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Laptop and tablet use and their influence on total motile sperm count parameters: are laptops linked to infertility in Jamaican men?

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Abstract

Background: This study aims to determine the impact of laptop and tablet use on total motile sperm count (TMSC) in men being investigated for assisted reproduction. **Methods**: A cross-sectional study was conducted on 156 men attending a fertility clinic in Jamaica. Routine semen analyses were performed and parameters specific to TMSC assessed. All data analyses were performed using SPSS Version 26. Logistic regression analyses were performed to independently predict the impact of quantifiable measures of laptop and tablet use. The main outcome measures were the parameters associated with TMSC. **Results**: Overall, 64% of the participants reported using laptops and 36% reported using tablets. There was a significant relationship seen with time spent on laptops and time trying to conceive (p = 0.015). Regression analyses showed that persons who used their laptops for 2 to 5 h daily were approximately 16 times (adjusted Odds Ratio (aOR) = 15.9; 95% Confidence Interval (CI), 2.5–103.3, p = 0.004) more likely to be diagnosed with low semen volume (hypospermia). Although no significant association was found between total motile sperm count (TMSC) and laptop use, a trend towards significance was observed with high laptop use (p = 0.052), suggesting potential implications for TMSC as a predictor of pregnancy outcomes. **Conclusions**: Our findings highlight the need for clinicians to take into consideration wireless device usage in men undergoing fertility investigations.

Keywords

Assisted reproduction; Infertility; Electromagnetic radiation; Wireless device; Laptop use; Tablet use; Semen volume; Total motile sperm count

Uso de laptops y tabletas y su influencia en los parámetros del conteo total de espermatozoides móviles: ¿están las laptops relacionadas con la infertilidad en hombres jamaicanos?

Resumen

Antecedentes: Este estudio tiene como objetivo determinar el impacto del uso de computadoras portátiles y tabletas en el recuento total de espermatozoides móviles (TMSC) en hombres que están siendo investigados para reproducción asistida. Se realizó un estudio transversal en 156 hombres que asistieron a una clínica de fertilidad en Jamaica. **Métodos**: Se realizaron análisis rutinarios de semen y se evaluaron parámetros específicos del TMSC. Todos los análisis de datos se realizaron utilizando SPSS Versión 26. Se realizaron análisis de regresión logística para predecir de manera independiente el impacto de medidas cuantificables del uso de computadoras portátiles y tabletas. Las principales medidas de resultado fueron los parámetros asociados con el TMSC. **Resultados**: En general, el 64% de los participantes informaron que usaban computadoras portátiles y el 36% que usaban tabletas. Se observó una relación significativa entre el tiempo dedicado a las computadoras portátiles y el tiempo tratando de concebir (p = 0.015). Los análisis de regresión mostraron que las personas que usaban sus computadoras portátiles durante 2 a 5 h diarias tenían aproximadamente 16 veces (Razón de Momios Ajustada (Ora) = 15.9; Intervalo de Confianza (IC) del 95%, 2.5–103.3, p = 0.004) más probabilidades de ser diagnosticadas con un volumen de semen bajo (hipospermia). Aunque no se encontró una asociación significativa entre el recuento total de espermatozoides móviles (TMSC) y el uso de computadoras portátiles, se observó una tendencia hacia la significación con el uso elevado de computadoras portátiles (p = 0.052), lo que sugiere implicaciones potenciales para TMSC como predictor de los resultados del embarazo. **Conclusiones**: Nuestros hallazgos destacan la necesidad de que los clínicos tomen en consideración el uso de dispositivos inalámbricos en hombres que se someten a investigaciones de fertilidad.

Palabras Clave

Reproducción asistida; Infertilidad; Radiación electromagnética; Dispositivo inalámbrico; Uso de computadoras portátiles; Uso de tabletas; Volumen de semen; Recuento total de espermatozoides móviles

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1. Introduction

Infertility is characterized by the failure to achieve conception following one year of unprotected sexual intercourse. Infertility has been estimated to affect 20% of couples of reproductive age worldwide, with half of these cases due to male factor infertility [1–4]. Of note, there have been increased reports globally of decreased sperm quality and fertility [5]. Although the exact reason for this decline remains unknown, environmental and lifestyle factors are of concern [6–8]. With the advancement of the wireless communications sector and subsequent increase in wireless device usage, their potential impact on semen quality has attracted much attention [7, 9].

Wireless devices emit low-level radiofrequency electromagnetic radiation (RF-EMR) at frequencies starting from 800 MHz [10]. Wireless fidelity (Wi-Fi) technology has risen to the top of the internet communication and connectivity rankings [11]. Wi-Fi signals operate in the unlicensed spectrum band ranging from 2.4 to 5 GHz [12], lowering their operating costs. Wi-Fi use has thus become ubiquitous and is widely used in a variety of devices. The use of portable computers (such as laptops and tablets) has increased tremendously [13], offering versatility and portability to users. RF-EMR emitted from these portable devices has been linked to both thermal and non-thermal effects on biological tissues [14]. The signals emitted from these devices are absorbed by the human body and are believed to have deleterious effects on the male reproductive system [10, 13]. Laptops and tablets are used in closer proximity to the male reproductive system compared with other wireless devices that are commonly used. Further, differences in the physical characteristics of these devices and their transmitters, as well as the positions in which they are used may affect the RF-EMR distribution and subsequent absorption by the human body [15, 16].

Recent studies indicate that fertile and subfertile males react differently to various modifiable lifestyle factors [8, 17] and may suggest that the reproductive effects resulting from Wi-Fi enabled devices may vary in these two populations. As studies have reported that the total motile sperm count (TMSC) is a better predictor of male factor fertility [18–20], we aimed to explore the link between TMSC and both laptop and tablet usage and TMSC in men undergoing investigation for infertility. In addition, our focus on laptops and tablets was driven by the recent increase in usage due to online teaching modalities and work from home orders, which have been triggered by the Covid-19 pandemic [21].

2. Materials and methods

2.1 Setting and participants

The Hugh Wynter Institute for Reproductive Healthcare and Endoscopic Surgery (HW-IRHES) is the only university-based fertility institute in the island of Jamaica, and all male patients over an 18-month period (n = 188) who were referred for fertility assessments to the HW-IRHES were recruited to take part in the study. The calculation of the sample size was predicated on the HW-IRHES typically receiving on average 20 semen analysis referrals each month from men in relationships where the couple is undergoing infertility evaluations. Based on a population size of 240 and a 50% distribution of male factor infertility, with a 5% margin of error and 95% confidence interval, the minimum recommended sample size was found to be 148. Among the men who were approached, 26 declined participation and 6 were excluded from the study, resulting in a final sample size of 156 participants who provided written informed consent, yielding a response rate of 83%. Men with a self-reported medical history of conditions known to affect sperm quality, such as previous diagnoses of mumps, undescended testes, varicocele/varicocele repairs, and certain diagnosed sexually transmitted diseases, were excluded from the study. No physical examinations were conducted prior to semen analyses, thereby not eliminating other potential exclusion factors such as varicoceles.

2.2 Instruments and procedures

Data were collected over the period from February 2020 to July 2021. Participants were invited to participate in the study and were asked to abstain from ejaculation for 2–3 days prior to all analyses. The 25-item questionnaire on wireless device usage, created by the principal investigators (embryologist and wireless communication engineer), was designed to assess the frequency of laptop and tablet use. In addition, we gathered socio-demographic data and self-reported information on general health, lifestyle and reproductive history from the standard registration form utilized for fertility assessments at HW-IRHES.

Participants were placed in a private room where their samples were collected by masturbation. The samples were then analyzed within 30 minutes of collection. Semen analyses were conducted in accordance with the methodologies specified by the guidelines established by the World Health Organization [22]: normal volume $\geq$1.5 mL, normal motility $\geq$40%, normal sperm count $\geq$15 M/mL, and normal TMSC $>20 \times 10^6$ spermatozoa [18]. Semen analyses were conducted without prior knowledge of device usage.

2.3 Patient grouping and study variables

The primary independent variable of interest was a measurable indicator of the frequency of both laptop and tablet usage. For both laptop and tablet use was divided into three categories; low use $<$2 h/day; medium use 2–5 h/day; and high use $>$5 h/day, based on previous literature [23].

Further independent variables included in the statistical analyses encompassed age, duration of attempts to conceive, prior pregnancies, and recreational drug usage. The outcome variables were volume (mL), motility (%), sperm count (M/mL) and total motile spermatozoa (10^6). These parameters were classified as dichotomies with normal parameters (normozoospermia) and the abnormal parameter: volume $<$1.5 mL (hypospermia), motility $<$40% (asthenozoospermia), low sperm count (oligozoospermia), low total motile spermatozoa $\leq 20 \times 10^6$ (abnormal), no spermatozoa in ejaculate (azoospermia) and no ejaculate (aspermia).

2.4 Statistical analyses

Percentages within the sample using both laptops and tablets were determined after adjusting for missing data. Preliminary Pearson's chi-squared analyses were performed in order to ascertain independent associations of individual device usage with covariates as well as with the seminal parameters. Binary univariate logistic regression analyses were performed in order to determine the unadjusted odds ratios (unOR) and their 95% confidence intervals (CI) for these associations with the semen variables. To select confounders for the final binary multivariate logistic regression model, a significance value of $p < 0.05$ was used as the criterion. Unadjusted and adjusted analyses of TMSC and its associated individual parameters (semen volume, sperm count and sperm motility) across indices of laptop and tablet use, along with previously selected confounders were conducted. The *p*-Values from Wald *F*-tests were reported. All analyses were performed using SPSS Version 26 statistical software (SPSS, Inc., Chicago, IL, USA), and the results were presented with a 95% CI at $p < 0.05$ for statistical significance.

3. Results

Table 1 outlines the primary characteristics of the study samples. Of the 156 participants who consented, 68% were younger than 40 years, with ages ranging between 22 and 60 years (mean (M) = 37.21, standard deviation (SD) = 7.27). The majority of the subjects were of normal weight, consumed alcohol, and few reported recreational drug use (See Tables 1 and 2). In addition, just below half of the respondents (48%) had at least one abnormal semen parameter. The distribution of laptop and tablet users was 64% (n = 100) and 36% (n = 57), respectively. The majority of the participants reported using their laptops and tablets on a desk (73% and 78%, respectively).

Table 1 presents the distribution of socio-demographic characteristics and other clinically relevant criteria for the 156 participants, categorized according to device usage. Participants reporting high laptop use were more likely to have been trying to conceive for one or more years and were more likely to be younger in age (<40 years), respectively (Table 1). This was also found to be the case for participants reporting high tablet use. The findings from chi-squared analyses on the associations between laptop and tablet use and semen parameters are detailed in Table 2. The only statistically significant difference observed was between participants with normal and abnormal semen volume and those who reported laptop use for 2 h or more per day, which corresponded to medium and high use (Table 2).

The identified risk factors affecting semen parameters are detailed in Tables 3 and 4. A *p*-value < 0.05 was used to select covariates for the final regression model. When logistic regression was performed, those participants ≥40 years were more likely to be categorized with abnormal semen volume (hypospermia). Further, time trying for a baby was associated with all sperm parameters except semen volume, while recreational drug use was associated with sperm count only (Table 3). The only semen parameter associated with device use was volume (Tables 4 and 5). Results of unadjusted logistic regression analyses showed that with medium laptop use, the likelihood of being identified as having low semen volume was approximately 16 times greater (aOR = 15.9; 95% CI, 2.5–103.3, $p = 0.004$) when compared to non-users.

TABLE 1. Characteristics of the study participants by laptop and tablet use.

	Time spent on Laptop			Time spent on Tablet		
	Low (n = 41) %	High (n = 59) %	*p*-Value	Low (n = 44) %	High (n = 13) %	*p*-Value
Age						
<40	70.7	64.4	0.508	59.1	69.2	0.018*
≥40	29.3	35.6		40.9	30.8	
BMI (n = 156)						
Underweight (<18.5)	31.7	33.9	0.542	34.1	15.4	0.386
Normal (18.5–24.9)	46.3	52.5		52.3	61.5	
Overweight (>24.9)	22.0	13.8		13.6	23.1	
Trying for baby (n = 154)						
Less than 1 yr	22.5	22.0	0.015*	14.0	30.8	0.241
1 to 3 yr	15.0	40.0		34.9	15.4	
Over 3 yr	62.5	37.3		51.2	53.8	
Recreational drugs (n = 156)						
Yes	9.8	15.3	0.421	13.6	86.4	0.566
No	90.2	84.7		7.7	92.3	

*$p \leq 0.05$. *BMI: Body Mass Index.*

TABLE 2. Percentage difference between normal and abnormal sperm parameters by device use.

	Semen Volume			Sperm Count			Sperm Motility			Total Motile Sperm Count		
	Normal ≥1.5 mL (n = 130) %	Abnormal <1.5 mL (n = 26) %	*p*-Value	Normal >20 × 10^6 (n = 82) %	Abnormal ≤20 × 10^6 (n = 72) %	*p*-Value	Normal ≥40 (n = 99) %	Abnormal <40 (n = 55) %	*p*-Value	Normal >20 mil (n = 127) %	Abnormal ≤20 mil (n = 27) %	*p*-Value
Time Spent on Laptop												
Low (<2 h per day)	46.4	12.5		36.5	45.7		39.7	41.7		43.2	27.8	
Medium (2–5 h per day)	8.3	31.3	0.007*	9.6	15.2	0.325	14.3	8.3	0.681	12.3	11.1	0.417
High (>5 h per day)	45.2	56.3		53.8	39.1		56.0	50.0		44.4	61.2	
Time Spent on Tablet												
Low (<2 h per day)	43.1	66.7		53.6	40.7		41.2	54.5		46.7	45.5	
Medium (2–5 h per day)	33.3	16.7	0.539	17.9	40.7	0.170	32.4	27.3	0.600	28.9	36.4	0.854
High (>5 h per day)	23.5	16.7		28.6	18.5		26.5	18.2		24.4	18.2	

**p ≤ 0.05.*

TABLE 3. Unadjusted odds ratios for simple logistic regression analyses to identify risk factors for semen parameters.

	Abnormal Semen Volume (n = 154)			Abnormal Sperm Count (n = 150)			Abnormal Sperm Motility (n = 156)			Abnormal Total Motile Sperm Count (n = 156)		
	unOR	95% CI	*p*-Value	unOR	95% CI	*p*-Value	unOR	95% CI	*p*-Value	unOR	95% CI	*p*-Value
Age												
<40												
≥40	3.7	[1.6, 8.8]	0.003*	0.94	[0.5, 1.9]	0.855	1.0	[0.5, 2.1]	0.959	1.3	[0.5, 3.0]	0.580
Trying for baby												
Less than 1 yr												
1 to 3 yr	0.7	[0.2, 2.2]	0.540	2.50	[9.1, 0.7]	0.077	3.0	[1.1, 10.4]	0.039*	2.0	[0.4, 11.0]	0.418
Over 3 yr	0.6	[0.2, 1.7]	0.307	3.80	[1.5, 9.0]	0.004*	4.0	[1.4, 11.3]	0.011*	4.8	[1.1, 22.0]	0.043*
Recreational drugs												
Yes	1.0	[0.3, 3.4]	0.913	0.18	[0.4, 0.6]	0.008*	0.6	[0.2, 1.8]	0.465	0.5	[0.1, 2.4]	0.400
No												

**p ≤ 0.05. unOR: unadjusted odds ratios; CI: confidence intervals.*

TABLE 4. Unadjusted odds ratios for simple logistic regression analyses for sperm parameters.

	Abnormal Sperm Volume (n = 154)			Abnormal Sperm Count (n = 150)			Abnormal Sperm Motility (n = 156)			Abnormal Total Motile Sperm Count (n = 156)		
	unOR	95% CI	*p*-Value	unOR	95% CI	*p*-Value	unOR	95% CI	*p*-Value	unOR	95% CI	*p*-Value
Time Spent on Laptop												
Low (<2 h per day)												
Medium (2–5 h per day)	13.929	[2.20, 86.5]	0.005*	1.267	[0.3, 4.7]	0.723	0.556	[0.1, 2.4]	0.428	1.400	[0.2, 8.3]	0.712
High (>5 h per day)	4.618	[0.90, 22.8]	0.060	0.582	[0.3, 1.4]	0.216	1.034	[0.4, 2.5]	0.939	2.139	[0.7, 6.8]	0.197
Time Spent on Tablet												
Low (<2 h per day)												
Medium (2–5 h per day)	0.324	[0.03, 3.2]	0.332	3.000	[0.8, 11.2]	0.101	0.636	[0.2, 2.2]	0.482	1.292	[0.3, 5.7]	0.735
High (>5 h per day)	0.458	[0.10, 4.6]	0.506	0.852	[0.2, 3.3]	0.818	0.519	[0.1, 2.1]	0.360	0.764	[0.1, 4.6]	0.768

**p ≤ 0.05. unOR: unadjusted odds ratios; CI: confidence intervals.*

TABLE 5. Adjusted odds ratios for multiple logistic regression analyses for sperm parameters.

	Abnormal Sperm Volume (n = 154)			Abnormal Sperm Count (n = 150)			Abnormal Sperm Motility (n = 156)			Abnormal Total Motile Sperm Count (n = 156)		
	aOR[a]	95% CI	*p*-Value	aOR[b]	95% CI	*p*-Value	aOR[c]	95% CI	*p*-Value	aOR[c]	95% CI	*p*-Value
Time Spent on Laptop												
Low (<2 h per day)												
Medium (2–5 h per day)	15.9	[2.5, 103.2]	0.004*	1.36	[0.3, 5.7]	0.672	0.450	[0.1, 2.0]	0.289	1.4	[0.2, 8.7]	0.736
High (>5 h per day)	4.3	[0.9, 21.7]	0.074	0.74	[0.3, 1.9]	0.538	1.130	[0.4, 3.0]	0.803	3.6	[1.0, 13.2]	0.052
Time Spent on Tablet												
Low (<2 h per day)												
Medium (2–5 h per day)	0.5	[0.1, 5.8]	0.587	3.45	[0.8, 14.5]	0.092	0.494	[0.1, 2.0]	0.290	1.1	[0.2, 5.5]	0.928
High (>5 h per day)	0.6	[0.1, 6.5]	0.675	0.98	[0.2, 4.2]	0.983	0.535	[0.1, 2.3]	0.403	0.6	[0.9, 4.4]	0.639

[a]*Odds ratios were adjusted for age group.* [b]*Odds ratios were adjusted for time trying for a baby and recreational drug use.*
[c]*Odds ratios were adjusted for time trying for a baby.* **p ≤ 0.05. CI: confidence intervals; aOR: adjusted odds ratios.*

Although no significant association was found between TMSC and laptop use, significance was approached with high laptop use and TMSC ($p = 0.052$). Importantly, the observation that laptop use is linked to low semen volume, a parameter of TMSC, carries significant clinical implications.

4. Discussion

This is the first reported study to examine the influence of laptop and tablet use on sperm quality in the Caribbean region. We found that in men seeking fertility assessments, increased frequency of laptop use reduced semen volume, and for users who spent 2 to 5 h per day on laptops, the odds were approximately 16 times greater that they would be diagnosed with low semen volume. Further, participants with increased laptop use (medium or high use) spent a longer time trying to conceive than those with low laptop use. The only significance seen with tablets was with usage among the younger males. However, it is important to note that tablet use, while not as impactful as laptop use, still presented notable findings among specific subgroups, particularly younger males. This suggests that the mode and duration of wireless device use may have varying effects on sperm quality, warranting further investigation into these differences.

To the best of our knowledge, this is the first report to show that deleterious effects on fertility (low semen volume and increased time trying to conceive) were only seen with laptop use. This finding was interesting and may allude to the physical characteristics of wireless devices as laptops and tablets that are Wi-Fi enabled emit RF-EMR in the same frequency bands. The physical characteristics of wireless devices need to be considered as reflections from perfect electrical conductors (PEC), *i.e.*, metals, used in the manufacture of these devices may influence how RF-EMR is transmitted. In addition, although laptops and tablets both transmit RF-EMR, the differences in the relative size and proximity of the Wi-Fi antennas in both devices to organs and tissues may lead to differences in the distribution and absorption of RF-EMR [24]. The position of tablets, typically held farther from the lap and reproductive organs compared to laptops, may result in lower RF-EMR exposure to the testes. This difference in positioning may contribute to the observed lower significance in the impact of tablet use on TMSC, as discussed in our findings. Future studies are needed to explore what are "safe" distances for the operation of wireless devices and to differentiate between RF-EMR-specific thermal effects and non-thermal effects on sperm parameters. Albeit, as the majority of our sample reported using their laptops on a desk as opposed to in their laps, there is a greater likelihood of non-thermal RF-EMR exposure as opposed to thermal effects.

Our finding that increased laptop usage correlates to a reduction in semen volume is of concern and underscores the possibility that RF-EMR may impact TMSC, which has been demonstrated to be a more reliable indicator of male fertility [18–20]. Secretions from the seminal vesicles and prostate gland make up about 90% of semen volume. Animal studies have found significant pathological changes to the seminal vesicles following exposure to Wi-Fi radiation [25]. These findings may provide support for the decreased semen volume seen in this group of men seeking fertility investigations. This reduced semen volume may negatively impact fertility as an adequate amount of fluid is needed to bring the sperm in contact with the cervix [22]. Although the association with increased laptop use and TMSC only approached significance, significance may have been achieved with a larger sample size.

Most studies indicate that laptop use negatively impacts sperm count, motility and DNA integrity [13, 23, 26], with a recent review showing that motility was the parameter most affected by EMR exposure [9]. As such, our finding that semen volume is decreased following the use of laptops for 2 to 5 h per day may be unique to this Jamaican cohort. It is considered that there may be anatomical changes in the male reproductive system of Jamaican males seeking infertility investigations when exposed to RF-EMR over time. There have been several reports showing that African-Caribbean males, in particular Jamaican males, respond differently to certain external factors, resulting in the unusually high incidence of prostate cancer compared with the reported incidence worldwide [27, 28]. Altogether, these findings support the need for other culturally relevant future studies to further explore the effects of EMR exposure on the accessory glands of the male reproductive tract.

In addition, our finding that there is an association with increased laptop usage and an increased time trying to conceive is of particular concern. In 2019, it was estimated that 218 million laptops were sold worldwide, and in 2020, this number increased drastically owing to the growing number of individuals engaged in remote work and learning during the Covid-19 pandemic [29]. Further, worldwide usage of these devices has increased steadily amongst prepubescent males still undergoing developmental changes to their reproductive system [30]. Our findings are timely and highlight the need for worldwide educational and sensitization campaigns on safe device usage for males, particularly those in their prime reproductive years.

We propose that inquiries into wireless device usage be incorporated as a standard procedure when evaluating men for infertility. In particular, males in the medium- and high-use groups should be advised to take protective measures to minimize the risk of excessive EMR exposure from these devices. As laptops are widely used by young men of reproductive age, further studies are warranted to evaluate the impact of using these devices on testicular function and fertility.

Some limitations in our study design necessitate acknowledgment. The findings may not be broadly applicable to the broader male demographic as our investigation focused exclusively on men undergoing infertility assessments. Additionally, reliance on self-reported medical histories and the absence of physical examinations as exclusion criteria should be noted. This approach might have overlooked anatomical irregularities like varicoceles, potentially impacting semen quality assessment. Another limitation of mention is that RF-EMR emissions were not measured during the analysis. In addition, we did not specifically measure scrotal temperature or the distance between the wireless devices and the testicles, and we thus could not definitively rule out possible thermal effects.

5. Conclusions

To the best of our knowledge, this study is the first of its kind in the Caribbean. We have extended the literature on previous studies that examine the impact of RF-EMR on TMSC parameters in men being investigated for infertility. Our findings indicate that increased laptop usage may decrease semen volume which is an important component of TMSC. As hypospermia may directly impact TMSC, which is one of the better predictors of achieving a pregnancy [18–20]. This study highlights the clinical significance of evaluating wireless device usage as part of treatment considerations for men or couples experiencing concerns related to subfertility.

AVAILABILITY OF DATA AND MATERIALS

The data presented in this study are available on reasonable request from the corresponding author.

AUTHOR CONTRIBUTIONS

LRH and KC—envisaged this study; critically reviewed the manuscript and added relevant information. LS—prepared the manuscript. All authors read and approved the final manuscript before publication. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Ethical approval was granted by the Ethics Committee of the Faculty of Medical Sciences at the University of the West Indies (UWI), Mona, Jamaica (ECP 15, 19/20). All participants were required to sign a consent form for their data to be used in the study and before the interviewer-administered questionnaire was conducted.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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