



The role of parental control apps and parental knowledge in adolescents' sleep-related screen use: A nationwide study

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ABSTRACT

Background: Previous studies have shown significant associations between screen-based device (SBD) use and adverse sleep outcomes among children and adolescents. Although parenting factors may play a protective role, no quantitative studies have specifically examined the association between parental technical mediation and adolescents' SBD use around sleep.

Aims: The present study investigated the main and interaction effects of parental technical mediation and parental knowledge on adolescents' SBD use before sleep and after awakening, separately for school and non-school days.

Methods: A cross-sectional survey was conducted among adolescents in Gibraltar (total $N = 2472$; final eligible sample $N = 1743$; 51.15% female; mean age = 14.21 years, $SD = 1.91$), assessing adolescent and family background characteristics, SBD use patterns, sleep-related SBD use, and parental technical mediation and knowledge.

Results: Structural equation modelling indicated that, on school days, the presence of parental control apps on all devices was weakly ($\beta = .19$) associated with a longer interval between stopping SBD use and going to sleep. On school days, a significant interaction also emerged ($\beta = .19$) where the presence of parental control apps was associated with a longer delay in post-wake SBD use, but only when parental knowledge was high ($B = 0.37$, $p < .001$). No significant main or interaction effects were observed for non-school days.

Conclusions: The observed modest associations between parental technical mediation and adolescents' sleep-related SBD use were consistent with prior research on parental mediation strategies. The findings further suggest that the potential effects of parental technical mediation may be context-dependent and operate in interaction with broader family-related factors when addressing adolescent SBD use around sleep.

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1. Introduction

1.1. Sleep-related screen-based device use

Screen-based devices (SBDs) include both traditional technologies (e.g., televisions, desktop computers) and modern, portable ones (e.g., smartphones, tablets) (Demetrovics et al., 2026). Portable SBDs are particularly notable for enabling constant internet access and interactive digital engagement (e.g., social media use, gaming, video streaming). Their widespread and growing use among children and adolescents has drawn increasing research attention due to the developmental and policy challenges it raises (Boniel-Nissim et al., 2024; Thomas et al., 2020). This age group also appears more vulnerable to problematic screen use, which is often marked by diminished control and associated negative consequences (Busch & McCarthy, 2021). These consequences may include lower academic achievement, social difficulties, and adverse mental and physical health outcomes (e.g., depression and anxiety symptoms, stress, somatic symptoms) (Busch & McCarthy, 2021; Elhai et al., 2017; Paterna et al., 2024).

Among the various negative health outcomes, the potential impact of SBD use on sleep is particularly notable. Systematic reviews and meta-analyses (Alimoradi et al., 2019; Carter et al., 2016; Hale & Guan, 2015; Lund et al., 2021; Zhang et al., 2022) have consistently demonstrated significant associations between SBD use and less favorable sleep outcomes among children and adolescents. Frequent and problematic SBD use in general, along with use before bedtime, has been associated with poorer sleep quality, delayed bedtimes, reduced sleep duration, and heightened daytime sleepiness (Alimoradi et al., 2019; Carter et al., 2016; Hale & Guan, 2015; Lund et al., 2021; Zhang et al., 2022). Although a bidirectional relationship is possible (Hale et al., 2019), recent daily-level evidence suggests that within-person increases in SBD use are primarily associated with later sleep onset, whereas no significant associations were observed for other sleep-related outcomes (e.g., sleep duration, sleep efficiency, and subjective sleep quality) (Bourke et al., 2026). This finding may be compatible with the sleep displacement hypothesis, whereby bedtime SBD use primarily contributes to delayed bedtime, sleep initiation, and sleep onset (Bauducco et al., 2024).

In this context, the timing of SBD use in relation to sleep may also be relevant. Using SBDs before sleep or in the bedroom may affect sleep more strongly than overall usage patterns (Bauducco et al., 2024; Hale et al., 2019). Research on SBD use after awakening remains limited (Toh et al., 2019). Examining SBD use both before sleep and after awakening may therefore contribute to a more comprehensive understanding of sleep-related SBD use. Although these behaviors do not necessarily indicate problematic SBD use, they may reflect subtle signs of impaired control or preoccupation (Harris et al., 2020) and may therefore represent potentially relevant indicators of adolescents' digital health behaviors.

The separate examination of SBD use before sleep and after awakening is also supported by theoretical frameworks. First, process-oriented models of sleep disturbances distinguish between processes occurring before sleep and those occurring after awakening and during the daytime (Harvey, 2002; Perlis et al., 2011). Although these models primarily describe cognitive and behavioral mechanisms underlying sleep disturbances, they suggest that behaviors occurring in different temporal contexts may serve different functions, which may also be relevant for understanding sleep-related SBD use. Second, theoretical models of potentially addictive behaviors, such as the I-PACE model (Brand et al., 2016, 2019, 2025), emphasize that digital behaviors are shaped not only by stable individual characteristics but also by situational demands and context-dependent self-regulation. Accordingly, SBD use before sleep and after awakening may involve different situational goals and self-regulatory challenges.

1.2. Parental and contextual factors

Given the potential importance of sleep-related SBD use, identifying factors associated with more favorable behavioral patterns is essential. Parenting strategies aimed at regulating children's and adolescents' use of internet-connected SBDs may play a protective role, for example, by setting rules, monitoring usage, educating, and maintaining open communication (Király et al., 2020). SBD-specific parenting strategies may include co-use (i.e., joint parent-adolescent SBD use), active mediation (i.e., nonjudgmental SBD-related discussions), and restrictive mediation (i.e., parental rules on duration, timing, and content) (Lukavská et al., 2022; Modecki et al., 2022; Vossen et al., 2024).

In contrast to interpersonal forms of parental mediation, technical mediation refers to the use of software or apps (so-called 'parental control apps') that enable parents to monitor and restrict SBD use directly through the device, including limits on screen time, content, contacts, and communication (Chandrima et al., 2020; Geržičáková et al., 2023). However, technical mediation does not operate independently of other parental mediation strategies. For example, parental technical mediation has been shown to be positively associated with active mediation, restrictive mediation, and parental monitoring (Geržičáková et al., 2023). Previous research also suggests that parental control apps are more commonly used by parents who are more actively involved in their children's digital lives and who place greater emphasis on rule setting and online safety (Stoilova et al., 2024). Accordingly, technical mediation should be interpreted within the broader parenting context rather than as a stand-alone strategy (Stoilova et al., 2024). Against this background, the present study focused specifically on parental technical mediation.

However, previous research on parental technical mediation has yielded mixed findings. It has been only weakly associated with lower levels of negative SBD use outcomes, including problematic gaming, involvement in cyberbullying, and overall screen time (Benrazavi et al., 2015; Stoilova et al., 2024). Other studies have reported no significant associations or have identified potential adverse effects, such as increased family conflict, reduced adolescent autonomy, and heightened problematic SBD use (Miltuze et al., 2021; Stoilova et al., 2024). To date, no quantitative study has specifically examined the association between technical mediation and adolescents' SBD use before and after sleep. However, previous research suggests that parental rules and restrictions related to sleep, irrespective of whether they are implemented through the device, are associated with more favorable SBD and sleep-related outcomes (Bauducco et al., 2024). These findings point to the potential relevance of technical mediation in this context.

To gain a more comprehensive understanding of the relationship between technical mediation and SBD use around sleep, it is also important to consider additional factors. One such factor is parental knowledge of the adolescent's SBD use, which may represent one important aspect of the broader parenting context. Because technical mediation is primarily intended to enhance parental awareness, some studies have reported a positive association between technical mediation and perceived parental knowledge (Geržičáková et al., 2023; Symons et al., 2017). However, this is not always the case because children and adolescents may conceal their use or circumvent monitoring tools (Toh et al., 2019). Although their combined effects on sleep-related SBD use have not yet been examined, it is plausible that the most favorable outcomes (e.g., reduced use before sleep and delayed use after awakening) occur when technical mediation is paired with high parental knowledge. This interaction may be grounded in a warm parent-child relationship and open communication, which are central to both effective mediation and high parental knowledge (Geržičáková et al., 2023; Marciano et al., 2022; Stoilova et al., 2024; Symons et al., 2017; Álvarez-García et al., 2019).

Another relevant contextual factor is the potential difference between school days and non-school days. Parents may enforce stricter rules and monitor more actively on school days, while adopting a more

relaxed approach on weekends or holidays (e.g., deactivating controls or lowering supervision). Consequently, although empirical evidence is lacking, the protective effects of technical mediation and parental knowledge may be stronger on school days, when limiting SBD use around sleep is often prioritized (Hale & Guan, 2015). At the same time, previous research has associated evening SBD use with negative sleep outcomes on both weekdays and weekends (Mireku et al., 2019).

1.3. Aims and hypotheses

The present study examined the main and interaction effects of parental technical mediation and perceived parental knowledge on adolescents' SBD use before sleep and after awakening, separately for school days and non-school days. The proposed structural model is illustrated in Fig. 1. It was hypothesized that the presence of parental control apps on all or some of the adolescents' SBDs, as well as high perceived parental knowledge regarding SBD use, would be associated with stopping SBD use earlier before going to sleep and with a longer delay before using an SBD after awakening, on both school and non-school days. Moreover, it was hypothesized that the predictive effect of parental control apps on all or some SBDs would be stronger at higher levels of perceived parental knowledge than at lower levels. To the authors' knowledge, the present study is the first to examine the independent and combined associations of parental technical mediation and parental knowledge with sleep-related SBD use, separately on school and non-school days.

2. Methods

2.1. Participants and procedure

2.1.1. Procedure

Data for the present study were drawn from the cross-sectional Gibraltar School Survey 2024, which examined adolescent health and risk behaviors among 11- to 19-year-old students (grades 7–13) in Gibraltar, a British Overseas Territory. Data were collected in November 2024 in all secondary schools of the country except for two small religious schools with approximately 90 students in total. Participation

rates across school years ranged between 75% and 90%, except for the two final grades, (i.e., grade 11 [67%] and grade 13 [52%]), where the overlapping closing exams made participation more difficult. In total, the study involved 78% of students in the participant schools, corresponding to 76% of all secondary school students in Gibraltar. Surveys were administered to all classes of the participating schools by teachers during a pre-scheduled class period and returned in sealed envelopes to the researchers. Parents were informed about the study's aims and methods prior to data collection and parental consent was obtained passively (i.e., non-response was taken as consent unless parents actively declined). Students provided active informed consent. Participation was anonymous and voluntary, with the option to skip questions or withdraw at any time. The study was approved by the University of Gibraltar Research Ethics Committee on 8 November 2024 (No.: 173/2024/UniGib).

2.1.2. Participants

A total of 2472 students participated in the survey. For the purposes of the present study, students were excluded from the final sample if they (i) did not report their school grade ($N = 22$), (ii) reported no SBD use or had missing data on SBD use-related variables ($N = 481$), or (iii) were unsure whether parental control apps were installed on their devices ($N = 479$). After applying these criteria (which could overlap and were not mutually exclusive), the final eligible sample comprised 1743 students, of whom 51.15% were female ($N = 891$), 46.79% were male ($N = 815$), 0.98% identified as a gender other than male or female ($N = 17$), and 1.09% preferred not to disclose their gender ($N = 19$). The mean age of the final eligible sample was 14.21 years ($SD = 1.91$). Detailed sociodemographic information for the final eligible sample is provided in Table S1.

For the primary multivariable analyses addressing the study aims, the final analytic sample comprised 1569 participants after excluding cases with missing values on observed exogenous variables ($N = 174$). The analytic sample included 50.73% female participants ($N = 796$), 47.10% male participants ($N = 739$), 16 participants identifying as a gender other than male or female (1.02%), and 18 participants who preferred not to disclose their gender (1.15%). The mean age of the final analytic sample was 14.28 years ($SD = 1.92$).

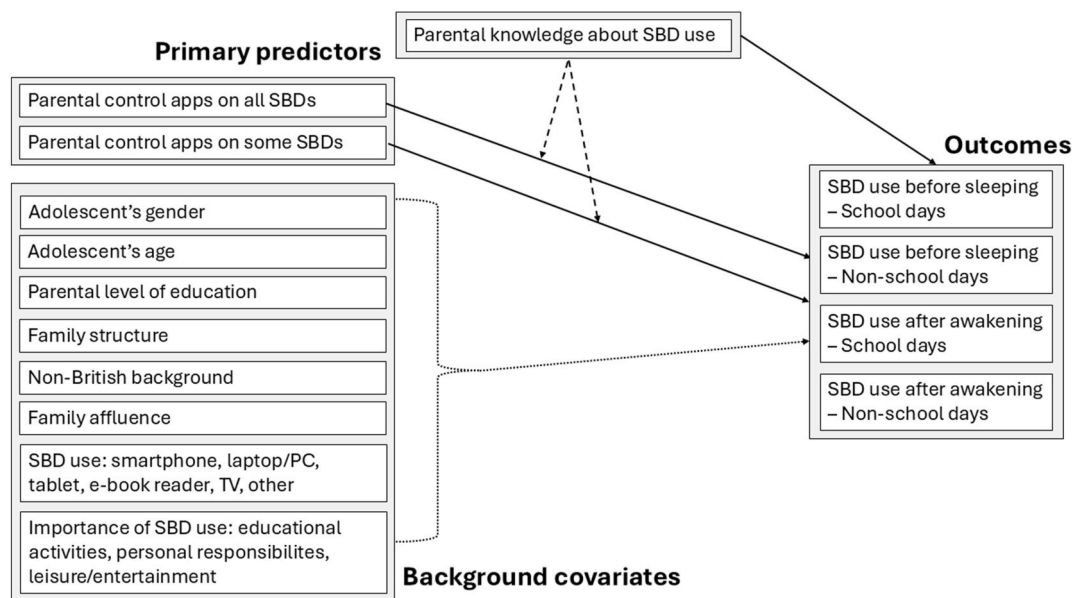


Fig. 1. Proposed structural model.

Note. SBD: screen-based device. Solid lines indicate main effects associated with the primary predictors, whereas dashed lines pointing to these paths represent interaction effects between the predictors. Dotted lines indicate effects related to background covariates, which were included as controls and are not central to the study aims.

To examine potential biases related to the selection of the final eligible sample, adolescents included in and excluded from the final eligible sample were compared. The results of these comparisons are presented in Table S2. Significant differences were observed across several study variables between included and excluded individuals. However, all statistically significant differences were characterized by small effect sizes. More specifically, adolescents who were excluded from the final sample were less likely to be female, were younger, were more likely to come from families in which neither parent held a university degree, and reported lower family affluence. Regarding SBD use, excluded adolescents reported lower use of smartphones, laptops/PCs, and televisions. They also reported lower perceived functional importance of SBDs for both school-related and leisure-related activities. Moreover, parental control apps were more frequently reported to be used on all SBD devices among excluded adolescents (and less frequently reported as not installed or not used). Finally, excluded adolescents were less likely to report using SBDs until falling asleep on both school and non-school days.

2.2. Measures

2.2.1. Background characteristics

The survey assessed adolescents' and families' background characteristics. For the present analyses, adolescents' gender and age, parental education, and family structure were included (see Table S1 for details). To capture the extent of non-British background, a continuous latent variable was constructed from the adolescent's and both parents' birthplaces, the adolescent's nationality, and length of residence in Gibraltar (see Table S1). Higher scores indicated a more pronounced non-British background, characterized by greater likelihood of non-British nationality or birthplace, and shorter residence in Gibraltar. The variable showed close to adequate internal consistency ($\omega = .92$).

The six-item Family Affluence Scale III (FAS-III) was used to assess indicators of family wealth (Torsheim et al., 2016). Items varied in response format, with three using four-point Likert scales and two using binary options (see Table S1). A continuous latent variable was derived from the six items, with higher scores indicating greater family affluence. Internal consistency was close to adequate in the present sample ($\omega = .66$).

Adolescents also reported characteristics related to SBD use. More specifically, they indicated whether they used each type of SBD, including smartphone, laptop/PC, tablet, e-book reader, television, and other SBD (0 = no, 1 = yes). Moreover, as a proxy for domain-specific patterns and functional relevance of screen use, participants reported the perceived importance of SBD use across different functional domains in their own lives, including school and educational activities, personal or household responsibilities, and leisure and entertainment. Each item was rated on a five-point Likert scale (1 = not at all, 5 = absolutely essential).

2.2.2. Adolescents' SBD use around sleep

Separate items assessed the time between going to sleep and stopping SBD use, and the time before starting SBD use after awakening, for both school days and non-school days. Pre-sleep items used a five-point Likert scale (1 = uses SBDs until falling asleep, 5 = stops SBD use at least 2 h before going to sleep), and post-sleep items a six-point Likert scale (1 = starts using SBDs immediately after awakening, 6 = starts using SBDs more than 2 h after awakening). Although the validity of these items was not formally tested and were developed for the purposes of the present study, this measurement approach is supported by prior research that has used separate items to assess SBD use before going to sleep (Levenson et al., 2017; Pillion et al., 2022; Smith et al., 2020), as well as in other studies that have examined SBD- and sleep-related outcomes separately for school and non-school days (Horváth et al., 2022; Scott et al., 2019).

2.2.3. Parental factors concerning adolescents' SBD use

Technical mediation was assessed with a single item asking whether parental control apps were installed on all, some, or none of the adolescent's devices. This item was developed for the purposes of the present study, and its validity has not been formally established. However, prior research has similarly assessed parental control app use or installation using single-item measures or non-continuous (i.e., dichotomous) variables (Geržičáková et al., 2023; Law et al., 2010; Przybylski & Nash, 2018).

Perceived parental knowledge of adolescents' SBD use was assessed on a four-point Likert scale (1 = nothing, 2 = little, 3 = a lot, 4 = everything). Given the low response frequency in the "Nothing" category ($N = 68$), and to facilitate interpretability of the corresponding findings, this variable was recoded into a dichotomous format: low (nothing or little) vs. high (a lot or everything) knowledge. The applied assessment of perceived parental knowledge is consistent with single-item measures used in previous studies (Geržičáková et al., 2023; Valentic et al., 2024).

2.3. Statistical analyses

As a preliminary analysis, bivariate correlations were calculated among dichotomous (i.e., family structure, use of different SBDs, parental knowledge of SBD use), ordinal (i.e., domain-specific perceived importance of SBD use and measures of SBD use around sleep), and continuous latent or observed variables (i.e., adolescent age, non-British background, and family affluence). Tetrachoric correlations were used for dichotomous variables, polychoric correlations for associations involving ordinal variables, biserial correlations for associations between dichotomous and continuous variables, polyserial correlations for associations between ordinal and continuous observed or latent variables, and model-implied correlations for associations between continuous observed or latent variables. These correlations were estimated within a structural equation modelling (SEM) framework using the weighted least squares means and variances adjusted (WLSMV) estimator.

In addition, bivariate associations involving the nominal categories of technical mediation (i.e., parental control apps used on all SBDs, some SBDs, or not installed) were examined using chi-square tests for categorical variables (i.e., dichotomous and ordinal variables) and one-way analyses of variance (ANOVA) for continuous variables. Finally, primary study variables (i.e., parental knowledge, technical mediation, and measures of SBD use around sleep) were compared across categories of adolescent gender and parental education level using chi-square tests.

Taken together, these preliminary bivariate analyses were conducted using data from the final eligible sample ($N = 1743$), with the effective sample size varying across analyses because of variable-specific missing data. For the bivariate correlations estimated within the SEM framework, missing data were accommodated under the WLSMV estimation procedure using all available pairwise information for parameter estimation (covariance coverage = .93–1.00). In contrast, chi-square tests, independent-samples *t*-tests, and one-way ANOVA were based on listwise deletion of missing data.

The study aims were examined using SEM in the final analytic sample ($N = 1569$), incorporating four observed ordinal outcome variables and a combination of observed and latent predictors. The outcomes measured the time between stopping SBD use and going to sleep, and the time between awakening and starting SBD use, on both school and non-school days. The analysis first included the main effects of perceived parental knowledge and technical mediation, with their interaction added in a second step.

Statistically significant interaction effects were further examined using simple slope analyses, in which the association between parental technical mediation and the outcome variable was estimated at different levels of parental knowledge. Models controlled for adolescent gender and age, parental education, family structure, non-British background,

family affluence, types of SBDs used, and domain-specific perceived importance of SBD use. These variables were included based on prior research associating them with parental mediation, parental knowledge, and SBD use around sleep (Busch & McCarthy, 2021; Geržičáková et al., 2023; Lund et al., 2021; Stoilova et al., 2024). That is, in line with a theory-driven (a priori) SEM approach, the inclusion of primary predictors and background covariates was not based on data-driven selection procedures (e.g., p -value thresholds). Although these variables were selected a priori, all background characteristics were also significantly associated with at least one SBD use outcome around sleep or with one of the primary predictors (see Tables 1 and 2). Therefore, they were retained in all models to account for potential confounding and to ensure consistency across models, thereby facilitating comparisons across outcome variables.

All predictors were observed variables, except for the latent constructs of non-British background and family affluence. Because the latent variables were based on categorical indicators, models were estimated using the WLSMV estimator with delta parameterization and a probit link. Model fit was considered acceptable if the comparative fit index (CFI) and Tucker–Lewis index (TLI) were $\geq .90$, and the RMSEA was $\leq .08$. In accordance with the handling of missing data for SEM including observed exogenous variables, participants with missing values on any observed predictor or covariate ($N = 174$) were excluded from the multivariable analyses. Missing data on endogenous variables and indicators of the latent constructs were accommodated under the WLSMV estimation procedure using all available pairwise information for parameter estimation. Covariance coverage for these variables ranged from .96 to 1.00, indicating minimal missingness.

Additional analyses were conducted to evaluate the robustness and reproducibility of the primary findings. First, the moderation models were re-estimated using the original four-category parental knowledge variable, treated as an approximately continuous predictor, instead of the dichotomized moderator. This analysis examined whether the observed main and interaction effects were robust to the operationalization of parental knowledge. Second, to evaluate the reproducibility of the interaction effects given the relatively small number of participants in one subgroup (i.e., adolescents with low parental knowledge and parental control apps installed on all SBDs), the analytical sample was randomly divided into two approximately equal subsamples ($N = 784$ and $N = 785$, respectively), and the fully adjusted interaction models were re-estimated separately in each subsample.

Finally, approximate critical unstandardized and standardized regression coefficients (i.e., critical effect size values) were calculated for the main and interaction effects of parental knowledge and parental control app use, as well as for conditional slopes associated with statistically significant interaction effects. In the absence of an a priori power analysis, these critical regression coefficients provide an estimate of the minimum coefficient magnitude required to achieve statistical significance under the achieved sample size and model specification (Perugini et al., 2025). Because no established procedure is currently available for ordinal regression models estimated with WLSMV, these coefficients were approximated by adapting the calculation approach used in the Wald test framework for linear regression (Perugini et al., 2025). Accordingly, the critical regression coefficients were calculated as $[1.96 \times SE]$, where 1.96 represents the two-tailed critical z value for $\alpha = .05$ and SE denotes the standard error of the regression coefficient.

All analyses were performed using *Mplus 8.1* (Muthén & Muthén, 2017) and *IBM SPSS Statistics 30.0* (IBM Corporation, 2024).

3. Results

3.1. Preliminary analyses

Table 1 presents the bivariate correlations among the study variables. Concerning the primary predictors and SBD use outcomes around sleep, several significant, although mostly small, correlations were

observed. Higher parental knowledge was associated with greater family affluence, tablet and e-book reader use, lower perceived functional importance of SBD use for leisure and entertainment, and later initiation of SBD use after awakening on school days.

With regard to SBD use around sleep, younger age, non-use of smartphones, and lower perceived importance of SBD use for leisure and entertainment were consistently associated with a longer interval between going to sleep and stopping SBD use, as well as later initiation of SBD use after awakening across both school and non-school days. For SBD use before sleep, non-use of laptops/PCs, tablets, and televisions, as well as lower perceived importance of SBD use for school-related activities, were associated with a longer interval between going to sleep and stopping SBD use on both school and non-school days. In addition, lower perceived importance of SBD use for personal or household responsibilities was associated with a longer interval only on non-school days.

For SBD use after awakening, a longer time elapsed between awakening and starting SBD use was associated with stronger non-British background, e-book reader use, and lower perceived importance of SBD use for personal or household responsibilities across both school and non-school days. Higher family affluence was associated with later SBD use after awakening on school days only, whereas non-use of tablets and televisions, as well as lower perceived importance of SBD use for school-related activities, were associated with later SBD use after awakening on non-school days. The four sleep-related SBD use outcomes showed significant and positive intercorrelations.

Table 2 presents the comparisons across groups based on parental technical mediation. Although significant differences emerged across several variables, all were of small magnitude except for adolescent age, which showed a moderate effect size. Adolescents for whom parental control apps were not installed were older and had the highest proportion of families in which neither parent held a university degree, as well as the highest proportion not living with both biological parents. They also showed somewhat lower rates of non-use of smartphones and laptops/PCs, and reported the highest perceived functional importance of SBD use for both school/education and leisure/entertainment purposes. In addition, this group showed lower levels of parental knowledge about SBD use (i.e., “a lot” or “everything”), and the highest proportion of adolescents who reported using SBDs until falling asleep, as well as initiating SBD use immediately after awakening.

Comparisons according to parental education level and adolescent gender are presented in Tables S3 and S4, respectively. Parental level of education showed significant but weak associations with parental control app installation and adolescents’ SBD use before sleep on both school and non-school days, and with SBD use after awakening on non-school days. Adolescent gender showed significant but weak associations with parental knowledge and SBD use after awakening on both school and non-school days.

3.2. Predictive effects on SBD use before sleeping and after awakening

Tables 3 and 4, together with Figs. 2 and 3, summarize predictors of SBD use before sleep and after awakening, analyzed separately for school and non-school days. All significant associations were weak. In the final model, which included interaction terms ($\chi^2 [321] = 1038.495$, $p < .001$; RMSEA [90% CI] = .038 [.035–.040]; CFI = .945; TLI = .925), a longer interval between stopping SBD use and going to sleep was associated with younger age, higher family affluence, and lower perceived importance of SBD use for leisure and entertainment in both contexts. On school days, it was also associated with non-use of tablets and the presence of parental control apps on all devices. A longer delay in SBD use after awakening was associated with male gender (relative to female gender), younger age, e-book reader use, television non-use, greater perceived importance of SBD use for school and educational activities, and lower perceived importance of SBD use for leisure and entertainment activities, consistently across school and non-school days.

Table 1
Bivariate correlations among dichotomous, ordinal and continuous variables.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.
1. Adolescent's age																	
2. Family structure ¹ : Living with both biological parents	-.02																
3. Non-British background ²	.00	.03															
4. Family affluence ³	.00	.31***	.10**														
5. SBD used ⁴ : Smartphone	.41***	.01	-.16*	.17*													
6. SBD used ⁴ : Laptop or PC	.28***	.11**	.09*	.23***	.23**												
7. SBD used ⁴ : Tablet	-.12***	.10*	-.21***	.18***	.15*	.07											
8. SBD used ⁴ : E-book reader	.05	.08	.02	.07	-.12	.20***	.17**										
9. SBD used ⁴ : Television	-.02	.17***	-.11**	.17***	.53***	.40***	.31***	.06									
10. SBD used ⁴ : Other SBD	-.24***	-.01	.00	.00	-.30***	-.05	.03	-.01	.08								
11. Perceived functional importance of SBD use ⁵ : School and educational activities	.37***	.02	.01	.09**	.23***	.30***	.07*	.09*	.14***	-.19***							
12. Perceived functional importance of SBD use ⁵ : Personal or household responsibilities	.12***	.08*	-.02	.17***	.24***	.09**	.15***	.01	.12***	-.02	.29***						
13. Perceived functional importance of SBD use ⁵ : Leisure and entertainment	.06*	-.02	-.06	.02	.14*	.06	.10**	-.15**	.13***	.14***	.12***	.14***					
14. Parental knowledge about SBD use ⁶ : A lot or everything	-.01	.08	-.02	.16***	.05	.06	.09*	.15*	.04	-.02	.06	.03	-.08*				
15. SBD use before sleeping ⁷ : School days	-.14***	.02	-.01	.05	-.20**	-.08*	-.09**	.02	-.11**	-.02	-.10***	-.05	-.11***	.01			
16. SBD use before sleeping ⁷ : Non-school days	-.17***	.03	-.02	.04	-.24***	-.09**	-.07*	-.03	-.12**	-.04	-.10***	-.07*	-.12***	-.03	.84***		
17. SBD use after awakening ⁸ : School days	-.22***	.06	.10**	.07*	-.17**	.02	-.06	.13**	-.07	.07	-.03	-.09***	-.11***	.09**	.18***	.15***	
18. SBD use after awakening ⁸ : Non-school days	-.22***	.05	.09**	.06	-.16**	-.05	-.07*	.11*	-.09*	.05	-.05	-.08**	-.17***	.03	.24***	.27***	.63***

Note. $N = 1743$. Tetrachoric correlation estimates were calculated between dichotomous variables (nos. 2, 5–10, and 14). Polychoric correlation estimates were calculated between dichotomous (nos. 2, 5–10, and 14) and ordinal variables (nos. 11–13 and 15–18), as well as between ordinal variables (nos. 11–13 and 15–18). Biserical correlation estimates were calculated between dichotomous variables and continuous observed/latent variables (nos. 1, 3, and 4). Polyserial correlation estimates were calculated between ordinal (nos. 11–13 and 15–18) and continuous observed/latent variables (nos. 1, 3, and 4). Product-moment correlation estimates were calculated between continuous observed/latent variables (nos. 1, 3, and 4).

Level of significance: * $p < .05$, ** $p < .01$, *** $p < .001$. Level of model fit: $\chi^2(187) = 624.741$, $p < .001$; $RMSEA [90\% CI] = .037 [.033-.040]$; $CFI = .974$; $TLI = .952$. ¹Reference category: Not living with both biological parents and/or living with step-parents. ²Higher values indicate a stronger non-British background, including increased likelihood of non-British nationality (coded as: 0 = UK-based or Gibraltar-based British nationality, 1 = Non-British nationality) and birthplace (coded as: 0 = Born in Gibraltar or the UK, 1 = Born outside of Gibraltar or the UK), and shorter time living in Gibraltar (coded as: 1 = Born in Gibraltar, 2 = Living in Gibraltar for more than 10 years, 3 = Living in Gibraltar for 5–9 years, 4 = Living in Gibraltar for 1–4 years, 5 = Living in Gibraltar for less than a year, 6 = Living outside of Gibraltar). ³Higher scores on the latent factor indicate greater family affluence. ⁴Reference category: Not using the given SBD. ⁵Higher scores indicate greater perceived importance of SBD use in the respective functional domain. ⁶Reference category: Nothing or little. ⁷Higher scores indicate a longer interval between going to sleep and stopping screen-based device use, whereas lower scores reflect a shorter interval. ⁸Higher scores indicate a longer time elapsed before using a screen-based device after awakening, while lower scores reflect shorter delays.

Table 2

Comparison across groups based on parental control app installation on adolescents' screen-based devices (SBDs).

	All devices (A)	Some devices (S)	Not installed (N)	Test statistic & effect size	Pairwise comparisons (Cohen's d)
Adolescent's gender <i>N</i> (%)				$\chi^2 = 2.41^{NS}$	
Males/Boys	99 (43.42%)	205 (47.02%)	511 (47.40%)	$V = .03$	
Females/Girls	125 (54.82%)	220 (50.46%)	546 (50.65%)		
Other	2 (0.88%)	6 (1.38%)	9 (0.83%)		
Prefer not to disclose	2 (0.88%)	5 (1.15%)	12 (1.11%)		
Adolescent's age					
<i>M</i> (<i>SD</i>)	12.92 (1.54)	13.46 (1.65)	14.80 (1.84)	$F = 157.77^{***}$ $\eta^2 = .16$	A-S: 0.31*** A-N: 1.07*** S-N: 0.76***
Parental level of education: university degree <i>N</i> (%)					
Both parents/step-parents have	68 (31.63%)	122 (29.05%)	240 (22.92%)	$\chi^2 = 14.82^*$	
Only the mother/step-mother has	28 (13.02%)	63 (15.00%)	131 (12.51%)	$V = .07$	
Only the father/step-father has	21 (9.77%)	35 (8.33%)	110 (10.51%)		
Neither of the parents has	98 (45.58%)	200 (47.62%)	566 (54.06%)		
Family structure: living with both biological parents <i>N</i> (%)					
Not living with them and/or living with step-parents	44 (19.30%)	103 (23.57%)	311 (28.85%)	$\chi^2 = 11.07^{**}$	
Living with both biological parents	184 (80.70%)	334 (76.43%)	767 (71.15%)	$V = .08$	
Non-British background¹					
<i>M</i> (<i>SD</i>)	0.19 (0.77)	0.13 (0.72)	0.09 (0.71)	$\chi^2 = 1.90^{NS}$ $V < .01$	
Family affluence²					
<i>M</i> (<i>SD</i>)	0.07 (0.69)	0.05 (0.71)	−0.05 (0.75)	$F = 4.53^*$ $\eta^2 = .01$	A-S: 0.04 ^{NS} A-N: 0.17 ^{NS} S-N: 0.13 ^{NS}
Smartphone use <i>N</i> (%)					
No	13 (5.70%)	21 (4.81%)	25 (2.32%)	$\chi^2 = 10.18^{**}$	
Yes	215 (94.30%)	416 (95.19%)	1053 (97.68%)	$V = .08$	
Laptop or PC use <i>N</i> (%)					
No	106 (46.49%)	204 (46.68%)	343 (31.82%)	$\chi^2 = 38.45^{***}$	
Yes	122 (53.51%)	233 (53.32%)	735 (68.18%)	$V = .15$	
Tablet use <i>N</i> (%)					
No	114 (50.00%)	180 (41.19%)	506 (46.94%)	$\chi^2 = 5.92^{NS}$	
Yes	114 (50.00%)	257 (58.81%)	572 (53.06%)	$V = .06$	
E-book reader use <i>N</i> (%)					
No	211 (92.54%)	395 (90.39%)	1007 (93.41%)	$\chi^2 = 4.12^{NS}$	
Yes	17 (7.46%)	42 (9.61%)	71 (6.59%)	$V = .05$	
Television use <i>N</i> (%)					
No	57 (25.00%)	84 (19.22%)	223 (20.69%)	$\chi^2 = 3.09^{NS}$	
Yes	171 (75.00%)	353 (80.78%)	855 (79.31%)	$V = .04$	
Other SBD use <i>N</i> (%)					
No	177 (77.63%)	332 (75.97%)	872 (80.89%)	$\chi^2 = 4.98^{NS}$	
Yes	51 (22.37%)	105 (24.03%)	206 (19.11%)	$V = .05$	
Perceived functional importance of SBD use³ <i>M</i> (<i>SD</i>)					
School and educational activities	3.24 (1.27)	3.31 (1.23)	3.67 (1.22)	$F = 19.17^{***}$ $\eta^2 = .02$	A-S: 0.06 ^{NS} A-N: 0.35*** S-N: 0.29***
Personal or household responsibilities	3.15 (1.37)	3.02 (1.30)	3.19 (1.41)	$F = 2.42^{NS}$ $\eta^2 < .01$	
Leisure and entertainment	3.63 (1.15)	3.87 (1.05)	3.97 (1.11)	$F = 8.46^{***}$ $\eta^2 = .01$	A-S: 0.22* A-N: 0.30*** S-N: 0.09 ^{NS}
Parental knowledge about SBD use <i>N</i> (%)					
Nothing or little	28 (12.28%)	93 (21.28%)	347 (32.25%)	$\chi^2 = 47.47^{***}$	
A lot or everything	200 (87.72%)	344 (78.72%)	729 (67.75%)	$V = .17$	
SBD use before sleeping – School days <i>N</i> (%)					
Uses until falling asleep	27 (11.84%)	99 (22.65%)	333 (30.89%)	$\chi^2 = 68.55^{***}$	
Stops use at least 10 min before going to sleep	43 (18.86%)	113 (25.86%)	271 (25.14%)	$V = .14$	
Stops use at least half an hour before going to sleep	64 (28.07%)	114 (26.09%)	212 (19.67%)		
Stops use at least 1 h before going to sleep	50 (21.93%)	76 (17.39%)	156 (14.47%)		
Stops use at least 2 h before going to sleep	44 (19.30%)	35 (8.01%)	106 (9.83%)		
SBD use before sleeping – Non-school days <i>N</i> (%)					
Uses until falling asleep	43 (18.86%)	150 (34.32%)	421 (39.05%)	$\chi^2 = 46.41^{***}$	
Stops use at least 10 min before going to sleep	50 (21.93%)	107 (24.49%)	232 (21.52%)	$V = .12$	
Stops use at least half an hour before going to sleep	47 (20.61%)	67 (15.33%)	128 (11.87%)		
Stops use at least 1 h before going to sleep	41 (17.98%)	48 (10.98%)	114 (10.58%)		
Stops use at least 2 h before going to sleep	47 (20.61%)	65 (14.87%)	183 (16.98%)		
SBD use after awakening – School days <i>N</i> (%)					
Starts using immediately after awakening	30 (13.16%)	63 (14.42%)	218 (20.22%)	$\chi^2 = 49.85^{***}$	
Starts using within 10 min of awakening	54 (23.68%)	106 (24.26%)	326 (30.24%)	$V = .12$	
Starts using within 30 min of awakening	44 (19.30%)	128 (29.29%)	264 (24.49%)		
Starts using within an hour of awakening	38 (16.67%)	60 (13.73%)	130 (12.06%)		
Starts using within 2 h of awakening	22 (9.65%)	25 (5.72%)	49 (4.55%)		
Starts using more than 2 h after awakening	40 (17.54%)	55 (12.59%)	91 (8.44%)		
SBD use after awakening – Non-school days <i>N</i> (%)					

(continued on next page)

Table 2 (continued)

	All devices (A)	Some devices (S)	Not installed (N)	Test statistic & effect size	Pairwise comparisons (Cohen's d)
Starts using immediately after awakening	37 (16.23%)	79 (18.08%)	287 (26.62%)	$\chi^2 = 57.87^{***}$ $V = .13$	
Starts using within 10 min of awakening	37 (16.23%)	114 (26.09%)	306 (28.39%)		
Starts using within 30 min of awakening	47 (20.61%)	94 (21.51%)	189 (17.53%)		
Starts using within an hour of awakening	36 (15.79%)	61 (13.96%)	122 (11.32%)		
Starts using within 2 h of awakening	28 (12.28%)	29 (6.64%)	53 (4.92%)		
Starts using more than 2 h after awakening	43 (18.86%)	60 (13.73%)	121 (11.22%)		

Notes. *N* (%): frequency (percentage within the category parental control app installation on adolescents' screen-based devices). *M* (*SD*): mean (standard deviation). χ^2 : Pearson's Chi-square statistic. *V*: Cramer's *V* effect size index. *F*: omnibus test related to one-way analysis of variance (ANOVA). η^2 : eta-squared effect size index. Pairwise comparisons were conducted only when the omnibus *F*-test was significant, with Bonferroni correction applied. Level of significance: ^{NS} $p \geq .05$, * $p < .05$, ** $p < .01$, *** $p < .001$. ¹Higher values indicate a stronger non-British background, including increased likelihood of non-British nationality (coded as: 0 = UK-based or Gibraltar-based British nationality, 1 = Non-British nationality) and birthplace (coded as: 0 = Born in Gibraltar or the UK, 1 = Born outside of Gibraltar or the UK), and shorter time living in Gibraltar (coded as: 1 = Born in Gibraltar, 2 = Living in Gibraltar for more than 10 years, 3 = Living in Gibraltar for 5–9 years, 4 = Living in Gibraltar for 1–4 years, 5 = Living in Gibraltar for less than a year, 6 = Living outside of Gibraltar). ²Higher scores on the latent factor indicate greater family affluence. ³Higher scores indicate greater perceived importance of SBD use in the respective functional domain.

On school days, being male (compared with adolescents identifying as a gender other than male or female), a more pronounced non-British background, laptop/PC use, and lower perceived importance of SBD use for personal or household responsibilities were also associated with longer delays in SBD use after awakening (Table 4; Figs. 2 and 3).

Of the four outcome variables, only one significant interaction emerged: parental control app use on all SBDs interacted with perceived parental knowledge to predict SBD use after awakening on school days. Simple slope analyses indicated that the presence of parental control apps on all SBDs was associated with a longer delay in post-wake SBD use, but only when perceived parental knowledge was high ($B = 0.37$, $SE = 0.10$, $p < .001$). When perceived parental knowledge was low, this association was non-significant ($B = -0.28$, $SE = 0.23$, $p = .209$).

This interaction effect is also reflected in the joint distribution of perceived parental knowledge and technical mediation, as shown in Table S6. Among adolescents without parental control apps installed on their SBDs, the cumulative proportion of SBD use within 30 min of awakening was similar for those reporting low perceived parental knowledge (76.34%) and high perceived parental knowledge (74.88%), and was comparable to the proportion observed in the total sample (75.36%). In contrast, among adolescents with parental control apps installed on all SBDs, those reporting low perceived parental knowledge showed a higher cumulative proportion of SBD use within 30 min of awakening (81.81%). Conversely, among those with high perceived parental knowledge, the corresponding proportion was substantially lower (48.23%).

Overall, including interaction terms resulted in only marginal increases in the explained variance compared to the main effects model ($\chi^2(299) = 1055.715$, $p < .001$; RMSEA [90% CI] = .040 [.038–.043]; CFI = .945; TLI = .925; Table 3). A key finding from the main effects model was that parental control app use on all SBDs was significantly, positively, and weakly associated with all four outcomes. However, in the final model (Table 4 and Figs. 2 and 3), neither the main nor interaction effects of parental technical mediation remained significant for outcomes related to non-school days.

3.3. Robustness and reproducibility analyses

3.3.1. Alternative operationalization of parental knowledge

Re-estimating the moderation models using the original four-category parental knowledge variable yielded results that were largely consistent with the primary analyses (Table S7). Most importantly, the interaction between parental control app use on all SBDs and parental knowledge remained statistically significant for SBD use after awakening on school days, demonstrating that the key moderation finding was robust to the operationalization of parental knowledge. Consistent with the primary analyses, simple slope analyses indicated that parental control app use on all SBDs was positively associated with a longer delay in SBD use after awakening only at high (1 *SD* above the mean) levels of

parental knowledge ($B = 0.48$, $SE = 0.11$, $p < .001$), whereas no significant associations were observed at the mean ($B = 0.15$, $SE = 0.10$, $p = .142$) or at low (1 *SD* below the mean) levels of parental knowledge; $B = -0.18$, $SE = 0.16$, $p = .256$).

Regarding the main effects, the positive association between parental control app use on all SBDs and SBD use before sleep on school days remained statistically significant. In addition, significant positive main effects were also observed for the two non-school-day outcomes, which were not statistically significant in the primary analyses.

3.3.2. Random split-sample analyses

Randomly splitting the analytical sample into two approximately equal subsamples yielded results that were generally consistent with the primary analyses (Table S8). Most importantly, the interaction between parental control app use on all SBDs and parental knowledge in relation to SBD use after awakening on school days remained statistically significant in one subsample and showed an association in the same direction in the second subsample, although it did not reach statistical significance. Similarly, the positive main effect of parental control app use on all SBDs in relation to SBD use before sleep on school days remained statistically significant in one subsample and showed an association in the same direction in the second subsample, although it did not reach statistical significance. Overall, these findings provide some support for the stability of the primary findings across the two randomly selected subsamples.

3.3.3. Critical regression coefficients

Approximate critical unstandardized and standardized regression coefficients are presented in Table S9. Overall, the estimated critical coefficients were small, indicating that the achieved sample size and model specification provided sufficient sensitivity to detect relatively small effects. A comparison of the observed and corresponding critical regression coefficients indicated that the statistically significant main effects, interaction effects, and conditional slopes were not merely attributable to coefficients close to the estimated detection threshold.

4. Discussion

4.1. Interpretation of the findings

The present study examined the independent and combined associations of parental technical mediation and perceived parental knowledge with adolescents' sleep-related SBD use before sleep and after awakening, separately on school and non-school days. Overall, parental technical mediation across all SBDs was significantly, albeit weakly, associated with a longer interval between stopping device use and going to sleep. Technical mediation was also associated with a longer post-wake delay in SBD use when accompanied by high perceived parental knowledge. Notably, these associations emerged only on school days,

Table 3

Structural equation models examining the main effects of parental technical mediation and perceived parental knowledge on SBD use before sleep and after awakening, separately for school and non-school days.

	SBD use before sleeping – school days ¹ β (SE)	SBD use before sleeping – non-school days ¹ β (SE)	SBD use after awakening – school days ² β (SE)	SBD use after awakening – non-school days ² β (SE)
Adolescent's gender ³ :				
Females/Girls	–.03 (.03)	–.02 (.03)	–.09 (.03)**	–.12 (.03)***
Other	–.02 (.02)	–.03 (.02)	–.07 (.03)*	.00 (.02)
Prefer not to disclose	–.01 (.03)	–.01 (.03)	.00 (.03)	–.03 (.03)
Adolescent's age	–.09 (.03)**	–.14 (.03)***	–.22 (.03)***	–.20 (.03)***
Parental level of education ⁴ :				
Both parents/step-parents have a university degree	–.03 (.03)	–.05 (.03)	.03 (.03)	.05 (.03)
Only the mother/step-mother has a university degree	–.01 (.03)	–.02 (.03)	.00 (.03)	.02 (.03)
Only the father/step-father has a university degree	–.02 (.03)	–.04 (.03)	.01 (.03)	.01 (.03)
Family structure ⁵ :				
Living with both biological parents	.01 (.03)	.03 (.03)	.03 (.03)	.01 (.03)
Non-British background ⁶	–.04 (.03)	–.02 (.03)	.09 (.03)**	.06 (.03)*
Family affluence ⁷	.07 (.04)*	.08 (.04)*	.06 (.04)	.04 (.04)
SBD used ⁸ :				
Smartphone	–.04 (.03)	–.05 (.03)	–.03 (.02)	–.01 (.02)
SBD used ⁸ : Laptop or PC	–.01 (.03)	–.02 (.03)	.08 (.03)**	.01 (.03)
SBD used ⁸ : Tablet	–.06 (.03)*	–.04 (.03)	–.04 (.03)	–.04 (.03)
SBD used ⁸ : E-book reader	.01 (.03)	–.02 (.03)	.06 (.03)**	.06 (.03)*
SBD used ⁸ : Television	–.04 (.03)	–.04 (.03)	–.06 (.03)*	–.06 (.03)*
SBD used ⁸ : Other SBD	–.02 (.02)	–.03 (.03)	.01 (.03)	–.02 (.03)
Perceived functional importance of SBD use ⁹ : School and educational activities	–.02 (.03)	–.01 (.03)	.08 (.03)**	.07 (.03)**
Perceived functional importance of SBD use ⁹ : Personal or household responsibilities	–.01 (.03)	–.01 (.03)	–.06 (.03)*	–.04 (.03)
Perceived functional importance of SBD use ⁹ : Leisure and entertainment	–.06 (.03)*	–.07 (.03)**	–.07 (.03)**	–.12 (.03)***
Parental knowledge about SBD use ¹⁰ : A lot or everything	–.02 (.03)	–.03 (.03)	.07 (.03)**	.01 (.03)
Parental technical mediation on SBDs ¹¹ :				
Parental control apps on all SBDs	.14 (.03)***	.08 (.03)**	.09 (.03)***	.10 (.03)***

Table 3 (continued)

	SBD use before sleeping – school days ¹ β (SE)	SBD use before sleeping – non-school days ¹ β (SE)	SBD use after awakening – school days ² β (SE)	SBD use after awakening – non-school days ² β (SE)
Parental control apps on some of the SBDs	.02 (.03)	–.03 (.03)	.04 (.03)	.04 (.03)
Explained variance (R^2)	6.5%	6.8%	12.0%	10.7%

Note. $N = 1569$. β (SE): standardized regression coefficient (standard error). Level of significance (highlighted in bold): * $p < .05$, ** $p < .01$, *** $p < .001$. Level of model fit: χ^2 (299) = 1055.715, $p < .001$; $RMSEA$ [90% CI] = .040 [.038–.043]; $CFI = .945$; $TLI = .925$. Correlations between the outcome variables are shown in Table S5. ¹Higher scores indicate a longer interval between going to sleep and stopping screen-based device use, whereas lower scores reflect a shorter interval. ²Higher scores indicate a longer time elapsed before using a screen-based device after awakening, while lower scores reflect shorter delays. ³Reference category: Males/Boys. ⁴Reference category: Neither of the parents has a university degree. ⁵Reference category: Not living with both biological parents and/or living with step-parents. ⁶Higher values indicate a stronger non-British background, including increased likelihood of non-British nationality (coded as: 0 = UK-based or Gibraltar-based British nationality, 1 = Non-British nationality) and birthplace (coded as: 0 = Born in Gibraltar or the UK, 1 = Born outside of Gibraltar or the UK), and shorter time living in Gibraltar (coded as: 1 = Born in Gibraltar, 2 = Living in Gibraltar for more than 10 years, 3 = Living in Gibraltar for 5–9 years, 4 = Living in Gibraltar for 1–4 years, 5 = Living in Gibraltar for less than a year, 6 = Living outside of Gibraltar). ⁷Higher scores on the latent factor indicate greater family affluence. ⁸Reference category: Not using the given SBD. ⁹Higher scores indicate greater perceived importance of SBD use in the respective functional domain. ¹⁰Reference category: Nothing or little. ¹¹Reference category: No parental control apps on any of the screen-based devices.

consistent with the proposed hypotheses for this context.

Based on standardized regression coefficients, the associations between parental technical mediation and sleep-related SBD use outcomes were consistently weak in magnitude across both main-effect models and models including interaction terms. The inclusion of interaction terms also resulted in only modest increases in explained variance. However, these relatively small effect sizes are consistent with broader patterns reported in the parental mediation literature, where active mediation, restrictive mediation, co-use, and technical mediation have typically shown similarly small associations with adolescents' SBD-related outcomes (Fam et al., 2023; Lukavská et al., 2022; Stoilova et al., 2024; Vossen et al., 2024). It is also important to note that the associations involving parental technical mediation remained statistically significant after adjustment for a broad range of background characteristics, including socio-demographic, family, and SBD-related factors, as well as perceived parental knowledge. Moreover, the magnitude of these associations was comparable to that of other relatively stable and less modifiable factors identified in the models, such as age, gender, family affluence, and cultural background.

Several explanations may account for the significant interaction between technical mediation across all SBDs and high perceived parental knowledge in relation to adolescents' post-sleep SBD use on school days. One possible explanation is that parental control apps may facilitate parental awareness and supervision. When adolescents know their use is being monitored, they may be more likely to follow parental rules regarding SBD use before and after sleep (Geržičáková et al., 2023; Toh et al., 2019). Alternatively, some parents adopt technical mediation because they view their adolescent's SBD use as problematic and difficult to control, especially after other strategies have been perceived as ineffective. In such cases, higher perceived parental knowledge may reflect a more reactive implementation of parental technical mediation and may be associated with longer intervals before SBD use after

Table 4

Structural equation models examining the main and interaction effects of parental technical mediation and perceived parental knowledge on SBD use before sleep and after awakening, separately for school and non-school days.

	SBD use before sleeping – school days ¹ β (SE)	SBD use before sleeping – non-school days ¹ β (SE)	SBD use after awakening – school days ² β (SE)	SBD use after awakening – non-school days ² β (SE)
Adolescent's gender ³ :				
Females/Girls	-.03 (.03)	-.02 (.03)	-.08 (.03)**	-.12 (.03)***
Other	-.02 (.02)	-.03 (.02)	-.07 (.03)*	-.01 (.02)
Prefer not to disclose	-.01 (.03)	-.01 (.03)	.00 (.03)	-.03 (.03)
Adolescent's age	-.10 (.03)**	-.14 (.03)***	-.22 (.03)***	-.20 (.03)***
Parental level of education ⁴ :				
Both parents/step-parents have a university degree	-.03 (.03)	-.05 (.03)	.03 (.03)	.05 (.03)
Only the mother/step-mother has a university degree	-.01 (.03)	-.02 (.03)	.00 (.03)	.02 (.03)
Only the father/step-father has a university degree	-.02 (.03)	-.04 (.03)	.01 (.03)	.01 (.03)
Family structure ⁵ : Living with both biological parents	.01 (.03)	.03 (.03)	.03 (.03)	.01 (.03)
Non-British background ⁶	-.04 (.03)	-.02 (.03)	.09 (.03)**	.06 (.03)
Family affluence ⁷	.07 (.04)*	.08 (.04)*	.06 (.04)	.04 (.04)
SBD used ⁸ : Smartphone	-.04 (.03)	-.05 (.03)	-.04 (.02)	-.01 (.02)
SBD used ⁸ : Laptop or PC	-.01 (.03)	-.02 (.03)	.07 (.03)**	.01 (.03)
SBD used ⁸ : Tablet	-.06 (.03)*	-.04 (.03)	-.04 (.03)	-.04 (.03)
SBD used ⁸ : E-book reader	.01 (.03)	-.02 (.03)	.07 (.02)**	.06 (.03)*
SBD used ⁸ : Television	-.03 (.03)	-.04 (.03)	-.07 (.03)*	-.06 (.03)*
SBD used ⁸ : Other SBD	-.02 (.03)	-.03 (.02)	.00 (.03)	-.02 (.03)
Perceived functional importance of SBD use ⁹ : School and educational activities	-.02 (.03)	-.01 (.03)	.08 (.03)**	.07 (.03)**
Perceived functional importance of SBD use ⁹ : Personal or household responsibilities	-.01 (.03)	-.02 (.03)	-.06 (.03)*	-.04 (.03)
Perceived functional importance of SBD use ⁹ : Leisure and entertainment	-.06 (.03)*	-.07 (.03)**	-.07 (.03)**	-.12 (.03)***
Parental knowledge about SBD use ¹⁰ : A lot or everything	-.01 (.03)	-.01 (.03)	.04 (.03)	.00 (.03)
Parental technical mediation on SBDs ¹¹ :				
Parental control apps on all SBDs	.19 (.08)*	.15 (.08)	-.09 (.07)	.08 (.06)
Parental control apps on some of the SBDs	.05 (.06)	.00 (.06)	.02 (.05)	.01 (.05)

Table 4 (continued)

	SBD use before sleeping – school days ¹ β (SE)	SBD use before sleeping – non-school days ¹ β (SE)	SBD use after awakening – school days ² β (SE)	SBD use after awakening – non-school days ² β (SE)
Interaction terms				
Parental control apps on all SBDs × Parental knowledge	-.06 (.08)	-.07 (.08)	.19 (.07)**	.02 (.06)
Parental control apps on some of the SBDs × Parental knowledge	-.03 (.06)	-.04 (.06)	.03 (.06)	.03 (.06)
Explained variance (R ²)	6.5%	6.8%	12.4%	10.7%

Note. $N = 1569$. β (SE): standardized regression coefficient (standard error). Level of significance (highlighted in bold): * $p < .05$, ** $p < .01$, *** $p < .001$. Level of model fit: χ^2 (321) = 1038.495, $p < .001$; RMSEA [90% CI] = .038 [.035–.040]; CFI = .945; TLI = .925. Correlations between the outcome variables are shown in Table S5. ¹Higher scores indicate a longer interval between going to sleep and stopping screen-based device use, whereas lower scores reflect a shorter interval. ²Higher scores indicate a longer time elapsed before using a screen-based device after awakening, while lower scores reflect shorter delays. ³Reference category: Males/Boys. ⁴Reference category: Neither of the parents has a university degree. ⁵Reference category: Not living with both biological parents and/or living with step-parents. ⁶Higher values indicate a stronger non-British background, including increased likelihood of non-British nationality (coded as: 0 = UK-based or Gibraltar-based British nationality, 1 = Non-British nationality) and birthplace (coded as: 0 = Born in Gibraltar or the UK, 1 = Born outside of Gibraltar or the UK), and shorter time living in Gibraltar (coded as: 1 = Born in Gibraltar, 2 = Living in Gibraltar for more than 10 years, 3 = Living in Gibraltar for 5–9 years, 4 = Living in Gibraltar for 1–4 years, 5 = Living in Gibraltar for less than a year, 6 = Living outside of Gibraltar). ⁷Higher scores on the latent factor indicate greater family affluence. ⁸Reference category: Not using the given SBD. ⁹Higher scores indicate greater perceived importance of SBD use in the respective functional domain. ¹⁰Reference category: Nothing or little. ¹¹Reference category: No parental control apps on any of the screen-based devices.

awakening on school days. An alternative explanation is that high perceived parental knowledge may not solely result from parental technical mediation, but may also reflect a warm, supportive parent–adolescent relationship characterized by open communication and adolescent willingness to disclose. This interpretation further highlights the importance of considering parental mediation and knowledge within the broader context of family dynamics (Geržičáková et al., 2023; Stoilova et al., 2024; Symons et al., 2017).

In contrast, neither the main nor the interaction effects of technology-based parental mediation were significant on non-school days, or when combined with low perceived parental knowledge in relation to post-sleep SBD use on school days. The absence of a main and interaction effects on non-school days did not correspond with the proposed hypotheses, whereas the attenuated effect in combination with low perceived parental knowledge on post-sleep SBD use on school days was consistent with them. This aligns with some earlier studies reporting no clear associations between digital parental control tools and SBD-related outcomes (Stoilova et al., 2024). One possible explanation is that adolescents may attempt to bypass restrictions by using devices covertly or finding workarounds (Geržičáková et al., 2023; Toh et al., 2019). The lack of significant effects on non-school days may also reflect more permissive parental approaches or reduced parental monitoring during weekends, highlighting the context-sensitive nature of the association between parental technical mediation and sleep-related SBD use. However, these interpretations should be considered with caution because the present study was not designed to

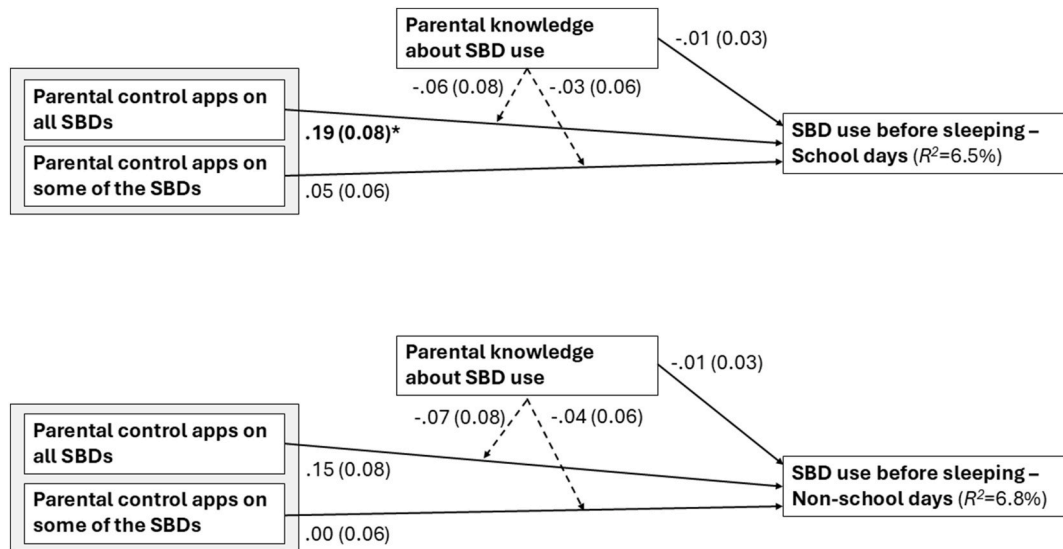


Fig. 2. Main and interaction effects of parental control app use and knowledge on screen-based device (SBD) use before sleep on school and non-school days. Note. Solid lines represent main effects, whereas dashed lines indicate interaction effects between the primary predictors. Values on the paths are standardized regression coefficients (β), with corresponding standard errors (SE) in brackets. Statistical significance is indicated as follows: $p < .05$ (highlighted in bold). Associations with background covariates are not shown to facilitate interpretation.

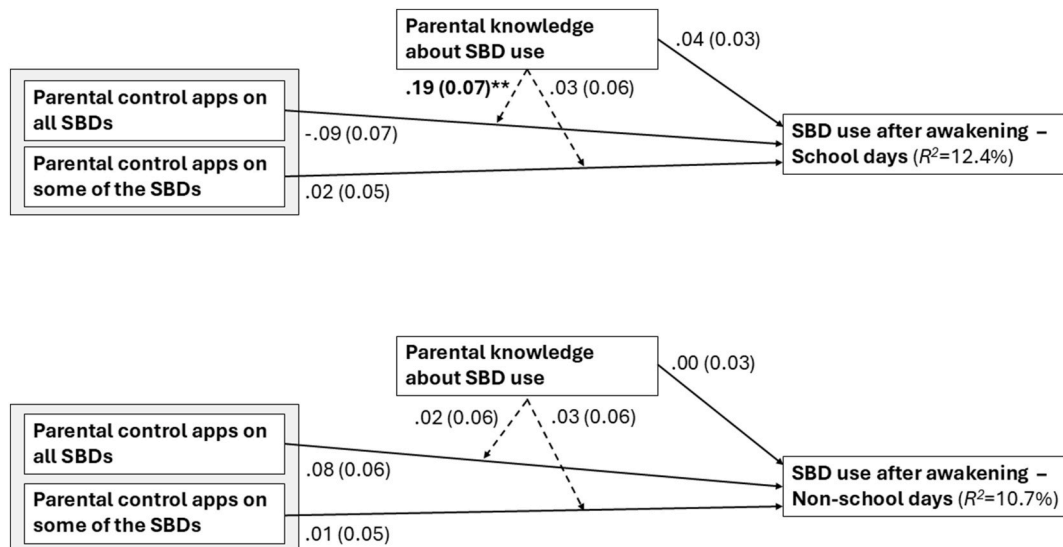


Fig. 3. Main and interaction effects of parental control app use and knowledge on screen-based device (SBD) use after waking on school and non-school days. Note. Solid lines represent main effects, whereas dashed lines indicate interaction effects between the primary predictors. Values on the paths are standardized regression coefficients (β), with corresponding standard errors (SE) in brackets. Statistical significance is indicated as follows: $p < .05$ (highlighted in bold). Associations with background covariates are not shown to facilitate interpretation.

examine these mechanisms directly.

4.2. Limitations

A cautious interpretation of the present findings is warranted due to several limitations. First, the cross-sectional design does not permit conclusions about potential bidirectional causal relationships between parental factors and adolescents' SBD use around sleep.

Second, although a nationwide sampling procedure was applied, the representativeness of the sample may have been limited. Non-participation may have occurred due to systematic reasons, because lower participation rates were observed in final school grades, given that data collection coincided with the closing exam period. In addition, adolescents who were absent from school during data collection may

differ from those who participated in terms of specific sociodemographic factors (e.g., lower affluence, non-British background), and may have shown higher levels of SBD-related or sleep-related difficulties. Moreover, although the observed differences between included and excluded participants were generally small, some degree of selection bias cannot be ruled out.

Third, measurement-related limitations may have affected the results. All variables were assessed through adolescent self-report, which may have introduced bias, particularly in reporting SBD use around sleep and family background. Key constructs, including SBD use, parental technical mediation, and perceived parental knowledge, were each assessed with a single item, which may have increased measurement error, limited construct depth, and raises concerns regarding construct validity.

More specifically, the assessment of parental technical mediation did not allow differentiation from other forms of parental mediation (e.g., restrictive or active mediation), and the extent to which these constructs overlap remains unclear (e.g., parents who apply technical mediation may also be more likely to apply other types of mediation). Moreover, the survey did not assess which SBDs or apps were subject to parental mediation, nor what types of restrictions were applied (e.g., time, content, communication, or sleep-specific restrictions). It also did not account for whether adolescents complied with or circumvented these restrictions, nor for potential differences between parents, and adolescents' own perspectives on parental control apps were not recorded. Broader parenting factors were likewise not assessed or included in the survey, including parent–adolescent relationship quality and the use of other SBD-specific mediation strategies. Therefore, it remains unclear whether the observed main and interaction effects of parental technical mediation would persist after accounting for other forms of parental mediation, given that parents who apply technical mediation may also be more likely to use other mediation strategies (e.g., restrictive mediation).

Moreover, the study did not include direct measures of sleep outcomes (e.g., sleep quality, sleep problems, or objective indicators of sleep functioning), and therefore the findings relate to SBD use behaviors around sleep rather than to sleep functioning itself. As such, these behaviors may only indirectly influence sleep functioning, and the extent to which they translate into clinically relevant sleep-related outcomes remains unclear (e.g., which levels of pre-sleep SBD use are associated with clinically relevant sleep disturbances). In addition, it was not possible to determine to what extent shorter intervals between stopping SBD use before sleep and initiating SBD use after awakening reflect reduced control over SBD use or negative consequences resulting from SBD use.

Finally, the study did not assess the duration of SBD use or device-specific usage patterns, nor the motivations or problems associated with the use of specific devices. More comprehensive and continuous assessments of both perceived and actual SBD use duration, as well as SBD-related problems and motives, may have provided a more precise understanding of adolescents' SBD use patterns than the dichotomous indicators of device use and the single-item measures of domain-specific perceived functional importance applied in the present study.

4.3. Strengths

Despite these limitations, the present study has several notable strengths. A major strength is that, to the authors' knowledge, this is the first quantitative study to examine the independent and combined associations of parental technical mediation and perceived parental knowledge with adolescents' sleep-related SBD use, with a particular focus on pre- and post-sleep behaviors across school and non-school days. This differentiated assessment of sleep-related SBD use enabled the examination of context-specific associations that have received limited empirical attention in relation to parental technical mediation. Additionally, the nationwide sampling strategy, covering approximately 76% of all secondary school students in Gibraltar, enabled the examination of parental technical mediation in a small, dense, and culturally diverse population while providing sufficient statistical power to detect relatively small associations. Finally, the analytical approach enabled the simultaneous examination of a broad range of socio-demographic, family, and SBD-related factors, allowing a more nuanced understanding of correlates of sleep-related SBD use.

4.4. Practical implications

Although the observed associations were modest, the findings may have several implications for research, clinical practice, and public health. For researchers, the findings suggest that the timing of SBD use in relation to sleep may represent a distinct behavioral dimension that

complements established indicators of adolescents' SBD use and sleep-related outcomes. They also highlight the importance of conceptualizing parental technical mediation as one component of broader parenting practices and considering relevant contextual factors, rather than examining parental technical mediation in isolation or focusing exclusively on its main effects. Such an approach may help identify the circumstances under which parental technical mediation is more likely to be associated with favorable sleep-related SBD use behaviors.

For clinicians and practitioners working with families and adolescents, the present findings suggest that parental control apps should not be viewed as standalone solutions for promoting changes in adolescents' sleep-related SBD use behaviors. Although parental control apps may represent one potentially modifiable strategy, family- and adolescent-focused interventions and psychoeducational programs may benefit from going beyond simply promoting their use by also addressing the broader parenting and contextual characteristics in which they are embedded. Accordingly, such programs may include strengthening parental awareness and knowledge of adolescents' SBD use, fostering open parent–adolescent communication, and establishing consistent family routines and rules regarding SBD use (Hale et al., 2018; Martin et al., 2021). They may also help families recognize that the potential role of parental technical mediation is likely to be context-sensitive and may vary across situations, encouraging parents to consider when and under what circumstances parental control apps may be most relevant.

From a public health perspective, the present study's findings also suggest that communication and educational campaigns may benefit from moving beyond focusing exclusively on overall screen time by raising awareness that the timing of SBD use around sleep may represent another potentially relevant aspect of adolescents' digital behavior. Such campaigns may also promote realistic expectations regarding parental control apps by emphasizing the context-sensitive nature of their potential role, including the influence of broader parenting characteristics, rather than presenting them as universally effective technological solutions. Consistent communication of these messages across settings (e.g., schools, pediatric care, and family-based programs) may contribute to a more coordinated and coherent public health approach to adolescents' sleep-related SBD use.

4.5. Future directions

To better understand the role of parental technical mediation regarding adolescents' SBD use around sleep, future research should replicate the findings here across different age groups and cultural contexts, as well as employ intensive longitudinal methods (e.g., ecological momentary assessment) or randomized controlled trials. Longitudinal studies may also help determine whether the relatively small effect sizes associated with parental technical mediation have meaningful implications over longer developmental periods and whether repeated exposure to parental mediation contributes to cumulative differences in adolescents' sleep-related SBD use over time (Funder & Ozer, 2019).

More accurate assessment should involve data from parent–adolescent dyads, including validated and more comprehensive measures of parental mediation (including different types of mediation strategies), SBD use around sleep, and sleep outcomes (e.g., sleep quality and disturbances), as well as objective, non-self-report measures of SBD use (e.g., duration of use), technical mediation, and sleep parameters (e.g., sleep duration). Future studies should also examine whether other family or parental factors moderate or mediate the effects of technical mediation. Finally, to inform research and public education, it is important to establish threshold levels of pre- and post-sleep SBD use that distinguish normative from problematic patterns among adolescents (Lund et al., 2021).

5. Conclusions

The present study examined the independent and combined associations of parental technical mediation and perceived parental knowledge with adolescents' sleep-related SBD use before sleep and after awakening, separately on school and non-school days. Overall, parental technical mediation was associated with stopping SBD use earlier before going to sleep on school days. It was also associated with delaying SBD use after awakening on school days, but only among adolescents who reported high perceived parental knowledge. No corresponding associations were found on non-school days. These findings suggest that the role of parental technical mediation may be context-dependent, varying between SBD use before sleep and after awakening, as well as between school and non-school days. In addition, the moderating role of perceived parental knowledge underscores the importance of considering parental technical mediation within the broader parenting context rather than in isolation.

Declaration of AI and AI-assisted technologies in the writing process

During the preparation of this work the authors used OpenAI's ChatGPT to perform linguistic checks and improve readability. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

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CRedit authorship contribution statement

Zsolt Horváth: Conceptualization, Formal analysis, Visualization, Writing – original draft, Writing – review & editing. **Julia Tibot:** Data curation, Investigation, Project administration, Writing – review & editing. **Orsolya Király:** Supervision, Writing – review & editing. **Shu M. Yu:** Investigation, Writing – review & editing. **Borbála Paksi:** Methodology, Writing – review & editing. **Andrea Eisinger:** Data curation, Investigation, Writing – review & editing. **Mark D. Griffiths:** Supervision, Writing – review & editing. **Beáta Bóthe:** Supervision, Writing – review & editing. **Marco Zavagni:** Investigation, Writing – review & editing. **Helen Carter:** Investigation, Writing – review & editing. **Lorena Soler Casale:** Investigation, Writing – review & editing. **Keri Scott:** Investigation, Writing – review & editing. **Jackie Linares:** Investigation, Writing – review & editing. **Zsolt Demetrovics:** Conceptualization, Methodology, Supervision, Writing – review & editing. **Andrea Czako:** Conceptualization, Data curation, Investigation, Methodology, Project administration, Supervision, Writing – review & editing.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

MDG has received research funding from *Norsk Tipping* (the gambling operator owned by the Norwegian government). MDG has received funding for a number of research projects in the area of gambling education for young people, social responsibility in gambling and gambling treatment from *Gamble Aware* (formerly the *Responsibility in Gambling Trust*), a charitable body which funds its research program based on donations from the gambling industry. MDG undertakes consultancy for various gambling companies in the area of player protection and social responsibility in gambling. The other authors declare that they have no known competing interests.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.chbr.2026.101193>.

Data availability

Data will be made available on request.

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