptoms, and awake and sleep bruxism (% of subjects from each study group)

Symptoms	KP Group	CU Group	SP Group	*P*	Test
TMD	14%	30%	29%	.000*, KP < CU = SP	Chi-square
AB	8%	10%	24%	.000,* KP = CU < SP	Chi-square
SB	6%	10%	21%	.000*, KP = CU < SP	Chi-square

AB, awake bruxism; CU, combined use; KP, kosher phone; SB, sleep bruxism; SD, standard deviation; SP, smartphone; TMD, temporomandibular disorders.
*Statistically significant ($P < .05$).

groups were 13% and 15%, respectively (chi-square, $P < .001$). Moreover, only 8% of the KP group reported high levels of mobile phone overuse, compared to 15% for the CU group and 19% for the SP group (chi-square, $P < .001$).

Daytime sleepiness

There were significant differences among groups regarding daytime sleepiness (Table 3). The SP group differed from the two others regarding all levels of daytime sleepiness, with higher percentages of its members claiming daytime sleepiness (as high as 19% reported experiencing various degrees of excessive daytime sleepiness, chi-square, $P < .05$).

Anxiety and depression

Significant differences among groups were apparent also in their level of trait anxiety, general anxiety, and depression (Table 4), with the KP and CU groups differing from the SP group in all of these parameters (Kruskall-Wallis, *P* values ranging .000 to .001). Notably, the SP group was most affected by severe trait anxiety ($P < .01$) and depression ($P < .05$).

Presence of TMD symptoms, AB, and SB

TMD symptoms, SB, and AB were most prevalent in the SP group as compared to the KP and to the CU groups ($P < .001$ for TMD, SB, and AB) (Table 5).

Multivariate analyses

A series of logistic regression calculations was carried out in order to evaluate the effect of the demographic, anxiety, depression, and patterns of mobile phone use variables on daytime sleepiness in the three study groups.

Table 6 Final logistic regression model with sleepiness as dependent variable

					95% CI for odds ratio	
Variable	**B**	**SE**	**Sig.**	**Odds**	**Lower**	**Upper**
Depression	0.150	0.031	.000*	1.162*	1.092*	1.235*
Gender	1.002	0.296	.001*	2.723*	1.523*	4.867*
Phone – Night[†]			.016*			
Phone – Night (1)[‡]	−0.990	0.353	.005*	0.372*	0.186*	0.742*
Stress – Phone[§]			.020*			
Stress – Phone (2)[‖]	1.379	0.497	.005*	3.973*	1.501*	10.514*

*Statistically significant (*P* < .05).
[†]Phone – Night, general effect of the variable.
[‡]Phone – Night (1), comparison between low versus medium categories of the variable.
[§]Stress – Phone, general effect of the variable.
[‖]Stress – Phone (2), comparison between low versus high categories of the variable.

Table 7 Final logistic regression model with temporomandibular disorders as the dependent variable

					95%CI for odds ratio	
Variable	**B**	**SE**	**Sig.**	**Odds ratio**	**Upper**	**Lower**
Anxiety (GAD-7)	0.102	0.027	.000*	1.107*	1.049*	1.168*
Gender	0.699	0.226	.002*	2.011*	1.290*	3.135*
Phone-Night[†]			.005*			
Phone-Night (1)[‡]	0.466	0.238	.050	1.594*	0.999*	2.543*
Phone-Night (2)[§]	1.003	0.325	.002*	2.727*	1.442*	5.156*
Stress-Phone[‖]			.000*			
Stress-Phone (1)[¶]	1.002	0.226	.000*	2.724*	1.748*	4.245*

*Statistically significant (*P* < .05).
[†]Phone Night – general effect of variable.
[‡]Phone Night (1) – comparison between low versus medium categories of the variable.
[§]Phone Night (2) – comparison between low versus high categories of the variable.
[‖]StressPhone – general effect of variable.
[¶]Stress Phone (1) – comparison between low versus medium categories of the variable.

Daytime sleepiness

The results of a logistic regression for daytime sleepiness are presented in Table 6. The variable mostly responsible for increasing the odds of daytime sleepiness (by almost four times) was stress caused by mobile phones (low versus high categories of the variable, odds ratio [OR] 4.0, $P < .01$) and female sex (increasing the odds of daytime sleepiness by 2.7, $P < .005$). Additional variables that significantly increased the odds of daytime sleepiness were depression (OR 1.2, $P < .001$) and awakening to check the mobile phone at night (low versus medium group OR 0.4, $P < .01$).

TMD symptoms

The results of the logistic regression for TMD symptoms are presented in Table 7. The variables mostly responsible for increasing the odds of TMD belonged to the high category of mobile phone use at night and to the medium category of stress caused by mobile phone use (each one increasing the odds of TMD by almost three times compared to the low categories of these variables, $P < .005$ and .001, respectively). Additional variables in the equation were female sex (OR 2.0, $P < .005$), phone use at night (low versus medium category, OR 1.6, $P = .05$), and general anxiety (OR 1.1, $P < .001$).

Table 8 Final logistic regression model with sleep bruxism as dependent variable

					95% CI for odds ratio	
Variable	**B**	**SE**	**Sig.**	**Odds**	**Upper**	**Lower**
Sleepiness	0.282	0.134	.035*	1.326	1.020	1.723
Anxiety (GAD-7)	0.085	0.032	.007*	1.089	1.023	1.129
Family status†	0.858	0.286	.003*	2.357	1.345	4.132
Stress – Phone‡			.001*			
Stress – Phone (1)§	1.033	0.285	.000*	2.809	1.606	4.911
Group‖			.026*			
Group (1)¶	-0.868	0.356	.015*	0.420	0.209	0.844

*Statistically significant ($P < .05$).
†Family status, Married or divorced versus single or in a significant relationship.
‡Stress – Phone, general effect of the variable.
§Stress – Phone (1), comparison of low versus medium categories of the variable.
‖Group, general effect of the variable.
¶Group (1), comparison between smartphone versus kosher phone groups.

Table 9 Final logistic regression model with awake bruxism as dependent variable

					95% CI for Odds Ratio	
Variable	**B**	**SE**	**Sig.**	**Odds**	**Upper**	**Lower**
Anxiety (GAD-7)	0.083	0.030	.006*	1.087*	1.025*	1.153*
Stress – Phone†			.000*			
Stress – Phone (1)‡	1.124	0.272	.000*	3.076*	1.807*	5.238*
Overuse§			.038*			
Overuse (1)‖	0.749	0.294	.011*	2.114*	1.189*	3.761*
Group¶			.011*			
Group (1)#	-0.801	0.326	.014*	0.449*	0.237*	0.850*
Group (2)**	-0.827	0.375	.027*	0.437*	0.210*	0.912*

*Statistically significant ($P < .05$).
†Stress – Phone, general effect of variable.
‡Stress – Phone (1), comparison between low versus medium categories of the variable.
§Overuse, general effect of variable.
‖Overuse(1), comparison between low vs. medium categories of variable.
¶Group, general effect of group.
#Group (1), comparison of smartphone vs kosher phone groups.
**Group (2), comparison between smartphone vs combined use groups.

Bruxism

The results of a logistic regression for SB are presented in Table 8. Variables that mostly increased the odds of reporting SB were stress caused by mobile phones (belonging to the medium category increased the odds of SB by 2.8 compared to the low category, $P < .001$) and family status (being single or divorced increased the odds of SB by 2.4 compared to being married or in a significant relationship, $P < .005$). Additional variables that significantly increased the odds of SB were daytime sleepiness (OR 1.3, $P < .05$), general anxiety (OR 1.1, $P < .01$), and belonging to the KP group compared to the SP group (OR 0.4, $P < .05$).

The results of the logistic regression for AB are presented in Table 9. Medium versus low category of phone-related stress increased the odds of AB by three times ($P < .001$) while mobile phone overuse (medium versus low category) increased the odds by over twice ($P < .05$). The additional variables that significantly increased the odds of AB were general anxiety (OR 1.1, $P < .01$) and belonging to the CU and KP groups compared to the SP group (OR 0.4, $P < .05$).

Discussion

The effect of smartphones on sleep, daytime sleepiness, and other possibly associated clinical syndromes is a relatively new topic, mostly studied among children and adolescents. One study among secondary school children in Belgium showed that mobile phone use after lights out is a prevalent phenomenon and that it is related to increased levels of tiredness.[30] The use of mobile phones for calling and sending text messages after lights out was associated with sleep disturbances among Japanese adolescents as well.[4]

The relationship between the use of smartphones and possible negative outcomes is under-studied in adult populations. Appleton et al[31] showed that nearly 20% of Australian adults are waking up from sleep to engage with an electronic device on two or more nights per week, and that this activity is associated with adverse daytime outcomes, such as sleep problem-related adverse driving and occupational outcomes. To the best of the present authors' knowledge, the present study is one of the first to evaluate the implications of mobile phone use not only on daytime sleepiness but also on two common orofacial syndromes, TMD and bruxism. The ability to compare between young adults who do not connect to the internet (the KP group), to young adults who use the internet in a limited manner (the CU group), and to young adults who use it to the fullest extent (the SP group) enabled evaluation of the effect of modern cellular technology on this age group.

As expected, when looking at first order comparisons among groups, the groups differed significantly in their mobile phone use characteristics. The KP group showed significantly lower levels of waking up at night due to mobile phone use, less need for availability, less stress caused by the mobile phone, and less mobile phone overuse. Subjects of both religious groups showed lower levels of daytime sleepiness than the secular group. Similar group differences were also evident with regard to the presence of TMD and both SB and AB. Therefore, engaging with mobile phone technology can apparently affect not only daytime sleepiness but also lead to adverse clinical symptoms.

When looking at the multivariate analyses, it is evident that in spite of several demographic (eg, number of children, age of youngest child) and emotional (anxiety, depression) variables with a potential impact on daytime sleepiness, the variable that mostly increased the odds of daytime sleepiness emerged as being stress related to use of the mobile phone. The odds of daytime sleepiness were also higher among females (by almost three times that of males) and among subjects with depression. The findings are in accordance with those of Boccabella and Malouf,[28,32] who demonstrated that females are more likely to feel excessively more tired and depressed as compared to men.[33] These differences between sexes are not necessarily a result of sleep deprivation but may be an outcome of different ways in which males and females respond to tools such as the Epworth sleepiness scale.[34]

Female sex also increased the odds of TMD, a fact that is well documented in the literature.[35,36] Other than sex, the variables with the highest impact on increasing the odds of TMD (among those evaluated in the present study) were use of the mobile phone at night and stress caused by the phone. Stress from mobile phones also increased the odds of SB and AB (in addition to other factors such as family status, anxiety, and being part of the KP group). Nevertheless, the analysis was limited to several demographic variables and myriad other possible etiopathogenic factors were not taken into consideration.

The close association between TMD and bruxism with anxiety and depression is well documented.[37,38] Dahl and Lewin[39] suggested that social stresses, including fear, anxiety, and emotional arousal, interfere with the ability to fall asleep. Anxious people tend to be fatigued, exhausted, and likely to revert to different coping strategies. The finding that stress, anxiety, and depression co-exist with greater muscle tenderness[40,41] can further explain the increased likelihood of myogenous TMD.

Stress sensitivity and anxiety, as well as poor coping skills, were shown to be associated with bruxism in several studies.[42-47] While AB is mainly related to psychosocial factors, SB is associated with sleep phenomena in which adrenaline and noradrenaline are activators of the behavior.[48-50] This might explain why use of mobile phones just before bedtime or waking up during the night to check the mobile phone may activate SB. Subjects with bruxism during sleep are not good sleepers. A study by Kim and Han[51] showed that daytime sleepiness is significantly higher among bruxing subjects compared to healthy controls. The present results show that associations between TMD, bruxism, and daytime sleepiness are possibly mediated by the willingness and/or need to be constantly available, connected, and reacting. The phenomenon of mobile phone and social media overuse, termed "fear of missing out" (FOMO), is a pervasive apprehension arising from anxiety that one may be missing out on a rewarding experience that other people are having.[2,52] FOMO is usually associated with negative affect, fatigue, stress, and physical symptoms. Abel et al[53] reported that nearly 40% of young people reported that they experience FOMO sometimes or often, and a majority reported that they want to say yes to everything due to FOMO. Milyavskaya et al[54] showed that students particularly experience FOMO later in the day and later in the week. That observation may partially explain our findings on the two religious groups who do not use their mobile phone or any other appliances on the Sabbath, thereby protecting the CU group, at least in part, from the stress associated with the technology. However, a limited use of an internet-connected mobile phone did not differentiate between the CU group from the KP groups far as daytime sleepiness, AB, and SB (Tables 3 and 5). Interestingly, the CU group resembled the SP group with regard to TMD. Moreover, logistic regression assessments indicated that belonging to the SP group significantly increases the odds of SB and AB, but not of TMD or daytime sleepiness.

Daytime sleepiness has harmful consequences for the individual and for society, as exemplified by the high risk of motor vehicle accidents).[55] The findings that use of the mobile phone at night and that stress caused by the use of the phone significantly increase the odds of daytime sleepiness point to potentially alarming consequences of modern technology.

The differences in the levels of trait anxiety, general anxiety, and depression among the study groups (consistently highest among the secular group) probably originate in the different lifestyles of the groups. These findings were not within the scope of the present study and are not discussed here.

The findings that various aspects of mobile phone use increase the odds of TMD and bruxism call for concern over the adverse effects that the new technology has on public health. Chronic orofacial pain and irreversible damage to hard dental tissue structures are only part of the negative consequences of TMD and bruxism. The treatment costs of orofacial dysfunctions, such as TMD and bruxism, are estimated at around $100 billion a year in the US alone.[56] Unfortunately, changing the way in which mobile phones are used is practically impossible. Wolfers et al[57] suggest that interventions that focus on the treatment of problematic media use should be adapted to a specific target group and include a differentiated view that is not simply directed at reducing media use time as a whole, but addresses the way digital media is used.

Study limitations

Although the study shows that the use of smartphones can elicit potential negative effects, the results should be considered with caution. Subjects participating in the present study (ultra-Orthodox, religious, and secular young adults) are not necessarily representative samples of their sectors. Several additional demographic, cultural, and lifestyle differences might have affected the results.

Further studies are necessary to map the multifactorial effects that smartphones have on our lives.

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Declaration

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References

1. Lee YK, Chang CT, Lin Y, Cheng Z-H. The dark side of smartphone usage: psychological traits, compulsive behavior and technostress. Comput Hum Behav 2014;31:373–383.

2. Przybylski AK, Murayama K, DeHaan CR, Gladwell V. Motivational, emotional, and behavioral correlates of fear of missing out. Comput Hum Behav 2013;29:1841–1848.

3. King ALS, Valença AM, Silva ACO, Baczynski T, Carvalho MR, Nardi AE. Nomophobia: dependency on virtual environments or social phobia? Comput Hum Behav 2013;29: 140–144.

4. Munezawa T, Kaneita Y, Osaki Y, et al. The association between use of mobile phones after lights out and sleep disturbances among Japanese adolescents: a nationwide cross-sectional survey. Sleep 2011;34:1013–1020.

5. Söderqvist F, Carlberg M, Hardell L. Use of wireless telephones and self-reported health symptoms: a population-based study among Swedish adolescents aged 15–19 years. Environ Health 2008;7:18.

6. Matar Boumosleh J, Jaalouk, D. Depression, anxiety, and smartphone addiction in university students-A cross sectional study. PLoS One. 2017;12:e0182239.

7. Gradisar M, Wolfson AR, Harvey AG, Hale L, Rosenberg R, Czeisler CA. The sleep and technology use of Americans: findings from the National Sleep Foundation's 2011 Sleep in America poll. J Clin Sleep Med 2013;9: 1291–1299.

8. Thomée S, Härenstam A, Hagberg M. Mobile phone use and stress, sleep disturbances, and symptoms of depression among young adults: a prospective cohort study. BMC Public Health 2011;11:66.

9. Crow HC, Gonzalez YM, Ohrbach R. Diagnosis and management of TMDs. In: De Leeuw R, Klasser GD (eds). Orofacial Pain. Guidelines for Assessment, Diagnosis, and Management, 5th ed. Chicago: Quintessence Publishing, 2013:127–186.

10. McNeil C. Temporomandibular disorders: guidelines for classifications, assessment, and management. American Academy of Orofacial Pain. Chicago: Quintessence Publishing, 1993.

11. The Glossary of Prosthodontic Terms. The Academy of Prosthodontics. J Prosthet Dent 1994;71:41–112 .

12. Lobbezoo F, Ahlberg J, Glaros AG, et al. Bruxism defined and graded: an international consensus. J Oral Rehabil 2013;40:2–4.

13. Lobbezoo F, Ahlberg J, Raphael KG, et al. International consensus on the assessment of bruxism: Report of a work in progress. J Oral Rehabil 2018;45:837–844.

14. Balasubramaniam R, Klasser GD, Cistulli PA, Lavigne GJ. The link between sleep bruxism, sleep disordered breathing and temporomandibular disorders: an evidence-based review. J Dent Sleep Med 2014;1:27–37.

15. Bader G, Lavigne G. Sleep bruxism; an overview of an oromandibular sleep movement disorder. Sleep Med Rev 2000;4:27–43.

16. Klasser GD, Rei N, Lavigne GJ. Sleep bruxism etiology: the evolution of a changing paradigm. J Can Dent Assoc 2015;81:f2.

17. American Academy of Sleep Medicine. International classification of sleep disorders. Diagnostic and Coding Manual, 2nd edition. Darien: American Academy of Sleep Medicine, 2005;189–192.

18. i24News. Global survey ranks Israel second highest in smartphone usage. https://www.i24news.tv/en/news/israel/society/194712-190205-global-survey-ranks-israel-second-highest-in-smartphone-usage. Accessed 24 December 2020.

19. Ariel Y, Elishar-Malks V, Avidar R, Chen-Levi E. Smartphone usage among young Israeli adults: a combined quantitative and qualitative approach. Israel Affairs 2017;23: 1–17.

20. Petry NM. A comparison of young, middle-aged, and older adult treatment-seeking pathological gamblers. Gerontologist 2002; 42:92–99.

21. Johns MW. A new method for measuring daytime sleepiness: the Epworth sleepiness scale. Sleep 1991;14:540–545.

22. Spielberger CD, Gorsuch RL, Lushene R, et al. State-Trait Anxiety Inventory for Adults Sampler Set Manual, Instrument and Scoring Guide (Form Y). Palo Alto: Consulting Psychologists Press, 1983.

23. Schiffman E, Ohrbach R, Truelove E, et al. Diagnostic criteria for temporomandibular disorders (DC/TMD) for clinical and research applications: recommendations of the International RDC/TMD Consortium Network and Orofacial Pain Special Interest Group. J Oral Facial Pain Headache 2014;28:6–27 .

24. Spitzer RL, Kroenke K, Williams JB, Löwe B. A brief measure for assessing generalized anxiety disorder: the GAD-7. Arch Intern Med 2006;166:1092–1097.

25. Kroenke K, Spitzer RL. The PHQ-9: a new depression diagnostic and severity measure. Psychiatr Ann 2002;32:509–515.

26. Winocur E, Messer T, Eli I, et al. Awake and sleep bruxism among Israeli adolescents. Front Neurol 2019;10:443.

27. Perlman AE, Lobbezoo F, Zar A, Friedman Rubin P, van Selms MK, Winocur E. Self-reported bruxism and associated factors in Israeli adolescents. J Oral Rehabil 2016; 43:443–450.

28. van Selms MK, Visscher CM, Naeije M, Lobbezoo F. Bruxism and associated factors among Dutch adolescents. Community Dent Oral Epidemiol 2013;41:353–363.

29. Suni E. How much sleep do we really need? https://www.sleepfoundation.org/press-release/national-sleep-foundation-recommends-new-sleep-times. Accessed 24 December 2020

30. Van den Bulck J. Adolescent use of mobile phones for calling and for sending text messages after lights out: results from a prospective cohort study with a one-year follow-up. Sleep 2007;30:1220–1223.

31. Appleton SL, Reynolds AC, Gill TK, Melaku YA, Adams R. Waking to use technology at night, and associations with driving and work outcomes: a screenshot of Australian adults. Sleep 2020;43:zsaa015.

32. Boccabella A, Malouf J. How do sleep-related health problems affect functional status according to sex? J Clin Sleep Med 2017;13:685–692.

33. Lin CM, Davidson TM, Ancoli-Israel S. Gender differences in obstructive sleep apnea and treatment implications. Sleep Med Rev 2008;12:481–496.

34. National Survey of Mental Health and Wellbeing: Summary of Results, 2007. Australian Bureau of Statistics website. http://www.abs.gov.au/ausstats/abs@.nsf/mf/4326.0. Accessed 24 December 2020.

35. Häggman-Henrikson B, Liv P, Ilgunas A, et al. Increasing gender differences in the prevalence and chronification of orofacial pain in the population. Pain 2020;161: 1768–1775.

36. Bueno CH, Pereira DD, Pattussi MP, Grossi PK, Grossi ML. Gender differences in temporomandibular disorders in adult populational studies: a systematic review and meta-analysis. J Oral Rehabil 2018;45:720–729.

37. Lajnert V, Francisković T, Grzic R, et al. Depression, somatization and anxiety in female patients with temporomandibular disorders (TMD). Coll Antropol 2010;34: 1415–1419.

38. Smardz J, Martynowicz H, Wojakowska A, Michalek-Zrabkowska M, Mazur G, Wieckiewicz M. Correlation between sleep bruxism, stress, and depression: a polysomnographic study. J Clin Med 2019 29;8:1344.

39. Dahl RE, Lewin DS. Pathways to adolescent health: sleep regulation and behavior. J Adolesc Health 2002;31:175–184.

40. Wieckiewicz M, Zietek M, Smardz J, Zenczak-Wieckiewicz D, Grychowska N. Mental status as a common factor for masticatory muscle pain: a systematic review. Front Psychol 2017;8:646.

41. Berger M, Oleszek-Listopad J, Marczak M, et al. Psychological aspects of temporomandibular disorders – literature review. Curr Issues Pharm Med Sci 2015;28:55–59.

42. Manfredini D, Colonna A, Bracci A, et al. Bruxism: a summary of current knowledge on aetiology, assessment and management. Oral Surg 2020;13:358–370.

43. Manfredini D, Lobbezoo F. Role of psychosocial factors in the etiology of bruxism. J Orofac Pain 2009;23:153–166.

44. Manfredini D, Fabbri A, Peretta R, Guarda-Nardini L, Lobbezoo F. Influence of psychological symptoms on home-recorded sleep-time masticatory muscles activity in healthy subjects. J Oral Rehabil 2011;38: 902–911.

45. Manfredini D, Arreghini A, Lombardo L, et al. Assessment of coping and anxiety features in bruxers: a portable EMG/ECG study. J Oral Fac Pain Head 2016;30:249–254.

46. Pierce CJ, Chrisman K, Bennett ME, Close JM. Stress, anticipatory stress, and psychologic measures related to sleep bruxism. J Orofac Pain 1995;9:51–56.

47. Winocur E, Uziel N, Lisha T, Goldsmith C, Eli I. Self-reported bruxism associations with perceived stress, motivation for control, dental anxiety and gagging. J Oral Rehabil 2011;38:3–11.

48. Lobbezoo F, Lavigne GJ, Tanguay R, Montplaisir JY. The effect of catecholamine precursor L-dopa on sleep bruxism: a controlled clinical trial. Mov Disord 1997;12:73–78.

49. Lavigne GJ, Kato T, Kolta A, Sessle BJ. Neurobiological mechanisms involved in sleep bruxism. Crit Rev Oral Biol Med 2003; 14:30–46.

50. Huynh N, Lavigne GJ, Lanfranchi PA, Montplaisir JY, de Champlain J. The effect of 2 sympatholytic medications – propanolol and clonidine – on sleep bruxism: experimental randomized controlled studies. Sleep 2006;29:307–316.

51. Kim H, Han HJ. Sleep quality in adult patients with sleep related bruxism. Sleep Biol Rhythms 2014;13:94–98.

52. Franchina V, Vanden Abeele M, Van Rooij AJ, Lo Coco G, De Marez L. Fear of missing out as a predictor of problematic social media use and phubbing behavior among Flemish adolescents. Int J Environ Res Public Health 2018;15:2319.

53. Abel JP, Buff CL, Burr SA. Social media and the fear of missing out: scale development and assessment. J Business Econ Res 2016;14:33–44.

54. Milyavskaya M, Saffran M, Hope N, Koestner R. Fear of missing out: prevalence, dynamics, and consequences of experiencing FOMO. Motiv Emot 2018:42:725–737.

55. Bioulac S, Micoulaud-Franchi JA, Arnaud M, et al. Risk of motor vehicle accidents related to sleepiness at the wheel: a systematic review and meta-analysis. Sleep 2017; 40:zsx134.

56. List T, Jensen RH. Temporomandibular disorders: old ideas and new concepts. Cephalalgia 2017;37:692–704.

57. Wolfers LN, Festl R, Utz S. Do smartphones and social network sites become more important when experiencing stress? Results from longitudinal data. Comput Hum Behav 2020;109:106339.

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