Insufficient physical activity and overweight: Does caregiver screen-viewing matter?

Abstract

Physical activity (PA) is essential for children's health and well-being, yet many children around the world do not meet the recommended PA levels. Screen-viewing behavior is one of the possible factors leading to low levels of PA and being overweight. Although research in Western countries shows that caregivers' screen-viewing behavior and rule-setting are associated with their children's screen-viewing behavior, these results may not be generalizable to East Asian populations. Therefore, the current study proposed two mediation models to investigate whether insufficient physical activity mediates the relationship between children's screen viewing behavior and overweight status, and whether such screen-viewing behavior mediates the relationship between caregiver factors and children's overweight status. The participants in this study comprised 1,031 elementary school students (516 boys and 515 girls) in Taiwan. Through a cross-sectional design, caregivers reported their children's PA levels, screen-viewing time, body mass index (BMI), home environment, and caregivers' rules regarding screen-time restrictions. Additionally, a χ^2 test was used to examine the differences between children with and without sufficient PA. The results from χ^2 tests suggest that, in the insufficient PA group, the caregivers tend to have excessive screen time per day and have no rules to manage their children's screen-viewing behavior. Furthermore, the children in this group are more likely to have excessive screen-viewing time per day than their counterparts. Sobel tests revealed that insufficient PA was a mediator in the relationship between children's screen-viewing behavior and being overweight. Children's screen-viewing behavior was also found to be a mediator in the relationship between caregivers' factors and being overweight. The results of the current study indicate that caregivers' screen-viewing behavior and caregivers' screen-viewing rules may be associated with their children's insufficient PA levels and overweight problems, which, in turn, are related to their children's screen-viewing behavior. Future efforts at childhood overweight intervention should consider the inclusion of educational and behavioral programs designed for caregivers, rather than targeting children alone.

Keywords: Child, Overweight, Caregivers' Rules, Physical Activity, Screen Time

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Introduction

Participating in physical activity (PA) on a regular basis is crucial to enhancing children's health and well-being (Gao, Zhang, & Stodden, 2013). Specifically, sufficient PA maintains both physical health and psychological health (Janssen & LeBlanc, 2010; World Health Organization [WHO], 2011). The WHO PA guidelines indicate that children from 5–17 years of age should engage in moderate to vigorous intensity PA (MVPA) for at least 60 minutes per day (WHO, 2011). Unfortunately, the global average rate of PA is below the recommended levels in children and adolescents. Insufficient PA often results in being overweight. Indeed, a negative relationship was found between PA and body mass index (BMI) among residents of 29 countries (Janssen et al., 2005), and the increased prevalence of being overweight in children across Europe, Canada, and the United States from 2002 to 2010 may be attributable to the decline in PA (Ahluwalia et al., 2015). Thus, making PA a habit has been proposed to help prevent children and adolescents from overweight (Jimenez-Pavon, Kelly, & Reilly, 2010).

A global survey across 105 countries found that up to 80% of 13- to 15-year-old children did not meet the WHO's PA guidelines (Hallal et al., 2012). In Taiwan, approximately 33% of elementary school-aged children achieved the standard of 30 minutes of daily PA (Lan, Kuo, & Zhang, 2015), in line with the level recommended by Taiwan's Bureau of Health Promotion. This national policy—implemented in 2015 for children from 6-18 years of age—advocates that children engage in PA at school for at least 150 minutes per week (Sports Administration, Ministry of Education, 2015). However, 150 minutes per week is still below the WHO's PA standard. Furthermore, the Sports Administration declared that the rate of participation in PA for children aged 6-18 decreases as they grow older (Sports Administration, Ministry of Education, 2016). Therefore, for Taiwanese children, the level of PA engagement is lower than that which has been recommended.

Exploring the possible factors related to insufficient PA is warranted because of the critical role of PA. Although many studies have demonstrated a negative relationship between PA and weight, one review paper showed there were some contradictory findings (Prentice-Dunn & Prentice-Dunn, 2012). For instance, levels of PA were not correlated with BMIs in some German children (Graf et al., 2004). On the other hand, among children in New Zealand, higher levels of screen-viewing (e.g., watching TV and playing computer games) were associated with higher BMIs (Oliver et al., 2011). Hence, the effect of PA on weight may be complicated when the influence of screen-viewing behavior is involved. Indeed, the declining level of PA engagement for children may be due to screen-viewing behavior apart from other causes. With the growth of technology, researchers have begun to notice that screen-viewing behavior (e.g., using smartphones and computers, or watching TV) is

restricting children from engaging in PA (Boone, Gordon-Larsen, Adair, & Popkin, 2007; Marshall, Biddle, Gorely, Cameron, & Murdey, 2004; Sisson, Broyles, Baker, & Katzmarzyk, 2010).

However, the issue regarding screen-viewing behavior has been subject to very little research in Chinese populations, especially in Taiwan. The National Health Interview Survey in Taiwan showed that the average TV viewing time of 3- to 11-year-old children was 107.2 minutes per day on weekdays, and 203.7 minutes per day on weekends (National Health Research Institutes, 2012). Today, the accelerating development of digital technology has resulted in the increasing accessibility of electronic screen products. It seems common for caregivers to use electronic devices such as TVs or smartphones to calm or reward their children (Lampard, Jurkowski, & Davison, 2013). As children's screen time is prolonged, the duration of their physical activities declines (Gebremariam et al., 2012). Such an issue has also emerged in Taiwanese society, and studying the relationship between screen-viewing behavior and PA in Taiwan is thus imperative.

The phenomenon of engaging more in screen-viewing behavior but less in PA may contribute to weight problems. Overweight individuals tend to have less PA and more TV time than normal-weight individuals (Janssen et al., 2005). In addition, for children aged 6-17 in the U.S., the odds ratio of being overweight was nearly doubled for children who engaged in low PA (having 20 minutes of PA on only two or fewer days per week) and high screen-viewing time (more than 2 hours per day) compared to children who had high levels of PA and low screen-viewing time (Sisson et al., 2010). One study in Taiwan showed that high school adolescents had higher BMIs when they had higher levels of TV viewing, but only when they also had lower levels of exercise (less than 1 hour per day) (Yen et al., 2010). A longitudinal study in the U.S. indicated that TV-viewing is a predictor of changes in BMIs (Proctor et al., 2003). In the age span that included children aged 4 to 11, the group of children who watched TV most frequently experienced the most weight gain, while the group with the middle-watching levels experienced intermediate weight gain, and the lowest watching level group experienced the least weight gain.

In light of these concerns, healthcare providers and clinicians are keen to identify potential factors related to children's screen-viewing behavior. Two factors have been identified: caregivers' screen-viewing behavior and caregivers' rules on their children's screen-viewing behavior (Barr-Anderson et al., 2011; Birken et al., 2011; Jago et al., 2014). In England, when fathers and mothers watched TV for more than 2 hours per day, their 5- to 6-year-old children were approximately 3.5 times more likely to watch TV for more than 2 hours on weekdays (Jago et al., 2014). These associations were even stronger on weekends, where the odds ratios of children who watched TV for more than 2 hours was approximately 5 for those with parents who also watched

TV for more than 2 hours.

Caregivers' rules may be a protector. Lampard et al. (2013) illustrated that rule-setting can control children's screen-viewing. When caregivers in the U.S. classified themselves as high restrictors of their 2- to 5-year-old children's screen time, their children were three times more likely to meet the recommendation (i.e., screen time less than 2 hours per day) than children whose caregivers classified themselves as low restrictors. Similar results were shown in a study from England by Jago et al. (2011): the chance of watching TV for 2 to 4 hours and more than 4 hours for children aged 10-11 with fewer parental screen time limits was 2.2 to 3.3 times higher than those with more parental screen time limits.

However, it is unclear whether caregivers' screen-viewing behavior and caregivers' rules are indirectly associated with insufficient PA and being overweight through children's screen-viewing behavior. It is also unclear whether the associations could be applied in an East Asian culture. Bürgi et al. (2010) suggest that even within the same country, the level of PA and screen time varies among different ethnicities. This could be explained by cultural norms and beliefs (Bürgi et al., 2010). Thus, the level of PA and screen time among East Asians may also be different from Western populations. Specifically, Chinese people are firmly attached to their families (high connectedness) and usually adopt values, behaviors or habits from their particular context (Li, 2002). Hence, caregivers' screen-viewing behavior and rules may be more influential among children in East Asian cultures than in those in Western cultures. In terms of rules and restrictions, cultural differences were found between Euro-Canadian and Chinese in the way parents manage their children's behaviors (Mah & Johnston, 2012). Given the aforementioned research gaps, studying an Asian sample is warranted to investigate the mediated effects of insufficient PA on the weight status of children, and the mediated effects of children's screen-viewing behavior in the associations between caregiver factors (i.e., caregivers' rules and their screen-viewing behavior) and their children's PA and weight status.

Therefore, a community sample in Taiwan was used to examine associations between caregiver and child factors associated with children's PA and weight status. Two mediation models were proposed to understand the associations: Model 1 was a basic model which suggested that children's screen-viewing was linked to their insufficient levels of PA, which then led to their being overweight; Model 2 further incorporated caregivers' screen-viewing behavior and caregivers' rules in Model 1 (Figure 1a), and hypothesized that both caregiver factors were associated with children's screen-viewing behavior, which then led to children's insufficient levels of PA and to their being overweight (Figure 1b). The proposed models may provide additional knowledge about the associations between caregiver factors, children's screen-viewing behavior, children's PA,

and children's weight status with the analyses comparing sufficient/insufficient PA groups. Although Model 2 was a more comprehensive model than Model 1, comparing Model 2 with 1 can help us examine whether omitted-variable bias exists in the simpler model (Model 1). Thus, future studies should not ignore the caregiver factors in studying children's screen-viewing behavior, PA, and weight status. Such information may be used to foster possible interventions to increase children's PA and to prevent children from becoming overweight. Having a familial intervention involving caregivers may be more effective than using individual interventions for children in Eastern cultures.

(Insert Fig. 1 about here)

Method

Participants

Participants aged between 7 and 12 were recruited from two elementary schools in Yi-Lan City, Taiwan. The eligibility criteria to enroll in this study were that the children needed to be of elementary school age, with no physical disabilities (e.g., wheel-chair users), intellectual disabilities, or chronic diseases (e.g., Asthma) that would affect their participation in PA. After excluding those who did not meet our inclusion criteria, the recruitment yielded a valid sample size of 1,031 cases.

Procedures

Before collecting the data, the study protocol was approved by the Research Ethics Committee of National Taiwan University Hospital's Institutional Review Board (IRB). The participating respondents (including parents and primary caregivers, such as grandparents) were all the legal guardians of the children involved. All the respondents were given consent forms, and information sheets stating the clear purposes of the study. Once the caregivers had signed and returned the written consent forms, the study questionnaires were sent to the families. The questionnaire included information regarding the status of their children's health, PA levels, screen-viewing time (weekdays, weekends and weekly averages for both the children and their caregivers), and caregivers' rules. 1,300 copies of the questionnaire were distributed, of which 1,031 completed copies were returned, yielding a participation rate of 79.3%.

Measures

Demographic data. The studied sample comprised 516 boys and 515 girls. The distribution in each grade level was as follows: 188 first graders (18.2%), 127 second graders (12.3%), 178 third graders (17.3%), 184 fourth graders (17.8%), 180 fifth graders (17.5%), and 174 sixth graders (16.9%). Parents comprised 93.9% of the respondents, of which more than half had an educational level equal to or higher than college (53.6%).

Physical activity. In line with the policy in Taiwan encouraging children to engage in PA for at least 150 minutes per week at school (Sports Administration, Ministry of Education, 2015), the PA standard for children in this study was designated by requiring that the child should "engage in PA (MVPA) for at least 30 minutes per day." The single question used to assess the children's PA was, "In the past week, how many days did your child reach 30 minutes (or more) of physical activities?" The options for the answers ranged from 0 to 7 days. Children were categorized as meeting the recommended standard if the response to the PA question was 7 days per week.

Screen time. Screen time was measured based on the survey questionnaire developed by Gebremariam et al. (2012), which contains four main questions based on weekday and weekend usage of computers/smartphones/tablets and TVs, featuring the following questions: (1) "How much time does your child typically spend on using the Internet, reading emails, online chatting or gaming with a computer, smartphone or tablet during his/her free time on weekdays?" (2) "How much time does your child typically spend on using the Internet, reading emails, online chatting or gaming with a computer, smartphone or tablet during his/her free time on weekends?" (3) "How much time does your child typically spend watching TV during his/her free time on weekdays?" (4) "How much time does your child typically spend watching TV during his/her free time on weekends?" The choices for the answers included the following: less than 30 minutes, 30 minutes-1 hour, 1-2 hours, 2-3 hours, 3-4 hours, or more than 4 hours. The test-retest reliability of the original questionnaire was acceptable ($r = 0.66$-0.73) (Gebremariam et al., 2012). The internal consistency reliability in this study was found to be satisfactory for all subscales and total scores (Cronbach's $\alpha = 0.76$-0.80). For each of the questions, the responses were dichotomized to either "Screen-viewing equal to or less than 2 hours" and "Screen-viewing more than 2 hours". Children who had "Screen-viewing equal to or less than 2 hours" for each question were categorized into the "proper screen time" group, while the others were categorized into the "excessive screen time" group. The same four questions were also used for the caregivers.

Weight status. Participating caregivers were asked to report the weight and height of their children, based on their children's physical examination reports issued twice a year by their schools. The children's weight and height were not measured exactly at the time the study was conducted since the measurements for the children's physical examination reports had just been completed before data collection for the study began, and these were available for use in the study.

On receipt of the information, the BMI for each child was calculated as weight in kilograms divided by height in meters squared. Based on the specific age standard (Health Promotion Administration, Ministry of

Health and Welfare, 2013), which is widely used in Taiwan, we applied different BMI cut-off points to define what being overweight consisted of for different ages. For example, the BMI cut-off points for being overweight for 7- and 8-year-old children are 18.6 and 19.3 kg/m^2 respectively, and the children were categorized into the non-overweight or overweight groups accordingly.

Home environment. To evaluate the home environment—which may serve as an additional explanation for a child's screen-viewing behavior—the following questions were asked: "Whether the children have their own room"; "Number of computers and TVs the family owns," "Whether children have a TV in their room."

Caregivers' rules. Whether or not the caregivers set restrictions on children's recreational screen-viewing time was determined through the question: "Do you set a time limit for your children's screen-viewing?" The answer options were simply "Yes" or "No.", however, those respondents who answered "Yes" were required to indicate the length of the limit.

Data Analysis

Descriptive statistics were performed for the demographics of the entire sample, the sufficient PA group, and the insufficient PA group. In addition, a χ^2 test was used to examine whether the two groups differed on demographic variables. Three odds ratios with 95% confidence interval (CI) were conducted (de Jong et al., 2013; Szumilas, 2010): the first tested whether children's screen-viewing behavior is a risk factor for being overweight; the second tested whether children's screen-viewing behavior is a risk factor for insufficient PA; the third tested whether having a TV in the child's room is a risk factor for excessive screen-viewing. Moreover, we constructed a regression model to examine how the children's health was related to insufficient PA and screen-viewing behavior. In addition, age and gender were controlled for in the regression model.

Two models were used to examine the mediation effects of sufficient PA (Figure 1a) and children's screen-viewing behavior (Figure 1b). Specifically, the relationships between the factors of the children's screen-viewing behavior, insufficient PA, and overweight status in Model 1 (Figure 1a) were examined, while the two caregiver factors of caregivers' screen-viewing behavior and caregivers' rules were added to Model 2 (Figure 1b). Both models were adjusted for age and gender. Sobel tests (Sobel, 1982) were used to examine the mediated effect. In both models, we adopted comparative fit index (CFI), weighted root mean square residual (WRMR), and root mean square error of approximation (RMSEA) to decide whether the model was acceptable. We used CFI greater than 0.9, WRMR less than 1.0, and RMSEA less than 0.08 to indicate satisfactory fit (Cook, Kallen, & Amtmann, 2009; Lin, Oveisi, Burri, & Pakpour, 2017; Lin, Strong, Tsai, Lin, & Fung, 2018;

Lin, Updegraff, & Pakpour, 2016). However, it should be noted that the WRMR is a newly-developed index which is significantly influenced by a large sample size (DiStefano, Liu, Jiang, & Shi, 2018). Distefano et al. (2018) also suggested that it is appropriate to set the cutoff of the WRMR slightly higher than 1.0. Therefore, a slightly higher cutoff point over 1.0 would be regarded as acceptable (Distefano et al., 2018).

All the analyses were performed using SPSS 23.0 (IBM, Armonk, NY, USA), except for the mediation models, which were conducted using the latent variable analysis (lavaan) package (Rosseel et al., 2015) in R software.

Results

Table 1 shows that there were no significant differences between the group with sufficient PA and the group with insufficient PA, in terms of age, gender, family income, children having their own bedrooms, and the number of computers, TVs, and smartphones in the home. The insufficient PA group had more children without caregivers' rules than the sufficient PA group (28.3% *vs.* 19.2%, p=0.005), more children's screen-viewing behavior of more than 2 hours per weekend day (p<0.001), more caregivers' screen-viewing behavior more than 2 hours per weekend day (p<0.001), and more overweight children (24.1% *vs.* 11.3%, p<0.001).

(Insert Table 1 here)

Table 2 demonstrates that children's screen-viewing behavior was a risk factor both for becoming overweight (OR = 5.68; 95% CI = 3.86, 8.38; p<0.001) and for undertaking insufficient PA (OR = 3.31; 95% CI = 2.43, 4.50; p<0.001). Having a TV in the child's room also increased the likelihood of screen-viewing behavior being more than 2 hours (OR = 3.28; 95% CI = 2.01, 5.35; p<0.001).

(Insert Table 2 here)

With regard to the mediation models, Model 1 had acceptable model fit (CFI=0.93, WRMR=1.07, RMSEA=0.07). Although the WRMR was higher than 1.0, both the CFI and the RMSEA were satisfactory. Subsequently, we adopted our alternative cutoff for the WRMR (i.e., less than 1.1) in this model, and thus, Model 1 was acceptable. It also showed that both children's screen-viewing behavior (β=0.407, p<0.001) and their insufficient level of PA (β=0.121, p=0.011) were significantly associated with being overweight. Furthermore, children's screen-viewing behavior was significantly correlated with insufficient PA (β=0.272, p<0.001) after controlling for age and gender (Figure 1a). Sobel tests also showed the mediated effects of insufficient PA in the relationship between the children's screen-viewing behavior and their overweight status (β=0.033, p=0.02) (Table 3). Given that the direct association between children's screen-viewing behavior and their overweight status was significant, insufficient PA only partially mediated the association.

(Insert Table 3 here)

After including the two caregiver factors, Model 2 also had satisfactory fit (CFI=0.93, WRMR=0.80, RMSEA=0.05). Furthermore, it showed similar relationships between the children's screen-viewing behavior and being overweight (β=0.390, p<0.001), between their insufficient levels of PA and being overweight (β=0.084, p=0.101), and between children's screen-viewing behavior and insufficient levels of PA (β=0.274, p<0.001). Model 2 also showed a positive relationship between caregivers' screen-viewing behavior and their children's screen-viewing behavior (β=0.362, p<0.001), and a negative association between caregivers' rules and children's screen-viewing behavior (β=-0.235, p<0.001) (Figure 1b). That is, children who were subject to caregivers' rules on their viewing time undertook less screen-viewing than those who were not. Moreover, children's screen-viewing behavior had stronger associations with caregivers' screen-viewing behavior than with caregivers' rules (χ^2=25.80, *df*=1; p<0.001). However, neither caregivers' screen-viewing behavior (β=0.022, p<0.68) nor caregivers' rules (β=-0.070, p=0.17) were directly associated with the overweight status of their children. Therefore, the associations between caregiver factors and children's being overweight were fully mediated by the children's screen-viewing behavior.

The Sobel tests suggest that the relationship between the two caregiver factors and being overweight were mediated by the children's screen-viewing behavior (β=0.141 and -0.092, p<0.001), however, they were not mediated by the children's screen-viewing behavior plus their insufficient levels of PA (β=0.010 and -0.006, p=0.09) (Table 3).

Discussion

In the current study, insufficient PA and excessive children's screen-viewing were identified as risk factors for children's health. Model 1 carried out the concept with straight forward and clear association between these variables, and the Model 2 outperforms Model to indicate that the mediating effects of insufficient PA might not actually exist. In other words, the models laid the foundation for further exploring how insufficient PA was found to be a mediator in the relationship between children's screen-viewing behavior and being overweight (Model 1). Children's screen-viewing behavior was also found to be a mediator in the relationship between caregiver factors and being overweight (Model 2). More specifically, children's screen-viewing behavior could be determined by caregivers' screen-viewing behavior and rules, which may subsequently contribute to children becoming overweight. The results indicate that children's overweight status could be associated with their screen-viewing behavior and their PA levels, which are correlated to caregiver factors, including caregivers' screen-viewing behavior and caregivers' rules.

In Model 1, a simple and straightforward model initially expressing the associations between variables, the children's screen-viewing behavior showed both direct and indirect (through insufficient PA) influences on being overweight, which is consistent with previous studies on the relationship between children's screen-viewing behavior and levels of PA, as well as the relationship between children's screen-viewing behavior and being overweight (Boone et al., 2007; Costigan, Barnett, Plotnikoff, & Lubans, 2013; LeBlanc et al., 2015). The association between screen-viewing behavior and being overweight may result from the home environment, such as having an increased food intake, which has been induced by food advertising (Crespo et al., 2001; de Jong et al., 2013; Janssen et al., 2005), or having a TV in the child's bedroom. The study found that children with a TV in their bedrooms tended to have longer screen-viewing time than their counterparts. The results are consistent with the findings of studies indicating that children with a TV in their bedrooms watch more TV and are at increased risk of being overweight compared to their counterparts (Schmidt et al., 2012; Wethington, Pan, & Sherry, 2013). The association between insufficient PA and being overweight agrees with other studies which indicate that insufficient PA leads to overweight status (Janssen et al., 2005; Jimenez-Pavon et al., 2010). Moreover, as children's screen-viewing increases, their PA levels decrease, and maintaining a healthy weight becomes more difficult (Costigan et al., 2013). One possible reason is the issue of time pressures. Aside from schooling and homework, children have less time to engage in PA because they spend more time looking at screens. This situation magnifies the weight problem. Our mediation model provides a comprehensive picture, and reflects the interrelationships between the three factors, such that as children's screen-viewing increases, their PA levels decrease, and maintaining a healthy weight becomes more difficult.

The purpose of Model 2 was to investigate how caregiver factors were indirectly associated with insufficient PA and being overweight as a consequence of children's screen-viewing behavior. Model 2 revealed that caregivers could actually influence their children's weight status through the children's screen-viewing behavior, which is consistent with prior research. Model 2 also identified that caregivers' own screen-viewing behavior may increase the likelihood of the same behavior by their children (Barr-Anderson et al., 2011; Jago et al., 2014). Because of these effects, children are prone to imitate caregivers' screen-viewing behavior (Carlson et al., 2010). Furthermore, an increase in the children's screen-viewing behavior leads to lower levels of PA and, consequently, to problems with being overweight. Zarychta, Mullan, and Luszczynska (2016) found that the relationship between perceived parental health behaviors (diet and PA) and children's BMI was mediated by the children having a healthy diet and PA. Parental involvement has a direct and positive effect on children's PA levels (Eddolls, McNarry, Stratton, & Mackintosh, 2016). In other words, children's behavior could be guided

through caregivers' modeling processes and, in turn, change their habits and health status. Therefore, caregivers' screen-viewing behavior is believed to be an important factor for modifying their children's screen-viewing behavior.

Model 2 also reflected on the findings of previous studies (Jago et al., 2011; Lampard et al., 2013), which found that caregivers' rules may reduce children's screen-viewing behavior. However, caregivers' rules (β=-.270) had a significantly weaker association with children's screen-viewing behavior than the effect of caregivers' screen-viewing behavior (β=.365). Interestingly, however, a western study (Barr-Anderson et al., 2011) claimed that the effects of caregivers' rules (β=-.35) and caregivers' screen-viewing behavior (β=.35) shared similar magnitude. These diverse findings may be explained by cultural differences. Our participants lived in a Chinese culture, which thinks highly of close relationships with family, and which values collectivism (Li, 2002). That is, family members often have shared beliefs, values, and may even behave similarly. Therefore, the relationship between caregivers and their children's screen-viewing behavior may be stronger in an East Asian country with its predominant collectivism, than similar relationships in a western country where individualism is more prevalent.

Our results revealed the importance of parenting for tackling children's weight problems. Rather than an individual problem, the problem of children becoming overweight may be viewed as a family problem in East Asian countries. In addition to the trend towards prolonging screen-viewing time, in Asian culture, children having a full figure represent a blessing. Thus, weight problems can initially be overlooked (i.e., the family could be the source to cause weight problems) and concern should be focused on the family (i.e., the entire family should be targeted for intervention on weight problems). Clinicians should consider the need for caregivers' involvement in the weight management of their children, or at least by suggesting that caregivers reduce their own screen-viewing time in front of their children. Indeed, a meta-analysis has reported solid evidence that the involvement of caregivers brings benefits to pediatric weight management programs (Berge & Everts, 2011). Although the magnitude of the effect of rule setting was weaker than caregivers' behaviors, it still had some impact. Because Chinese cultures promote harmony and shared beliefs, children usually obey their caregivers' rules, which means children tend to conform to screen-viewing time limits (Li, 2002). Caregivers should be educated to set rules to restrict children's screen-viewing time, and should be aware of their children's time management, in respect of the proportion between PA and screen-viewing time. Caregivers may be advised to set rules, such as, "You may only watch TV after you finish your exercise," to achieve both PA and screen-time recommendations.

Limitations

There were some limitations in this study. First, the study was based on a cross-sectional design, from which no causal effects can be concluded. Thus, further longitudinal studies to corroborate our findings are warranted. Second, all the measures, including the screen-viewing behavior and PA levels, were self-reported, and it should be noted that social desirability may affect participants' responses in our questionnaires. However, due to the size of the sample, the caregiver-reported questionnaire was probably the most feasible and efficient approach for collecting data regarding children's PA or screen-viewing time, compared to using an accelerometer or a passive sensing technology-measured approach, although the limitation of this approach is fully recognized. Nevertheless, the use of a questionnaire is supported by other studies (Berglind & Tynelius, 2018; Sarker et al., 2015) which state that the parent-report may be a valid measure of physical activity and screen time for children. It must be noted that the options for answers could have been over-simplified by simply allowing for a Yes or No response, and this may have led to the loss of valuable information. Another drawback is recall bias, which may have affected the accuracy of the data. Objective measures, such as accelerometers or ActiGraph (Lin, Yang, & Su, 2013) can accurately measure levels of PA, while standardized and validated questionnaires (e.g., quality of life; Strong, Lin, Tsai, & Lin, 2017) can assess caregivers' rules and children's health precisely. Future studies should make use of more robust measures to corroborate our findings. Third, all participants were recruited from suburban or rural areas. The results of this study may not be generalizable to urban areas. For example, lifestyles may differ within urban, suburban, and rural areas. Also, the participants in this study were quite highly educated and findings may not generalize to individuals with less education. Fourth, the cutoff of the WRMR we used does not have strong evidence to support it. Nevertheless, we justified that our model did not have serious misconceptaulization problems because our WRMR was only slightly higher than 1.0 (i.e., 1.07). Also, other fit indices fully support our model with satisfactory values. Also, the children's weight and height were not measured directly at the time of the study since the schools had just completed their physical examinations before the data collection for this study began. The request of measuring the children's weight and height again was thus not authorized. Therefore, the caregivers were asked to provide the information based on the physical examination reports which they received from the schools. Finally, caregiver's PA levels could be examined in future studies, which could further explore why caregiver's screen-viewing related factors and overweight status were not mediated by children's screen-viewing behavior and insufficient levels of PA. Future studies are needed to further tackle these issues to corroborate our findings.

The current study suggests two mediation models to explain the relationships between caregivers'

screen-viewing behavior, caregivers' rules, children's screen-viewing behavior, insufficient levels of PA, and overweight status. More importantly, Model 2 highlights the importance of caregivers' influence, especially caregivers' screen-viewing behavior, which seemed to outperform caregivers' rules in our sample. These findings may provide information for caregivers, educators and healthcare providers to encourage children's PA and reduce their risk of becoming overweight, and to improve their health and quality of life.

Conflict of Interest statement: All the authors declare that there is no conflict of interest.

Compliance with Ethical Standards:

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Ethical approval: All procedures performed in studies involving human participants complied with the ethical standards of the institutional and/or national research committee, and were in accordance with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. The Institutional Review Board of the National Taiwan University approved this study.

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

Author contributions:

YCL: designed and executed the study, collected the data, and wrote the Method section of the paper. XCCF: interpreted the data, wrote the Introduction and Discussion sections of the paper. MCT, CS and YPH: collaborated with the design, assisted with the data analyses, and assisted in writing of the study. CYL: designed the study, analyzed the data, wrote part of the results, and collaborated in the writing and editing of the paper.

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Table 1. Demographic data of participants

	n (%) or *M*±*SD*				
	Total	Sufficient PA	Insufficient PA	X^2 or (t)	*p*
Age (year)	9.55±1.72	9.69±1.72	9.51±1.72	(1.44)	0.15
Grade				5.66	0.34
1st grade	187(18.2)	40(17.1)	147(18.5)		
2nd grade	126(12.2)	24(10.3)	102(12.8)		
3rd grade	178(17.3)	35(15.0)	143(18.0)		
4th grade	184(17.9)	50(21.4)	134(16.9)		
5th grade	180(17.5)	39(16.7)	141(17.7)		
6th grade	174(16.9)	46(19.7)	128(16.1)		
Gender				3.55	0.06
Boys	516(50.1)	130(55.6)	386(48.6)		
Girls	513(49.9)	104(44.4)	409(51.4)		
Caregivers' Rules in screen time				7.74	0.005
No	758(73.7)	45(19.2)	225(28.3)		
Yes	270(26.3)	189(80.8)	569(71.7)		
Caregivers' screen-viewing: using computer/smartphone on weekdays				3.18	0.08
≤ 2 hours per day	829(80.6)	198(84.6)	631(79.4)		
> 2 hours per day	200(19.4)	36(15.4)	164(20.6)		
Caregivers' screen-viewing: using computer/smartphone on weekends				6.09	0.014
≤ 2 hours per day	782(76.0)	192(82.1)	590(74.2)		
> 2 hours per day	247(24.0)	42(17.9)	205(25.8)		
Caregivers' screen-viewing: watching TV on weekdays				7.30	0.007
≤ 2 hours per day	865(84.1)	210(89.7)	655(82.4)		
> 2 hours per day	164(15.9)	24(10.3)	140(17.6)		
Caregivers' screen-viewing: watching TV on weekends				12.57	<0.001
≤ 2 hours per day	722(70.2)	186(79.5)	536(67.4)		
> 2 hours per day	307(38.6)	48(20.5)	259(32.6)		

Children's screen-viewing: using computer/smartphone on weekdays				0.10	0.75
≤ 2 hours per day	971(94.5)	222(94.9)	749(94.3)		
> 2 hours per day	57(5.5)	12(5.1)	45(5.7)		
Children's screen-viewing: using computer/smartphone on weekends				13.56	<0.001
≤ 2 hours per day	812(79.0)	205(87.6)	607(76.4)		
> 2 hours per day	216(21.0)	29(12.4)	187(23.6)		
Children's screen-viewing: watching TV on weekdays				1.31	0.25
≤ 2 hours per day	905(88.0)	211(90.2)	694(87.4)		
> 2 hours per day	123(12.0)	23(9.8)	100(12.6)		
Children's screen-viewing: watching TV on weekends				24.48	<0.001
≤ 2 hours per day	607(59.1)	171(73.1)	436(55.0)		
> 2 hours per day	420(40.9)	63(26.9)	357(45.0)		
PA (# of days per week met sufficient PA)	3.92±2.29	7.00±0.00	3.02±1.78	63.01	<0.001
Body mass index (BMI; kg/m^2)					
1st grade	16.54±2.98	16.21±2.09	16.63±3.17	0.98	0.33
2nd grade	16.90±3.09	16.23±2.45	17.07±3.22	1.20	0.23
3rd grade	17.28±3.63	16.67±2.82	17.43±3.80	1.32	0.19
4th grade	17.98±3.07	17.16±2.45	18.29±3.23	2.53	0.013
5th grade	18.19±3.63	16.95±1.79	18.52±3.91	3.54	0.001
6th grade	18.79±3.73	17.76±3.51	19.16±3.75	2.27	0.03
Overweight (Yes)	213(21.2)	26(11.3)	187(24.1)	17.47	<0.001
Monthly household income				4.83	0.19
Poor (≤NTD 30,000)	102(9.9)	27(11.5)	75(9.4)		
Low (NTD 30,001-50,000)	354(34.4)	82(35.0)	272(34.2)		
Mid (NTD 50,001-70,000)	310(30.1)	58(24.8)	252(31.7)		
High (NTD >70,000)	263(25.6)	67(28.6)	196(24.7)		
Having their own bedrooms				0.31	0.58
No	508(49.5)	112(47.9)	396(49.9)		
Yes	519(50.5)	122(52.1)	397(50.1)		

TV in the bedroom				4.86	0.03
No	927(90.3)	220(94.0)	707(89.2)		
Yes	100(9.7)	14(6.0)	86(10.8)		
# of Computers at home				0.94	0.82
0	79(7.7)	19(8.1)	60(7.6)		
1	503(48.9)	108(46.2)	395(49.7)		
2	314(30.5)	75(32.1)	239(30.1)		
>3	132(12.8)	32(13.7)	100(12.6)		
# of TVs at home				4.59	0.21
0	17(1.7)	6(2.6)	11(1.4)		
1	290(28.2)	70(29.9)	220(27.7)		
2	398(38.7)	96(41.0)	302(38.0)		
>3	323(31.4)	62(26.5)	261(32.9)		
# of Smartphones at home				6.21	0.10
0	30(2.9)	5(2.1)	25(3.1)		
1	87(8.5)	17(7.3)	70(8.8)		
2	292(28.4)	81(34.6)	211(26.5)		
>3	620(60.3)	131(56.0)	489(61.5)		

PA = physical activity; 30NTD ≈ 1USD

Table 2. Odds ratios (OR) and 95% confidence interval (CI) of child screen-viewing on overweight, insufficient physical activity and having TV in the bedroom.

	n (%)		OR (95% CI)
	Screen-viewing over 2 hours	Screen-viewing equal to or less than 2 hours	
Weight status			5.68 (3.86, 8.38)
Overweight	178 (32.2)	35 (7.7)	
Non-overweight	374 (67.8)	418 (92.3)	
Physical activity			3.31 (2.43, 4.50)
Insufficient	488 (86.5)	307 (66.0)	
Sufficient	76 (13.5)	158 (34.0)	
TV in the bedroom			3.28 (2.01, 5.35)
Yes	79 (14.0)	22 (4.7)	
No	485 (86.0)	443 (95.3)	

Table 3. Mediators in the associations between independent variables and overweight status tested using Sobel test

	Independent variable: coefficient (SE)/standardized coefficient		
Model #: Mediator(s)	Caregivers' screen-viewing	Caregivers' rules	Child screen-viewing
M1: Insufficient physical activity	--	--	0.075 (0.033)/ 0.033*
M2: Child screen-viewing	0.322 (0.072)/ 0.141***	-0.281 (0.055)/ -0.092***	--
M2: Child screen-viewing and insufficient physical activity	0.022 (0.013)/ 0.010	-0.015 (0.009)/ -0.006	--

*p<0.05; **p<0.01; ***p<0.001

Note: all the models were adjusted for grade and gender.