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Published in:
Paediatric and Perinatal Epidemiology

DOI:
10.1111/ppe.12956

Publication date:
2023

Document version:
Final published version

Received: 9 September 2022 | Revised: 9 January 2023 | Accepted: 11 January 2023

DOI: 10.1111/ppe.12956

Paediatric and Perinatal Epidemiology WILEY

ORIGINAL ARTICLE

Recreational screen time trajectories during early childhood and imaging-measured body composition at age 7 in the Odense child cohort

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Funding information
European Research Council, Grant/Award Number: 716657; Novo Nordisk Fonden, Grant/Award Number: NNF20SH0062965

Abstract

Background: Children spend increasing amounts of time on recreational screen media, which may lead to an obesogenic environment.

Objectives: We investigated the association of trajectories of screen time across ages 3, 5 and 7 years with body composition at age 7 in the Odense Child Cohort.

Methods: Data were collected in the Municipality of Odense, Denmark, between 2010 and 2019. Group-based trajectory modelling was applied to group participants into four trajectories of prospective parent-reported screen time. Body composition was assessed using dual-energy x-ray absorptiometry with calculated fat-mass index (FMI) as the primary outcome. Primary models were linear multivariable regression models adjusted for participants' sex, age, birthweight, maternal origin, maternal education, maternal body-mass-index, and maternal age. Further models were adjusted for additional possible confounders. Selection bias was addressed by inverse probability weighting.

Results: In total, 803 children (48.2% female) were included in the primary analysis. Participants with screen time at all time points were assigned to four trajectory groups [constant low screen time (12.7%), low increase (36.3%), high increase between ages 3 and 5 (33.5%) and high increase in screen time (17.5%)]. Sample characteristics differed across missing data status and trajectories. Mean FMI (kg/m^2) and standard deviation (SD) were 3.7 (SD 1.3) and 3.9 (SD 1.6) for the constant low versus high screen time, respectively. No differences in FMI were found between screen time trajectory groups at age 7 (adjusted mean difference 0.1 kg/m^2, 95% confidence interval −0.3, 0.5 for constant low versus high screen time). No consistent associations between screen time groups and secondary body composition outcomes were found.

Conclusions: Results from this study do not suggest that recreational screen time from age 3 to 7 years is associated with adiposity or other measures of body composition.

KEYWORDS
body composition, children, dual X-ray absorptiometry, screen time

1 | BACKGROUND

Screen time is a common sedentary recreational activity, and children's screen use increases heavily during childhood.[1] According to the latest Common Sense Media report, American children aged 5–8 years spend a daily average of 3 h on screen time.[2] Moreover, 75% of parents report concerns regarding their children's recreational screen use.[2]

Studies have reported that digital screen use may affect children's physical behaviour, sleep, and diet. High levels of screen time displace a substantial amount of habitual physical activity (PA),[3] and screen time before bed may delay bedtime and affect sleep in children.[4–6] Also, screen habits may alter dietary intake, partly due to higher exposure to food advertising that could influence caloric intake and promote unhealthy food choices,[7] but also in the absence of food advertising.[8]

By affecting aetiological factors of body composition such as physical inactivity and sleep, screen time has been suggested to be associated with obesity in children.[9] However, due to difficult experimental designs, confounding factors in observational data, and outdated evidence based on traditional screen use (i.e. television [TV]), the evidence for an association between screen time and adiposity remains unclear. Body composition has often been assessed using body-mass index (BMI) or using other indirect measures.[10] The accuracy of these methods for estimating adiposity is limited by their failure to account for fat mass (FM)[11] and fat free mass (FFM),[12] underestimation of obesity[13], and disregard of effects of height,[14] respectively. Techniques such as dual-energy x-ray absorptiometry (DXA) may eliminate these limitations.[15]

There is a lack of studies investigating the association between accurately measured body composition and screen time.[9,10,16,17] Moreover, few cohort studies have reported the repeated assessment of children's screen use and careful control for confounders. In this study, we aimed to investigate the prospective association of screen time trajectories comprising measurements at age 3, 5, and 7 years with DXA-estimated body composition at age 7. In secondary analyses, we examined cross-sectional associations of screen time with imaging-measured body composition at age 7.

Synopsis

Study question

This study investigated the prospective association of screen time between the ages three, five, and seven years with dual-energy x-ray absorptiometry-assessed body composition at age seven among Danish children (n=803) in the Odense Child Cohort study.

What is already known

Previously, observational cross-sectional studies and few prospective studies have reported associations of screen time with indirect measures of body composition.

What this study adds

Findings of this study did not suggest an association of the prospective development of screen time, including repeated assessments of screen time, with imaging-assessed body composition. Sensitivity analyses emphasize the importance of addressing several sources of bias, such as careful adjustment for putative confounding factors and prevention of selection bias. Further cohort and experimental studies are required to corroborate the findings of this study.

2 | METHODS

2.1 | Study design

A statistical analysis plan was preregistered prior to commencing the analyses (https://osf.io/q6e8v/). The Odense Child Cohort (OCC) is a birth cohort initiated in the Municipality of Odense in the Region of Southern Denmark in 2010. Between January 2010 and December 2021, 43% of pregnancies in the municipality were recruited for the OCC. Information on the cohort study can be obtained from a previous publication.[18] Clinical markers, questionnaire data, and physiological information from 2665 children from 2500 families were collected.[18] Parents complete questionnaires and participants undergo clinical examinations and blood tests biennially. Reporting followed the STROBE statement.[19]

2.2 | Exposure

Screen time was parent-reported using questionnaires at ages 3, 5, and 7. To reflect the changing nature of screen time over time, questions were updated across all ages. We used a simpler question about screen time at ages 3 and 5, estimating time spent using different devices (television, gaming console, tablet, PC and smartphone) in time categories. At age 7, questions were significantly revised including the following categories: (i) movies, TV shows, YouTube video clips/movies and entertainment programs; (ii) games (on a smartphone, tablet, game console and computer); (iii) school-related tasks using screen media devices; (iv) video calls (e.g. Facetime and Skype); (v) social media or other types of communication (e.g. Facebook, Messenger, Twitter, WhatsApp, Snapchat, Instagram, email and text messaging); and (vi) other (e.g. drawing apps, making musical or stop-motion videos). Updated questions at age 7 were based on questions from our recently validated SCREENS-Q questionnaire.[20] Original questions can be found in the statistical analysis plan. Total daily recreational screen time (excluding school-related screen use) was calculated as described in the statistical analysis plan. Screen time

distribution was examined using histograms, and a normal distribution was confirmed.

Participants with less than three repeated measures were excluded, and trajectories were modelled as a function of age. A single-class model was constructed applying a censored normal distribution. The number of classes and complexity of the polynomial distributions were increased until optimal models were identified. The optimal model specification was assessed using the Bayesian information criterion in combination with other diagnostic criteria, as a single metric cannot adequately capture model fit.[21] Modelling decisions were based on a combination of four diagnostic criteria: (i) a minimum average posterior probability of group membership of 0.7, (ii) agreement between the estimated group membership probability and the actual proportion of participants assigned to each group based on the posterior probability, (iii) minimum odds of correct classification greater than five and (iv) precise confidence interval (CI) around estimations of group membership probabilities.[21,22]

The cross-sectional analysis of the association of screen time with body composition at age 7 was included to leverage an expected improved accuracy in screen time assessment, higher exposure variability, and larger sample size as compared to the prospective analysis. Cross-sectional exposure was estimated using daily screen time reported at age 7. A variable classifying low, moderate, and high screen time was calculated using the median and 85th percentile of screen use in a Danish sample of 7-year-olds as cutoffs,[1] grouping the sample by the categories <90, 90–180, and >180 min of daily screen time. In post hoc analysis, the sample was divided into quintiles of screen time at age 7 to increase the contrast between groups. Both classifications were used to relax the assumption of linearity.

2.3 | Outcomes

The basic three-compartment model, dividing bone, FFM and FM, was used to investigate body composition.[23] As FFM and FM increase with height, mass indices divided by height^2 were used to account for height differences.[24] The primary outcome was fat mass index (FMI, kg/m^2) computed using total FM retrieved from DXA scans and measured height [FM/height (m^2)].[25] A variable describing excess FMI dichotomised by the 75th percentile of sex-specific references obtained from 7-year-old British children[26] was used. Secondary outcomes were FFM index [FFMI, kg/m^2, FFM/height (m^2)] and the ratio of FM to FFM (FM:FFM). Skeletal muscle mass was estimated using the lean mass index (LMI, kg/m^2)[27] and appendicular lean soft tissue index (ALSTI, kg/m^2),[28] which were calculated by subtracting total and appendicular bone mass from total FFM and appendicular FFM, respectively, and then dividing by height^2. Both markers have previously been used only as indirect estimators of muscle mass as DXA-estimated lean mass includes fluid retentions, skin, cartilages, and other connective tissue, possibly overestimating skeletal muscle.[29,30] The android-gynoid ratio (A:G), calculated by dividing android per cent body fat (%BF) at the waist by gynoid %BF at the hip, has been proposed as a marker of insulin resistance and dyslipidaemia in children[31] and was used as an additional outcome. As various previous studies used BMI-based measures of body composition, we calculated BMI z-scores using World Health Organisation reference data[32] for more direct comparison.

2.4 | Covariates

Information on covariates was parent-reported or recorded at birth. Previous reports have suggested that children's body composition may be associated with the age and sex,[11] birthweight,[33] ethnicity,[14] PA,[34] sleep,[35] diet[36] and maternal BMI,[37] age[38], and socioeconomic status (SES).[39] A directed acyclic graph is presented in Figure S1. Age was calculated using the birthdate and the date of DXA examination. Sex and birthweight were recorded at birth. In addition, maternal origin, maternal BMI, age, and SES were collected at enrolment. Information on PA, sleep and fish intake was repeatedly collected in parent-reported questionnaires at follow-up. PA was reported as status of parent-perceived PA compared with others of the same age and was dichotomised to 'less or similar PA' and 'more PA' due to skewed distribution. Fish intake was recorded as the cumulative average of fish servings per month, and sleep was estimated as mean sleep duration on a typical night.

2.5 | Statistical analysis

The association of screen time with body composition in prospective and cross-sectional analyses was examined in model 1 using multivariable linear regression for continuous outcomes adjusted for age and sex. Multivariable adjusted risk ratios (RR) or prevalence ratios were estimated using a generalised linear model specified with a Poisson distribution and log link function for excess FMI and BMI-determined overweight. Model 2 was additionally adjusted for birthweight, maternal origin, maternal education, maternal BMI, and maternal age. Model 3 was subsequently adjusted for BMI z-score at age three to account for children's BMI at baseline as screen time may have affected body composition before baseline. Finally, model 4 was adjusted for PA, fish intake, and sleep, as these lifestyle factors may confound the association of screen time with adiposity. For the outcome FFMI, models were adjusted for FMI, as increases in FM have been shown to be associated with increased lean mass.[40]

Statistical analysis was carried out in Stata (Version 17).

2.6 | Missing data

Baseline characteristics of participants with missing data for exposure, outcomes, or covariates were compared to participants with complete information for primary analyses. Inclusion in the analysis required complete information on exposure, outcome, and covariates adjusted for in corresponding models. To account for possible selection bias, we used inverse probability weighting (IPW).[41]

Inverse values of predicted probabilities were calculated from a multivariable logistic regression model with missing data status as the outcome and sex, age, birthweight, and maternal age, BMI, education, and origin as predictors. Selection bias within the OCC was examined by comparing IPW results with unweighted results and by performing 50 multiple imputations (MI) using chained equations following Royston and White.[42] FMI, FFMI, LMI, and A:G were imputed for 2481 participants based on complete data describing sex, birthweight, and maternal characteristics registered at enrolment for prospective and cross-sectional analyses (Figure 1).

2.7 | Ethics approval

The Regional Scientific Ethical Committees for Southern Denmark and the Danish Data protection agency (S-20170033, S-20090130) approved this study. Children were orally informed about research procedures. Written-informed parental consent was obtained.[18]

3 | RESULTS

Between January 2010 and December 2012, 2874 pregnant women were recruited and 2665 infants enrolled in the OCC. A total of 2481 participants had complete data on sex, birthdate, birthweight, maternal age, origin, education, and BMI at enrolment; 1093 participants reported complete data at baseline. Overall, 1678 participants were excluded due to missing data, of which 1388 and 290 participants were excluded at baseline and follow-up. A flowchart of participants is shown in Figure 1.

3.1 | Prospective associations

At follow-up, 810 children (48.2% female) had complete data on exposures, outcomes, age, and sex. Furthermore, 803, 730, and 661 children reported information for subsequent models 2–4. Descriptive data on children and their mothers who were included or excluded due to missing data in the primary model are shown in Table 1. The percentage of participants with low birthweight was modestly higher in individuals with missing information. Moreover, the percentage of participants with low maternal education was 11.1% higher in this group, and non-western origin was 3% more common in participants with missing data (Table 1).

Group-based trajectory modelling (GBTM) was performed for all 965 participants (38% of 2481) with complete screen time information at all ages. Model quality was confirmed according to predefined thresholds (Table S1). A trajectory model with four

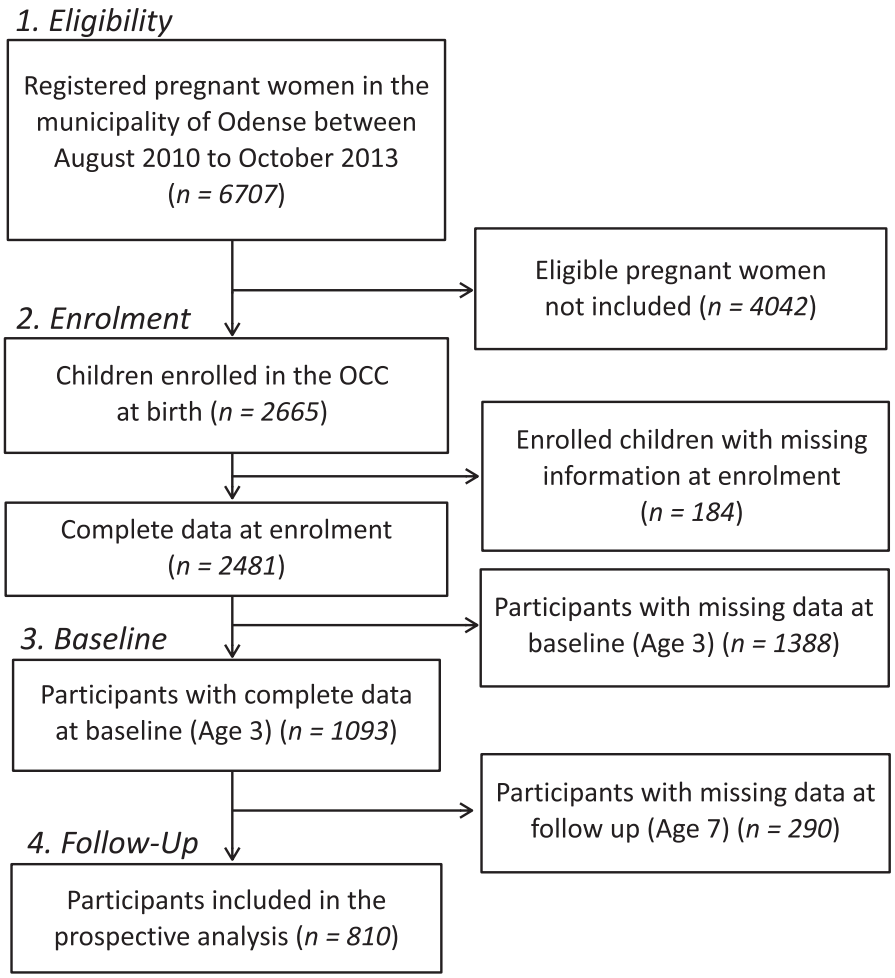

FIGURE 1 Flow chart of participants from the introduction of OCC to follow-up for prospective and cross-sectional analysis. Complete data refer to data required for the final analyses. Reasons for non-enrolment of pregnant women can be found in the previously published work by Kyhl et al.[18] Differences across participants with/without missing data at baseline can be obtained from Table 1. *n*, number of participants.

trajectories grouping participants with (i) constant low screen time, (ii) a low increase through age 7, (iii) a high increase between age 3 and 5, and then a low increase through age 7, and (iv) a high increase in screen time from age 3–7 was determined best suited (Figure 2).

At ages 3, 5, and 7, 37 (4.6%), 68 (8.5%), and 131 (16.3%) children with complete data on all confounders reported excessive screen time. Screen time at age 7 was normally distributed, and mean values (standard deviation [SD]) at age 7 were 44.0 (16.7), 81.8 (25.6), 137.6 (36.6), and 207.8 (87.3) min/day in the constant low, low increase, high increase from age 3 to 5, and high increase trajectories. Comparing trajectories, the constant low screen time group had a lower median maternal BMI of 22.8 kg/m^2 compared to the high screen time increase trajectory, which had a median maternal BMI of 24.5 kg/m^2. Moreover, 39.4% of mothers in the high increase group had a low education, compared to 22.5% in the lowest trajectory group. Fewer participants in the high increase group were described to be more physically active than classmates with 35.4% in the constant low screen time trajectory group and 20% in the high screen time increase group. Fish intake was highest in participants with constant low screen time (9.6 servings/month; Table 2). Means (SD) for body composition outcomes by trajectory are provided in Table S2. PA status at age five was identical to PA at age 7 for all children.

Results regarding FMI, FFMI, LMI, and A:G at age 7 are presented in the main text, while results for other outcomes can be found in the Table S3. A negligent difference for FMI between constant low and high screen time was observed (adjusted mean difference 0.1, 95% CI −0.3, 0.5 kg/m^2) in the primary model (Table 3). However, results differed across models. Other secondary outcomes did not suggest any consistent relationship between trajectories and body composition at age 7 (Table 3 and Table S3). Comparing estimates obtained with and without IPW showed associations between group membership in the third and highest trajectories with multiple markers of body composition in model 1 in unweighted analyses (Table S4). Analyses based on imputed data did not alter the results (model 2, Table S5).

TABLE 1 Descriptive information across included and excluded participants at baseline.

	Participants included in primary model (n = 803)		Participants with missing primary information (n = 1678)	
Baseline information	***n***	**Median (IQR) or Number (%)**	***n***	**Median (IQR) or Number (%)**
Age (Years)[a]	803	3 (3, 3)	1030	3 (3, 3.1)
BMI (kg/m^2)[a]	735	15.8 (15.1, 16.5)	958	15.7 (15, 16.5)
Infant sex[b]				
Male	803	416 (51.8)	1678	888 (52.9)
Female	803	387 (48.2)	1678	790 (47.1)
Birthweight (g)[b]				
<2500	803	21 (2.6)	1678	90 (5.4)
2500–4000	803	635 (79.1)	1678	1329 (79.2)
>4000	803	147 (18.3)	1678	259 (15.4)
Maternal age (years)[a]	803	31 (28, 34)	1678	31 (27, 34)
Maternal BMI (kg/m^2)[a]	803	23.4 (21.2, 26.4)	1678	23.4 (21.2, 26.4)
Maternal education[b]				
Low	803	188 (23.4)	1678	578 (34.5)
Moderate	803	413 (51.4)	1678	806 (48)
High	803	202 (25.2)	1678	294 (17.5)
Maternal origin[b]				
Western country	803	786 (97.9)	1678	1593 (94.9)
Non-western country	803	17 (2.1)	1678	85 (5.1)
Behavioural factors				
Sleep duration (h/day)[a]	793	11 (10.6, 11.5)	748	11 (10.6, 11.5)
Intake of fish (days/month)[a]	787	9 (5, 15)	739	9 (5, 14)
Physical activity[b]				
Much less, a little less, equally active	802	616 (76.8)	762	555 (72.8)
More active	802	186 (23.2)	762	207 (27.2)

Abbreviations: BMI, body mass index; h, hours; n, sample size; m^2, square meters; SD, standard deviation.

[a]Continuous descriptive characteristics are presented as median (IQR).

[b]Categorical variables are described as count per category (% of group).

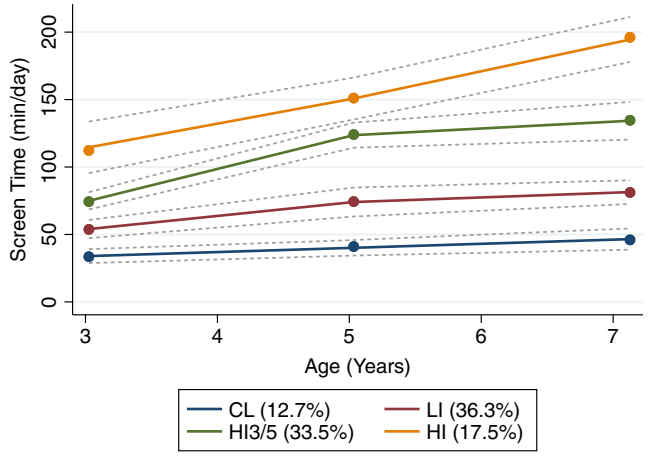

FIGURE 2 Group-based trajectories of screen time development across ages 3–7. The lines indicate group-based trajectories of screen time (coloured) with 95% confidence intervals (scattered). The sample was classified into four groups of development of screen time. In the graph, one can define four trajectories: Group CL – Constant low screen time (blue); Group LI – Low increase in screen time (red); Group HI3/5 – High increase in screen time between age three and five (green); Group HI – High increase in screen time (yellow). The legend includes the percentage of children (%) belonging to each group. Bayesian Information Criterion = −14,325.5. CL, constant low screen time; HI, high increase in screen time; HI3/5, high increase in screen time between age 3 and 5; LI, low increase in screen time.

3.2 | Secondary analyses

The cross-sectional analyses included 1383, 1363, 1201, and 749 participants in the multivariable models 1, 2, 3, and 4. At age 7, 573 (42%), 564 (41.4%) and 226 (16.6%) participants included in the primary model reported screen time < 90 min/day, between 90 and 180 min/day, and above 180 min/day. Results for multivariable regression analyses by continuous screen time and body composition markers are presented in Table S6. Screen time was positively associated with the primary outcome FMI in model 1 and model 4 (Table S6). Associations of screen time with excess FMI in model 1 and with FFMI in model 4 were suggested. Subsequently, repeating the analyses without IPW resulted in a consistently stronger association of screen time and FMI across models 1–4 (Table S7). IPW removed certain associations of A:G with screen time at age 7 which were apparent in unweighted model 1 (Table S7). In the imputed analysis, a minimal association between screen time and FMI was detected ($\beta = 0.1$, 95% CI 0.0, 0.1; Table S8).

The cross-sectional analyses with categorical screen time at age 7 provided comparable results to the linear analysis. Model 1 showed a higher FMI and lower FFMI comparing children with high versus low daily screen time (Table S9A). No associations were found in models with additional adjustments for putative confounders. When IPW was removed, an association of FMI among participants with high screen time remained, the association of screen time with FFMI was discarded, and associations between high screen time and A:G ratio and between moderate screen time and excess FMI appeared (Table S9B). In post hoc analyses, the membership in the highest quintile of screen time was suggested to be associated with FMI, excess FMI and FFMI in model 1 (Table S10). In model 2, only FFMI was associated with the membership in the highest quintile of screen time (adjusted mean difference [95% CI]: −0.2 [−0.3, −0.0] kg/m^2). Removal of IPW introduced associations of A:G in model 1 and consistent associations of FMI across models 1–3 (Table S11).

4 | COMMENT

4.1 | Principal findings

In this prospective study of Danish children from 3 to 7 years of age, we found no association of recreational screen time trajectories with DXA-estimated FMI at 7 years. No associations were observed for body composition outcomes in relation to screen time trajectories. The cross-sectional analysis of screen time at age 7 with adiposity suggested inconsistent associations. Our investigations indicate potential confounding by maternal socio-demographics, maternal adiposity, PA, diet and the likely presence of selection bias in unweighted analyses.

4.2 | Strengths of the study

This study has several strengths. We applied imaging-assessed body composition to investigate the association of screen time with body composition. By using DXA, the limitations of anthropological body composition measures such as BMI,[11,12] WtHR[13], and %BF[14] were eliminated. Furthermore, the cohort design provides extensive, repeated documentation of covariates, such as SES and maternal attributes from early pregnancy, factors commonly disregarded when investigating the association of screen time and adiposity in children. We observed differences in child- and maternal covariates across trajectory groups highlighting potential confounding that needed to be controlled for. The prospective design with repeated assessment of screen time likely prevents information bias, and at year 7, a validated questionnaire was employed to assess screen time.[20] Additionally, GBTM is a data-based method reducing investigator bias.[43] Several sensitivity analyses were used to investigate selection bias.

4.3 | Limitations of the data

While the control of selection bias is a strength of the analyses, the bias itself may limit our findings. If data are not missing at random, MI and IPW may produce biased results in an unknown direction. Due to the observational design, residual and unknown confounding cannot be ruled out. Additionally, parent-reported variables tend to be affected by social desirability bias and recall

TABLE 2 Sample characteristics across trajectories of screen time development for participants included in the primary model.

Trajectory group	*n*	Constant low screen time (CI)	Low increase in screen time (LI)	High increase in screen time between 3 and 5 (HI3/5)	High screen time increase (HI)
Age (years)[a]	803	7.1 (7, 7.2)	7.1(7, 7.2)	7.1 (7.1, 7.2)	7.1 (7.1, 7.2)
Sex[b]	803				
Male	416	44 (44.9)	133 (44.3)	160 (56.5)	79 (64.8)
Female	387	54 (55.1)	167 (55.7)	123 (43.5)	43 (34.3)
Birthweight[b]	803				
Low	21	3 (3.1)	6 (2)	7 (2.5)	5 (4.1)
Normal	635	79 (80.6)	253 (84.3)	214 (75.6)	89 (73)
High	147	16 (16.3)	41 (13.7)	62 (21.9)	28 (23)
Maternal age at birth (years)[a]	803	31 (29, 33)	30 (28, 33)	32 (29, 35)	31 (28, 34)
Maternal BMI (kg/m^2)[a]	803	22.8 (20.7, 25.4)	22.8 (21.1, 25.5)	23.5 (21.2, 26.7)	24.5 (22.3, 28.5)
Maternal origin[b]	803				
Western country	786	93 (94.9)	298 (99.3)	278 (98.2)	117 (97.9)
Non-Western country	17	5 (5.1)	2 (0.7)	5 (1.8)	5 (4.1)
Maternal education[b]	803				
Low	188	22 (22.5)	60 (20)	58 (20.5)	48 (39.4)
Moderate	413	39 (39.8)	165 (55)	151 (53.4)	58 (47.5)
High	202	37 (37.8)	75 (24)	74 (26.2)	16 (13.1)
BMI z-score (at age 3)[a]	730	0.2 (−0.5, 0.8)	0.2(−0.2, 0.7)	0.2(−0.3, 0.8)	0.1 (−0.4, 0.7)
Physical activity (at age 3)[b]	661				
Much less, a little less, equally active	510	57 (72.2)	194 (76.4)	191 (80.3)	68 (75.6)
More active	151	22 (27.9)	60 (23.6)	47 (19.8)	22 (24.4)
Physical activity (at age 5/7)[b]	661				
Much less, a little less, equally active	508	51 (64.6)	194 (76.4)	191 (80.3)	72 (80)
More active	153	28 (35.4)	60 (23.6)	47 (19.8)	18 (20)
Sleep duration (h)[a]	730	11.8 (11.6, 12)	11.8 (11.7, 11.9)	11.8 (11.6, 11.9)	11.8(11.6, 12)
Fish intake (servings/month)[a]	803	9.6 (6, 15)	9.3(5.7, 13.4)	9.3 (5, 13.7)	7.5 (4.3, 12)

Abbreviations: BMI, body mass index; h, hours; *n*, sample size; m^2, square meters; SD, standard deviation.

[a]Continuous crude, descriptive characteristics are presented as median (IQR).

[b]Categorical variables are described as count per category (% of group).

bias, or by insufficient knowledge about the children's behaviour possibly impacting the ability to correctly address confounding.[44] Parent-reported screen time varied over time. It is likely to be underestimated by parents leading to misclassification in trajectories and presumably underestimation of investigated associations. Lastly, there is a risk of reverse causation bias due to the observational design as some outcomes may be predictors of recreational sedentary time often spent using screen devices.[45]

4.4 | Interpretation

Most current evidence on screen time and adiposity in children is cross-sectional.[10] While prospective studies have been published, the certainty of evidence for longitudinal studies was very low in a systematic review and meta-analysis published in 2016.[10] Several older studies examining the association of screen time with body composition only recorded time spent watching television.[10]

In 2014, Olafsdottir et al.[46] investigated the prospective association of screen time with BMI in 2- to 9-year-old children in Europe. The findings suggested an association between screen time habits and changes in BMI. Changes in body composition were mostly assessed using anthropometric indicators in current literature.[10,46,47] For comparison, Heilman et al.[48] carried out a study in the United Kingdom examining body composition assessed by bioelectrical impedance analysis and reported that television time at age 7 was associated with FMI at age 11 only in girls. While this study carefully attempted to control for confounding, they did repeatedly

TABLE 3 Primary analysis: Association of trajectories of screen time development between the age 3 and 7 with DXA-measured fat-mass-index.

		Model 1	Model 2	Model 3	Model 4
Outcome	Group	Coef. (95% CI)	Coef. (95% CI)	Coef. (95% CI)	Coef. (95% CI)
FMI (kg/m^2)	CL	0.0 (Reference)	0.0 (Reference)	0.0 (Reference)	0.0 (Reference)
	LI	−0.0 (−0.4, 0.3)	−0.0 (−0.3, 0.3)	−0.1 (−0.4, 0.1)	−0.1 (−0.3, 0.2)
	HI3/5	0.3 (−0.1, 0.7)	0.2 (−0.1, 0.5)	0.2 (−0.1, 0.4)	0.2 (−0.1, 0.4)
	HI	0.3 (−0.1, 0.7)	0.1 (−0.3, 0.5)	−0.0 (−0.3, 0.3)	0.1 (−0.3, 0.4)
Excess FMI (RR)	CL	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
	LI	0.94 (0.65, 1.36)	0.92 (0.65, 1.30)	0.87 (0.61, 1.25)	0.78 (0.55, 1.12)
	HI3/5	1.39 (0.99, 1.97)	1.24 (0.89, 1.44)	1.32 (0.95, 1.84)	1.09 (0.77, 1.54)
	HI	1.22 (0.84, 1.79)	1 (0.69, 1.44)	1 (0.68, 1.47)	0.87 (0.57, 1.32)
FFMI (kg/m^2)	CL	0.0 (Reference)	0.0 (Reference)	0.0 (Reference)	0.0 (Reference)
	LI	−0.0 (−0.2, 0.2	−0.0 (−0.2, 0.2)	−0.0 (−0.2, 0.1)	−0.0 (−0.2, 0.1)
	HI3/5	−0.1 (−0.3, 0.1)	−0.1 (−0.3, 0.1)	−0.1 (−0.3, 0.1)	−0.1 (−0.3, 0.1)
	HI	0.0 (−0.2, 0.2)	0.1 (−0.12, 0.3)	0.0 (−0.2, 0.2)	0.0 (−0.2, 0.2)
LMI (kg/m^2)	CL	0.0 (Reference)	0.0 (Reference)	0.0 (Reference)	0.0 (Reference)
	LI	−0.0 (−0.2, 0.2)	0.0 (−0.2, 0.2)	−0.0 (−0.2, 0.1)	−0.0 (−0.2, 0.1)
	HI3/5	−0.1 (−0.3, 0.1)	−0.1 (−0.3, 0.1)	−0.1 (−0.3, 0.1)	−0.1 (−0.2, 0.1)
	HI	0.0 (−0.2, 0.2)	0.1 (−0.1, 0.3)	0.0 (−0.2, 0.2)	0.0 (−0.2, 0.2)
A:G	CL	0.0 (Reference)	0.0 (Reference)	0.0 (Reference)	0.0 (Reference)
	LI	−0.0 (−0.1, 0.0)	−0.0 (−0.0, 0.0)	−0.0 (−0.1, 0.0)	−0.0 (−0.0, 0.0)
	HI3/5	0.0 (−0.0, 0.1)	0.0 (−0.0, 0.0)	−0.0 (−0.0, 0.0)	0.0 (−0.0, 0.0)
	HI	0.0 (−0.0, 0.1)	−0.0 (−0.1, 0.0)	−0.0 (−0.1, 0.0)	−0.0 (−0.0, 0.0)

Note: Multivariable regression results for the association of longitudinal trajectories of screen time development with DXA-measured FMI. Model 1 was adjusted for sex and age; model 2 was adjusted for sex, age, birthweight (cat.), and maternal age, origin, education, and BMI; model 3 was adjusted for all confounders in model 2 and BMI z-score at age 3; model 4 was adjusted for all confounders of model 3 and physical activity, sleep, and fish intake.

Abbreviations: A:G, android-gynoid ratio; CI, confidence interval; CL, constant low increase in screen time; Coef., coefficients; FFMI, fat free mass index; FMI, fat mass index; HI, high increase; HI3/5, high increase in screen time between age 3 and 5; LI, low increase in screen time; LMI, lean mass index; RR, risk ratio.

assess screen use and employed an indirect assessment of body composition.

Comparing our publication to current evidence, several differences should be pointed out. While our study suggested confounding by several maternal characteristics and child lifestyle factors, this may only apply in a Danish context. We do however expect similar confounding structures in other populations of children, and less attention to confounding in other studies may explain discordant findings.[46] In addition to our attempt to remove bias arising from confounding, selection bias may explain why the present findings differ from previous analyses.[9] Our sensitivity analyses highlight the importance of addressing selection bias and may suggest that previous reports could have been subject to selection bias as a result of high loss-to-follow-up (e.g. 27%,[49] 32%[46] and 69.9%[50]). To our knowledge, all previous publications did not repeatedly assess screen time likely exposing their analyses to misclassification bias.[51] Missing data in comparable studies were often computed using MI.[46,48,50] Lastly, when considering all differences between this analysis and previous publications, we propose that the current literature is more closely related to the findings of model 1 without IPW (Table S4) in this analysis. Although this model suggests an association between FMI and the trajectories 'high increase between three and five' and 'high increase' in the OCC, it disregards various biases.

Furthermore, Padmapriya et al.[50] recently published a prospective analysis reporting a significant association of screen time at ages 2 and 3 years with magnetic resonance imaging-assessed abdominal fat at 4.5 years. As this study was adjusted for various confounders and entailed sensitivity analyses, similar studies are warranted. In summary, current observational evidence remains insufficient to determine with confidence whether there is a prospective association between screen time and accurately assessed body composition in children. Regarding experimental literature, our findings are in line with a recent meta-analysis concluding that there was no evidence for the effect of an exclusive screen time reduction intervention on the risk of obesity in children.[52]

In summary, the evidence for a positive association of screen time and FM remains weak. Prospective observational studies using

accurate measures of body composition, objectively and repeatedly assessed screen time, and well-selected covariates are warranted. Randomised controlled trials should be carried out to further investigate the effect of changing digital screen use habits on obesogenic behaviours in children. Such studies are needed to significantly improve the quality of evidence for a relationship between screen time and body composition and will inform the current guidelines on screen use in children.

5 | CONCLUSIONS

Our findings show no relationship of recreational screen time in early childhood with adiposity. Moreover, results highlight that several sources of bias may be an issue within current evidence including the importance of confounding and the prevention of selection bias.

AUTHOR CONTRIBUTIONS

MR and AG conceptualized the study. MR, JSP, and AG developed the statistical analysis plan. HKE, MGBR, PLK, JSP, and AG designed parts of the data collection tools and monitored data collection. MR and AG conducted statistical analysis with the assistance of JSP. MR, JSP, and AG drafted the initial manuscript and revised the paper. MGBR, HKE, NW, and PLK critically revised the manuscript and carefully contributed to intellectual content. All authors reviewed and approved the final manuscript.

ACKNOWLEDGEMENTS

We would like to acknowledge all families who continuously take the time to participate in the Odense Cohort study. Moreover, we would like to thank the staff at the study centre for recording and supplying the necessary data for this study. Additionally, we thank the OPEN, the researcher service organisation 'Open Patient data Explorative Network' for their large efforts for the OCC.

FUNDING INFORMATION

This work was supported by the European Research Council (Grant number 716657). AG was also supported by grants from the Novo Nordisk Foundation (Grant number NNF20SH0062965). The funder of the study had no role in study design; collection, analysis, and interpretation of data; writing the report; and the decision to submit the report for publication.

CONFLICT OF INTEREST STATEMENT

The authors declare no competing interests.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

PATIENT CONSENT

Not applicable.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Rietz M, Schmidt-Persson J, Rasmussen MGB, et al. Recreational screen time trajectories during early childhood and imaging-measured body composition at age 7 in the Odense child cohort. *Paediatr Perinat Epidemiol*. 2023;37:415-424. doi:10.1111/ppe.12956