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## Double Dose: The cumulative effect of TV viewing at home and in preschool on children's activity patterns and weight status

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### Abstract

Little is known about how screen-based sedentary behavior at home and in preschool influences children's health and activity patterns. The current study examined the individual and cumulative influence of TV viewing at home and in preschool on children's physical activity (PA) and weight status. Children (n=339) attending 16 preschools in South Carolina were grouped into high and low TV groups based on parent report of children's TV viewing at home and director report of TV use/rules in preschool. T-tests and mixed model ANOVAs examined differences in weight status and PA (min/hr) by high and low TV groups. Results revealed that children who were classified as High TV both at home and in preschool had significantly lower levels of moderate-to-vigorous PA compared with their Low TV counterparts. These findings demonstrate the importance of total environmental TV exposure on preschooler's PA. Longitudinal and observational research to assess preschoolers' cumulative screen-based sedentary behavior and its relationship with PA and weight status is needed.

### INTRODUCTION

Childhood obesity and inactivity have reached epidemic levels in the U.S., extending into the preschool-aged population. Although the American Academy of Pediatrics (AAP) recommends that parents limit children's screen-viewing time to no more 2 hours per day (3), data from the 2001–2006 National Health and Nutrition Examination Survey indicated that more than one third of preschool-aged children do not meet these guidelines (24). Evidence is accumulating that excessive screen-based sedentary behavior is associated with overweight and obesity in preschool children (14–16;19;27). As childhood obesity levels surge, efforts to reduce children's time in sedentary behaviors is warranted. However, parents' efforts to limit children's screen time at home may be offset by the time children spend in sedentary pursuits while in child care.

Studies of activity within the preschool setting have reported relatively low levels of physical activity (2;9;22;28;29) and high levels of sedentary behavior (2;6;13;22;25)

throughout the school day. Further, studies have reported that specific characteristics of the preschool environment are associated with children's physical activity (5;10;30) and television viewing (7;8). For example, the type of program (home-based vs. center-based), staff education, poverty level of the surrounding area, and hours of operation have all been associated with children's television viewing in the preschool setting (7;8). Currently, little is known about the relationship between screen-based sedentary behavior within the preschool environment and children's health and activity patterns.

More than 11 million U.S. children under the age of 5 are enrolled in some type of child care, spending an average of 36 hours per week in non-parental care (1). Preschool children in day care settings watch a considerable amount of television in addition to what is viewed at home. A recent study of daily screen time in preschool-aged children found that preschoolers' cumulative screen time (home and preschool viewing combined) exceeded AAP recommendations and most previous estimates (26). This study found that, on average, children accumulated 4.0 hours of screen time per day - 3.6 hours at home, and 0.4 hours in child care. The results of this study underscore the pressing need to better understand the effects of screen time viewing on young children. To date, no studies have examined the cumulative effect of screen-based sedentary behaviors and practices at home and in preschool on children's physical activity and weight status.

The purpose of this study was to examine the separate influence of home TV and preschool TV and the cumulative influence of TV viewing at home and in preschool on children's physical activity patterns and weight status. It is likely that the health of children attending preschools with practices conducive to higher TV use who also have high TV viewing at home will be at-risk. The hypothesis of the study was that children who viewed more TV at home and who attended preschools with more access/use of a television during the day would be less physically active and more sedentary, and have a higher weight status than children who viewed less TV.

## METHODS

### Participants and Setting

Participants were enrolled in the Study of Health and Activity in Preschool Environments (SHAPES), a multi-component intervention designed to increase physical activity energy expenditure in 3- to 5-year-old children by modifying the social and physical environment of preschools. Preschools were recruited from a pool of 62 preschools (43 public, 19 private) in South Carolina that met the following eligibility criteria: the program was educative in nature, the curriculum met state standards, the instructional staff included a lead teacher who had a degree in early childhood education and an assistant teacher who had completed in-service training in early childhood education. Of the 62 schools that met these criteria, a stratified random sample of 16 schools (8 public and 8 private) were drawn and invited to take part in the study. Schools consented to participate in the study prior to randomization to the intervention arm.

For the current study, data were drawn from 3 waves of SHAPES (2008–2011) from 16 preschools; baseline data included intervention and control schools from year 1 and only

control schools in years 2 and 3. Accelerometer data and parent questionnaires were collected from 396 children (49.8% male) over a 5-day period. After deletions for missing parent report of TV and school TV, body mass index (BMI), and <2 days of monitor wear, complete data were available for 339 children (Wave 1, n=184, Wave 2, n=83, and Wave 3, n=72). Children for whom data were available and were not available did not differ by age, BMI, or physical activity levels; however, children did differ by race/ethnicity. In the original sample of 396, 47.2% were black, 36.6% were white, and 16.2% were in the other race group, whereas in the study sample of 339, 46.3% were black, 38.9% were white, and 14.8% were in the other race group. Written informed consent was obtained from children's parents or guardians prior to data collection. The study was approved by the University of South Carolina Institutional Review Board.

## Measures

**Accelerometry**—Physical activity was measured by ActiGraph GT1M and GT3X (Pensacola, FL) accelerometers during a 5-day period (Monday-Friday). Children wore the monitors on an elastic belt on their right hip. Parents were instructed to remove the monitor only during water-related activities (e.g., bathing, swimming) and when the child went to bed at night. Monitors were initialized prior to data collection and were set to begin collecting data at the start of the school day on Monday. Research staff returned to the school each morning throughout the week to give replacement monitors to children who were not wearing their previously- assigned monitors. These monitors were set to begin collecting data at 5:00 am of the day they were given, and data from the replacement monitors were merged with the original monitors as necessary. Data were collected and stored in 15-second intervals to capture the sporadic activity patterns that are characteristic of 3- to 5-year-old children.

Accelerometer data were reduced using activity intensity cut-points developed specifically for 3- to 5-year-old children to categorize intervals as sedentary (< 200 counts/15 s), light (200 to 420 counts/15 s), moderate (420 to 842 counts/15 s), and vigorous (> 842 counts/15 sec) activity (20). Sixty minutes of consecutive zeros were considered non-wear time. Minutes per hour of observation of sedentary, light, moderate-to-vigorous physical activity (MVPA) and total physical activity (light + MVPA) were then calculated, using each child's wear time as the divisor. Time spent napping during the child's day was not excluded from the analyses but rather was treated as a period of sedentary activity if accelerometer counts were < 200 counts/15 s. Days that children were absent from preschool or were not present for at least half of the school day were excluded from the analyses because they did not represent typical days.

**TV viewing at home**—Home TV viewing was estimated by parental report of the number of hours per day in an average week that their child watched television; response options ranged from < 1 hour to > 5 hours. TV viewing at home was re-coded as High TV – Home (> 2 hrs/day) and Low TV – Home (< 2 hrs/day) according to AAP recommendations to limit children's total media time to no more than 1 to 2 hours of quality programming per day (3). This 2 hour cutoff has been used in previous studies with preschool-aged children

(17;19;23;31), and has been associated with risk of overweight/obesity and with higher skinfold thicknesses in this population (17;19).

**TV viewing at preschool**—Information about TV availability, rules, and use within the preschool setting were assessed with 3 items on the preschool director's survey. Directors were asked about TV availability in the preschool with response options including: '0=no TVs are available,' '1= available on portable carts moved between classrooms,' '2= available in a specific room where children are taken to watch TV,' or '3= available in each classroom.' Directors reported rules regarding TV use at the preschool with response options including: '1= TV used rarely and only for educational programs,' '2= TV on for part of the time, some days,' '3= TV on for part of the time, most days,' and '4= TV on throughout the day.' Directors also reported information about how often children were able to watch TV/videos and play video games; response options included '1= 1 time/week or less,' '2= 2–4 times/week,' '3= once a day,' and '4= throughout the day.'

An overall preschool TV score was calculated at each wave by summing the responses of the three items (i.e., TV availability, TV rules, and TV use) for each of the 16 schools. Next, the mean of the summed scores across all of the schools was calculated for each wave of data (Wave 1 mean-  $4.1 \pm 1.8$ ; Wave 2 mean-  $3.5 \pm 1.8$ ; Wave 3 mean-  $3.5 \pm 1.3$ ). High TV – Preschool and Low TV – Preschool groups were created by splitting the 16 schools above and below the mean of the summed scores from the 3 items. Thus, a given preschool could have been ranked as High TV at Wave 1, and Low TV at Wave 2 or 3, etc. This enabled us to account for changing preschool TV practices over time.

**Cumulative TV viewing**—To assess the effect of total TV exposure on children's physical activity and weight status, high and low home and preschool combined TV groups were created. The High TV - Combined group included children who were in the High TV – Home group and in the High TV – Preschool group. Children from 3 different TV exposure combinations (i.e., Low TV – Home and Low TV – Preschool; Low TV – Home and High TV – Preschool; High TV- Home and Low TV – Preschool) were included in the Low TV – Combined group.

**Weight Status**—Children's height and weight were measured by trained staff at baseline with children in light clothing and without shoes using Shorr measuring boards and Seca model 770 scales. BMI was calculated using the standard equation (body weight [kg] / height [m]<sup>2</sup>). Children's waist circumference was measured in triplicate to the nearest 0.1 cm using a tension-regulated tape with the child in the standing position.

**Sociodemographic variables**—Parents completed a survey at baseline that included information about their child's age, gender, and race/ethnicity. Child race/ethnicity was recoded to 'Black,' 'White' and 'Other.' Parents reported the highest level of parental education which was used as a proxy for socio-economic status (SES); this item was recoded to 'high school or less' and 'greater than high school.' Parents also reported the number of TVs that the child had access to at home, and whether the child had a TV in his/her bedroom (yes/no).

## Statistical Analysis

Descriptive statistics (frequencies and means with standard deviations) were calculated for each variable. T-tests were used to determine if there were differences between the high and low TV groups (home, preschool, and home and preschool combined) in the unadjusted means for BMI, BMI z-score, waist circumference, and minutes per hour of sedentary behavior, light activity, MVPA and total physical activity. Mixed model ANOVA (PROC Glimmix and mixed) was utilized to determine if there were differences in weight status and physical activity between TV groups. Each model included school as a random variable with children nested within the school. All models were calculated adjusting for gender, race/ethnicity, SES, and length of school day (1/2 day [instructional time < 4 hours] or full day [instructional time >4 hours]). All analyses were conducted with SAS 9.2 (SAS Institute Inc., Cary, NC, USA). Statistical significance was set at  $p < .05$ .

## RESULTS

On average, children were  $4.5 \pm 0.3$  years old, 52% were male, 46% were black, and 60% of parents had more than a high school education (Table 1). Children spent the majority of their time in sedentary activity ( $44.7 \pm 3.2$  min/hr), while only  $7.7 \pm 2.1$  min/hr were spent in MVPA. At home, children watched an average of  $2.3 \pm 1.2$  hours of television per day in a typical week. Parents reported that children had access to an average of 2 televisions at home, and 47% of children had a TV in their bedroom.

Results of the t-tests for mean differences between the TV groups revealed there were no differences in any of the weight status or physical activity variables for children in the High TV – Home vs. Low TV – Home groups (Table 2). Children in the High TV – Preschool group had significantly higher BMIs (high TV:  $16.5 \pm 1.9$ , low TV:  $16.1 \pm 1.8$ ;  $p = .04$ ), BMI-z scores (high TV:  $0.6 \pm 1.1$ , low TV:  $0.4 \pm 1.1$ ;  $p = .02$ ), and significantly lower levels of light physical activity (high TV:  $7.1 \pm 1.3$  min/hr, low TV:  $8.1 \pm 2.0$  min/hr;  $p < .0001$ ), compared with children in the Low TV – Preschool group. For the combined groups, children in the High TV - Combined group had significantly lower levels of light physical activity compared with children in the Low TV – Combined group ( $7.7 \pm 4.4$  min/hr vs.  $7.1 \pm 4.2$  min/hr, respectively;  $p < .01$ ).

Adjusted mixed model ANOVAs (controlling for gender, race/ethnicity, SES, and length of school day) revealed no significant differences between the high and low TV groups at home or in preschool (Table 3). However, children in the High TV - Combined group had significantly lower levels of MVPA compared with children in the Low TV – Combined group ((low TV:  $7.6 \pm 0.2$  min/hr, high TV:  $8.3 \pm 0.3$  min/hr,  $p = .047$ ). Of all the covariates, gender was significant in the home, preschool, and combined models for sedentary behavior ( $p < .01$ ), MVPA ( $p < .0001$ ), and total PA ( $p < .01$ ). T-tests revealed that boys compared to girls had significantly lower levels of sedentary behavior ( $44.1 \pm 3.1$  min/hr vs.  $45.2 \pm 3.3$  min/hr, respectively;  $p < .01$ ), and higher levels of MVPA ( $8.1 \pm 2.2$  min/hr vs.  $7.3 \pm 2.0$  min/hr, respectively;  $p < .0001$ ) and total PA ( $15.9 \pm 3.1$  min/hr vs.  $14.8 \pm 3.3$  min/hr, respectively;  $p < .01$ ).

## DISCUSSION

This is the first study to observe lower levels of MVPA in children who engage in high TV viewing at home and who also attend preschools that have practices conducive to higher TV use. This study aligns with previous studies that have found a negative association between TV viewing and physical activity in children (11;18). However, this finding is in contrast to two studies that examined the preschool TV environment and found that children's physical activity levels were higher with increased TV viewing and access (5;10). The present findings demonstrate the importance of total environmental TV exposure, at home and through preschool policies and practices, on preschool children's activity patterns.

In contrast to the literature and the study hypothesis, children from the High and Low TV – Combined groups did not differ by weight status. These null findings may point to issues of small sample size in the High TV - Combined group and/or limitations of the measures employed. While t-tests revealed small differences in weight status and light physical activity between the high and low preschool TV groups, it is not clear which setting was contributing to these differences. Further study is needed to explore these preliminary findings, including studies that employ more accurate measures of home and preschool TV viewing using observational or objective methods.

A study by Pate et al. (21) found that children's physical activity levels were highly variable among preschools, suggesting that preschool policies and practices influence the activity levels of the children who attend. However, many states lack specific physical activity and screen time regulations for the child-care environment (4). Such regulations are necessary in order to address the obesity epidemic and instill healthy habits for life, beginning in early childhood. Messages about physical activity and screen-related sedentary behavior need to be consistent across settings.

Preschools can play an important role in educating parents about current physical activity recommendations. Suggestions given to parents by staff and directors should be practical and compatible with the parents' values. Further, child-care providers should heed recent recommendations from the Institute of Medicine to debrief parents on the amount of physical activity and screen-time the child engaged in while in the preschool setting (12); this way parents can adjust children's activity time at home accordingly. Additionally, this study revealed that preschool girls are already exhibiting a disparity in physical activity; as such, parent- and teacher-directed approaches to increase physical activity and decrease sedentary behavior in children may need to be tailored differently for boys and girls.

The strengths of this study lie in its use of a diverse sample of children, inclusion of both public and private preschools, and objective measurement of physical activity. However, this study is not without limitations. The home TV variable was based on parental report and may not accurately reflect actual child TV viewing levels. Likewise, the preschool TV variable was based on director report. Because directors reported on general preschool policies and rules, their assessment may not accurately reflect the classroom practices of individual teachers. Further, home TV viewing was assessed at the individual-level, whereas preschool TV viewing was assessed at the school-level; as such, the preschool TV variable

should not be interpreted as individual children with high or low TV viewing at preschool. Future studies examining the effect of preschooler's TV viewing on their physical activity and weight status would benefit from the use of objective measures of TV viewing both at home and in the preschool setting. Finally, due to sample size limitations, the Low TV – Combined group included some children who had mixed TV viewing (i.e., High TV – Home and Low TV – Preschool, or Low TV – Home and High TV – Preschool). Studies with larger sample sizes would allow for comparisons between other types of TV groups (i.e., High TV, Mixed TV, and Low TV) to provide a more nuanced view of the cumulative effect of home and preschool TV viewing on preschooler's health and activity patterns.

In conclusion, this study provides cross-sectional evidence for the influence of total TV exposure on children's activity patterns. Children attending preschools with more open practices regarding TV access/use, who also engaged in high levels of TV viewing at home, had lower MVPA than those who do not. Longitudinal and observational research that tracks young children's screen-related sedentary behavior over time and examines its relationship with physical activity and other health outcomes is needed. Particularly, studies focusing on how TV viewing within the home and preschool environments contribute to the weight status of young children are necessary. Both settings should be targeted in the promotion of preschoolers' physical activity.

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**Table 1**

Study variables for all children (n=339)

Characteristic	TOTAL % or Mean (SD)
Age, years, mean (SD)	4.5 (0.3)
Gender, Male, %	52.2
Race, %	
Black	46.3
White	38.9
Other	14.8
Parents with >high school education, %	60.2
BMI, mean (SD)	16.3 (1.9)
BMI z-score, mean (SD)	0.5 (1.1)
Waist circumference, mean (SD)	52.7 (4.8)
Sedentary activity, min/hr, mean (SD)	44.7 (3.2)
Light activity, min/hr, mean (SD)	7.6 (1.8)
MVPA, min/hr, mean (SD)	7.7 (2.1)
Total PA, min/hr, mean (SD)	15.3 (3.2)
TV viewing, hr/day, mean (SD)	2.3 (1.2)
# of TVs in home, mean (SD)	2.3 (1.1)
TV located in child's bedroom, %	47

Note: BMI, body mass index; MVPA, moderate-to-vigorous physical activity; PA, physical activity;

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Mean differences (t-test) in weight status and physical activity (min/hr) between high and low TV groups for home, preschool, and home & preschool combined

**Table 2**

	HOME			PRESCHOOL			COMBINED		
	Low TV Mean (SD) (n=229)	High TV Mean (SD) (n=110)	P	Low TV Mean (SD) (n=213)	High TV Mean (SD) (n=126)	P	Low TV Mean (SD) (n=271)	High TV Mean (SD) (n=68)	P
BMI	16.3 (1.6)	16.4 (2.3)	.75	16.1 (1.8)	16.5 (1.9)	<b>.04</b>	16.3 (1.7)	16.4 (2.3)	.59
BMIz	0.5 (1.0)	0.4 (1.1)	.47	0.4 (1.1)	0.6 (1.1)	<b>.03</b>	0.5 (1.0)	0.5 (1.2)	.80
WC	52.9 (4.4)	52.3 (5.6)	.30	52.6 (4.7)	52.9 (4.9)	.57	52.8 (0.3)	52.4 (0.7)	.68
Sedentary Activity	44.7 (3.2)	44.7 (3.2)	.93	44.4 (3.3)	45.0 (3.1)	.09	44.7 (3.2)	44.7 (3.4)	.87
Light Activity	7.7 (1.8)	7.4 (1.6)	.14	8.0 (2.0)	7.2 (1.1)	<b>&lt;.0001</b>	7.7 (4.4)	7.1 (4.2)	<b>&lt;.01</b>
MVPA	7.6 (2.1)	7.9 (2.2)	.28	7.6 (2.1)	7.9 (2.2)	.27	7.6 (2.1)	8.2 (2.3)	.06
Total PA	15.3 (3.2)	15.3 (3.2)	.93	15.6 (3.3)	15.0 (3.1)	.09	15.3 (3.2)	15.3 (3.4)	.87

Note: BMI, body mass index; WC, waist circumference; MVPA, moderate-to-vigorous physical activity; High and low TV groups were created using information on preschool (director report) and home (parent report) TV use and rules. For the combined groups, 'High TV - Combined' included children from the High TV - Home and High TV - Preschool groups, while 'Low TV - Combined' included children from the following groups: Low TV - Home and Low TV - Preschool, and High TV - Home and Low TV - Preschool.

**Table 3**  
Results of adjusted mixed model ANOVA by high and low TV groups, LSMeans (SE)

	HOME			PRESCHOOL			COMBINED		
	Low TV Mean (SD) (n=229)	High TV Mean (SD) (n=110)	P	Low TV Mean (SD) (n=213)	High TV Mean (SD) (n=126)	P	Low TV Mean (SD) (n=271)	High TV Mean (SD) (n=68)	P
BMI	16.4 (0.2)	16.3 (0.2)	.71	16.2 (0.2)	16.5 (0.2)	.20	16.4 (0.2)	16.2 (0.3)	.65
BMIz	0.6 (0.1)	0.4 (0.1)	.15	0.4 (0.1)	0.6 (0.1)	.18	0.6 (0.1)	0.3 (0.2)	.14
WC	53.1 (0.4)	52.6 (0.6)	.37	52.8 (.6)	53.2 (0.6)	.60	53.0 (0.4)	52.7 (0.7)	.61
Sedentary Activity	44.7 (0.4)	44.3 (0.5)	.30	44.5 (0.5)	44.5 (0.5)	.97	44.7 (0.4)	44.0 (0.5)	.17
Light Activity	7.6 (0.3)	7.7 (0.3)	.61	7.7 (0.4)	7.6 (0.3)	.73	7.6 (0.3)	7.7 (0.3)	.72
MVPA	7.7 (0.2)	8.0 (0.3)	.23	7.6 (0.3)	8.0 (0.3)	.32	7.6 (0.2)	8.3 (0.3)	<b>.047</b>
Total PA	15.3 (0.4)	15.7 (0.5)	.30	15.5 (0.6)	15.5 (0.5)	.97	15.3 (0.4)	16.0 (0.5)	.17

Note: BMI, body mass index; WC, waist circumference; MVPA, moderate-to-vigorous physical activity; Analyses were adjusted for gender, race/ethnicity and socio-economic status (parental education), and length of school day (in the preschool & combined analyses)