RESEARCH

The relationships between parents’ and children’s screen times on body mass index: a cross-sectional path analysis

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Abstract

Background: Understanding factors contributing to an individual reducing screen time is essential for promoting a healthy weight. Parents’ behavior affects children by influencing their daily decision-making through modeling, rules or restrictions, social support, and co-participation. We examined how the direct and indirect effects of parents’ and children's behaviors regarding screen time influenced body mass index (BMI) among Japanese elementary school children.

Methods: We included 283 Japanese children, one child per household, aged 6-12 years, who were randomly selected from resident registries of two cities. The questionnaires were completed by children and their mothers and fathers. Screen time and sociodemographic attributes, including sex, age, employment status, height, and weight, were assessed using a mail-based survey. Path analyses were conducted to determine associations among children's, fathers', and mothers' variables. It was hypothesized that after controlling for household income and children's sex and age, mothers' and fathers' screen time on weekdays and weekends would be related to children's weekdays and weekend screen time, respectively. In addition, we hypothesized that children's weekday and weekend screen time was related to children's BMI.

Results: Both fathers' and mothers' weekday screen times were associated with children's weekday and weekend screen times. BMI was affected by children's weekday screen time (0.117). The path coefficients for the indirect effects of mothers' and fathers' screen time on children's BMI through children's weekday screen time were 0.016 from the fathers' weekday screen time and 0.024 from the mothers' weekday screen time (GFI = .980, AGFI = .953, RMSEA = .030, AIC = 93.030).

Conclusions: Both fathers' and mothers' weekday screen times indirectly affected children's BMI through children's weekday screen time among Japanese elementary school children. The strongest indirect effects could be seen by examining the paths of a mother's weekday screen time through children's screen time to BMI. Mothers who spend much time with their children are role models, and their behavior could affect the child's behavior. The findings imply that intervention strategies to reduce screen time in children should also focus on modeling the mothers' behavior.

Keywords: Sedentary behavior, Elementary school children, Sitting, Body mass index, Asia

Background

Obesity in children is a public concern worldwide and is associated with type 2 diabetes, hypertension, and an increased risk of obesity in adulthood [1, 2]. For example, in Japanese school-aged children, 11.1% of boys and 8.8%...
of girls aged 11 years were classified as obese in 2019 [3]. Compared to other developed countries, levels of obesity in Japanese school-aged children are low [4]; however, the percentage has grown in the last 10 years [3]. Especially in girls, elementary school-age students are more likely to be obese or overweight than junior high school or high school-age students [3]. Therefore, preventing obesity in children is vital for their future health.

Excessive sedentary behavior is associated with poor health and can result in increased adiposity, worse cardiometabolic health and fitness, impaired behavioral conduct/pro-social behavior, and reduced sleep duration [5]. For children, several current physical activity guidelines [6, 7] recommend recreational screen time of no more than 2 h per day (i.e., watching television [T.V.], digital video discs, or videos, playing T.V. games, or using computers or the internet) and avoiding prolonged periods of sitting. Nevertheless, children spend too much time on their recreational screen time worldwide [8]. For instance, in the United States, 66% of children spend at least 2 h of screen time per day [9]. In Japan, approximately 60% of children have been found to exceed the 2 h per day mark of screen time [10].

Parents play an essential role in children’s daily decision-making through modeling, rules or restrictions, social support, and co-participation [11, 12]. Previous review studies have shown that parents’ screen time is positively correlated with children’s screen time [13–27], and co-viewing with parents has been associated with increased screen time in children [28, 29]. Moreover, the impact on children’s screen time appears to be dependent on the sex of the guardian, as a previous study reported that mothers’ screen-based behaviors showed a positive correlation with children’s screen time [17, 28, 29]. However, few studies have considered gender differences in parental roles. Studies that have examined both the father’s and mother’s influence on children’s sedentary behavior report that compared to the father’s sedentary behavior, the mother’s sedentary behavior influences the child’s sedentary behavior more [28, 29]. Xu et al. [30] concluded that reducing parents’ screen time could decrease their child’s screen time. Therefore, examining the impact of both fathers’ and mothers’ screen time on children is necessary.

In addition to the influence of the parents’ gender, it has been reported that the influence of the parents’ screen time on children’s screen time varies between weekdays and weekends [19, 27]. Jago et al. (2014) [27] concluded that associations observed between parent and child screen-viewing were different between weekdays and the weekend; they showed that on a weekday, children were 3.4 times more likely to exceed 2 h of screen viewing if their father watched T.V. for at least 2 h per day, while for a weekend day, children were 4.8 times more likely. There were similar associations for mothers; children were 3.7 times more likely to exceed 2 h of screen viewing if their mother watched T.V. for at least 2 h per day on a weekday, while children were 4.7 times more likely for a weekend. However, to our knowledge, only a few studies have examined the differentiation between weekdays and weekends [18, 19, 27].

The indirect effects and the strength of paternal and maternal screen time on children’s screen time and body mass index (BMI) have not been examined. However, some studies have examined each of these variables directly, such as parents’ screen time and children’s screen time [13–30] or children’s screen time and BMI [5]. Considering the impact of the behaviors of both father and mother on children in real life, parental behaviors may impact children’s screen time and BMI, and suggestions for specific interventions to improve children’s health might be possible through research. Thus, the present study examined how the direct and indirect effects of parents’ and children’s screen time behaviors influenced children’s BMI among Japanese elementary school children.

Methods
Participants and data collection
The present cross-sectional study was conducted in a cohort of children living in Musashino City, Japan, in 2018 and Kokubunji City, Japan, in 2017. A total of 4800 potential residents aged 6–12 years, one child per household, were randomly selected from the residential registries of their respective cities. These selected children and their parents were the study participants. Musashino (population: 150,660 in October 2021) and Kokubunji (population: 130,636 in October 2021) are cities in Tokyo, Japan. Because both cities have approximately the same size of age population, the present study stratified them to account for this population ratio. Potential participants were stratified by sex (boys/girls) and school grade (1st grade: 6–7 years, 2nd grade: 7–8 years, 3rd grade: 8–9 years, 4th grade: 9–10 years, 5th grade: 10–11 years, and 6th grade: 11–12 years). All mailings related to the mail-based survey were addressed to the children and their parents. First, invitation letters explaining the study were sent to all potential participants. A questionnaire and accelerometer were sent to those who responded to the invitation letter indicating they were willing to participate. To encourage a response, potential participants were told that a 1000-yen book voucher would be offered to those who returned the questionnaire and accelerometer. A
total of 1772 families (37.6% overall response rate; 881 responders from Musashino and 891 from Kokubunji) responded to the invitation. Then, self-administered questionnaires for children and their mothers and fathers were given, which included questions about sociodemographic variables, screen time, and children’s height and weight, were mailed to those who responded that they would be willing to participate (620 individuals; 12.9% of all the invited respondents who mentioned they would be willing to participate, 310 people in each city). A total of 484 tryads completed the questionnaire and accelerometer measurements (78.1% overall response rate; 81.0% from Musashino, and 71.3% from Kokubunji). Data from 283 children and their parents who fully completed both questionnaires were included in the analysis (Fig. 1). Participation was voluntary, and confidentiality was ensured. A previous study [31] suggested that children younger than 10 years cannot report their activity patterns accurately or reliably. Alternatively, parental reports of physical activity among 6-year-olds have been shown to strongly correlate with heart rate measures during physical activity [32]. Therefore, parents of the children were asked to complete the questionnaire with their children. In addition, only mothers were asked to respond to the mothers’ questionnaire and only fathers to the fathers’ questionnaire.

**Standard protocol approvals, registrations, and patient consent**

All children, mothers, and fathers signed an informed consent form before answering the questionnaire. The Ethics Committee of Waseda University, Japan, approved the study before its commencement (2017–245). The present study was conducted in accordance with the principles of the 2013 Declaration of Helsinki.

**Measures**

**Self-reported screen time**

Domain-specific sedentary behaviors were assessed using a questionnaire. For children, sedentary behavior was divided into six domains [10] (1) reading or listening to music, (2) TV or video viewing, (3) TV game use, (4) internet or e-mail (computer or tablet) use outside of class, (5) doing homework or assignments, and (6) car travel for transport. Participants were asked how many days on average per week and how much time (hours and minutes) on average per day they engaged in these sedentary behaviors during weekdays and weekends in each domain. Then the weekly frequency was multiplied by the number of minutes per day. Each domain-specific

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**Fig. 1** Participation flow

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sédentaire comportement a été examiné séparément, et nous avons calculé le nombre total moyen de minutes pour chaque semaine (lundi–vendredi) et week-ends (jours × minutes par jour). Le temps écran a été calculé en utilisant le total de domaines (2), (3), et (4). Les mères et pères ont été invités à rapporter le temps écran quotidien, séparément pour les jours de travail (lundi–jeudi pour les non-employés) et les jours de congé (weekend pour les non-employés) dans les six domaines suivants: (1) transport vers et depuis les lieux; (2) transports publics; (3) à la maison; (4) vision de télévision, de videos, et de DVDs; (5) l'utilisation d’un ordinateur, d’un téléphone portable, et de tablette; (6) temps libre (à l’exclusion de la vision de télévision, de videos, et de DVDs) [33]. La totalité du temps écran quotidien a été calculée par sommation de (4) et (5) pour les jours de travail et les jours de congé. Le temps écran quotidien a été calculé en tenant compte du nombre de jours ouvrables et de week-ends.

**Sociodémographiques facteurs**

Les données sur l’âge et le sexe des enfants ont été recueillies par les registres résidentiels. L’âge et le poids des enfants ont été obtenus de la questionnaire auprès des enfants. Le BMI a été calculé à partir de la hauteur et le poids (BMI = poids/hauteur [2]). Les BMI percentiles ont été calculés en utilisant le système métrique du Centers for Disease Control and Prevention [34]. Les enfants ont été classés en fonction de l'âge et du poids selon les recommandations BMI pour l’âge [34]: <5ème percentile, sous-poids; 5–85ème percentile, poids normal; 85ème percentile, surpoids ou obésité. En outre, le niveau de revenus des familles a été déterminé par le niveau de revenus (≥10,000,000 yens) et l'état de l'emploi (employé ou non) ont été évalués à partir des réponses des parents.

**Analyse statistique**

L’analyse statistique implique d'analyser les réponses des parents et des enfants. Les analyses ont été conduites pour déterminer la présence de toute association entre le poids et l'âge des enfants. Il a été hypothésé que le temps écran quotidien et les week-ends serait réglé à temps écran quotidien et les week-ends, respectivement; il est également été hypothésé que les temps écran quotidien et les week-ends serait réglé à temps écran quotidien et les week-ends. Les coefficients de path et corrélation sont rapportés comme estimées standardisées. Le modèle a été évalué en utilisant la statistique de la qualité de la programmation (GFI), ajusté goodness-of-fit statistique (AGFI), racine moyenne carrée de l’erreur d’approximation (RMSEA), et Akaiake information criterion (AIC).

GFI et AGFI indices étaient utilisés pour estimer comment bien le modèle fit les données. Les valeurs de 0.90 ou plus indiquaient un bon modèle ajusté [35]. RMSEA est une mesure de la statistique descriptive des mesures de modèle ajusté. Un RMSEA score valeur inférieure à 0.05 indiquait un bon ajustement [36]. Une valeur du AIC pour un modèle indiquait un meilleur ajustement que les autres modèles [37]. Le modèle a été considéré pour être ajusté suffisamment bien lorsque les critères suivants étaient vérifiés: GFI > 0.90, AGFI > 0.90, RMSEA < 0.06, et une valeur plus faible AIC comparé aux modèles concurrents. Statistique significative a été ajusté à p < 0.05. Les données ont été analysées en utilisant des analyses par path estimé à l'aide IBM SPSS AMOS 27.0 pour Windows (IBM Corp., Armonk, N.Y., USA).

**Résultats**

**Demographics and screen time of the participants**

Un total de 283 enfants japonais et dyads (127 garçons et 156 filles; 144 en Musashino et 139 en Kokubunji) ont complété le questionnaire. Le tableau 1 montre les caractéristiques démographiques des participants et leur temps écran lors de la semaine et les week-ends. L'enfant moyen (standard deviation) d'âge était de 8.7 (1.7) ans, et 82.3% des enfants avaient un poids de santé. En ce qui concerne la situation socio-économique, 41.7% des familles avaient un revenu de ≥10,000,000 yens. Le poids, le poids de la mère, et le père moyens temps écran étaient de 112.5 (92.1), 148.1 (112.4), 123.1 (86.6) sur les jours de travail, 155.4 (102.1), 167.5 (108.3), et 212.9 (134.8) sur les week-ends, respectivement. Le pourcentage de employé mère et le père répondants étaient de 66.1 et 99.3%, respectivement.

**Direct and indirect effects of parents’ and children’s screen time behaviors on BMI**

Figure 2 montre les relations directes et indirectes entre le jour de travail et les week-ends et les temps écran des parents et des enfants, le temps écran des enfants, le temps écran des parents, et le BMI. Les coefficients de path standard jugé co-efficient les coefficients de régression. Avec les coefficients de path standard, la magnitude de chaque facteur peut être directement comparé avec les autres facteurs dans le modèle. Le présent étude n'a pas identifié de significative associations entre (1) les parents’ or mothers’ weekday screen times and children’s weekend screen times, or (2) between fathers’ or mothers’ weekend screen times and children’s weekday screen times, or (3) between children’s weekend screen times and BMI (GFI = 0.985, AGFI = 0.953, RMSEA = 0.029). Recalculating the model using modified indices reduced the AIC value from 96.351 to 93.030. Thus, the final model demonstrated an acceptable fit (GFI = 0.980, AGFI = 0.953, RMSEA = 0.030). Both parents’ and mothers’ weekday screen times were seen to affect children’s weekday screen times:...
Discussion

The present study indicated that both fathers’ and mothers’ weekday screen times indirectly affected children’s BMI through children’s weekday screen times among Japanese elementary school children.

There have been no consistent research findings on whether weekday or weekend screen times influence children’s BMI. Only children’s weekday (and not weekend) screen times were associated with BMI in the present study. A study of adolescents showed no significant correlation between weekday and weekend T.V. viewing times and BMI [38]; on the other hand, a study of preschool children showed that only children’s weekend screen times were associated with BMI [18]. The small number of studies evaluating the effects on BMI that separated weekday and weekend screen times may have contributed to the lack of consistent results because whether it is a weekday or a weekend, a previous study [5] suggested that the total screen time has an impact on BMI. However, to reduce children’s screen time, it would be helpful to consider what factors should be addressed on weekdays and weekends separately to adopt those concrete strategies. For example, a study of preschool children [18] reported that there was an association between screen time and BMI on weekends; however, the reason for no association between screen time and BMI on weekdays was that the total amount of time spent in front of a screen on weekdays was low. After all, the preschooler/students went to kindergarten/preschool/school. In this study, the total screen time per week (9.4 hours on weekdays, 5.2 hours on weekends) was also significantly higher on weekdays than at weekends, which may be one of the reasons for this discrepancy.

Fathers’ and mothers’ weekday screen times influenced children’s weekday screen time, which influenced BMI, and for both weekdays and weekends, the influence of a mother’s screen time was stronger than that of a father’s screen time. One previous study on the influences of parent screen time indicated that increased T.V. time of the child was associated with increased father’s T.V. time (father odds ratio = 2.33 times, mother odds ratio = 2.24 times) than with mother’s T.V. time [24]. The impact of fathers’ T.V. time on children’s T.V. time was stronger than that of mother’s T.V. time in elementary school children (mean age 7.6 years), a similar cohort to the present study [24]. On the other hand, adolescents aged 12–13 years watching T.V. ≥ 2 hours per day were associated with mothers who watched T.V. ≥ 2 hours per day, but there was no association with fathers’ T.V. time [28]. One of the reasons that these relationships were stronger for mothers than fathers in this study was that children in Japan spend more time with their mothers. A 2016 Ministry of Internal Affairs and Communications survey showed a

| Table 1 | Descriptive characteristics (numbers and percentages) |
|---------|-----------------------------------------------|
| **Variables** | **n** | **%** |
| Overall | 283 | 100.0 |
| Sex | | |
| Boys | 127 | 44.9 |
| Girls | 156 | 55.1 |
| Age, group | | |
| 6years | 18 | 6.4 |
| 7years | 61 | 21.6 |
| 8years | 69 | 24.4 |
| 9years | 49 | 17.3 |
| 10years | 38 | 13.4 |
| 11years | 29 | 10.2 |
| 12years | 19 | 6.7 |
| Mean±S.D. | | |
| BMI percentile for age and sex | | |
| Underweight (< 5th %ile) | 21 | 7.4 |
| Normal BMI (5th - 85th %ile) | 233 | 82.3 |
| Overweight or obese (≥ 85th %ile) | 29 | 10.2 |
| Household income level | | |
| <3,000,000 yen | 3 | 1.1 |
| <5,000,000 yen | 26 | 9.2 |
| <7,000,000 yen | 41 | 14.5 |
| <10,000,000 yen | 95 | 33.6 |
| ≥10,000,000 yen | 118 | 41.7 |
| Employment status, employed | | |
| Mother | 79 | 66.1 |
| Father | 280 | 99.3 |
| Screen time-weekday, min/day, Mean±S.D. | | |
| Children | 112.5±92.1 |
| Mothers | 148.1±112.4 |
| Fathers | 123.1±86.6 |
| Screen time-weekend, min/day, Mean±S.D. | | |
| Children | 155.4±102.1 |
| Mothers | 167.5±108.3 |
| Fathers | 212.9±134.8 |

Abbreviations: BMI Body mass index, S.D. Standard deviation

0.136, from mothers’ weekday screen times: 0.203), and both fathers’ and mothers’ weekend screen times were seen to affect children’s weekend screen times (from fathers’ weekend screen times: 0.139, from mothers’ weekend screen times: 0.271). BMI was affected by the children’s weekday screen times (0.117). The path coefficient for the indirect effects of mothers’ and fathers’ screen times on BMI through children’s weekday screen times was 0.016 from the fathers’ weekday screen times and 0.024 from the mothers’ weekday screen times.
significant difference in the average time spent with elementary school-aged (over 10 years old) children per day: 4 hour 52 min for mothers and 2 hour 40 min for fathers [39]. Moreover, this trend seems to be associated with the employment rate of both parents in this study, as fathers were 33.2% more likely than mothers to be employed. Parents are role models for their children, and by shared time, their behavior could affect a child's behavior. Therefore, maternal modeling might have a stronger effect than paternal modeling on child behavior, as Japanese children spend much time with their mothers.

Moreover, a previous study [19] that examined weekday and weekend screen times separately found no association between parents’ and children’s screen times; this study did not examine the fathers’ and mothers’ screen times separately. In contrast, another study [27] that examined weekday and weekend screen times found associations between children's weekday and weekend screen times and both fathers’ and mothers’ screen times on weekdays and weekends; this study examined the fathers’ and mothers’ screen times separately. In a study with at least one parent and a child aged 5–6 years, when parents exceeded 2 h of T.V. watching, children were 3.4 times and 4.8 times more likely to spend ≥2 hours T.V. watching during the weekdays and weekends, respectively, if their father exceeded the threshold; the odds were 3.7 for the weekdays and 4.7 for the weekends if their mothers exceeded the threshold [27]. This means that the influence of fathers and mothers may be different on weekdays and weekends. However, in the present study, although both fathers’ and mothers’ weekday screen times influenced children's weekday screen times and both the fathers’ and mothers’ weekend screen times influenced children's weekend screen times, the influence of the mothers’ screen times was stronger than that of the fathers’ screen times on both weekdays and weekends. Japanese children aged 10–14 years spend an average of 258 min with their mothers and 125 min with their fathers on weekdays, but on Sundays, they spend 411 min with their mothers and 272 min with their fathers; thus, although the children spend some time with their fathers, they spend 1.5 to 2 times longer time with their mothers [39]. Given this difference in Japan, the results of this study, which examined weekday and weekend screen times and paternal and maternal screen times separately, help develop intervention strategies to prevent obesity in Japanese children and reduce screen time.

Regarding the indirect effects on BMI, the strongest path was the influence of maternal weekday screen times on BMI via children’s weekday screen times (0.024). On the other hand, fathers’ indirect effects were 0.016. This may be partly due to the strong maternal commitment to weekday children’s screen times, which suggests that mothers’ influence should be considered when reducing screen time to improve BMI among Japanese children. Although the study did not examine fathers or mothers separately and was conducted in preschool-aged children, the indirect effect of parental screen time on children’s BMI was found only on weekends [18]. In addition, the study that did not examine weekdays and weekends separately examined fathers’ and mothers’ physical activities separately and showed that the effect of mothers’ physical activity on children’s physical activity, which affects children’s BMI, was significant, but the effect of fathers’ physical activity was not [22]. There is a lack of research on modeling fathers’ and mothers’ behaviors on children’s behaviors, and of children’s behaviors on BMI; further research should be conducted in the future. For
example, previous studies have reported efforts to reduce sedentary behavior in children and their parents through interventions targeting mothers and children [40]. There have been efforts to reduce parental sedentary behavior through parent education [41]. In the case of Japanese children, these interventions have not been reported. These efforts are expected to improve maternal literacy and reduce children's screen time, thereby improving their anthropometric indices.

Some limitations of this study should be considered. First, the study's cross-sectional nature limits the conclusions that can be drawn about the cause and effect of the observed relationships between parents' and children's screen times and anthropometric factors. Second, to estimate screen time, the study relied on self-reported measures with the potential for error owing to different interpretations of the questions. However, for children, the screen time scale has been used in a national survey of Japanese elementary school children [42], and the parent screen time scale confirmed its reliability and validity [33]. Third, the study respondents were slightly different from the general population. To estimate the representativeness of the participants’ responses, the population percentage by age group in the present study was compared with data from population estimates [43]. The proportion of boys and girls aged 6–12 years was 45% (Kokubunji:44.6%, Musashino:45.1%) for boys and about 55% (Kokubunji:55.4%, Musashino:54.9%) for girls in this study, while the national data was about 51% for boys and 49% for girls. Therefore, the essential characteristics of respondents might have been biased. The findings in such a setting may not sufficiently apply to the general population. However, the present study randomly selected participants from a registry of each city's residential addresses, allowing an equal number of potential selects to be obtained from both sexes and each age group category between 1st grade and 6th grade. Although only sex and age distributions, the comparable variables investigated in this study, are compared, the present study population can be considered to have characteristics of the general population. Despite these limitations, few studies have been conducted on this topic in a randomly selected Japanese population, and the findings from the present study will contribute to a greater understanding of parental influences on children’s screen time and anthropometric factors and may also help to develop new strategies and interventions to promote public health and well-being in Japan.

Conclusions
The present study indicates that both the fathers’ and mothers’ weekday screen times indirectly affected children's BMI through children's weekday screen times among Japanese elementary school children. The influence of the mothers’ screen times was stronger than that of the fathers’ screen times. The strongest indirect effects were seen by examining the paths of the mothers’ weekday screen times via children's screen times to BMI. The total effect of the mothers’ weekday screen times on BMI was 0.024. The present study’s findings imply that intervention strategies to reduce screen time should also focus on mothers’ modeling of children’s health status.

Abbreviations
AGFI: Adjusted goodness-of-fit statistic; AIC: Akaike information criterion; BMI: Body mass index; GFI: Goodness-of-fit statistic; RMSEA: Root mean square error of approximation; T.V.: Television.

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Authors’ contributions
K.I conceived the study, participated in the design of the study, performed the statistical analyses, and drafted the manuscript. A.S and K.O participated in the design of the study and coordination, and helped in drafting the manuscript. M.J.K contributed to the writing and assisted with the interpretation of the results. All the authors have read and approved the final manuscript.

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Availability of data and materials
The datasets generated and/or analyzed during the current study are not publicly available because ethical considerations but are available from the corresponding author on reasonable request.

Declarations
Ethics approval and consent to participate
All children, mother, and father signed an informed consent form before answering the questionnaire. The Ethics Committee of Waseda University, Japan, approved the study prior to its commencement (2017–245). The present study was conducted in accordance with the principles of the 2013 Declaration of Helsinki.

Consent for publication
Informed consent was obtained from all the participants for publish the data in open access journal.

Competing interests
The authors declare that they have no competing interests.

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