

POPULATION STUDY ARTICLE



Displacement of peer play by screen time: associations with toddler development

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BACKGROUND: Young children’s digital media use may adversely affect child development, but the mechanisms of this association are unclear. We evaluated whether screen time displaces reading and peer play time, which are subsequently associated with child development.

METHODS: When children were 12, 18, 24, 30, and 36 months, mothers ($n = 3894$) reported the time their children spent on screens, being read to by an adult, and playing with other children. At 36 months, mothers completed the Ages and Stages Questionnaire[®], an assessment of their child’s developmental status.

RESULTS: In unadjusted models, screen time from 12 to 36 months was not associated with reading but was associated with less time engaging in play with peers. In adjusted models accounting for developmental delay at 12 months, family and child characteristics, screen time was not directly associated with developmental delay. More peer play time was associated with a lower likelihood of developmental delay, and having higher screen time increased the likelihood of developmental delay indirectly through reduced peer play time. Results were similar for developmental delays in fine and gross motor, communication, and personal-social domains.

CONCLUSIONS: Screen time in early childhood did not displace reported time spent reading, but did displace reported peer play time.

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IMPACT:

- Among children 1–3 years of age, more screen time was associated with less time engaged in peer play but not less reading with an adult.
- Having higher screen time from 1 to 3 years increased the odds of developmental delay indirectly through reduced peer play time.
- Ensuring that children engage in adequate time playing with peers may offset the negative associations between screen time and child development.

The American Academy of Pediatrics discourages digital media use (other than video chatting) for children younger than 18 months, recommends that parents co-watch only high-quality programming for children 18–24 months, and recommends limiting children between 2 and 5 years to 1 h per day of high-quality programming,¹ but recent (2008–2020) cohort studies indicate that most families do not follow these guidelines.^{2–5} The amount of time in which young children engage with digital media (i.e., screen time) has been associated with poorer cognitive development, especially among children under 2 years,^{6–12} but it is unclear why digital media use has negative effects. One long-standing theory is that digital media displaces other important activities that contribute to healthy child

development.^{13,14} For example, screen time has been shown to displace physical activity in young children and adolescents.^{13,15} However, the displacement hypothesis¹⁴ has rarely been explored in toddlers, especially in relation to behaviors that promote cognitive and socioemotional development, such as reading and playing with peers.

In addition to traditional media like television, young children routinely have access to handheld screens (e.g., smartphones and tablets). A 2020 (pre-pandemic) national survey reports that 40% of children under 2 and 93% of children aged 2–4 years have used a mobile device to engage with media and apps.⁵ The same survey reports that children under 2 engage in an average of 49 min of screen media per day, and children aged 2–4 years

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engage in 2.5 h, most of which is taken up by watching television and videos.⁵ Similar estimates have been reported elsewhere,^{2–4} and high screen time from ages 1–3 has been shown to predict screen time at 7 and 8 years,² suggesting that patterns of media use are established early.

Huston et al.¹⁶ explored whether TV watching displaced 2- to 7-year-old children's activities including reading, playing, socializing, outdoor recreation, video games, eating, and sleep, among others. Support was found for displacement of educational activities (e.g., reading, art, dance, and games), but not play, by general (non-educational) television watching among 2- to 5-year olds. Using data collected in 1997, Vandewater et al.¹⁷ found displacement between television viewing and creative play but not active play or reading in children under 5 years. However, the landscape of screen media has changed substantially in the 25 years since these data were collected. One study conducted in the 2010s found that within-person screen time at age 2 was associated with less reading at age 3 and subsequently more screen time at age 5.¹⁸ The displacement hypothesis has also been explored in older children and adolescents,^{13,19–21} but the activities that contribute to child development change with age, and findings with older children may not apply to young children. Reexamining the displacement hypothesis in toddlers with respect to screen time's associations with developmentally important activities such as reading and playing with other children is critical.

Displacement of reading and peer play by screen time is particularly important if there is a developmental consequence. Reading and playing with peers in infancy and toddlerhood have been shown to have lasting impacts on child development.^{22–31} Being read to at home in infancy and early childhood benefits child communication and problem-solving skills.^{25,26,29} Play with peers may also confer vast benefits for learning socialization skills that translate into the classroom,^{22–24,27} as well as cognitive and motor skills.^{28,30,31} Play is a primary mode of learning in early childhood.²⁸ Peer play may be particularly salient for child development because children are naturally closer to one another in skill level. Although parents scaffold their children's interactions by adjusting the level of their language and play when interacting with a child,³² peers and siblings start at a closer developmental level and may provide natural scaffolding of children's cognitive and social skills.³³ Peers and siblings also provide unique opportunities to learn social skills in the context of a horizontal relationship (versus a hierarchical parent–child relationship where the parent is always in charge).³⁴

For the current study, we included the Ages and Stages Questionnaire© (ASQ)^{35,36} to assess probable developmental delays in five domains: fine and gross motor, communication, personal-social functioning, and problem-solving skills. We also included controls for baseline developmental delays, time spent in daycare, and sociodemographic characteristics, all of which may be associated with time-use patterns and risk for developmental delay. Using data collected longitudinally from 2009 to 2013, we explored whether time spent engaging with screens displaced time being read to by an adult and engaging in play with peers and siblings (which we term peer play) from 12 to 36 months, as well as their associations with child development (see the conceptual model in Supplementary Fig. S1).

The data were collected in this study when smart devices were increasing in popularity. Since 2013, there have been vast changes in apps and services targeting children (e.g., the founding of YouTube Kids in 2015). Still, the vast majority of screen time in children under 3 is television viewing (estimated 92% for children under 2 and 81% for children aged 2–4).⁵ Furthermore, the amount of time engaging with screens has been relatively constant in children aged 0–8 between 2011 and 2020 (prior to the COVID-19 pandemic) despite large decreases in the proportion watched via aired television and DVDs and increases in the proportion watched online (e.g., YouTube) and via streaming

services.⁵ These figures suggest that although the medium may have changed, young children's screen time is largely similar from 2011 to 2020 and this study's data, collected between 2009 and 2013, is still relevant.

METHODS

Participants

The Upstate KIDS Study is a prospective population-based birth cohort of children born in 2008–2010, designed to evaluate the impact of infertility treatment on child growth and development.³⁷ Using birth certificates from the 57 counties in New York state, excluding the five boroughs in New York City, infants conceived via infertility treatment were oversampled, with all twins and higher-order multiples eligible to participate regardless of conception mode. All mothers of infants whose birth certificates indicated use of infertility treatment were invited to participate. Infants conceived by infertility treatment were frequency matched by birth region and plurality in a 1:3 ratio to those not conceived by infertility treatment. A total of 5034 mothers (27.2% of 18,479 approached) and 6171 children were recruited into the study when children were 4 months old. Previous studies using the cohort assessed the impact of infertility treatment on children's developmental delays³⁸ and screen time² and found no associations, suggesting the full cohort could be combined to explore associations between screen time and development. Because twins tend to engage in similar amounts of screen time and they were assessed at the same ages,² all singletons and one randomly selected child from each multiple set were included in this analysis. Analyses were restricted to participants with activity time data available for at least one point from 12 to 36 months of age ($n = 3894$). Human subjects research approval was obtained from all participating institutions (NYSDOH IRB #07–097; UAlbany #08–179), and informed consent was obtained prior to data collection.

Measures

Child activity time. Every 6 months, mothers were mailed questionnaires assessing their child's activities over the previous 6 months. In questionnaires when children were 12, 18, 24, 30, and 36 months, mothers reported in open fields the average number of hours and/or minutes per day their child spent watching television shows, watching movies, and playing computer games (including handheld games or video games); playing with same-age or younger children; playing with older children; and listening to stories read by an adult. Screen media time was coded as the total number of hours per day the child watched television shows and movies and played video games.² Given the social and cognitive opportunities that playing with older and younger children can provide,³⁹ we considered older, younger, and same-age child play partners, including siblings, as "peers" in this study. Because simultaneous play with younger and older children is likely, especially for children who attend daycare or have multiple siblings, the play was coded as the maximum number of hours per day the target child played with either same-age/younger or older children. For example, if the child reportedly played with same-age/younger children for 3 h and older children for 2 h, peer play was coded as 3 h per day. These maximum variables were very highly correlated with summed variables, $r_s = 0.89–0.91$, $p_s < 0.001$, and had fewer extreme values (e.g., >24 h). Reading time was coded as the number of hours per day the child listened to stories read by an adult. To reduce outliers, all activities were censored for a maximum of 10 h per day.

Child development. Mothers completed the Ages and Stages Questionnaire©, second edition (ASQ-2) at 12 months,³⁵ and third edition (ASQ-3) at 36 months.³⁶ The ASQ is a validated screening instrument designed to detect developmental impairments in five domains: fine motor, gross motor, communication, personal-social functioning, and problem-solving skills.^{40,41} ASQ items were scored as "yes" (10 points), "sometimes" (5 points), and "not yet" (0 points). On a given domain of the ASQ, a probable developmental delay is defined by a score that is two or more standard deviations below the United States national average for that development area and the specified age group. In addition to domain scores, a total ASQ delay score was computed as having a probable developmental delay on any domain of the ASQ. Associations between ASQ domains at 12 and 36 months were small to medium in size, $\phi_s = 0.07–0.29$, $p_s < 0.01$. Additional detail about the ASQ domains and scoring are available in the Supplementary material.

Covariates. A baseline questionnaire at 4 months assessed demographic factors, and vital records were abstracted. Mothers' ages and parity, and child plurality, gestational age in weeks, and sex were primarily obtained from vital records and supplemented with maternal reports when necessary. Mothers reported their education, marital status, race/ethnicity, infertility treatment use, birth of new siblings during the study period, and their child's hours in daycare at 12, 18, 24, 30, and 36 months. Vital records supplemented these maternal reports as available and needed. Education was dichotomized as less than college vs. college degree or higher. Marital status was coded as married, civil union, or domestic partnership vs. not. Race/ethnicity was coded as white, non-Hispanic vs. other. Infertility treatment was coded as none vs. any treatment including ovulation induction, intrauterine insemination, and/or in vitro fertilization. Plurality was coded as singleton vs. multiple. Only-child status was coded as yes vs. no using parity, plurality, and subsequent children born in the study period to identify children with no siblings.

Statistical analysis

Screen, peer play, and reading time were each assessed five times between ages 1 and 3 years. To separate the stable (time-invariant) between-person effects from within-person changes in each behavior,⁹ we used a random intercept cross-lagged panel model (RI-CLPM).⁴² See the Supplementary information for a detailed explanation of RI-CLPMs. First, RI-CLPMs were computed for associations of screen time with reading and peer play time in separate models. Second, the ASQ total and domain scores at 36 months were added as exogenous variables (in separate models) to assess unadjusted associations with the random intercepts of screen, reading, and peer play time. Third, covariates were added to the model to determine whether associations between screen, reading, and peer play time and the ASQ at 36 months were independent of ASQ at 12 months, maternal age, education, race/ethnicity, marital status, and insurance status, and child gestational age, sex, and hours spent in daycare over development (also modeled with a random intercept). ASQ at 12 months was included as a covariate to account for the possibility that children with developmental delays at the first timepoint could have different amounts of screen, reading, and peer play time from 12 to 36 months. Previous research has noted that home-based daycare is associated with a higher likelihood of extreme levels of screen time relative to center-based daycare,² but both home- and center-based daycare may provide opportunities for reading and peer play, so hours in daycare were controlled regardless of the type of daycare.

Because we were primarily interested in the displacement model, indirect (mediation) effects of screen time on ASQ at 36 months through reading and/or peer play time were assessed. Finally, moderation (effect modification) of the covariate models was explored across child sex, fertility treatment status, plurality, only-child status, and daycare status (parental only versus non-parental care⁴³) to determine whether the parameters in the model applied equally to all subgroups. The model for moderation across daycare status excluded controls for hours in childcare because children in parental care had almost no variance for hours. Models with all parameters allowed to vary across groups were compared with models with constraints on the stability, cross-lag, and predictive (associations with ASQ at 36 months, covariates, and among random intercepts) parameter estimates.

All models were fit in Mplus 8 using robust maximum likelihood estimation that provides the robust Satorra-Bentler χ^2 and other estimates that are robust to non-normality.⁴⁴ Models were considered to have a good fit if the χ^2 test was nonsignificant ($p > 0.05$), the CFI ≥ 0.95 , the RMSEA ≤ 0.06 , and the SRMR ≤ 0.08 , but less weight was given to the χ^2 significance because it is overly sensitive to sample size.^{45,46} For moderation models, significant differences in scaling-corrected χ^2 tests for the two models ($\Delta\chi^2$) indicated that one or more model parameters were moderated by group.⁴⁷

As is common in longitudinal studies, sample attrition was an issue. Missing data were handled using full information maximum likelihood (FIML) estimation in Mplus.⁴⁸ To account for differential attrition (details in Supplementary material), maternal age and education were included as auxiliary variables in the models to reduce bias in the FIML estimates.⁴⁹

RESULTS

Sample characteristics

Demographic characteristics of the sample are presented in Table 1. Table 2 presents descriptive statistics of the screen, play,

Table 1. Demographic characteristics of the sample.

	<i>n</i>	M (SD) or %	Range
Maternal			
Age (years)	3894	30.87 (5.96)	14–53
Education (college)	3894	55	0–1
Non-Hispanic white race	3894	83	0–1
Married or civil union	3748	81	0–1
Private health insurance	3891	78	0–1
Infertility treatment	3894	32	0–1
Child			
Gestational age	3894	38.07 (2.49)	23–42
Sex (male)	3894	52	0–1
Twin/multiple	3894	21	0–1
Only child	3376	15	0–1
Daycare hours (weekly)			
12 months	3089	15.14 (17.78)	0–95
18 months	2550	15.76 (17.87)	0–80
24 months	1988	15.08 (17.37)	0–70
30 months	2292	17.42 (17.97)	0–120
36 months	2180	16.92 (17.78)	0–60

Table 2. Average screen, peer play, and reading hours across age, and ASQ scores at 36 months.

	<i>n</i>	M (SD) or %	Range
Screen hours (daily)			
12 months	3081	0.89 (1.35)	0–10
18 months	2629	1.36 (1.46)	0–10
24 months	2304	1.92 (1.54)	0–10
30 months	2276	2.19 (1.54)	0–10
36 months	2184	2.51 (1.66)	0–10
Peer play hours (daily)			
12 months	3063	3.53 (3.29)	0–10
18 months	2597	3.95 (3.29)	0–10
24 months	2288	4.11 (3.20)	0–10
30 months	2259	4.04 (3.03)	0–10
36 months	2196	4.03 (2.79)	0–10
Reading hours (daily)			
12 months	3098	0.52 (0.64)	0–9
18 months	2634	0.64 (0.66)	0–10
24 months	2316	0.69 (0.61)	0–10
30 months	2285	0.68 (0.58)	0–10
36 months	2200	0.65 (0.52)	0–7
ASQ at 36 months (% with probable developmental delay)			
Total	1721	7	0–1
Fine motor	1792	3	0–1
Gross motor	1799	2	0–1
Communication	1796	3	0–1
Personal-social	1809	3	0–1
Problem solving	1772	3	0–1

reading, and ASQ variables at 36 months. As has been previously reported,² at 12 months, children engaged in less than 1 h of screen time, but by 30 months, children engaged in over 2 h per day on average. At all ages, children engaged in an average of

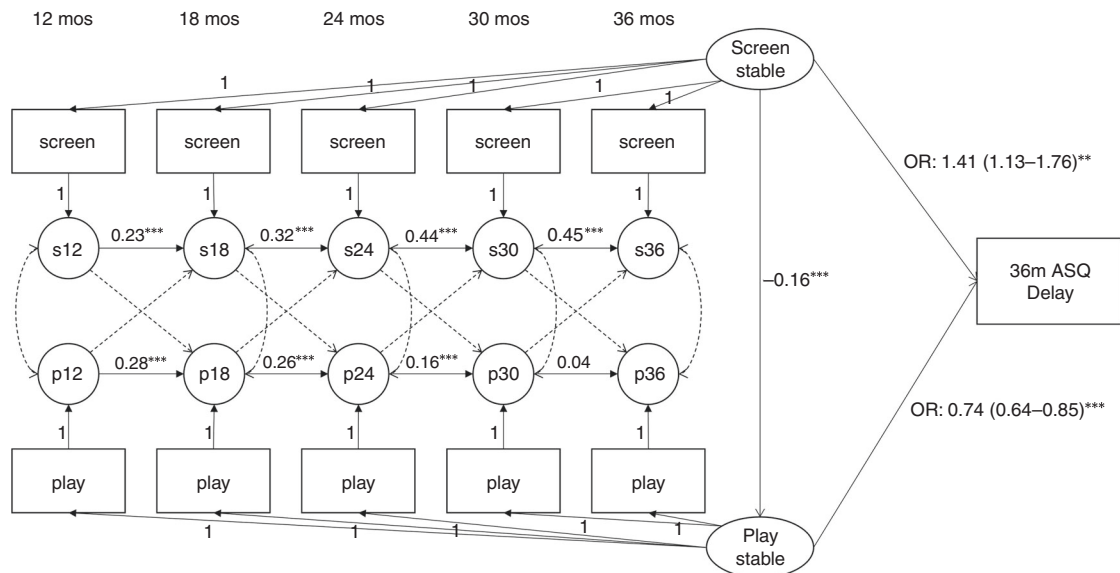


Fig. 1 Unadjusted RI-CLPM of screen and peer play time with total ASQ delay at 36 months. Unless otherwise noted, parameters are standardized betas (β). OR odds ratio (95% CI). Dashed lines were small ($|\beta| < 0.06$) and nonsignificant. ** $p < 0.01$. *** $p < 0.001$. See Supplementary material for a full explanation of the RI-CLPM.

3 or more hours per day of play time with peers. At all ages, children engaged in an average of less than 1 h (31–41 min) of reading with an adult. As expected, probable developmental delays on the ASQ at 36 months were low. Seven percent of children had a probable delay in one or more domains, but only 2–3% of children had a delay in any single domain.

Screen, reading, and peer play time

The RI-CLPMs of screen time with reading and peer play time both had good model fit: reading $\chi^2(21) = 74.48$, $p < 0.001$; CFI = 0.98; RMSEA = 0.03 (90% confidence interval [CI] 0.02, 0.03); SRMR = 0.02; play $\chi^2(21) = 182.52$, $p < 0.001$; CFI = 0.97; RMSEA = 0.04 (90% CI 0.04, 0.05); SRMR = 0.03. Screen time at each timepoint was associated with an increase in screen time at the next timepoint (6 months later) from 12 to 36 months (β s = 0.23–0.45). Reading time at each timepoint was associated with an increase in reading at the next timepoint from 12 to 24 months (β s = 0.22–0.29) but not from 24 to 36 months (β s = 0.12–0.16). Screen time was not associated with reading time at the between-person level $\beta = 0.01$ (95% CI = -0.08, 0.09), $p = 0.880$, or within-person level, β s = -0.04–0.05. Peer play time at each timepoint was associated with an increase in peer play time at the next timepoint from 12 to 30 months (β s = 0.16–0.28), but not from 30 to 36 months ($\beta = 0.03$). Higher screen time was associated with less peer play time at the between-person level, $\beta = -0.16$ (95% CI = -0.23, -0.09), $p < 0.001$, but not the within-person level across development, β s = -0.03–0.03. Screen and peer play time shared about 3% of their variance (square of the β) from 12 to 36 months.

Because screen time was associated with less peer play time at the between-person level, we next considered whether between-person variation in screen time and peer play time were associated with a probable developmental delay on the ASQ, and whether the effect of screen time on ASQ was mediated by peer play time (see Fig. 1 for an example model). Table 3 presents the results of the RI-CLPMs: odds ratios (ORs) and 95% CIs for the direct effects of screen time and peer play time on ASQ, as well as the indirect effect of screen time on ASQ, as mediated by peer play time. In unadjusted models, more screen time was associated with a higher odds of any delay (ASQ total) and delays in fine motor, communication, and personal-social. More peer play time was inversely associated with a delay in ASQ total

and all domains. The indirect effects of screen time on ASQ delay through peer play time were significantly above 1 for ASQ total and all domains.

In adjusted models accounting for ASQ at 12 months, maternal age, education, race/ethnicity, marital status, and insurance status, and child gestational age, sex, and between-person stability in hours spent in daycare from 12 to 36 months, screen time was no longer directly associated with an ASQ delay in any domain, but more peer play time was still related to a lower likelihood of probable ASQ delay in 4 of 5 domains (Table 3). Indirect effects of screen time on ASQ through peer play time were significantly above 1 for ASQ total and all domains except problem solving. These results suggest that when controlling for family and child characteristics, having higher screen time indirectly increases the likelihood of a probable ASQ delay in all domains except problem solving through reduced play time with peers.

Moderation models

In moderation (effect modification) models, the difference in model fit for girls and boys, $\Delta\chi^2(66) = 67.29$, $p = 0.433$, children born following fertility treatment and not, $\Delta\chi^2(66) = 78.85$, $p = 0.133$, and children in parental only and non-parental childcare, $\Delta\chi^2(40) = 51.89$, $p = 0.099$, indicated that these factors did not moderate the association of screen time and peer play time on ASQ delay. The difference in model fit for plurality, $\Delta\chi^2(66) = 138.50$, $p < 0.001$, and only-child status, $\Delta\chi^2(66) = 176.30$, $p < 0.001$, indicated that one or more model parameters were moderated by these factors. However, none of the paths between screen time, peer play time, and ASQ were moderated by plurality or only-child status (see Supplementary material for additional details).

DISCUSSION

Excessive and inopportune digital media use has been shown to have adverse effects on child development,^{8,9} but the mechanisms of those effects are unclear. This study suggests that one possible mechanism is the displacement of time spent playing with peers. Children who engaged in more screen time from 12 to 36 months spent less time playing with peers over the same time period, and less time playing with peers was associated with a higher odds of developmental delays in four of five

Table 3. Logistic regression results of between-subjects stability of screen time and peer play time from 12 to 36 months in relation to probable developmental delay on the Ages and Stages Questionnaire at 36 months.

36 months	Unadjusted				Adjusted ^a							
	Screen hours		Peer play hours		Screen hours		Peer play hours		Indirect			
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI		
ASQ total	1.41	1.13–1.76	0.74	0.64–0.85	1.10	1.04–1.17	1.12	0.83–1.52	0.73	0.61–0.88	1.09	1.01–1.18
Fine motor	1.37	1.01–1.86	0.72	0.60–0.86	1.10	1.03–1.19	1.20	0.80–1.79	0.77	0.62–0.96	1.08	1.00–1.16
Gross motor	1.19	0.73–1.92	0.67	0.54–0.84	1.13	1.04–1.24	0.90	0.56–1.45	0.62	0.49–0.79	1.14	1.02–1.27
Communication	1.59	1.22–2.07	0.64	0.52–0.79	1.15	1.06–1.25	1.38	0.87–2.19	0.60	0.42–0.86	1.16	1.01–1.32
Personal-social	1.58	1.17–2.15	0.54	0.41–0.71	1.22	1.08–1.37	1.27	0.79–2.04	0.54	0.37–0.80	1.18	1.02–1.37
Problem solving	1.28	0.89–1.85	0.75	0.59–0.94	1.10	1.01–1.19	1.00	0.56–1.78	0.74	0.54–1.01	1.09	0.98–1.22

Indirect = mediated indirect effect of screen time on ASQ through peer play time.

^aCovariates included ASQ at 12 months, maternal age, education, race/ethnicity, marital status, and insurance status, and child gestational age, sex, and between-person stability in hours spent in daycare from 12 to 36 months. ASQ at 12 months was associated with ASQ at 36 months, OR = 5.28 (95% CI = 2.98, 9.36) but not with screen time, $\beta = 0.01$ (95% CI = -0.04, 0.06), or peer play time, $\beta = 0.02$ (95% CI = -0.03, 0.07).

developmental domains, even when controlling for baseline developmental delays, time spent in daycare, and sociodemographic characteristics. Indirect effects of screen time on developmental delays indicated that play with peers mediated the link between screen time and developmental delay in four of the five domains. These effects were consistent across boys and girls, children conceived with and without fertility treatment, children in only parental and non-parental daycare, twins and singletons, and children with and without siblings. The sizes of associations were relatively small, but this study covers only 2 years in early development and the associations may compound over time. Previous research on trajectories of screen time suggest that children who engage in high levels of screen time early in development continue to do so later in development.^{2,4}

Studies of peer play suggest that children learn a wide variety of socioemotional and cognitive skills from their peers.^{22–24,27,28} This study classified siblings as peers, and previous studies also suggest that having siblings is associated with better social interactions and social cognitive skills in early childhood.^{50,51} Conversely, non-social cognitive and school performance is sometimes found to be lower in children with siblings than those without, potentially due to reduced time and resources available to each child in multi-child households.⁵² The different mechanisms at play for non-sibling peers and siblings may explain why the associations of screen time and peer play with the ASQ problem-solving domain were smaller. Future studies should separately assess play with siblings and children outside the household to disentangle these effects.

In this study, screen time compounded over time. Over and above the between-subjects level of screen time across the study (i.e., the random intercept), children who engaged in more screen time at one timepoint had increased screen time 6 months later. Reading time and peer play time also compounded across early development, but less from 24 to 36 months. However, there was no evidence of within-person cross-lagged associations between screen time and reading or peer play. The between-person overall level of screen time was associated with the overall level of peer play, rather than a child's screen time at one age contributing to an increase or decrease in peer play (or vice versa) at the next age. Given the time lag of 6 months between assessments, the lack of within-person cross-lagged effects may not be surprising. Cross-lagged effects may be seen over shorter time periods like hours or days rather than months.⁵³

This study also found no evidence of between-person screen time displacing between-person time spent reading in toddlerhood. Consistent with this study, McArthur et al.¹⁸ did not find a significant association between the stable aspects of screen time and reading, but contrary to this study they did find within-person associations over time. It is somewhat difficult to compare these studies due to differences in measurement for reading activities (minutes in our study and a time-varying 4-category variable in McArthur et al.). In our sample, children were read to by an adult for at least a half-hour per day on average at each timepoint. Some recent national data support this estimate (e.g., 28–33 min of daily reading in this age group),⁵ but other data suggest that American parents spend only 4 min per day reading to children under age 6.⁵⁴ It is possible that the associations between screen time and reading would be different in a more representative sample, but it is unlikely as there would be little reading time to displace, and reading with parents is likely tied to habitual practices (e.g., bedtime reading). The finding that peer play time but not reading time is displaced by screen time is also consistent with the functional similarity/equivalence hypothesis, which suggests that activities that are more similar in function are more likely to be displaced (e.g., screen time and play with peers are both entertainment).^{16,55}

Limitations and future directions

Due to the large sample size and the frequency of measurements (5 assessments over 2 years), mothers reported on their children's development via a brief screening instrument, which may be subject to social desirability bias and may lack precision.³⁵ Children's activities were assessed by global estimates which may overestimate actual engagement.⁵⁶ Digital media use can be measured in various ways, but all ways have their limitations.⁵⁶ Due to the longitudinal scope of this study, the financial and time costs of other methods were prohibitive (e.g., time diaries, direct observation). We only asked about the amount of time engaged with screens (television and video games), reading, and playing with peers, and not the context, content, or quality of that engagement. Some research has shown that if parents mediate their children's screen time by watching together and discussing the content, negative associations of screen time with child development are mitigated.⁵⁷ The quality of reading⁵⁸ and play²³ may also be important. Other forms of reading, such as by electronic devices, may replace time spent reading with parents that also requires further evaluation. This study included only two possible activities that could be displaced by screen time. Displacement of peer play is likely not the only mechanism of screen time's associations with healthy child development. Other potential culprits include interrupted sleep,^{59,60} and increased sensation-seeking behavior.⁶¹

The sample was largely non-Hispanic white and well-educated, which limits the generalizability of the findings. Furthermore, all measures in this study were reported by mothers. In early childhood, mothers may be the best reporters of their children's activities at home, but mothers may not know about all of their children's activities while in childcare, leading to flawed estimates. This concern is somewhat offset by the moderation model showing that model estimates were similar in children in only parental care and children in non-parental daycare. Still, using a single source in this study may have inflated associations between activity times and developmental delay.⁶² There was also considerable attrition over time in this study and early screen time was higher and maternal age and education were lower for nonresponders (see Supplementary material), but we used FIML with auxiliary variables to account for missing data, techniques that reduce bias.⁴⁹

Despite these limitations, this study included repeated assessments of a large sample of children over an important period of early development when screen time is increasing.² Future research on the impact of screen time on development should include a more diverse sample, account for the context, content, and quality of digital media as well as information about how parents moderate screen time, and account for parents' own digital media usage.

CONCLUSIONS

Screen time in toddlerhood was associated with lower peer play time, but not less time spent reading with an adult. Peer play time mediated the effects of screen time on probable developmental delays. Peer play has wide-ranging benefits for young children, and, in this study, was associated with a reduced likelihood of developmental delay in motor, communication, and personal-social domains, consistent with previous research.^{22,23,27,28,63} Ensuring that toddlers get adequate time to play with other children may help to disrupt the adverse associations between screen time and child development.

DATA AVAILABILITY

The datasets generated during and/or analyzed during the current study are not publicly available due to limitations of the informed consents but are available from the corresponding author on reasonable request.

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AUTHOR CONTRIBUTIONS

D.L.P. conceptualized and designed the study, conducted the formal data analyses, drafted the initial manuscript, and reviewed and revised the manuscript. M.-H.T. performed data analyses and reviewed and revised the manuscript. R.S. contributed to the methodology, provided supervision of the data analyses, and reviewed and revised the manuscript. E.M.B. acquired funding, conceptualized and designed the study, developed the methodology, curated data, and reviewed and revised the manuscript. A.G. and S.L.R. conceptualized and designed the study and critically reviewed the manuscript for important intellectual content. E.Y. conceptualized and designed the study, developed the methodology, curated data, provided supervision of the study, and reviewed and revised the manuscript. All authors approved the final manuscript as submitted.

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COMPETING INTERESTS

The authors declare no competing interests.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Human subject research approval was obtained from all participating institutions and informed consent was obtained prior to data collection.

ADDITIONAL INFORMATION

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