



Attainment of '5-2-1-0' obesity recommendations in preschool-aged children

Amrik Singh Khalsa^a, Roohi Kharofa^a, Nicholas J. Ollberding^b, Laurie Bishop^b,
Kristen A. Copeland^{a,*}

^a Division of General and Community Pediatrics, Cincinnati Children's Hospital Medical Center, 3333 Burnet Ave, MLC 7035, Cincinnati, OH 45229, United States

^b Division of Biostatistics and Epidemiology, Cincinnati Children's Hospital Medical Center, 3333 Burnet Ave, MLC 5041, Cincinnati, OH 45229, United States

ARTICLE INFO

Keywords:

Obesity prevention
Nutrition recommendations
Physical activity guidelines
Screen time
Child care

ABSTRACT

Obesity prevention guidelines recommend children eat ≥ 5 servings of fruits and vegetables, view ≤ 2 h of screen time, participate in 1 h of physical activity, and consume 0 sugar-sweetened beverages daily, commonly known as '5-2-1-0'. We sought to determine: the extent to which preschool-aged children attending child care meet these guidelines, predictors of attainment, and associations of attainment with weight status. We analyzed in 2016, 24-hour dietary, physical activity, and screen time data collected in 2009–10 from 398 preschool-aged children in 30 child-care centers in Cincinnati, OH. Dietary intake, screen time and body-mass index (BMI) were obtained by research staff during child care and from parents when at home. Accelerometers measured physical activity. Mixed-effects models and generalized estimating equations were used to determine associations between '5-2-1-0' recommendations, demographic variables, and BMI z-scores. Average child age was 4.3 ± 0.7 years; 26% had a BMI ≥ 85 th percentile. Seventeen percent of children with complete dietary data ($n = 307$) consumed ≥ 5 servings of fruits and vegetables and 50% consumed 0 sugar-sweetened beverages. $< 1\%$ with complete physical activity data ($n = 386$) met the activity recommendation; 81% of children ($n = 379$) had ≤ 2 h of screen time. Only 1 child met all of the '5-2-1-0' recommendations. There were no consistent demographic predictors of attaining individual recommendations. An additional hour of screen time was associated with a 0.11 (SD 0.06) increase in BMI z-score. Our data suggests there is ample room to increase fruit and vegetable intake and physical activity in preschool-aged children.

1. Introduction

The prevalence of childhood obesity has increased threefold over the past 30 years (Fryar et al., 2012) with over 9% of preschool-aged children currently obese (Ogden et al., 2016). Preschool-aged children who are overweight or obese have four-fold odds of being overweight or obese as adults (Whitaker et al., 1997; Singh et al., 2008). Preventing obesity is critical to averting obesity-associated comorbidities such as metabolic syndrome, type II diabetes mellitus, hypertension, and cardiovascular abnormalities (Dietz, 1998; Must et al., 2009; Daniels et al., 2005; Koplan et al., 2005; Barlow, 2007). The importance of establishing healthy habits early in life is underscored by research illustrating that dietary and physical activity habits track into later adolescence and adulthood (Birch and Doub, 2014; Daniels et al., 2015; Birch and Fisher, 1998).

The American Academy of Pediatrics (AAP) recommends that pediatricians counsel parents and patients at every well-child check on

diet and lifestyle goals as a part of obesity prevention initiatives (Hassink, 2010). These recommendations, initially put forth by the Maine Youth Overweight Collaborative obesity prevention program "Let's Go! 5-2-1-0", have been promoted locally and nationally for broad consumption (Rogers and Motyka, 2009). The '5-2-1-0' message, used by pediatric offices and in numerous public health campaigns (Obama, 2009; Nemours Health and Prevention Services NFPI, 2017; The Albert Schweitzer Fellowship), consists of the following:

- 5 - Consume at least 5 servings of fruits and vegetables daily
- 2 - Limit screen time to no more than 2 h per day
- 1 - Attain 1 h of physical activity daily
- 0 - Consume 0 sugar-sweetened beverages.

Few studies have examined adherence to the '5-2-1-0' recommendations collectively and assessed predictors of attainment (Foltz et al., 2011; Kunin-Batson et al., 2015; Rogers et al., 2013;

Abbreviations: AAP, American Academy of Pediatrics; BMI, body mass index; CACFP, Child and Adult Care Food Program; ICC, intra-class correlation; PEAS, Preschool Eating and Activity Study USDA, United States Department of Agriculture

* Corresponding author.

E-mail addresses: Amrik.Khalsa@cchmc.org (A.S. Khalsa), Kristen.Copeland@cchmc.org (K.A. Copeland).

<http://dx.doi.org/10.1016/j.pmedr.2017.08.003>

Received 28 May 2017; Received in revised form 9 August 2017; Accepted 14 August 2017

Available online 16 August 2017

2211-3355/ © 2017 The Authors. Published by Elsevier Inc. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Haughton et al., 2016; Gonzalez et al., 2015; Iannotti and Wang, 2013; Briefel et al., 2015; Turer et al., 2013). Furthermore, there is a paucity of studies that have assessed the association of '5-2-1-0' recommendations with BMI z-score or weight status in preschool-aged children (Schrempft et al., 2015; Gortmaker et al., 2015), which is important to consider given that 80% of children in this age group use screens daily (Rideout et al., 2003). Of the studies examining adherence to the '5-2-1-0' recommendations, most have relied on self-reported data (Rogers et al., 2013; Haughton et al., 2016; Gonzalez et al., 2015; Iannotti and Wang, 2013; Briefel et al., 2015) and have focused on school aged children (Kunin-Batson et al., 2015; Rogers et al., 2013; Haughton et al., 2016; Gonzalez et al., 2015) or adolescents (Foltz et al., 2011; Haughton et al., 2016; Iannotti and Wang, 2013) instead of preschoolers (Briefel et al., 2015; Turer et al., 2013; Schrempft et al., 2015). No study to our knowledge has used objective measures to examine adherence in preschool-aged children who attend child care. Thus, the primary aim of this study was to assess attainment of '5-2-1-0' guidelines in preschool-aged children who attend child care and to describe demographic predictors of attainment. Additionally, we sought to determine if attainment of the '5-2-1-0' guidelines was associated with child's BMI or weight status category.

2. Methods

2.1. Setting and participants

We conducted a secondary analysis of the Preschool Eating and Activity Study (PEAS), an observational study examining the influence of child care environment on preschool-aged children's dietary intake and physical activity. The details of the protocol have been described previously (Robson et al., 2015; Copeland et al., 2015). Briefly, two classrooms per child care center were recruited to participate from 30 randomly-selected, full-time licensed child care centers in Hamilton County, OH. Recruitment occurred from November 2009 through January 2011 to account for seasonal and temperature variation. Children within each classroom were eligible if they were: between the ages of 36–72 months, attended the child care center full time (≥ 5 h/day), were not enrolled in kindergarten, and had no disability limiting physical activity. Only one child per family was eligible. Data collection occurred over 24 h for each child, starting from the time of a child's drop-off at the child care center on day 1 and ending at the time of drop-off the following morning. A total of 579 children were in selected classrooms and were potentially eligible to participate; 447 (77%) provided consent, and 398 (69%) children were present for at least 5 h on the day of observation and thus eligible to participate (Fig. 1). To be included in this secondary analysis, children needed at least one of the following: 24 h dietary record, including a home diet record provided by parents and a complete account of dietary intake while in child care recorded by onsite research staff; 24 h record of screen time, including a diary at home completed by parents and assessments while in child care completed by onsite staff; or at least 10 h of activity recorded by the accelerometer. Data over 24 h were truncated to time of drop off to standardize measurements to a 24 h period. Written informed consent was obtained from a parent of each participating child and the directors at each child care center. This study was approved by the Institutional Review Board at Cincinnati Children's Hospital Medical Center.

2.2. Measures

2.2.1. Dietary intake ('5' fruits and vegetables & '0' sugar-sweetened beverages)

Foods and beverages consumed at meals and snack times while the child was at the child care center were recorded by trained study staff using a validated protocol for visually estimating dietary intake developed by Ball et al. (2007). Two trained observers recorded the intake of up to three children simultaneously during each meal. Food and

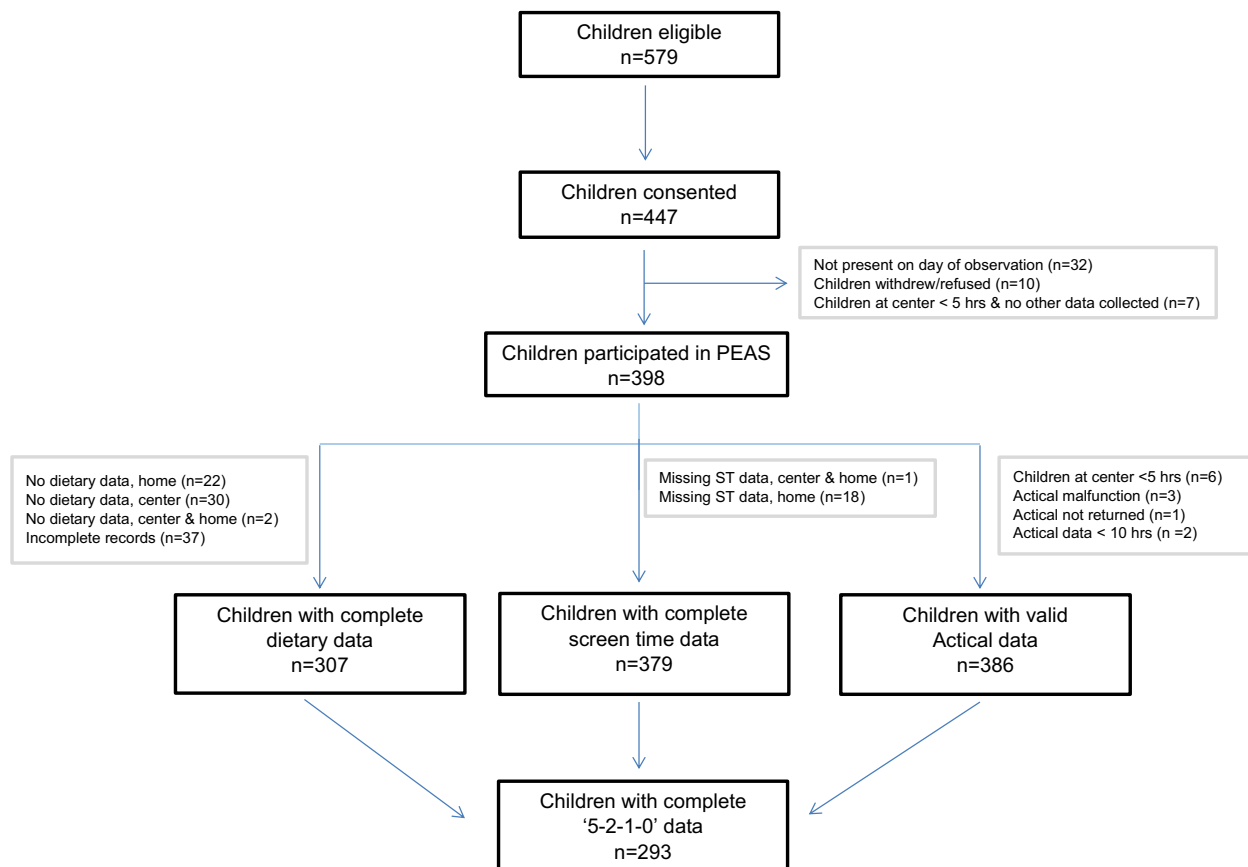
beverages consumed away from the child care center were recorded by parents on an estimated food record, a reliable and validated method to report dietary intake for children in this age group (Burrows et al., 2010). Parents indicated the time, type, and quantity for each food or beverage consumed outside the child care center. Detailed instructions with pictures were provided to aid in estimation of food quantities. Trained study staff reviewed dietary records, clarified questions, and resolved discrepancies with parents at the time of drop-off the next morning. All foods and beverages consumed, including quantities, were entered into the Nutrition Data System for Research (NDSR) software versions 2009, 2010, and 2011, developed by the Nutrition Coordinating Center (NCC), University of Minnesota, Minneapolis, MN. NDSR version 2011 software was used to categorize each child's total intake into food groups, servings, and energy intake (kcal) consumed over a 24-hour period. Fruit and vegetable servings in NDSR were based on the Dietary Guidelines for Americans (2010) and were defined for this age group as $\frac{1}{2}$ cup of chopped, cooked, or canned fruit or $\frac{1}{2}$ cup of cooked or raw vegetables (Robson et al., 2015). Thus, a child was considered to have attained the recommended minimum of 5 servings of fruits and vegetables if they consumed a minimum of 2.5 cups of fruits and vegetables in 24 h (US Department of Agriculture, 2016). For the purposes of this analysis, consumption of 4 oz of 100% fruit juice was counted as a serving of fruit, as allowed by the US Department of Agriculture's (USDA) Dietary Guidelines for Americans and the AAP's National Health and Safety Performance Standards (US Department of Agriculture, 2016; American Academy of Pediatrics et al., 2011). Sugar-sweetened beverage intake was defined using the 2010 USDA Dietary Guidelines for Americans and included any juices that were < 100% fruit juice, sweetened fruit drinks, soft drinks, sports drinks, sweetened water, and sweetened milk (1 serving = 4 oz) (U.S. Department of Agriculture and U.S. Department of Health and Human Services, 2010). A child who consumed zero sugar-sweetened beverages in the 24-hour period was considered to have attained the '0' portion of the '5-2-1-0' recommendation.

2.2.2. Screen time ('2' h of screen time)

Screen time measures included both TV and computer exposure at child care and at home. At child care, trained study staff recorded individual and classroom TV and computer exposure. Screen time at home was recorded by parents using standardized forms and instructions and included TV and computer use from the time of pick-up to drop-off the following morning. A child was considered meeting the screen time recommendation if they had less than or equal to 120 min of screen time (computer + TV) in a 24 h period (home and child care).

2.2.3. Physical activity ('1' h of moderate to vigorous physical activity)

Physical activity was measured using an Actical accelerometer (MiniMitter®, USA) worn at the hip with an elastic belt. Parents and children were asked to keep the accelerometers on throughout the entire 24 h period from drop-off on the first day to drop-off on the following day, with the exception of bath time. Activity was measured in 15 s epochs, and established cutoffs for counts per minute were used to quantify time in minutes/hour spent in light, moderate, vigorous, and sedentary physical activities (Pfeiffer et al., 2006). One hour of physical activity daily was defined as 60 min or more of moderate-to-vigorous physical activity, using the 2007 Expert Committee Recommendations for Obesity Prevention and Treatment guidelines (Barlow, 2007) since the AAP does not specify intensity of activity. More recently, the National Academy of Medicine and expert committees from three other countries (Canada, United Kingdom, and Australia) have recommended that preschool-aged children attain at least 180 min of any activity (light to vigorous) (Institute of Medicine, 2011a; National Physical Activity Guidelines for Australians, 2010; Canadian Physical Activity Guidelines and Canadian Sedentary Behaviour Guidelines, 2012; Department of Health, Physical Activity, Health Improvement and Protection, 2011). Thus, we also considered a threshold of 180 min of



Abbreviations:
PEAS, Preschool Eating and Activity Study

Fig. 1. PEAS child recruitment.

light to vigorous activity for analysis.

2.2.4. Anthropometric measurements

Trained study staff measured each participating child's height and weight at the child care center using a SECA portable stadiometer and Health-O-Meter portable high precision scale. Measurements were taken in triplicate while the child was in light clothing and measured to the nearest 0.1 cm and 0.1 kg for height and weight respectively. BMI and age-specific percentiles and z-scores were calculated based on the Centers for Disease Control and Prevention 2000 growth charts (Kuczmarski et al., 2000). Children who had a BMI percentile between 85th – 95th percentile for age and sex were classified as overweight and those at or above 95th percentile as obese.

2.2.5. Demographics

Parents completed a demographic questionnaire that included questions about their race/ethnicity, child's age and race/ethnicity, household income and composition, highest level of education, and eligibility status for free/reduced lunch in the Child and Adult Care Food Program (CACFP), a proxy for low-income status.

2.3. Analyses

Participant characteristics and individual '5-2-1-0' recommendations were described using means and standard deviations (SD) and medians and interquartile ranges for continuous variables, and frequencies and proportions for categorical variables. Dietary, physical activity, and screen time measures were evaluated as both continuous and dichotomous variables (recommendation attained vs not attained) in models determining predictors of attainment and associations with BMI. Demographic predictors of

fruit and vegetable intake, screen time, and physical activity were examined using linear mixed-effects models with center as a random effect to account for clustering of children within centers. Generalized estimating equations (GEE), utilizing a logit-link function and center as the clustering variable, were fit to calculate odds ratios and 95% confidence intervals (CI) for consuming sugar-sweetened beverages according to demographic predictors. All models were adjusted for income (< \$25,000, \$25,000–\$50,000, > \$50,000–\$100,000, > \$100,000), race (Black, Other, White), household composition (1-parent vs. 2-parent), and child gender where appropriate. Outcomes were transformed to the natural log scale where appropriate to meet model assumptions. Linear mixed-effects models and GEEs were also fit to model associations between '5-2-1-0' recommendations, BMI-z-score and BMI \geq 85th percentile. Model covariates included those described previously for '5-2-1-0' outcomes, as well as total energy intake when estimating associations for fruit and vegetable intake and sugar-sweetened beverages. Data was analyzed using SAS version 9.3 (SAS Institute Inc., Cary NC) with a p-value of < 0.05 considered statistically significant.

3. Results

Data from 398 children were available for this secondary analysis of whom 307 children had complete dietary data, 379 children had complete screen time data, and 386 children had complete physical activity data; 293 children had data for all 4 components of the '5-2-1-0' recommendations (Fig. 1). Response rates for the demographic, food diary, and screen time surveys from the parent study were all 95% or greater. Intra-class correlations (ICC) assessing the correlation of '5-2-1-0' recommendations within center was highest for screen time (ICC = 0.15), followed by sugar-sweetened beverage intake (ICC = 0.11),

Table 1

Demographic characteristics of participating children. Data collected from 30 child-care centers in Cincinnati, OH from Nov 2009–Jan 2011. Data analysis occurred in 2016–2017.

Child characteristics	Dietary data ('5 & 0')	Screen time ('2')	Physical activity ('1')	Complete '5-2-1-0'
Complete data, n	n ^a = 307	n = 379	n = 386	n = 293
Male, n (%)	140 (45)	180 (49)	188 (49)	132 (45)
Age (in years), mean (SD)	4.3 (0.7)	4.3 (0.7)	4.3 (0.7)	4.3 (0.7)
CACFP eligible, n (%)	173 (57)	206 (57)	211 (57)	164 (57)
Race, n (%)				
White	123 (41)	158 (43)	162 (44)	120 (41)
Black	126 (41)	147 (40)	150 (40)	118 (41)
Other ^b	55 (18)	62 (17)	60 (16)	52 (18)
Hispanic descent, n (%)	13 (4)	13 (4)	13 (3)	12 (4)
BMI percentile, mean (SD)	62 (28)	64 (26)	64 (26)	62 (28)
BMI z-score, mean (SD)	0.45 (1.0)	0.47 (1.0)	0.46 (1.0)	0.43 (1.0)
Household income (\$), n (%)				
< 25,000	114 (39)	133 (38)	136 (38)	107 (38)
25,000–50,000	66 (23)	79 (23)	82 (23)	64 (23)
> 50,000–75,000	27 (9)	32 (9)	31 (9)	25 (9)
> 75,000–100,000	21 (7)	25 (7)	25 (7)	21 (8)
> 100,000–150,000	33 (11)	40 (11)	41 (12)	32 (12)
> 150,000	31 (11)	40 (11)	39 (11)	29 (10)
Parent education, n (%)				
≤ High school	53 (18)	69 (19)	70 (19)	51 (18)
Associates/technical degree	130 (43)	149 (41)	153 (41)	124 (43)
≥ College grad	119 (39)	147 (40)	147 (40)	113 (39)
Household composition, n (%)				
2-Parent household	151 (50)	193 (53)	193 (52)	147 (51)
1-Parent household	149 (50)	170 (47)	175 (48)	139 (49)

CACFP, Child and Adult Care Food Program, a marker for low-income status.

^a Demographic data gathered via parent surveys and staff measurement of children. Sample sizes vary due to missing responses.

^b "Other" includes the following races: Asian, American Indian, mixed race, or other category.

moderate-to-vigorous physical activity (ICC = 0.08), fruit and vegetable intake (ICC = 0.06), and light-to-vigorous physical activity (ICC = 0.03). Demographics of the sample are reported in Table 1.

3.1. Attainment of the '5-2-1-0' recommendations

3.1.1. 5 – Consumption of ≥ 5 servings of fruits and vegetables daily

Of the 307 children with complete dietary data, 17% (n = 53) consumed 5 or more servings of fruits and vegetables (including 100% juice), with a median intake of 3.1 (IQR 1.9, 4.4) servings. The median dropped to 2.2 (IQR 1.4, 3.4) servings when excluding 100% juice (Table 2).

3.1.2. 2 – Viewing ≤ 2 h of screen time daily

A majority (81%) of the 379 children met the screen time recommendations with a median time

of 71 min (IQR 38,105). Nine percent (n = 36) had no TV or computer time in a 24 h period; removing them increased the median screen time to 75 min (IQR 45,111). Most screen time in this sample occurred while the child was at home (Table 2).

3.1.3. 1 – Obtaining ≥ 1 h of physical activity daily

Only 3 of 386 children met the 60 min of moderate-to-vigorous physical activity recommendation (Table 2). Median moderate-to-vigorous physical activity time for the entire sample was 14 min (IQR 7, 25). This increased to a median of 331 min (IQR 274, 377) when including light physical activity. Nearly all the children (n = 379) met the physical activity recommendation when using the National

Table 2

'5-2-1-0' recommendation attainment. Data collected from 30 child-care centers in Cincinnati, OH from Nov 2009–Jan 2011. Data analysis occurred in 2016–2017.

'5-2-1-0' component ^a	N ^b	Median (IQR)	Frequency (%)
'5' servings of fruits/vegetables	307		
Fruit intake, servings		1.1 (0.5, 2.0)	
Vegetable intake, servings		1.0 (0.4, 1.6)	
100% juice intake, servings		0 (0, 1.25)	
Fruits + vegetable + 100% juice, servings ^c		3.1 (1.9, 4.4)	
Fruits + vegetable (no juice), servings		2.2 (1.4, 3.4)	
# of children ≥ 5 servings fruits + vegetables + 100% juice ^c			53 (17%)
'2' hours of screen time	379		
Total screen time – all, ^d minutes		71 (38, 105)	
Screen time at home, minutes		60 (30, 90)	
Screen time at child care, minutes		0 (0, 19)	
Total screen time – excluding zeros, ^e minutes	343	75 (45, 111)	
# of children ≤ 2 h of screen time			308 (81%)
'1' hour of physical activity	386		
MV physical activity, minutes		14 (7, 25)	
LMV physical activity, minutes		331 (275, 377)	
# of children with ≥ 60 min of MV PA (%)			3 (< 1%)
# of children with ≥ 60 min of LMV PA (%)			386 (100%)
# of children with ≥ 180 min of LMV PA (%)			378 (98%)
'0' sugar-sweetened beverages	307		
Total – all children, servings		0 (0, 1.0)	
# of children with zero sugar-sweetened beverages			152 (50%)

LMV, light, moderate, vigorous physical activity; MV, Moderate to Vigorous; PA, Physical Activity.

^a Measured over a 24 h hour period.

^b Dietary, physical activity, and screen time data was gathered through parent surveys and staff measurement of children. Sample sizes vary due to missing responses.

^c 100% juice counted as a fruit serving.

^d All children with screen time data recorded.

^e Children with screen time greater than zero.

Academy of Medicine guideline interpretation of 180 min or more of light-to-vigorous activity daily (Institute of Medicine, 2011a).

3.1.4. 0 – Consumption of 0 sugar-sweetened beverages daily

Half (n = 152) of the 307 children had no sugar-sweetened beverages consumed in 24 h (Table 2). Of children who consumed any sugar-sweetened beverages (removing those with no sugar-sweetened beverages), the median number of servings was 1.0 (IQR 0.75, 1.5).

3.1.5. Attainment of '5-2-1-0' recommendations

Only one child met all four of the '5-2-1-0' recommendations when defining physical activity as 60 min of moderate to vigorous activity. Attainment increased to 23 (7.8%) children when using the alternative definition of 180 min of any level of physical activity.

3.2. Demographic predictors

Children whose parents reported an annual income between \$25,000 and \$50,000 had higher intake of fruit and vegetables compared to an annual income less than \$25,000 (Table 3). Children whose reported household income was greater than \$100,000 had a lower odds (OR 0.31 [0.10; 0.93]) of consuming sugar-sweetened beverages when compared to those earning < \$25,000 (Table 3). Sugar-sweetened beverages were examined as a binary variable due to the large number of children reporting zero consumption. Black children had higher levels of any activity (light-to-vigorous) (β 0.42 ± 0.19)

Table 4

Associations between '5-2-1-0' attainment, BMI-z-score, & weight status. Data collected from 30 child-care centers in Cincinnati, OH from Nov 2009-Jan 2011. Data analysis occurred in 2016–2017.

'5-2-1-0' component (n)	BMI z-score			BMI ≥ 85th percentile
	β ^a	SE	p-Value ^b	OR ^c (95% CI)
Fruit/vegetable/100% juice^d (282)				
Servings	0.057	0.031	0.069	1.04 (0.93; 1.17)
≥ 5 servings	0.017	0.168	0.309	1.03 (0.56; 1.89)
Fruit/vegetable (282)				
Servings	0.038	0.040	0.340	0.99 (0.85; 1.14)
≥ 5 servings	0.165	0.245	0.501	0.80 (0.30; 2.19)
Fruit (282)				
Servings	0.054	0.052	0.292	1.07 (0.88; 1.30)
Vegetables (282)				
Servings	0.018	0.066	0.787	0.86 (0.66; 1.12)
100% juice^d (282)				
Servings	0.092	0.051	0.075	1.14 (0.90; 1.44)
Screen time (344)				
Hours	0.112	0.057	0.049[†]	1.22 (0.99; 1.50)
≤ 120 min	−0.119	0.141	0.400	0.84 (0.48; 1.48)
Physical activity (341)				
MV, hours	−0.040	0.245	0.870	0.36 (0.11; 1.25)
LMV, hours	0.042	0.043	0.335	1.06 (0.88; 1.26)
Sugar-sweetened beverages (282)				
Servings	0.081	0.078	0.301	1.16 (0.79; 1.71)
0 servings	−0.217	0.132	0.101	0.67 (0.35; 1.29)
'5-2-1-0' score^e (268)	−0.085	0.082	0.304	0.71 (0.47; 1.08)

Models adjusted for sex, income, race, and household composition. Fruit and vegetable intake additionally adjusted for total energy.

BMI, body mass index; LMV, light, moderate, vigorous; MV, moderate to vigorous; OR, Odds Ratio; SE, standard error. Significant findings in bold.

^a Parameter estimate reflects association with BMI z-score for 1-unit increase in diet (serving), physical activity (hour of PA), or screen time (hours of screen time).

^b p-Value for linear mixed effects regression with center as random effect.

^c p-Value for generalized estimating equation (logit link function) with center as cluster.

^d 100% Juice counted as a fruit serving as per the 2007 Expert Committee recommendations.

^e Attainment of more than one of the '5-2-1-0' components.

[†] p ≤ 0.05.

compared to White children but did not have any significant difference with regards to moderate-to-vigorous activity. No other demographic variables examined were associated with any '5-2-1-0' recommendation.

3.3. Weight outcomes

Only screen time showed an association with BMI z-score: for every 1 h increase in screen time, there was a 0.11 ± 0.06 increase in BMI z-score when estimated within the range of the data (Table 4). The odds ratio for overweight status was 1.22 (0.99; 1.50) for an additional hour of screen time. There were no associations between any of the other individual '5-2-1-0' components and BMI z-score or weight status. Additionally, attainment of each additional component of the '5-2-1-0' recommendations was not associated with either BMI z-score or weight status (Table 4).

4. Discussion

To our knowledge, this is the first study to evaluate the attainment of the '5-2-1-0' recommendations in preschool-aged children who attend child care using objective measures of diet and physical activity. Our study shows that only one child met all four of the '5-2-1-0' recommendations as endorsed by the American Academy of Pediatrics (Hassink, 2010). Attainment remained low (n = 23) even after using an alternative definition of physical activity for preschool-aged children

(Institute of Medicine, 2011a; National Physical Activity Guidelines for Australians, 2010; Canadian Physical Activity Guidelines and Canadian Sedentary Behaviour Guidelines, 2012; Department of Health, Physical Activity, Health Improvement and Protection, 2011). Our findings are consistent with previous studies in school aged and adolescent children, with rates of '5-2-1-0' attainment ranging between 0 and 2% (Foltz et al., 2011; Kunin-Batson et al., 2015; Haughton et al., 2016). Studies in preschool-aged children have shown similar findings of attainment for individual recommendations (Briefel et al., 2015; Turer et al., 2013; Schrepft et al., 2015) with the exception of Briefel et al. who reported higher fruit and vegetable intake compared to our study (Briefel et al., 2015). Attainment of the '5-2-1-0' recommendations collectively have not been reported in preschool-aged children.

Several studies have now shown that attainment of the '5-2-1-0' recommendations is low (Foltz et al., 2011; Kunin-Batson et al., 2015; Haughton et al., 2016; Briefel et al., 2015; Turer et al., 2013). One possible explanation for low attainment is that even though the message is straightforward and easy to remember, it can be difficult for families to implement. As '5-2-1-0' is a composite of four separate recommendations, each recommendation requires a specific behavior change. Studies suggest that behavior change is more effective when completed in a staged approach. Thus, it may be more effective for health care providers to target one recommendation at a time with families, to increase the ease of implementation and resultant adherence (Institute of Medicine (US) Committee on Health and Behavior: Research, Practice, and Policy, 2001).

Fruit and vegetable intake in our sample was fairly low (median 3.1 servings), which is consistent with prior studies showing that less than one-third of children attain the daily recommended fruit and vegetable intake (Kunin-Batson et al., 2015; Rogers et al., 2013; Briefel et al., 2015; Turer et al., 2013; Kirkpatrick et al., 2012). Unlike previous literature however, which has shown fruit and vegetable intake in children to be correlated with race/ethnicity and income level (Kirkpatrick et al., 2012; Di Noia and Byrd-Bredbenner, 2014; Dubowitz et al., 2008), we found no consistent associations. This may be a function of our sample, including children in full-day child care, where meals and snacks are guided by dietary guidelines (Institute of Medicine, 2011b; U.S. Department of Agriculture, 2014).

Most children (81%) met screen time recommendation, concordant with prior studies (Hinkley et al., 2013; Hinkley et al., 2012; Okely et al., 2009; Dennison et al., 2002). Our data also shows that most of the screen time occurred at home (median time 60 min) versus at child care (median time 0 min), consistent with prior research (Tandon et al., 2011). Contrary to prior studies linking correlations between socioeconomic status and screen time (Tandon et al., 2011; Whitt-Glover et al., 2009; Atkin et al., 2014), we found no association.

Very few children (n = 3) met the physical activity recommendation of 60 min of moderate-to-vigorous physical activity, which is lower than many other studies of this age group (Fakhouri et al., 2013; Pujadas Botey et al., 2016; Pate et al., 2015; Beets et al., 2011). One possible explanation is that unlike other brands of accelerometers, the Actical has only one published validation study (Pfeiffer et al., 2006) to establish cut points between different levels of physical activity. Beets et al. has demonstrated that differences in accelerometer cut points can change the percent of children who attain the same physical activity guidelines (Beets et al., 2011). Additionally, the Pfeiffer et al. cut points appear to use a relatively strict threshold for moderate activity compared to other accelerometers (Beets et al., 2011). Our findings are in line with other studies of preschool children using this same accelerometer that have shown children attain < 20 min a day of moderate-to-vigorous activity (Turer et al., 2013; Dolinsky et al., 2011; LaRowe et al., 2010; Vanderloo and Tucker, 2015). Given the limited evidence of the benefits of moderate versus any level of activity (including light) on the health and developmental outcomes of preschoolers (Tandon et al., 2016; Office of Disease Prevention and Health Promotion, 2008), it would be more appropriate to use the more inclusive National

Academy of Medicine guidelines recommending 15 min/h of any activity for this age group (Pate et al., 2015). Our study also found that Black preschool children had higher levels of any activity compared to White children. This is in contrast with previous studies in preschool children who have not shown race/ethnicity to be predictors of physical activity (Pujadas Botey et al., 2016; Pate et al., 2015; Dolinsky et al., 2011; Finn et al., 2002).

Consistent with previous findings, we found that half of the preschool children met the recommended intake of zero sugar-sweetened beverages daily (Briefel et al., 2015; Turer et al., 2013; Fulgoni and Quann, 2012; Pabayo et al., 2012). We also found that children of families with an annual income greater than \$100,000 had a decreased odd of consuming any sugar-sweetened beverage. This is supported by a systematic review by Mazarello Paes et al. who showed that lower socioeconomic status is associated with higher sugar-sweetened beverage intake (Mazarello Paes et al., 2015).

In our study, only screen time was associated with BMI or weight status. This is supported by the literature which has shown that increases in screen time are associated with increased odds of overweight/obesity (Dennison et al., 2002), including longitudinally (Hesketh et al., 2007). Previous studies have similarly shown no associations between the collective attainment of the '5-2-1-0' recommendations and BMI both in cross-section (Schrempft et al., 2015) and longitudinally (Gortmaker et al., 2015).

Our study has some limitations. First, our study is a cross-sectional analysis that captured a 24 h snapshot of dietary and lifestyle behaviors; thus, we cannot establish usual dietary habits or physical activity levels of each individual child. Because we only examined days that children were in child care, we cannot comment on children's diet, physical activity, or screen time use on weekends – these behaviors are known to differ between weekends and weekdays (Rothausen et al., 2012; Hart et al., 2011). This may have led to inflated estimates of the proportion of subjects meeting recommendations and biased associations in models assessing body composition and sugar-sweetened beverage consumption. Second, we examined the correlation between recommendation attainment and BMI in cross-section, thus we were unable to determine the direction of causality between exposure and outcome. Lastly, our sample is from child care centers within one urban Midwest city and included relatively few Latino children and few children from rural child care settings. This potentially limits the generalizability of our results to other settings. However, our data are useful in understanding how children who spend a large part of their waking hours in child care settings are meeting recommendations for nutrition, activity, and screen time behaviors (Federal Interagency Forum on Child and Family Statistics, 2016).

5. Conclusion

This is the first study to our knowledge to examine the attainment of the '5-2-1-0' recommendations in preschool-aged children who attend full-time child care in the U.S. Our study demonstrates ample room for improvement in preschool-aged children's dietary intake, physical activity, and screen time. While our study shows limited associations of dietary intake or physical activity behaviors with BMI, each of the four individual recommendations have been associated with positive health outcomes, e.g., reduced incidence of chronic disease with increased fruit and vegetable intake (Boeing et al., 2012), reduced attention problems and increased quality of sleep with limited screen exposure (Christakis et al., 2004; Hale and Guan, 2015), improved cardiovascular function with increased physical activity (Cesa et al., 2014), and reduced risk of metabolic syndrome or type 2 diabetes with limited sugar-sweetened beverage intake (Hu and Malik, 2010). Future studies should include an assessment of usual dietary, physical activity, and sedentary behaviors, including sleep, on weekdays and weekends and should examine the longitudinal effects of adherence to recommendations among preschoolers on BMI and other health outcomes.

Funding sources

Ruth L. Kirschstein Institutional National Research Service Award, T32 HP 10027
NIH K23 HL088053
Robert Wood Johnson Foundation Faculty Scholars Award.

Acknowledgments

We appreciate the families, child care teachers, and child care centers who participated in the Preschool Eating and Activity Study (PEAS).

Funding

Amrik Singh Khalsa is supported by an Institutional awarded National Research Service Award granted to Cincinnati Children's Hospital Medical Center (T32 HP10027). Dr. Ollberding received support from this grant to provide biostatistical assistance. Dr. Copeland was supported by a K23 award (HL0880531) from the National Institutes of Health and a Robert Wood Johnson Foundation Faculty Scholars Award to conduct the parent PEAS study.

Conflicts of interest

The authors declare there is no conflict of interest.

References

- American Academy of Pediatrics, American Public Health Association, National Resource Center for Health and Safety in Child Care and Early Education, 2011. Caring for our Children: National Health and Safety Performance Standards; Guidelines for Early Care and Education Programs, Third Edition. American Academy of Pediatrics, Elk Grove Village, IL (Accessed February 20, 2017).
- Atkin, A.J., Sharp, S.J., Corder, K., et al., 2014. Prevalence and correlates of screen time in youth: an international perspective. *Am. J. Prev. Med.* 47 (6), 803–807. <http://dx.doi.org/10.1016/j.amepre.2014.07.043>.
- Ball, S.C., Benjamin, S.E., Ward, D.S., 2007. Development and reliability of an observation method to assess food intake of young children in child care. *J. Am. Diet. Assoc.* 107 (4), 656–661. <http://dx.doi.org/10.1016/j.jada.2007.01.003>.
- Barlow, S.E., 2007. Expert committee recommendations regarding the prevention, assessment, and treatment of child and adolescent overweight and obesity: summary report. *Pediatrics* 120 (Suppl. 4), S164–192. <http://dx.doi.org/10.1542/peds.2007-2329C>.
- Beets, M.W., Bornstein, D., Dowda, M., et al., 2011. Compliance with national guidelines for physical activity in U.S. preschoolers: measurement and interpretation. *Pediatrics* 127 (4), 658–664. <http://dx.doi.org/10.1542/peds.2010-2021>.
- Birch, L.L., Doub, A.E., 2014. Learning to eat: birth to age 2 y. *Am. J. Clin. Nutr.* 99 (3), 723S–728S. <http://dx.doi.org/10.3945/ajcn.113.069047>.
- Birch, L.L., Fisher, J.O., 1998. Development of eating behaviors among children and adolescents. *Pediatrics* 101 (3 Pt 2), 539–549.
- Boeing, H., Bechthold, A., Bub, A., et al., 2012. Critical review: vegetables and fruit in the prevention of chronic diseases. *Eur. J. Nutr.* 51 (6), 637–663. <http://dx.doi.org/10.1007/s00394-012-0380-y>.
- Briefel, R.R., Deming, D.M., Reidy, K.C., 2015. Parents' perceptions and adherence to children's diet and activity recommendations: the 2008 feeding infants and toddlers study. *Prev. Chronic Dis.* 12, E159. <http://dx.doi.org/10.5888/pcd12.150110>.
- Burrows, T.L., Martin, R.J., Collins, C.E., 2010. A systematic review of the validity of dietary assessment methods in children when compared with the method of doubly labeled water. *J. Am. Diet. Assoc.* 110 (10), 1501–1510. <http://dx.doi.org/10.1016/j.jada.2010.07.008>.
- Canadian Physical Activity Guidelines, Canadian Sedentary Behaviour Guidelines, 2012. Your plan to get active every day. www.csep.ca/guidelines, Accessed date: 31 January 2017.
- Cesa, C.C., Sbruzzi, G., Ribeiro, R.A., et al., 2014. Physical activity and cardiovascular risk factors in children: meta-analysis of randomized clinical trials. *Prev. Med.* 69, 54–62. <http://dx.doi.org/10.1016/j.jpmed.2014.08.014>.
- Christakis, D.A., Zimmerman, F.J., DiGiuseppe, D.L., et al., 2004. Early television exposure and subsequent attentional problems in children. *Pediatrics* 113 (4), 708–713.
- Copeland, K.A., Khoury, J.C., Kalkwarf, H.J., 2015. Child care center characteristics associated with preschoolers' physical activity. *Am. J. Prev. Med.* <http://dx.doi.org/10.1016/j.amepre.2015.08.028>.
- Daniels, S.R., Arnett, D.K., Eckel, R.H., et al., 2005. Overweight in children and adolescents: pathophysiology, consequences, prevention, and treatment. *Circulation* 111 (15), 1999–2012. <http://dx.doi.org/10.1161/01.CIR.0000161369.71722.10>.
- Daniels, S.R., Hassink, S.G., Committee on Nutrition, 2015. The role of the pediatrician in primary prevention of obesity. *Pediatrics* 136 (1), e275–292. <http://dx.doi.org/10.1093/peds/136.1.e275>.

- 1542/peds.2015-1558.
- Dennison, B.A., Erb, T.A., Jenkins, P.L., 2002. Television viewing and television in bedroom associated with overweight risk among low-income preschool children. *Pediatrics* 109 (6), 1028–1035.
- Department of Health, Physical Activity, Health Improvement and Protection. Start Active, Stay Active: a report on physical activity from the four home countries' Chief Medical Officers. London. 2011. <https://www.gov.uk/government/publications/start-active-stay-active-a-report-on-physical-activity-from-the-four-home-countries-chief-medical-officers>. Accessed 31 July 2017.
- Di Noia, J., Byrd-Bredbenner, C., 2014. Determinants of fruit and vegetable intake in low-income children and adolescents. *Nutr. Rev.* 72 (9), 575–590. <http://dx.doi.org/10.1111/nure.12126>.
- Dietz, W.H., 1998. Health consequences of obesity in youth: childhood predictors of adult disease. *Pediatrics* 101 (3 Pt 2), 518–525.
- Dolinsky, D.H., Brouwer, R.J., Evenson, K.R., et al., 2011. Correlates of sedentary time and physical activity among preschool-aged children. *Prev. Chronic Dis.* 8 (6), A131.
- Dubowitz, T., Heron, M., Bird, C.E., et al., 2008. Neighborhood socioeconomic status and fruit and vegetable intake among whites, blacks, and Mexican Americans in the United States. *Am. J. Clin. Nutr.* 87 (6), 1883–1891.
- Fakhouri, T.H., Hughes, J.P., Brody, D.J., et al., 2013. Physical activity and screen-time viewing among elementary school-aged children in the United States from 2009 to 2010. *JAMA Pediatr.* 167 (3), 223–229. <http://dx.doi.org/10.1001/2013.jamapediatrics.122>.
- Federal Interagency Forum on Child and Family Statistics, 2016. America's Children in Brief: Key National Indicators of Well-Being. U.S. Government Printing Office, Washington, DC (Accessed 8 March 2017). https://www.childstats.gov/pdf/ac2016/ac_16.pdf.
- Finn, K., Johannsen, N., Specker, B., 2002. Factors associated with physical activity in preschool children. *J. Pediatr.* 140 (1), 81–85. <http://dx.doi.org/10.1067/mpd.2002.120693>.
- Foltz, J.L., Cook, S.R., Szilagyi, P.G., et al., 2011. US adolescent nutrition, exercise, and screen time baseline levels prior to national recommendations. *Clin. Pediatr. (Phila.)* 50 (5), 424–433. <http://dx.doi.org/10.1177/0009922810393499>.
- Fryar, C.D., Carroll, M., Ogden, C.L., 2012. Prevalence of obesity among children and adolescents. In: *United States Trends 1963–1965 Through 2009–2010*. National Center for Health Statistics.
- Fulgioni 3rd, V.L., Quann, E.E., 2012. National trends in beverage consumption in children from birth to 5 years: analysis of NHANES across three decades. *Nutr. J.* 11, 92. <http://dx.doi.org/10.1186/1475-2891-11-92>.
- Gonzalez, M., Feinstein, R., Iezzi, C., et al., 2015. Nutrition intake and physical activity in a middle school in New York City. *Int. J. Adolesc. Med. Health.* 27 (3), 335–340. <http://dx.doi.org/10.1515/ijamh-2014-0035>.
- Gortmaker, S.L., Polacek, M., Letourneau, L., et al., 2015. Evaluation of a primary care intervention on body mass index: the Maine Youth Overweight Collaborative. *Child Obes.* 11 (2), 187–193. <http://dx.doi.org/10.1089/chi.2014.0132>.
- Hale, L., Guan, S., 2015. Screen time and sleep among school-aged children and adolescents: a systematic literature review. *Sleep Med. Rev.* 21, 50–58. <http://dx.doi.org/10.1016/j.smrv.2014.07.007>.
- Hart, C.N., Raynor, H.A., Osterholt, K.M., et al., 2011. Eating and activity habits of overweight children on weekdays and weekends. *Int. J. Pediatr. Obes.* 6 (5–6), 467–472. <http://dx.doi.org/10.3109/17477166.2011.590204>.
- Hassink, Sandra G., 2010. In: Tanski, Susanne, LCG, Duncan, Paula M., Weitzman, Michael (Eds.), *Weight Maintenance and Weight Loss. Performing Preventative Services: A Bright Futures Handbook*. American Academy of Pediatrics, pp. 185–190.
- Haughton, C.F., Wang, M.L., Lemon, S.C., 2016. Racial/ethnic disparities in meeting 5-2-1-0 recommendations among children and adolescents in the United States. *J. Pediatr.* 175, 188–194. e181. <http://dx.doi.org/10.1016/j.jpeds.2016.03.055>.
- Hesketh, K., Wake, M., Graham, M., et al., 2007. Stability of television viewing and electronic game/computer use in a prospective cohort study of Australian children: relationship with body mass index. *Int. J. Behav. Nutr. Phys. Act.* 4, 60. <http://dx.doi.org/10.1186/1479-5868-4-60>.
- Hinkley, T., Salmon, J., Okely, A.D., et al., 2012. Preschoolers' physical activity, screen time, and compliance with recommendations. *Med. Sci. Sports Exerc.* 44 (3), 458–465. <http://dx.doi.org/10.1249/MSS.0b013e318233763b>.
- Hinkley, T., Salmon, J., Okely, A.D., et al., 2013. The correlates of preschoolers' compliance with screen recommendations exist across multiple domains. *Prev. Med.* 57 (3), 212–219. <http://dx.doi.org/10.1016/j.jpmed.2013.05.020>.
- Hu, F.B., Malik, V.S., 2010. Sugar-sweetened beverages and risk of obesity and type 2 diabetes: epidemiologic evidence. *Physiol. Behav.* 100 (1), 47–54. <http://dx.doi.org/10.1016/j.physbeh.2010.01.036>.
- Iannotti, R.J., Wang, J., 2013. Trends in physical activity, sedentary behavior, diet, and BMI among US adolescents, 2001–2009. *Pediatrics* 132 (4), 606–614. <http://dx.doi.org/10.1542/peds.2013-1488>.
- Institute of Medicine, 2011a. Early childhood obesity prevention policies. The National Academies Press, Washington, DC <http://www.nap.edu/catalog/13124/early-childhood-obesity-prevention-policies>, Accessed date: 8 March 2017 (<http://dx.doi.org/doi:10.17226/13124>).
- Institute of Medicine, 2011b. Child and Adult Care Food Program: Aligning Dietary Guidance for All. The National Academies Press, Washington, DC (Accessed 15 February 2016). <https://www.nap.edu/catalog/12959/child-and-adult-care-food-program-aligning-dietary-guidance-for>.
- Institute of Medicine (US) Committee on Health and Behavior: Research, Practice, and Policy, 2001. 5. Individuals and families: models and interventions. Health and behavior: the interplay of biological, behavioral, and societal influences. National Academies Press (US), Washington (DC) <https://www.ncbi.nlm.nih.gov/books/NBK43749/>, Accessed date: 6 March 2017.
- Kirkpatrick, S.I., Dodd, K.W., Reedy, J., et al., 2012. Income and race/ethnicity are associated with adherence to food-based dietary guidance among US adults and children. *J. Acad. Nutr. Diet.* 112 (5), 624–635. e626. <http://dx.doi.org/10.1016/j.jand.2011.11.012>.
- Koplan, J.P., Liverman, C.T., Kraak, V.I., et al., 2005. Preventing childhood obesity: health in the balance: executive summary. *J. Am. Diet. Assoc.* 105 (1), 131–138. <http://dx.doi.org/10.1016/j.jada.2004.11.023>.
- Kuczumski, R.J., Ogden, C.L., Guo, S.S., et al., 2000. CDC growth charts for the United States: methods and development. *Vital Health Stat* 11. 2002 (246), 1–190.
- Kunin-Batson, A.S., Seburg, E.M., Crain, A.L., et al., 2015. Household factors, family behavior patterns, and adherence to dietary and physical activity guidelines among children at risk for obesity. *J. Nutr. Educ. Behav.* 47 (3), 206–215. <http://dx.doi.org/10.1016/j.jneb.2015.01.002>.
- LaRowe, T.L., Adams, A.K., Jobe, J.B., et al., 2010. Dietary intakes and physical activity among preschool-aged children living in rural American Indian communities before a family-based healthy lifestyle intervention. *J. Am. Diet. Assoc.* 110 (7), 1049–1057. <http://dx.doi.org/10.1016/j.jada.2010.04.009>.
- Mazarello Paes, V., Hesketh, K., O'Malley, C., et al., 2015. Determinants of sugar-sweetened beverage consumption in young children: a systematic review. *Obes. Rev.* 16 (11), 903–913. <http://dx.doi.org/10.1111/obr.12310>.
- Must, A., Barish, E.E., Bandini, L.G., 2009. Modifiable risk factors in relation to changes in BMI and fatness: what have we learned from prospective studies of school-aged children? *Int. J. Obes.* 33 (7), 705–715. <http://dx.doi.org/10.1038/ijo.2009.60>.
- National Physical Activity Guidelines for Australians, 2010. Physical activity recommendations for 0–5 year olds. Commonwealth of Australia, Canberra, Australia <http://www.health.gov.au/internet/main/publishing.nsf/content/phd-physical-activity-0-5-pdf-cnt.htm>, Accessed date: 31 January 2017.
- Nemours Health and Prevention Services NFPI, 2017. 5-2-1-almost none. www.nemours.org/service/health/growuphealthy/521almostnone.html, Accessed date: 8 March 2017.
- Obama, M., 2009. Let's move! America's move to raise a healthier generation of kids. <https://letsmove.obamawhitehouse.archives.gov/>, Accessed date: 8 March 2017.
- Office of Disease Prevention and Health Promotion, 2008. Physical Activity Guidelines for Americans. Health and Human Services, Washington (Accessed 24 March 2017). <https://health.gov/paguidelines/pdf/paguide.pdf>.
- Ogden, C.L., Carroll, M.D., Lawman, H.G., et al., 2016. Trends in obesity prevalence among children and adolescents in the United States, 1988–1994 through 2013–2014. *JAMA* 315 (21), 2292–2299. <http://dx.doi.org/10.1001/jama.2016.6361>.
- Okely, A.D., Trost, S.G., Steele, J.R., et al., 2009. Adherence to physical activity and electronic media guidelines in Australian pre-school children. *J. Paediatr. Child Health* 45 (1–2), 5–8. <http://dx.doi.org/10.1111/j.1440-1754.2008.01445.x>.
- Pabayo, R., Spence, J.C., Cutumisu, N., et al., 2012. Sociodemographic, behavioural and environmental correlates of sweetened beverage consumption among pre-school children. *Public Health Nutr.* 15 (8), 1338–1346. <http://dx.doi.org/10.1017/S1368980011003557>.
- Pate, R.R., O'Neill, J.R., Brown, W.H., et al., 2015. Prevalence of compliance with a new physical activity guideline for preschool-age children. *Child Obes.* 11 (4), 415–420. <http://dx.doi.org/10.1089/chi.2014.0143>.
- Pfeiffer, K.A., McIver, K.L., Dowda, M., et al., 2006. Validation and calibration of the Actical accelerometer in preschool children. *Med. Sci. Sports Exerc.* 38 (1), 152–157.
- Pujadas Botey, A., Bayrampour, H., Carson, V., et al., 2016. Adherence to Canadian physical activity and sedentary behaviour guidelines among children 2 to 13 years of age. *Prev. Med. Rep.* 3, 14–20. <http://dx.doi.org/10.1016/j.pmedr.2015.11.012>.
- Rideout, V.J., Vandewater, E.A., Wartella, E.A., 2003. Zero to six: electronic media in the lives of infants, toddlers and preschoolers: a Kaiser Family Foundation report. <https://kaiserfamilyfoundation.files.wordpress.com/2013/01/zero-to-six-electronic-media-in-the-lives-of-infants-toddlers-and-preschoolers-pdf.pdf>, Accessed date: 22 March 2017.
- Robson, S.M., Khoury, J.C., Kalkwarf, H.J., et al., 2015. Dietary intake of children attending full-time child care: what are they eating away from the child-care center? *J. Acad. Nutr. Diet.* 115 (9), 1472–1478. <http://dx.doi.org/10.1016/j.jand.2015.02.029>.
- Rogers, V.W., Motyka, E., 2009. 5-2-1-0 goes to school: a pilot project testing the feasibility of schools adopting and delivering healthy messages during the school day. *Pediatrics* 123 (Suppl. 5), S272–276. <http://dx.doi.org/10.1542/peds.2008-2780E>.
- Rogers, V.W., Hart, P.H., Motyka, E., et al., 2013. Impact of let's go! 5-2-1-0: a community-based, multisetting childhood obesity prevention program. *J. Pediatr. Psychol.* 38 (9), 1010–1020. <http://dx.doi.org/10.1093/jpepsy/jst057>.
- Rothausen, B.W., Matthiessen, J., Hoppe, C., et al., 2012. Differences in Danish children's diet quality on weekdays v. weekend days. *Public Health Nutr.* 15 (9), 1653–1660. <http://dx.doi.org/10.1017/S1368980012002674>.
- Schrempf, S., van Jaarsveld, C.H., Fisher, A., et al., 2015. The obesogenic quality of the home environment: associations with diet, physical activity, TV viewing, and BMI in preschool children. *PLoS One* 10 (8), e0134490. <http://dx.doi.org/10.1371/journal.pone.0134490>.
- Singh, A.S., Mulder, C., Twisk, J.W., et al., 2008. Tracking of childhood overweight into adulthood: a systematic review of the literature. *Obes. Rev.* 9 (5), 474–488. <http://dx.doi.org/10.1111/j.1467-789X.2008.00475.x>.
- Tandon, P.S., Zhou, C., Lozano, P., et al., 2011. Preschoolers' total daily screen time at home and by type of child care. *J. Pediatr.* 158 (2), 297–300. <http://dx.doi.org/10.1016/j.jpeds.2010.08.005>.
- Tandon, P.S., Tovar, A., Jayasuriya, A.T., et al., 2016. The relationship between physical activity and diet and young children's cognitive development: a systematic review. *Prev. Med. Rep.* 3, 379–390. <http://dx.doi.org/10.1016/j.pmedr.2016.04.003>.
- The Albert Schweitzer Fellowship The 5-2-1-0 healthy kids countdown. <https://>

- schweitzerfellowship.wordpress.com/category/5-2-1-0-healthy-kids-countdown/, Accessed date: 8 March 2017.
- Turer, C.B., Stroo, M., Brouwer, R.J., et al., 2013. Do high-risk preschoolers or overweight mothers meet AAP-recommended behavioral goals for reducing obesity? *Acad. Pediatr.* 13 (3), 243–250. <http://dx.doi.org/10.1016/j.acap.2013.01.003>.
- U.S. Department of Agriculture, 2014. Independent child care centers: a child and adult care food program handbook. U.S. Government Printing Office, Washington, DC <https://www.fns.usda.gov/sites/default/files/cacfp/Independent%20Child%20Care%20Centers%20Handbook.pdf>.
- U.S. Department of Agriculture, U.S. Department of Health and Human Services, 2010. Dietary guidelines for Americans, 2010. (7th edition) U.S. Government Printing Office, Washington, DC www.dietaryguidelines.gov, Accessed date: 31 July 2017.
- US Department of Agriculture, 2016. Choose MyPlate.gov. MyPlate. <https://www.choosemyplate.gov/MyPlate>, Accessed date: 24 May 2016.
- Vanderloo, L.M., Tucker, P., 2015. Weekly trends in preschoolers' physical activity and sedentary time in childcare. *Int. J. Environ. Res. Public Health* 12 (3), 2454–2464. <http://dx.doi.org/10.3390/ijerph120302454>.
- Whitaker, R.C., Wright, J.A., Pepe, M.S., et al., 1997. Predicting obesity in young adulthood from childhood and parental obesity. *N. Engl. J. Med.* 337 (13), 869–873. <http://dx.doi.org/10.1056/NEJM199709253371301>.
- Whitt-Glover, M.C., Taylor, W.C., Floyd, M.F., et al., 2009. Disparities in physical activity and sedentary behaviors among US children and adolescents: prevalence, correlates, and intervention implications. *J. Public Health Policy* 30 (Suppl. 1), S309–334. <http://dx.doi.org/10.1057/jphp.2008.46>.