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ORIGINAL ARTICLE

Sleep and new media usage in toddlers

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Abstract

Several studies over the years have demonstrated the association between lack of sleep in children and certain physical, psychological, and behavioral disorders. The aim of this study was to disentangle the association between new screen-based electronic devices and sleep problems in toddlers, adjusting for other covariates already known to be associated with sleep quality. We conducted a cross-sectional study with the aid of a national sample of 1117 toddlers. Parents reported children's sleeping habits such as total sleep time and sleep onset latency, recreational activities, bedtime routines, and temperament. An ordered logistic regression was run to assess the associations between new media exposure and two sleep outcomes (total sleep time and sleep onset latency). Everyday use of a tablet or smartphone raised the odds of a shorter total sleep time (OR 1.95 [1.00–3.79], $p < 0.05$) and a longer sleep onset latency (OR 2.44 [1.26–4.73] $p < 0.05$) irrespective of other factors, such as temperament (restlessness, sociability), or traditional screen exposure (watching TV or playing videogames).

Conclusion: New media usage is a factor associated in toddlers with sleeping fewer hours and taking longer to fall asleep, irrespective of other confounding factors.

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What is known
- *Studies have found an association between sleep behavior and the use of computers and video games in early childhood.*
- *The blue light emitted from TV screens suppresses endogenous melatonin.*

What is new
- *The study found an association between daily new media (tablet and smartphone) usage and sleep quality in toddlers*
- *New media usage exposes toddlers to the risk of fewer hours of sleep and taking longer to fall asleep, irrespective of other factors.*

Keywords Time · Sleep · Childhood · Toddlers · Touch screen device · Video games

Abbreviations
FIMP Federazione Italiana Medici Pediatri

Introduction

Sleep is essential to human health and development. Several studies over the years have demonstrated the association between lack of sleep in children and certain physical, psychological, and behavioral disorders. In particular, sleep disorders have been found significantly associated with attention-deficit/hyperactivity disorder [15], impulsive behavior [1], anxiety and depression [13], academic failure [30], and insecure attachment styles [2].

Despite the importance of sleep to health, it is quite common for children to have sleep-related problems [22]. Various factors contribute to this trend, including the use of electronic devices [21]. Numerous authors have examined the link between sleep behavior and the use of computers, video games and television in adolescence [28], and in childhood [19, 29]. Longer periods of exposure to traditional media have been associated with fewer minutes of sleep per night and more sleep-related problems [8]. The mechanisms behind this association include arousal prompted by the content [12], and endogenous melatonin suppression by the blue light emitted from TV screens [27].

The use of screen-based media has evolved and the use of touchscreen devices by young children is now common, even in toddlers [3]. This gives rise to a new type of exposure because such devices provide continuous stimulation, anytime and anywhere [7, 31]. As these media have become ubiquitous, there is growing concern about their negative impact on sleep duration and quality [4]. A few studies have investigated the link between portable screen media and inadequate sleep quantity and quality in school children [7, 11] and infants [31]. In a mixed age group (infants and toddlers), Cheung found a significant association between more touchscreen use and less sleep in terms of hours overall, with less night-time sleep and more daytime sleep, and with a longer sleep onset latency [9].

Given the paucity of population-level data concerning the use of new media (tablets or smartphones) and sleep problems in toddlers, this study is an attempt to disentangle the association between new screen-based electronic devices and sleep duration in this age group, adjusting for potential confounders.

Methods

Participants and setting

Between May and August 2016, we conducted a cross-sectional study with a convenience sample of 167 primary care pediatricians registered with the Italian Federation of Primary Care Pediatricians (FIMP) in 11 Italian regions (Abruzzo, Campania, Emilia-Romagna, Friuli Venezia Giulia, Lazio, Marche, Piemonte, Puglia, Sicilia, Veneto, and Toscana) that together account for 70% of the Italian population. The pediatricians were asked to administer anonymous questionnaires to consecutively seen parents of children from 12 to 23 months of age attending scheduled health check-ups conducted at the pediatricians' offices. In all, 1400 questionnaires were handed out, and 1117 were completed and collected, with a participation rate of about 80%. Parents who gave their verbal consent completed the self-administered questionnaire before or after their visit. The questionnaire was anonymous, so no written consent was required. The following exclusion criteria were adopted: children who did not have at least one parent of Italian nationality; children presenting with acute disease; children with chronic diseases capable of disrupting their circadian rhythm (neuropathies, brain disorders, cardiovascular diseases, pulmonary diseases, at least 4 respiratory tract infections in the previous 3 months, chronic kidney failure, endocrinopathies, neuromuscular disorders, craniofacial conditions, sensory impairments, obstructive sleep apnea syndrome, chromosome abnormalities); children being treated with drugs capable of affecting or promoting sleep (anti-epileptic agents, sedatives, antidepressants, melatonin, herbal preparations); children with caregivers unable to complete the survey due to a language barrier.

Variables

The questionnaire first concerned demographic data (the child's age, gender, the number of older and/or younger siblings, the parent's age and formal education) and questions about breastfeeding and kindergarten attendance. Then, there were questions about the child's sleeping behavior: the

amount of time spent sleeping at night and during the day and the sleep onset latency.

In the third part of the questionnaire, parents answered three questions on how often their children habitually book reading, used screen-based media (including tablets and smartphones), video games, and television (0 times = never; 1–3 times a month = rarely; once or twice a week = sometimes; 3–5 times a week = often; every day = always). This was followed by a question concerning children's bedtime routines: falling asleep with milk or another liquid; falling asleep with a book or fairy tale; falling asleep with parents; falling asleep with a TV program, or a cartoon in streaming (Yes/No). There were also two questions about whether the children were restless (they cannot sit still), and whether they were sociable (friendly with other children), and parents answered using a three-point Likert scale (not true = 0 points; somewhat or sometimes true = 1 point; very true or often true = 2 points).

Data analysis

Continuous variables were summarized as mean ± standard deviation. Categorical variables were summarized by means of contingency tables of frequencies and proportions. A preliminary bivariate analysis was conducted. The χ^2 test was applied to identify differences in the distribution of categorical variables by sleep time groups, while a Kruskal-Wallis test or ANOVA was used to check for differences in the mean values of continuous variables.

Two ordered logistic regressions were run to cope with the ordinal outcome variables reflecting the tertiles of the distributions of the children by total sleep time (night-time plus daytime sleep), and the sleep onset latency, which were considered as the two dependent variables—taking for reference the first tertile (the group that slept the least) and the third tertile (the group taking the longest to fall asleep), respectively. Tablet and smartphone use was considered as the independent variable. Potential confounding factors were considered as covariates, and these included gender; having siblings (yes or no); attending kindergarten (yes or no); breastfeeding (yes or no); age and formal education of mother and father (high school, university/PhD; taking primary or lower secondary school for reference); children's habitual bedtime routines (falling asleep with parents, falling asleep with milk or other liquid, falling asleep with a book or fairy tale, falling asleep with a TV program or cartoon in streaming; all yes or no); recreational activities such as playing video games (frequency), watching TV (frequency), or reading a book (yes [=always/often] or no [=never/rarely/sometimes]); and behavioral characteristics (restlessness/hyperactivity and sociability; all yes or no). The Brant test was also used to examine the proportional odds (or parallel lines) assumption for each variable, and it showed that the assumption was satisfied for each variable. Finally, to check models for multicollinearity, we calculated the variance inflation factor (VIF) using the OLS (ordinary least squares) model, which amounted to 1.36, indicating that there were no collinearity issues among the variables considered. The STATA software, ver. 12, was used for all the statistical analyses.

Results

The study concerned 1117 toddlers, 573 (51.3%) males and 544 (48.7%) females. The characteristics of the sample are shown in Table 1. Overall, 17.8% of the toddlers used tablets and smartphones sometimes (once or twice a week), 12.1% used them often (3–5 times a week), and 6.8% used them always (every day). The mean total sleep time was 11.81 h (± 1.03), with 9.97 h (± 0.99) of nighttime sleep, and 1.87 h (± 0.55) of daytime sleep, and the mean sleep onset latency was 28.9 m (± 15.60).

Table 2 shows the results of bivariate analyses showing the associations of the total sleep time and sleep onset latency with the other variables concerning the children, their families, their family's habits, and the children's sleeping habits.

Table 3 shows the results of the multivariate regression models. Everyday use of tablets or smartphones raised the odds of a shorter total sleep time (OR 1.95 [1.00–3.79], $p < 0.05$), and their frequent (3–5 times a week) or everyday use raised the odds of a longer sleep onset latency (OR 2.00 [1.24–3.22] $p < 0.05$; OR 2.44 [1.26–4.73] $p < 0.05$), irrespective of other factors.

Discussion

The present study indicates that toddlers' total sleep time (night-time plus daytime sleep) and sleep onset latency are associated with their use of touchscreen devices such as tablets and smartphones. In our sample, one in five children used tablets or smartphones often or always. Nowadays, most children in the developed world start using touchscreen technology in their first year of life, and regular usage by toddlers is widespread. Recent American and Irish studies found that more than one in two toddlers had daily access to touchscreen devices [3, 17].

As regards total sleep time, our sample of toddlers in Italy seemed to sleep less than their counterparts in other countries, such as Australia and England [5, 21], even if the average total sleep time recorded in our study is within the recommended range for toddlers (11–14 h) [14, 24]. A recent study reported much the same total sleep time for the same age group in another Italian sample [6], while a study comparing Italian children from 0 to 6 years old with those of other countries found that Italian children went to bed later and slept fewer hours overall. These differences may be due to sociocultural factors, such as the Italian habit of allowing children to have dinner late (at 8–9 pm) together with the adults [23].

Table 1 Characteristics of the sample

Variables		Percentage	Number	(Mean ± SD)
Sex	Female	48.7	543	
	Male	51.3	572	
Children's age in month				25.3 (± 0.37)
Breastfeeding	Yes	81.9	903	
Older sibling	Yes	50.4	559	
Younger sibling	Yes	13.3	136	
Mother's age				34.3 (± 0.31)
Father's age				37.5 (± 0.35)
Mother's formal education	Primary/Lower secondary school	14.8	162	
	High school	51.0	557	
	University/PhD	34.2	373	
Father's formal education	Primary/Lower secondary school	24.2	243	
	High school	54.8	551	
	University/PhD	21.0	211	
Falling asleep with parents	Yes	64.6	722	
Falling asleep with milk or other liquid	Yes	27.7	309	
Falling asleep with a book or fairy tale	Yes	13.8	154	
Falling asleep with TV or cartoon in streaming	Yes	8.4	94	
Book reading	Yes	40.0	418	
Tablet and smartphone use	Never	45.8	474	
	Rarely	17.7	183	
	Sometimes	17.8	184	
	Often	12.1	125	
	Always	6.8	70	
Videogame playing	Yes	2.6	27	
Sociability				34.3 (± 0.31)
Restlessness/hyperactivity				34.3 (± 0.31)

Our study confirms the association between the use of media such as tablets and smartphones with poor sleep in toddlers. Only one other study recently tested this association in very young children: Cheung analyzed data on infants and toddlers between 6 and 36 months old, finding a significant association between more touchscreen use and less sleep, less night-time sleep, and a longer sleep onset latency [9]. The impact of screen-based media usage on sleep in older, school-age children, and adolescents has been investigated much more often. In a systematic review and meta-analysis, Carter found a significantly higher risk of an inadequate quantity and poor quality of sleep in children and adolescents who used portable screen-based media devices at bedtime [7].

Several studies have examined potential ways in which the use of traditional screen-based media can affect children's sleep. First, using such media in the evening may directly delay bedtime and thereby reduce the hours of night-time sleep [17]. Second, inappropriate content such as adult programs may contribute to psychological arousal [12]. Third, bright blue light emission from screens can suppress endogenous melatonin [27]. Finally, some children may have behavioral characteristics, such as a difficult temperament or self-regulation problems, which could prompt both sleep-related problems and a greater use of media [20] (though our data were adjusted for the children's behavioral traits).

The mechanisms by which touchscreen usage affects sleep patterns differently from traditional media, such as television, have been underexplored because the development and adoption of these devices have outpaced research capabilities [7]. Hand-held devices have given rise to a new type of exposure because they can be used anywhere at any time, indoors and out, even in the evening and in the bedroom [4]. Children who have such portable devices in their bedroom may delay going to sleep in order to play on-screen games or watch videos. Playing with a touchscreen device could also be more stimulating than simply watching a stationary device with a non-interactive screen [9]. Being inundated with unnatural levels of sensory stimulation results in the need for ever more novel and stimulating activities [10], but overstimulation makes it very hard to fall asleep. Not surprisingly, we found a strong

Table 2 Results of bivariate analyses: association of factors relating to the child, the family domain, bedtime habits, and the behavioral domain, with total time spent sleeping (night-time plus daytime sleep) and sleep onset latency as dependent outcomes

Variables			Total sleep time ($N = 1117$) N (%)				Sleep onset latency ($N = 1117$) N (%)			
			> 12	11.6–12	≤ 11.5	p	≤ 15	16–30	> 30	p
CHILD	*Sex**	Female	190 (35.2)	108 (20.0)	242 (44.8)	0.032	222 (41.2)	216 (40.1)	101 (18.7)	0.198
		Male	159 (28.0)	133 (23.4)	276 (48.6)		214 (37.7)	258 (45.4)	96 (16.9)	
	*Breastfeeding**	Yes	275 (30.7)	198 (22.1)	424 (47.3)	0.709	357 (39.8)	385 (43.0)	154 (17.2)	0.501
		No	67 (33.7)	42 (21.1)	90 (45.2)		74 (37.2)	84 (42.2)	41 (20.6)	
	*Older sibling**	Yes	182 (32.7)	121 (21.8)	253 (45.5)	0.734	248 (44.6)	221 (39.7)	87 (15.6)	0.002
		No	166 (30.6)	120 (22.1)	257 (47.3)		185 (34.1)	252 (46.5)	105 (19.4)	
	*Younger sibling**	Yes	44 (32.8)	27 (20.1)	63 (47.0)	0.847	51 (37.5)	57 (41.9)	28 (20.6)	0.585
		No	285 (32.3)	197 (22.3)	400 (45.4)		346 (39.4)	383 (43.6)	149 (17.0)	
	*Kindergarten attendance**	Yes	104 (24.3)	98 (22.9)	226 (52.8)	< 0.001	175 (41.2)	180 (42.4)	70 (16.5)	0.563
		No	244 (35.9)	143 (21.1)	292 (43.0)		261 (38.3)	294 (43.2)	126 (18.5)	
	Restlessness / hyperactivity °	(Mean ± SD)	0.72 (± 0.73)	0.76 (± 0.76)	0.85 (± 0.77)	0.049	0.72 (± 0.76)	0.79 (± 0.73)	0.96 (± 0.78)	0.001
	Sociability°	(Mean ± SD)	1.86 (± 0.36)	1.82 (± 0.41)	1.81 (± 0.41)	0.145	1.86 (± 0.37)	1.82 (± 0.37)	1.78 (± 0.45)	0.064
FAMILY	*Mother's formal education**	Primary/Lower secondary school	63 (39.1)	33 (20.5)	65 (40.4)	0.142	58 (36.0)	61 (37.9)	42 (26.1)	0.051
		High school	160 (28.9)	118 (21.3)	275 (49.7)		221 (39.9)	243 (43.9)	90 (16.2)	
		University/PhD	116 (31.3)	84 (22.6)	171 (46.1)		147 (39.7)	164 (44.3)	59 (15.9)	
	*Father's formal education**	Primary/Lower secondary school	83 (34.4)	50 (20.7)	108 (44.8)	0.404	83 (34.3)	114 (47.1)	45 (18.6)	0.251
		High school	172 (31.3)	129 (23.5)	248 (45.2)		232 (42.3)	222 (40.4)	95 (17.3)	
		University/PhD	60 (28.7)	41 (19.6)	108 (51.7)		80 (38.5)	95 (45.7)	33 (15.9)	
	Mother's age°°	(Mean ± SD)	34.3 (± 5.1)	33.8 (± 5.0)	34.4 (± 5.0)	0.897	34.8 (± 4.9)	34.0 (± 5.1)	33.7 (± 5.4)	0.209
	Father's age°°	(Mean ± SD)	37.6 (± 6.0)	36.8 (± 5.4)	37.3 (± 5.6)	0.246	37.9 (± 5.5)	37.1 (± 5.6)	37.2 (± 5.9)	0.515
BEDTIME HABITS	*Falling asleep with parents**	Yes	202 (28.2)	158 (22.1)	356 (49.7)	0.005	236 (33.0)	344 (48.1)	135 (18.9)	< 0.001
		No	147 (37.3)	84 (21.3)	163 (41.4)		200 (50.8)	132 (33.5)	62 (15.7)	
	*Falling asleep with milk or other liquid**	Yes	91 (29.4)	68 (22.0)	150 (48.5)	0.657	135 (44.0)	123 (40.1)	49 (16.0)	0.140
		No	258 (32.2)	174 (21.7)	369 (46.1)		301 (37.5)	353 (44.0)	148 (18.5)	
	*Falling asleep with a book or fairy tale**	Yes	47 (31.1)	29 (19.2)	75 (49.7)	0.650	56 (36.6)	70 (45.8)	27 (17.6)	0.717
		No	302 (31.5)	213 (22.2)	444 (46.3)		380 (39.7)	406 (42.5)	170 (17.8)	
	*Falling asleep with TV or cartoon in streaming**	Yes	33 (35.1)	21 (22.3)	40 (42.6)	0.662	22 (23.4)	31 (33.0)	41 (43.6)	< 0.001
		No	316 (31.1)	221 (21.8)	478 (47.1)		414 (40.8)	445 (43.9)	155 (15.3)	
HABITS	*Book reading**	Often/always	57 (13.8)	173 (41.8)	184 (44.4)	0.801	188 (45.3)	94 (22.7)	133 (32.0)	0.009
		Sometimes/rarely/never	125 (20.0)	271 (43.4)	229 (36.6)		295 (47.3)	133 (21.3)	196 (31.4)	
	*Videogame playing**	Often	7 (25.9)	5 (18.5)	15 (55.6)	0.604	4 (15.4)	12 (46.2)	10 (38.5)	0.005
		Sometimes/rarely/never	316 (32.0)	219 (22.2)	452 (45.8)		395 (40.0)	426 (43.2)	166 (16.8)	

Table 2 (continued)

Variables		Total sleep time ($N = 1117$) N (%)				Sleep onset latency ($N = 1117$) N (%)			
		> 12	11.6–12	≤ 11.5	p	≤ 15	16–30	> 30	p
*Watching TV**	Often	164 (32.9)	111 (22.3)	223 (44.8)	0.641	185 (37.2)	213 (42.9)	99 (19.9)	0.121
	Sometimes/rarely/never	154 (30.5)	111 (22.0)	240 (47.5)		209 (41.4)	219 (43.4)	77 (15.2)	
*Tablet and smartphone use**	Never	154 (32.6)	111 (23.5)	207 (43.9)	0.474	209 (44.7)	194 (41.5)	65 (13.9)	< 0.001
	Rarely	54 (29.7)	46 (25.3)	82 (45.1)		78 (43.1)	80 (44.2)	23 (12.7)	
	Sometimes	55 (30.2)	37 (20.3)	90 (49.5)		66 (35.9)	83 (45.1)	35 (19.0)	
	Often	42 (33.9)	21 (16.9)	61 (49.2)		38 (30.4)	61 (48.8)	26 (20.8)	
	Always	22 (31.9)	10 (14.5)	37 (53.6)		20 (28.6)	26 (37.1)	24 (34.3)	

* $\chi 2$ test
° Kruskal-Wallis test
°° ANOVA

association between longer sleep onset latency and new media usage.

The brain develops most significantly in the first 3 years of life, which means that during those years, the brain is also at its most vulnerable stage of development [16]. The impact of new technologies on brain development is not well understood [26], and more studies are needed to ascertain their potential consequences. The influence of sleep quality on cognitive functioning is undeniable; however [18, 30], so it is likely that touchscreen devices indirectly affect children's development.

After reviewing the existing literature on traditional and new media, the American Academy of Pediatrics issued a policy statement in 2016 recommending that families avoid any digital media usage by children up to 18–24 months old and that they restrict screen use to 1 h a day of good-quality programs for children 2 to 5 years of age [20]. The early and pervasive exposure to digital devices identified in our own and other studies shows a general lack of awareness of their potential negative effects on children's health. Pediatricians need to advise parents to limit the time their children spend using technological devices and delay their adoption.

Our findings need to be interpreted in the light of this study's several limitations. First, this was a cross-sectional study, so temporality and causality issues could not be considered [19]. Second, all sleep measures and details of the children's habits and behavior were based on parents' reports, which may not be reliable. Media usage could be underreported due to a social desirability bias [12], though allowing respondents to answer anonymously helps to avoid this bias. In addition, a recent study found a weak association between parent-reported measures and an objective measure of the frequency of night awakenings, but a strong correlation of the former with night-time sleep duration in infants [25]. Thirdly, our questionnaire only measured the frequency of smartphone and tablet use, not the duration of exposure. Finally, although the study achieved a good response rate, we cannot completely rule out the possibility of a non-response bias (though this can apply only if responders differ from non-responders). The use of an anonymous questionnaire could have made it easier for parents to participate in the research without being embarrassed about how they answered the questions on their behavior, so their decision to participate may have been irrespective of their behavior. In addition, our respondents may have differed from the general population in terms of formal education because better-educated parents are more engaged and interested in the research question. On the other hand, we ascertained that the proportion (%) of mothers with a university degree in our study (34%) differs little from the national average (29% in women aged 30–35).

In conclusion, the usage of new media (tablets, smartphones) could be a risk factor for poor sleep outcomes

Table 3 Ordered logistic regression analysis of associations between tablet and smartphone use and the two sleep outcomes adjusted for confounding factors; ORs and 95% confidence intervals, *p* value

		OR unadjusted	[95% CI]	$P>\|z\|$	OR adjusted[a]	[95% CI]	$P>\|z\|$
Total sleep time (night-time plus daytime sleep)							
Tablet and smartphone use (ref Never)	Rarely	1.08	0.79–1.49	0.608	1.23	0.83–1.83	0.282
	Sometimes	1.19	0.87–1.65	0.275	1.35	0.89–2.06	0.151
	Often	1.11	0.76–1.62	0.587	1.15	0.71–1.87	0.551
	Always	1.29	0.79–2.11	0.301	1.95	1.00–3.79	0.049
Sleep onset latency							
Tablet and smartphone use (ref Never)	Rarely	1.02	0.74–1.41	0.882	1.09	0.72–1.63	0.669
	Sometimes	1.45	1.05–2.00	0.024	1.33	0.87–2.02	0.179
	Often	1.76	1.21–2.54	0.003	2.00	1.24–3.22	0.004
	Always	2.62	1.61–4.27	0.000	2.44	1.26–4.73	0.008

[a] OR from ordered logistic regression models, adjusted for sex, having siblings, kindergarten attendance, breastfeeding, mother's and father's age, and mother's and father's formal education, falling asleep with parents, falling asleep with milk or other liquid, falling asleep with a book or a fairy tale, falling asleep with TV or cartoon in streaming, playing videogames (frequency), watching TV (frequency), reading a book, and restlessness/hyperactivity and sociability

in toddlers, irrespective of other factors already known to be associated with sleep quality, such as temperament (aggressiveness, restlessness, sociability), and watching traditional screens at bedtime.

Interventions and policies are needed to raise public awareness of the potential health hazard of new media usage. Health care professionals should provide parents with guidance on a more appropriate media usage.

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Authors' contributions Dr. Gallimberti conceptualized the study, coordinated all study phases, and approved the final manuscript as submitted. Dr. Buja, Dr. Sperotto and Dr. Buzzetti designed the study, carried out the statistical analyses, reviewed and revised the manuscript, and approved the final manuscript as submitted. Dr. DeBattisti wrote the paper. Dr. Marini, Dr. Marconi and Dr. Terraneo were involved in the design of the study. Dr. Chindamo designed the data collection tools, coordinated and supervised data collection, and approved the final manuscript as submitted. Dr. Doria and Dr Chiamenti coordinated and supervised data collection, critically reviewed and revised the manuscript and approved the final manuscript as submitted. Dr. Ceschin, Dr. Malorgio, and Dr. Tommasi coordinated data collection and approved the final manuscript as submitted. Dr. Gomez Perez interpreted the data, critically reviewed and revised the manuscript, and approved the final manuscript as submitted. Prof Baldo designed the sampling methods, critically reviewed and revised the manuscript, and approved the final manuscript as submitted.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflicts of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

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