



Race/ethnic variations in school-year versus summer differences in adolescent physical activity



James F. Sallis*, Terry L. Conway, Kelli L. Cain, Carrie Geremia, Edith Bonilla, Chad Spoon

Department of Family Medicine and Public Health, University of California San Diego, United States of America

ARTICLE INFO

Keywords:

Youth
Obesity
Exercise
Sedentary behavior
Disparities
Health equity

ABSTRACT

Children and adolescents gain more weight in the summer than the school year, and there are race/ethnic differences in this pattern. Youth physical activity is lower in the summer, and the main aim of the present study was to examine race/ethnic and sex differences in adolescent physical activity, sedentary behavior, and related variables, comparing the school-year and summer. Adolescents aged 11–17 years were recruited from lower-income areas of five states in 2017–2018, and $n = 207$ completed surveys in both the school-year and summer: 56 African Americans, 30 American Indians, 21 Asian/Pacific Islanders, 49 Latinos, and 51 White, non-Hispanics. Of these, $n = 150$ also had accelerometer data. Objectively-measured physical activity was lower in the summer, especially among American Indian, Asian/Pacific Islander, and Latino subgroups. Reported screen time was substantially higher in the summer ($p < .04$), with the biggest increase among African Americans. Reported enjoyment of physical activity was generally lower in the summer ($p < .02$), which could help explain reduced physical activity. Which race/ethnic groups were at higher risk in the summer varied for physical activity and screen time, so interventions should be tailored for each group. Improved strategies to increase physical activity in the summer, especially among higher-risk groups, could contribute to youth obesity control.

1. Introduction

Childhood and adolescent obesity is a prevalent health problem in the United States that continues to increase (Health Resources and Services Administration, 2018; Skinner et al., 2018). There are persistent disparities, with particularly high obesity rates among American Indian, Latino/Hispanic, and African American youth (Ogden et al., 2018; Skinner et al., 2018). Over the past 10–15 years cities and states have mounted initiatives to reduce youth obesity with a variety of approaches and levels of comprehensiveness (Bleich et al., 2013; Ickes and Sharma, 2013). Several strategies were found to reduce youth obesity (Wang et al., 2015). The Healthy Communities Study of 130 communities found a relation between extent of interventions and reduced youth BMI overall. However, there was no relation between strength of interventions and BMI outcomes in predominantly Latino/Hispanic and lower-income communities (Strauss et al., 2018). These troubling inequalities in outcomes indicate that current interventions are not effective in some of the communities at highest risk for youth obesity. Interventions may need to be more tailored to each high-risk community, and this will likely require a better understanding of obesity risk factors and intervention opportunities among multiple high-

risk demographic groups.

One potential contributor to disparities in youth obesity and responses to intervention may be weight gain in the summer (Beets, 2015; Franckle et al., 2014). Several studies showed youth gained more weight during the summer than the entire school year (Baranowski et al., 2014; Moreno et al., 2013; Franckle et al., 2014; von Hippel et al., 2007). A large study of over 5000 children reported race/ethnic disparities in this pattern, with African American and Latino/Hispanic children increasing BMI more in the summer than other subgroups (von Hippel et al., 2007).

A possibly related phenomenon is the finding that children and adolescents were less physically active in the summer than during the school year (Beets, 2015). Similarly, increases in physical fitness as a result of effective school-based interventions were lost over the summer (Fu et al., 2017; Gutin et al., 2008; Yin et al., 2012; Sallis et al., 1997). Because young people are not required to sit for many hours in school during the summer, youth would be expected to have more time for physical activity during the summer. A major limitation of the studies on summer versus school-year physical activity was that results were not reported separately by demographic subgroups. Lower-income also appears to be a risk factor for inactivity (Stalsberg and Pedersen, 2010),

* Corresponding author at: Department of Family Medicine and Public Health, University of California, San Diego, MC 0631, 9500 Gilman Drive, La Jolla, CA 92093-0631, United States of America.

E-mail address: jsallis@ucsd.edu (J.F. Sallis).

<https://doi.org/10.1016/j.ypmed.2019.105795>

Received 24 April 2019; Received in revised form 29 June 2019; Accepted 6 August 2019

Available online 07 August 2019

0091-7435/ © 2019 Elsevier Inc. All rights reserved.

and it could potentiate risk in some racial and ethnic groups. Thus, it is not known whether race, ethnic, and income differences in summer weight gain are concordant with physical activity patterns.

To lay the foundation for evidence-based and subgroup-tailored solutions to summer inactivity and weight gain, a useful starting place is to examine physical activity patterns of youth during summer in contrast to the school year among major race/ethnic groups in the US. The primary aim of the present study was to compare physical activity and sedentary behaviors of adolescents across the summer and school year for major race/ethnic subgroups, as well as by sex. All participating youth were recruited from lower-income communities in several regions of the US. The secondary aim was to examine subgroup differences in expected psychosocial (preferred activities, enjoyment, self-efficacy, social support) and environmental (current and preferred places for physical activity) correlates of physical activity that could inform development of subgroup-tailored interventions to increase physical activity in the summer.

2. Methods

2.1. Study design

The target population was adolescents aged 10–17 years, living in lower income areas (based on a median split of 2010 census-based household income), and representing one of five race/ethnic groups: African American, American Indian, Asian/Pacific Islander, Latino, and White, non-Hispanic. Adolescents were targeted for the present study so a broad range of reported activities and psychosocial variables could be assessed. Using a repeated measures design, adolescents were measured once during the school year and once during summer break during 2017–2018. The Institutional Review Board at University of California San Diego reviewed and approved this study.

2.2. Study procedures

2.2.1. Recruitment

Procedures were designed to identify and recruit adolescents with highly diverse demographics living in selected low-income neighborhoods. To enhance diversity we recruited adolescents from several states, namely California, Mississippi, New Mexico, Maryland, and Hawaii. Based on 2010 census data, low-income neighborhoods were defined as census block groups below the county median household income in urban and suburban areas or below the state median household income in less densely populated or rural areas. Census data were used to identify neighborhoods with a high proportion of the population representing a particular race/ethnic group, so that targeted recruitment efforts could reach adolescents in each of the subgroups.

Initial recruiting efforts used lists purchased from a commercial marketing company to identify households containing adolescents within the study's age range. From this list, potential participants were randomly selected and contacted by both phone and mail. While this approach had been used successfully in previous studies conducted by the research team (e.g., Sallis et al., 2018), it proved only marginally successful in the current study due to inaccurate data that misidentified households with adolescents. Recruitment methods were therefore expanded to establish contacts for distributing study recruitment fliers through community organizations, schools, and other public sites (e.g., Craigslist) that served multiple race/ethnic communities within the identified low-income/high-ethnic population areas. See Botchwey et al. (in press) in this issue for more information on recruitment methods, challenges, and results.

When potential participants were reached by phone (either through recruiters' outreach or after they called the study's toll-free number provided on fliers), recruiters asked to speak to a parent/guardian to explain the study, and then asked to speak with the adolescent. Participation criteria included age range, targeted race/ethnic group,

and no condition that would affect their physical activity or ability to complete a survey. If both the parent/guardian and adolescent agreed, they were mailed consent/assent forms to sign and return.

Response rates were challenging to estimate because various recruitment approaches were used (e.g., commercial lists with phone numbers that research staff called versus flyers distributed with interested individuals calling the research team). There were almost 10,000 potential contact numbers in our recruitment database, but we were not able to make any contact with just over 83% (e.g., numerous phones were disconnected, wrong numbers, never answered). Of the 1684 households where contact was made, 927 (55%) did not have an eligible adolescent living there. Of the 757 eligible households contacted, the participation rate was 41% with 310 of 757 consenting to participate and providing some data (survey or accelerometer) at one or both time points (school year and summertime). However, only $n = 207$ of the 310 completed surveys at both time points (i.e., loss-to-follow up rate = 33%).

2.2.2. Data collection

Participants with signed parent permission and adolescent assent forms were asked to complete a survey (either a mailed paper version or online version) and wear an activity monitor (mailed along with wearing instructions). Completing the survey and wearing the activity monitor were required twice by each participant: once during the school year and once during summer break. Postage-paid return envelopes were provided for mailing all materials back to the university. Adolescents who participated at both time points and returned surveys and activity monitors received a \$30 gift card incentive.

2.3. Study measures

Three categories of measures were used: (a) objectively assessed physical activity and sedentary time (accelerometer); (b) self-reported physical and sedentary activities, including active transportation, leisure-time physical activity, screen time, current and preferred places and types of physical activity; and (c) psychosocial measures related to physical activity. Descriptions of measures, along with sources, scoring, and psychometric properties, are provided in Table 1.

The activity monitors were Actigraph accelerometers (models GT3X + or GT3X-BT; Pensacola, FL). Participants were instructed to wear the accelerometer on a belt around the waist during all waking hours (except when bathing or swimming) for 7–10 days, as well as complete a wear-diary. When accelerometers were returned, data were downloaded and aggregated to 30-s epochs using the Low Frequency Extension (Cain et al., 2013a) and screened for valid data and device malfunction. A valid wearing day was defined as having at least 10 h of wearing time, with non-wear time defined as 60+ minutes of consecutive '0' counts (Cain et al., 2017). Data were scored using Evenson cut points (Evenson et al., 2008) for moderate-to-vigorous physical activity (MVPA), and sedentary time was scored with the commonly-used cut point of ≤ 100 counts per minute (Evenson et al., 2008; Cain et al., 2013b) using MeterPlus version 5.0. The MVPA and sedentary time measures used in the statistical analyses were "average minutes per day", calculated by averaging minutes per day at a given intensity level (MVPA or sedentary) across all valid wearing days for each participant. Four days of accelerometer monitoring is generally considered a good estimate of habitual physical activity, at least for a given season (Trost et al., 2000). In the current sample of adolescents with accelerometer data at both time points, 90% of participants during the school-year and 80% during summer had 4+ valid wearing days. However, to maximize the sample size available for statistical analyses, only 1+ valid days of accelerometer wearing was required.

2.4. Statistical analyses

Analyses were conducted using SPSS Version 25. Descriptive

Table 1
Description of measures.

Measure	Descriptions	Number of items; responses	Measure used in analyses	Psychometric properties (reference)
Measures assessed twice: during the school year and during summer break: Objective physical activity (PA) and sedentary time (accelerometer) Moderate-vigorous physical activity (MVPA)	Actigraph accelerometer counts scored for time spent engaging in moderate to vigorous physical activity levels	Model: Actigraph GT3X. Epoch: 30 s Filter: Low frequency extension. Nonwear definition: 60 min consecutive '0' counts. Valid day: 10 h. Cut points: Evenson. Requested wear time: 10 days during waking hours. Required wear time for analyses: 1 day. Data processing software: MeterPlus, version 5.	Average minutes of MVPA per valid wearing day	Evenson et al., 2008, Cain et al., 2013a, 2013b Cain et al., 2017
Sedentary time (non-sleeping)	Actigraph accelerometer counts scored for time spent in sedentary activity levels		Average minutes of sedentary time per valid wearing day	
Leisure-time PA, active transportation, sedentary screen time, places youth currently do and Leisure PA outside of school	Self-reported number of sports teams or physical activity classes participated in outside of school	Single item; responses corresponded to the number of sports teams or activity classes participated in during the school year (or during summer break): 0, 1, 2, 3, 4 or more	Single-item indicator of non-school leisure-time PA participation: Number of sports teams or PA classes	Test-retest of original item, ICC = 0.65. Joe et al., 2012
Active transport scale	Self-reported typical frequency of walking or bicycling to/from 7 types of locations (e.g., indoor recreation facility, friend or relative's house, outdoor park/sports field, food store/restaurant, other retail store, non-school place for activities, public transportation stops) or skateboarding to various places. Self-reported time spent in sedentary "screen time" behaviors	8 items; six response options were recoded to correspond to weekly frequency: 0 = never, 0.25 = ≤ once a month, 0.50 = once every other week, 1 = once a week, 2.5 = 2–3 times a week, 4 = 4+ times a week.	Scale score: Sum of 8 items to reflect the frequency of active transportation to various non-school locations: Total times per week.	N/A; developed by investigators
Screen time	Self-reported time spent in sedentary "screen time" behaviors	Time (minutes per day) spent on a typical weekday and weekend day reported for 3 screen-time behaviors (computer/internet use for leisure; playing computer/video games; watching TV/videos)	Weighted sums (weekday + weekend days) computed to obtain minutes per week for each of 3 behaviors; then summed for overall Screen Time (total min per week)	Test-retest reliability: Norman et al., 2005 and construct validity: Rosenberg et al., 2010
Places where you do PA.	Self-reported frequency where adolescent does physical activity in 21 places (e.g., home, yard, driveway/alley, neighbor's house/yard, local street/sidewalk/vacant lot, nearby cul-de-sac, nearby park/open space, indoor recreation facility, beach/lake, bike/hiking trails, basketball court, playing fields/courts, indoor swimming pool, outdoor swimming pool, park outside neighborhood, public open space, friend's house, school grounds, ski/winter activity area, skatepark, parking lot)	21 items; six response options were recoded to correspond to weekly frequency: 0 = never, 0.25 = ≤ once a month, 0.50 = once every other week, 1 = once a week, 2.5 = 2–3 times a week, 4 = 4+ times a week.	Items examined individually to identify the places where adolescents in each race/ethnic group reported doing PA most frequently: Number of times per week	Test-retest ICC's ranged from 0.31 to 0.65. Joe et al., 2012
Ideal places where you would like to do PA	Self-reported ideal frequency where adolescent would like to do physical activity in 21 places (same list as above)	21 items; six response options were recoded to correspond to weekly frequency: 0 = never, 0.25 = ≤ once a month, 0.50 = once every other week, 1 = once a week, 2.5 = 2–3 times a week, 4 = 4+ times a week.	Items examined individually to identify the places where adolescents would like to do PA most frequently: Desired times per week	N/A; developed by investigators
Physical activities you would like to do often	Types of physical activities (e.g., walking, running, bicycling, swimming, dance, cheerleading, gymnastics, basketball, pushups/sit-ups/jumping jacks, football, soccer, baseball/softball, volleyball, racket sports, dodgeball/kickball, tag/chase games, play outdoors, water play in pools/lake, jump rope, outdoor yard chores, indoor house chores)	21 items of various types of PA; response options were "no" or "yes, want to do often"	Items examined separately to identify types of PA that adolescents wanted to do most often	N/A; developed by investigators
Psychosocial measures (survey-based) Self-efficacy for physical activity	Adolescents were asked to report "confidence" they could do PA in 6 situations (e.g., when stressed or sad, even if I have to get up early, when it is either raining or hot outside).	6 items. 5-point response scale ranged from "I know I can't" (1) to "I know I can" (5).	Scale score: Mean of 6 items; higher scores indicating higher self-efficacy for PA	$\alpha = 0.76$, test-retest ICC = 0.71 Norman et al., 2005
Enjoyment of physical activity	1 item assessed adolescents' enjoyment of physical activity (PA).	Responses on a 4-point scale ranged from "strongly disagree" (1) to "strongly agree." (4)	Single-item indicator of enjoyment of physical activity (PA); higher values indicating greater enjoyment of PA	Test-retest ICC = 0.43 Norman et al., 2005 (continued on next page)

Table 1 (continued)

Measure	Descriptions	Number of items; responses	Measure used in analyses	Psychometric properties (reference)
Social support for physical activity (2 scales)	Separate scales for youth-provided and adult-provided social support for physical activity (e.g., encourages physical activity or sports, does PA with adolescent).	2 items for support provided by “brothers/sisters or friends” and 3 items related to social support for PA from an “adult in household”. A five-point response scale ranged from 0 “never” to 4 “very often”.	2 scales: Mean of 2 youth items and mean of 3 adult-related items; higher scores indicate higher social support for PA	Family support $\alpha = 0.79$ Test-retest ICC = .74. Peer support $\alpha = 0.60$. Test-retest ICC = 0.68 Norman et al., 2005

analyses were done to examine distributional characteristics of all measures and ensure there were no improbable outliers. To address the primary aim of comparing physical activity, sedentary behavior, and psychosocial characteristics across school year and summer, by race/ethnic subgroups, and by sex, the General Linear Model (GLM) Repeated Measures procedure was used. Models contained two between-groups factors (race/ethnic group and sex), one within-group repeated measures “time” factor (school year versus summer), and one covariate (age). Main effects for race/ethnic groups, sex, and time, and the interaction effects for race/ethnic group*time and sex*time were tested in a model for each key outcome measure, and age-adjusted means were plotted (see Figures). The GLM models for accelerometer outcomes (MVPA and sedentary time) used for the figures did not include wear time as a covariate, so that an identical set of covariates could be used across all nine outcomes analyzed. However, we ran models both with and without wear time to ensure that results were not affected by its omission. The patterns of effects were identical, and there were no significant ($p > .05$) interactions between wear time and either race/ethnicity or sex. Lastly, to examine the most frequently reported current and preferred places to engage in physical activity and the preferred types of physical activities, simple descriptive statistics (means, percentages) were calculated and tabled.

3. Results

3.1. Participants

The final sample examined was $n = 207$ adolescents who completed both school year and summer time surveys, so differences between time points could be assessed. As shown in Table 2, the sample included 56 African Americans (39% girls), 30 American Indians (53% girls), 21 Asian/Pacific Islanders (52% girls), 49 Latinos (57% girls), and 51 White, non-Hispanics (41% girls). Overall, 56% of the adolescents lived in households with one or more members having a college degree (subgroups ranged from 33% among American Indians to 78% among White, non-Hispanics). A majority of the parents/guardians were married or living with a partner (65% overall, ranging from 45% to 82% across subgroups). For the overall sample, the median BMI percentile (CDC age- and sex-adjusted calculations) was 78.4, ranging from 66.2 for Asian/Pacific Islanders to 89.3 for American Indians. Of the 207 participants with surveys at both time points, 150 adolescents also provided accelerometer data at both time points. There were significant ($p < .05$) race/ethnic group differences for highest household education, parents' marital status, and number of accelerometer wearing days during school-year and summer assessments (see footnotes in Table 2). There were no significant race/ethnic group differences for age, sex, or BMI percentiles.

A goal of the present paper was to include as many findings as possible, so the multiple results could be interpreted in an integrated manner. To accomplish this while keeping the paper concise, the Results section is truncated, and the key results are both presented and interpreted in the Discussion section.

3.2. Race/ethnic groups, sex, and school versus summer effects

Comparisons assessing differences over time (school year versus summer), race/ethnic groups, and sex for 9 study measures are illustrated with plots of age-adjusted means and F/p-values from the GLM analyses (see Figs. 1 and 2). Differences between school year and summer, as indicated by either time main effects or time interaction effects with race/ethnic group or sex, were a consistent finding, with 7 of 9 measures showing at least one significant time-related main or interaction effect. Race/ethnic- and sex-related effects (trends or significant main or interaction effects) occurred in 5 of 9 outcomes examined though they were less consistent than time-related effects.

Table 2
Demographics of participants (N = 207) who completed both school-year and summer surveys and wore accelerometers by race/ethnic groups.

Race/ethnic group:	African American	American Indian	Asian/Pacific Islander	Latino	White, non-Hispanic	Total
Number of participants:	56	30	21	49	51	207
Age ^a in years:						
Mean	14.0	13.7	14.9	13.9	13.8	13.9
SD	1.94	0.88	1.88	2.03	1.92	1.85
Range	10–17	12–15	12–17	10–17	11–17	10–17
Sex ^c : counts						
Girls	22 (39%)	16 (53%)	11 (52%)	28 (57%)	21 (41%)	98 (47%)
Boys	34	14	10	21	30	109
Highest household education ^b : counts						
< High school degree	5	4	6	10	0	25
High school completed	11	8	0	10	3	32
Some college	5	8	4	10	8	35
College degree or higher	35 (63%)	10 (33%)	11 (52%)	19 (39%)	40 (78%)	115 (56%)
Parents' marital status ^c : counts						
Married or living with partner	25 (45%)	15 (50%)	16 (76%)	37 (76%)	42 (82%)	135 (65%)
Divorced or separated	13	7	4	11	9	44
Widowed or single/never married	18	8	1	1	0	28
Adolescents BMI percentile ^a (CDC):						
Mean	75.6	75.5	61.5	63.6	62.2	68.0
SD	28.4	29.6	23.7	34.4	31.8	30.9
Median	86.2	89.3	66.2	80.9	70.5	78.4
Interquartile range: 25th, 75th percentiles	71, 96	59, 96	46, 79	33, 96	34, 91	46, 95
Minimum	1.0	0.2	4.4	0.2	0.6	0.2
Maximum	99.6	99.3	96.6	99.6	99.4	99.6
Accelerometer data						
Number of participants	34	23	16	39	38	150
School year: Mean wearing days per person ^d	8	6	8	8	8	8
Summer time: Mean wearing days per person ^d	7	5	6	8	7	7

^a No significant ($p \geq .05$) differences across race/ethnic groups.

^b Significant ($p \leq .05$) differences across race/ethnic groups with fewer American Indians and Latinos and more White,non-Hispanics living in households with a college graduate.

^c Significant ($p \leq .05$) differences across race/ethnic groups with fewer African Americans and American Indians and more White,non-Hispanics living in households with parents that were married/living with a partner.

^d Significant ($p \leq .05$) differences across race/ethnic groups with American Indians wearing fewer days than other race ethnic groups.

3.3. Current and preferred places and activities

In Tables 3–5 descriptive results show the patterns of race/ethnic group and sex differences in the current and preferred places for physical activity and the types of physical activities adolescents like to do most often. For each subgroup the tabled values are the top 5–9 places with the highest average reported frequencies or with at least 70% of participants reporting activities they would like to do most often. In one's home or yard/common area were the places most consistently reported as the most frequent current and preferred places for physical activity. Walking was the type of physical activity adolescents reported wanting to do most often.

4. Discussion

4.1. School-year versus summer differences in physical activity and sedentary behaviors

The previously reported lower levels of youth physical activity during the summer were strongly replicated in the present diverse sample of adolescents using accelerometer measures (Fig. 1A). Declines from the school year to summer were apparent in all race/ethnic groups and both sexes in the current sample. The overall difference in objectively measured MVPA was about 14 min/day. However, there were significant race/ethnic differences in the decline. American Indians showed the greatest decline, about 27 min/day, and White non-Hispanics showed the least decline, about 5 min/day. One of the reasons for these differences may be that American Indians had the highest MVPA during the school year, and White non-Hispanics had the lowest. However, American Indian and Latino adolescents had the lowest

summer MVPA. The school year to summer decline showed a trend to be greater among boys (17 min/day) than girls (10 min/day), though girls' MVPA was consistently lower than boys'.

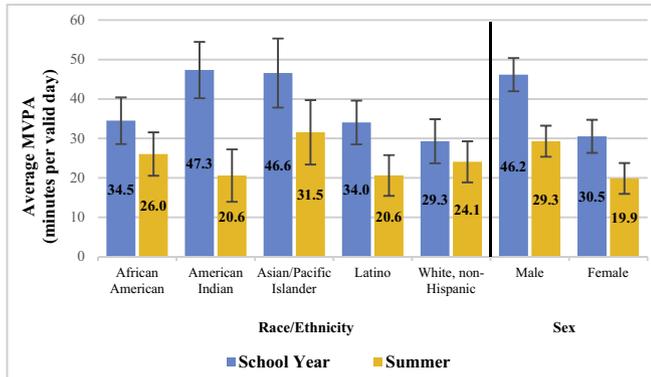
Although lower summer physical activity should be seen as a population-wide concern, present results identified substantial race/ethnic and sex inequalities that could be used to target intervention resources to groups at higher risk. Keep in mind that all participants were recruited from lower-income areas because lower-income is a risk factor for youth obesity (Ogden et al., 2018; Skinner et al., 2018). In the present sample, American Indians, Latinos, and girls had the lowest objectively-measured MVPA in the summer, indicating these subgroups were at particularly high risk.

Reported participation in organized leisure physical activity and active transport showed very different patterns across subgroups, supporting the promise of tailoring interventions to the needs of each subgroup. There were no significant season, race/ethnic, or sex differences in reported leisure time physical activity, defined as participation in organized sports teams and physical activity classes outside of school (Fig. 1B). However, this was a limited measure. It may be particularly limited with lower-income adolescents who may not be able to afford participation fees. The mean for every subgroup at both time points indicated the average adolescent participated in fewer than one team or class per assessment period. The lowest participation rates were seen among Latinos and girls, so extra efforts to provide free or low-cost programs throughout the year that appeal to, and are marketed to, these groups, appear to be justified.

Frequency of active transport varied widely across race/ethnic groups, and there was no consistent seasonal pattern across subgroups (Fig. 1C). The significant race/ethnic group-by-seasonal effect was due mainly to much higher active transport in summer, compared to the

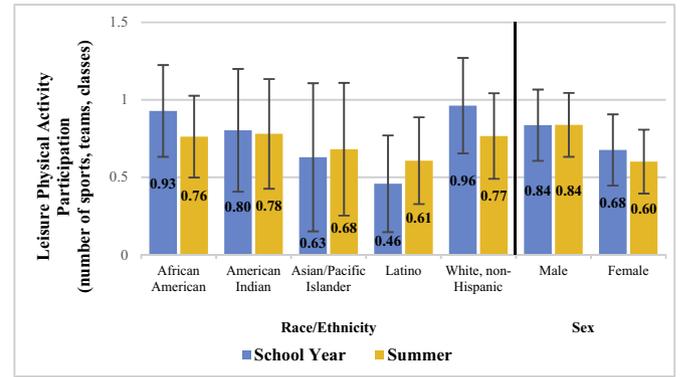
A) Moderate-to-Vigorous Physical Activity (MVPA, accelerometer measured). School-year vs summer differences by race/ethnicity and sex.

	F	p
Race/Ethnicity	3.06	0.019
Sex	28.03	<0.001
School v Summer	6.24	0.014
Interaction Race * Time	5.19	0.001
Interaction Sex * Time	3.59	0.060



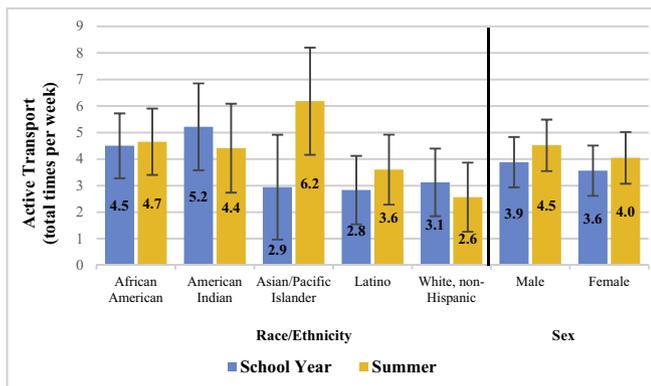
B) Reported Leisure-time Physical Activity: Participation in Sports Teams and Classes. School-year vs summer differences by race/ethnicity and sex.

	F	p
Race/Ethnicity	1.15	0.334
Sex	2.22	0.138
School v Summer	<0.01	0.990
Interaction Race * Time	0.93	0.451
Interaction Sex * Time	0.25	0.619



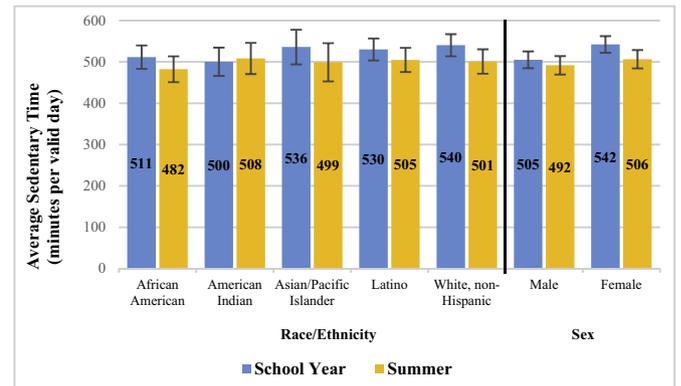
C) Reported Active Transportation to Various Places. School-year vs summer differences by race/ethnicity and sex.

	F	p
Race/Ethnicity	2.146	0.077
Sex	0.445	0.506
School v Summer	0.484	0.487
Interaction Race * Time	3.468	0.009
Interaction Sex * Time	0.054	0.817



D) Overall Sedentary Time (accelerometer measured). School-year vs summer differences by race/ethnicity and sex.

	F	p
Race/Ethnicity	0.644	0.632
Sex	4.249	0.041
School v Summer	0.001	0.976
Interaction Race * Time	0.985	0.418
Interaction Sex * Time	1.834	0.178



E) Reported Screen Time. School-year vs summer differences by race/ethnicity and sex.

	F	p
Race/Ethnicity	6.148	<0.001
Sex	2.856	0.093
School v Summer	4.378	0.038
Interaction Race * Time	2.319	0.058
Interaction Sex * Time	2.215	0.138

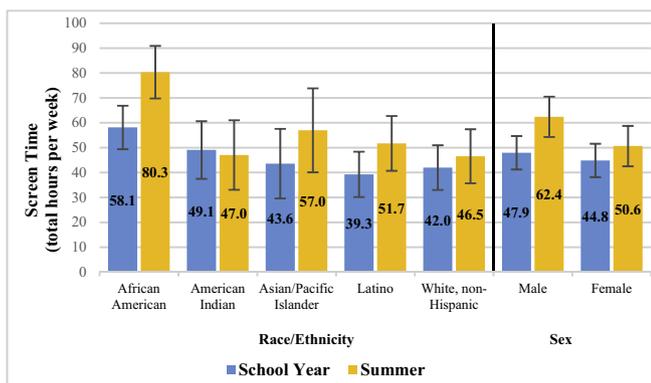
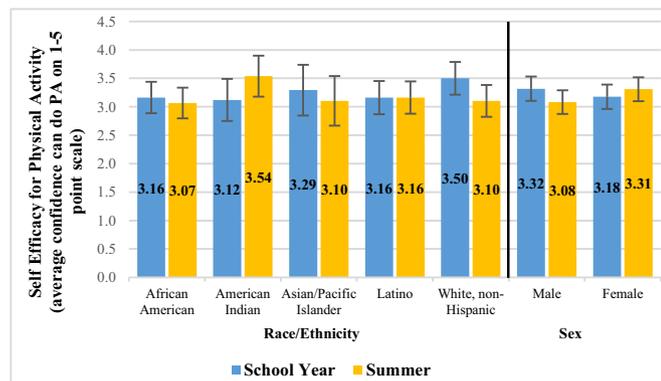


Fig. 1. A-E. School-year versus summer differences in physical activity and sedentary behavior by race/ethnicity and sex.

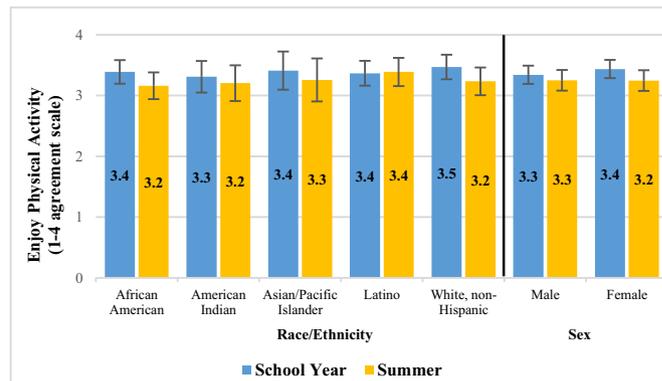
A) Self-Efficacy for Physical Activity. School-year vs summer differences by race/ethnicity and sex.

	F	p
Race/Ethnicity	0.476	0.753
Sex	0.106	0.745
School v Summer	0.447	0.504
Interaction Race * Time	3.344	0.011
Interaction Sex * Time	6.212	0.014



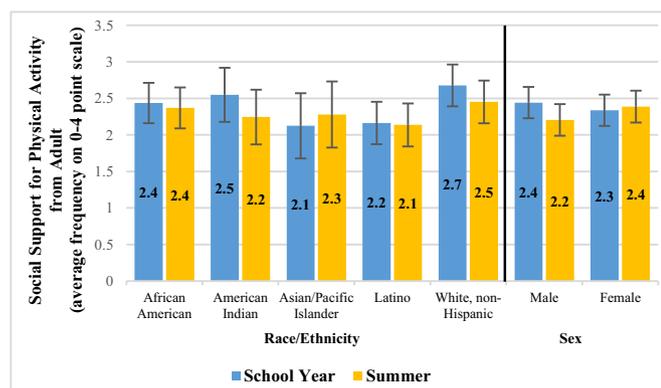
B) Enjoyment of Physical Activity. School-year vs summer differences by race/ethnicity and sex.

	F	p
Race/Ethnicity	0.269	0.898
Sex	0.224	0.636
School v Summer	5.841	0.017
Interaction Race * Time	0.836	0.504
Interaction Sex * Time	0.669	0.415



C) Social Support for Physical Activity from Adult in Household. School-year vs summer differences by race/ethnicity and sex.

	F	p
Race/Ethnicity	1.401	0.235
Sex	0.075	0.785
School v Summer	0.017	0.895
Interaction Race * Time	1.332	0.259
Interaction Sex * Time	5.384	0.021



D) Social Support for Physical Activity from Youth (Siblings and Friends). School-year vs summer differences by race/ethnicity and sex.

	F	p
Race/Ethnicity	2.091	0.083
Sex	0.033	0.855
School v Summer	4.915	0.028
Interaction Race * Time	0.996	0.411
Interaction Sex * Time	0.072	0.789

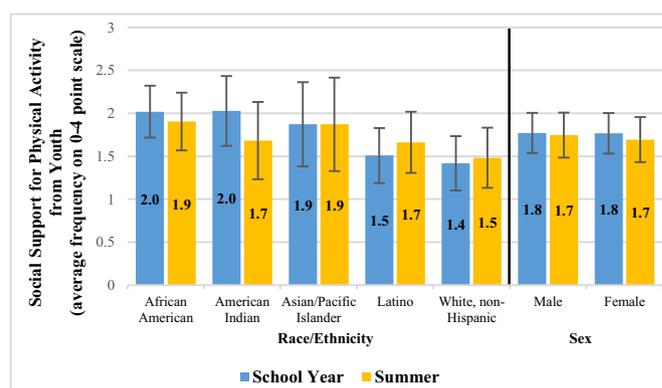


Fig. 2. A-D. School-year versus summer differences in physical activity-related psychosocial variables by race/ethnicity and sex.

school year, only in the Asian/Pacific Islander group. Qualitative follow-up studies are needed to identify reasons for this dramatic difference among Asian/Pacific Islander adolescents and the inconsistent differences seen across the race/ethnic subgroups. Active transport to/from school has been studied extensively (Larouche et al., 2014), but adolescent active transport to other destinations has been less studied. However, complex findings have been reported (e.g., Wang et al., 2017).

Youth sedentary behaviors have not been consistently associated with health outcomes such as obesity (van Ekris et al., 2016). However, because students are required to sit during school, it is of interest to understand seasonal differences in overall sedentary time and specific sedentary behaviors. In the present study accelerometer-measured sedentary time (Fig. 1D) was not significantly different by season or race/ethnic group, with all results in the range of 8–9 h per day. Girls had significantly more total sedentary time (average difference of 12.5 min/day) than boys. The similarity of sedentary time in the school year and summer was surprising and did not support a hypothesis that sedentary time might be less in the summer when school policies do not enforce sitting. Another hypothesis that was not tested is that in lower-income areas, high parental concern about crime safety (Ding et al., 2012) could lead to parental restrictions about adolescents going outdoors unsupervised in the summer.

The finding of greater screen time in the summer than the school year might be explained by restrictions on going outdoors, but many youth can use their portable screens anywhere, and the measure did not specify the location of screen use. It appears that all race/ethnic groups increased screen time in the summer, except American Indians (Fig. 1E). The summer increase in screen time was particularly high among African American adolescents, and this finding was consistent with previous studies of television viewing and screen time (Carson et al., 2015). One interpretation of the finding that screen time increased during summer is that enforced sitting time during school may be replaced by more screen time in the summer. Present results provide more seasonal specificity and suggest that interventions to reduce screen time in the summer are most needed for African American adolescents.

4.2. School-year versus summer differences in psychosocial variables

Several psychosocial variables were assessed that have been supported as physical activity correlates in prior studies (Sallis et al., 2000). These results can be used to inform the design of interventions targeting adolescents and their family that are tailored to the needs of different subgroups and to target specific times of year. A significant race/ethnicity-by-time interaction indicated self-efficacy for American

Table 3
Places where you do physical activity: top 5–9 responses per Race/Ethnic group and Sex for School Year and Summer.*

Means (times per week)*	African American		American Indian		Asian/Pacific Islander		Latino		White, non-Hispanic		Boys		Girls	
	School	Summer	School	Summer	School	Summer	School	Summer	School	Summer	School	Summer	School	Summer
	1.5	1.4	2.1	2.0	–	1.5	1.2	1.7	1.5	1.4	1.5	1.6	1.4	1.5
Places where you do physical activity during...	1.5	1.4	2.1	2.0	–	1.5	1.2	1.7	1.5	1.4	1.5	1.6	1.4	1.5
Inside your home	1.4	1.5	1.7	1.5	–	–	1.0	1.2	1.4	1.1	1.5	1.3	1.1	1.3
In your yard or common area	1.1	1.0	–	–	1.5	–	1.1	–	1.2	0.9	0.9	–	1.5	0.9
School grounds	1.4	–	1.4	1.3	1.0	–	0.9	–	1.2	–	1.3	–	1.0	0.8
Other playing fields/courts	1.2	1.0	1.6	1.4	1.1	–	–	–	–	–	1.2	1.0	–	–
Basketball court	–	–	1.8	1.3	–	1.0	–	0.8	–	–	0.9	0.9	0.7	0.8
In a nearby park or open space	–	–	–	–	–	1.1	–	0.9	1.1	–	–	0.8	–	1.1
Outdoor swimming pool	–	–	–	–	1.0	1.1	–	0.9	–	0.8	0.9	0.8	0.7	–
Indoor rec or exercise facility	–	1.0	–	–	1.0	–	–	–	–	–	0.9	0.8	0.7	–
Bike/hiking/walk-ing trails, paths	–	–	–	–	1.0	–	–	–	–	–	0.9	0.8	0.7	–
Public open space, not a park	–	–	–	–	–	–	0.7	–	–	–	–	–	–	–
On local street, sidewalk, or vacant lot	–	–	–	–	–	1.1	–	–	–	–	–	–	–	0.7

* Responses recoded to never = 0, = ≤ once a month = 0.25, once every other week = 0.50, once a week = 1, 2–3 times a week = 2.5, 4+ times a week = 4.

Table 4
Places where you would like to do physical activity: top 5–7 responses per Race/Ethnic group and Sex for School Year and Summer.

Means (times per week)*	African American		American Indian		Asian/Pacific Islander		Latino		White, non-Hispanic		Boys		Girls	
	School	Summer	School	Summer	School	Summer	School	Summer	School	Summer	School	Summer	School	Summer
	1.8	2.0	1.9	1.7	1.3	1.6	1.5	1.5	1.4	1.3	1.3	1.3	1.9	1.7
Places ideal for physical activity during...	1.8	2.0	1.9	1.7	1.3	1.6	1.5	1.5	1.4	1.3	1.3	1.6	1.9	1.7
Inside your home	1.7	1.7	–	1.6	1.3	–	1.3	1.5	1.3	1.1	1.4	1.6	1.4	1.2
In your yard or common area	1.7	1.2	1.6	–	1.6	1.6	1.1	1.3	1.3	–	1.5	1.4	–	–
Indoor rec or exercise facility	2.0	1.2	1.9	1.5	1.3	–	1.1	–	1.4	–	1.7	–	–	–
Other playing fields/courts	–	1.3	–	–	1.3	1.5	1.5	1.5	1.6	1.7	–	1.3	1.5	1.6
Outdoor swimming pool	–	1.2	1.7	–	1.7	1.4	1.1	–	–	–	1.3	–	1.4	1.1
Bike/hiking/walking trails, paths	1.6	–	1.5	1.7	–	–	–	–	–	–	1.5	1.3	–	–
Basketball court	–	–	–	–	–	–	1.2	–	1.3	–	–	–	–	–
School grounds	–	–	–	–	–	1.4	–	1.2	–	–	–	–	–	1.1
In a nearby park or open space	–	–	–	–	–	–	–	–	–	1.1	–	–	–	–
Beach, lake, river or creek	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Friend's or relative's house	–	–	–	–	–	–	–	–	–	1.1	–	–	–	–
Public park outside your n'hood	–	–	–	1.8	–	–	–	–	–	–	–	–	–	–

* Responses recoded to never = 0, = ≤ once a month = 0.25, once every other week = 0.50, once a week = 1, 2–3 times a week = 2.5, 4+ times a week = 4.

Table 5
Activities you would like to do often: percent of “yes” responses 70% or higher per Race/Ethnic groups and Sex for School Year and Summer.

	Percent of “yes” responses													
	African American		American Indian		Asian/Pacific Islander		Latino		White, non-Hispanic		Boys		Girls	
	School	Summer	School	Summer	School	Summer	School	Summer	School	Summer	School	Summer	School	Summer
Physical activities you would like to do during...														
Walking	91%	93%	87%	100%	100%	86%	90%	88%	76%	75%	83%	83%	93%	93%
Exercise	79%	70%	73%	77%	90%	76%	–	71%	75%	–	77%	71%	73%	72%
Running	82%	73%	87%	80%	81%	–	–	71%	73%	–	76%	72%	79%	68%
Water play	–	–	–	–	–	81%	81%	88%	–	80%	–	–	77%	87%
Bicycling	73%	73%	–	–	–	–	–	–	–	76%	72%	74%	–	–
Ball playing	71%	73%	80%	–	–	–	–	–	–	–	–	–	–	–
Outdoor play	–	–	–	–	–	–	–	–	–	75%	–	–	71%	74%
Swimming laps	–	–	–	–	–	–	–	73%	–	–	–	–	–	–

Indians was higher in the summer, showed the largest decline in the summer for White non-Hispanics, and was unchanged for Latinos (Fig. 2A). A significant sex-by-time interaction indicated self-efficacy was lower in the summer for boys but was higher in the summer for girls. The findings for American Indians, Latinos, and girls were not concordant with the MVPA patterns, so the relevance of self-efficacy in designing targeted interventions is not clear.

By contrast, the results for enjoyment of physical activity may be more informative (Fig. 2B). There were modest but significant declines in enjoyment of physical activity in the summer, so it is possible enjoyment is a mediator of the summer decline in physical activity. Reduced enjoyment in the summer was consistent across race/ethnic and sex subgroups. It would be valuable to conduct studies to understand reasons for this decline. One hypothesis to explore is that the greater difficulty of being active with peers in summer could reduce enjoyment of summer activities. While virtually all physical activities in or after school are with peers during the school year, in the summer most of these lower-income adolescents did not participate in organized activities, and they spent more time looking at their screens. Perhaps there are barriers to informal activities with peers living in lower-income areas that could be identified in research, then addressed in interventions.

Social support results may be useful in targeting adolescent subgroups that show reduced social support in the summer. Although the interaction effect was nonsignificant, reported social support from youth (peers, siblings) had a significant seasonal effect and trend for a race/ethnicity effect (Fig. 2C). The significant decline in peer social support during summer was accounted for primarily by African Americans and American Indians, who also had the highest school-year social support for physical activity from peers. Thus, both African American and American Indian youth might be able to benefit from culturally-tailored interventions to prevent the decline and enhance social support from peers in the summer. Reported social support from an adult in the household had a significant sex-by-time interaction, indicating social support for physical activity was lower for boys in the summer (Fig. 2D). Perhaps this is an indication that boys are more motivated than girls to be active in the summer and require less social support from an adult in the household.

4.3. Preferred activities and places for physical activity

The ratings of preferred physical activities and current and preferred places to be active shown in Tables 3–5 were intended to provide information that could be used in the design of subgroup-tailored interventions. Because this was considered formative evidence, statistical tests were not conducted, so interpretation was based on examination of the top-rated options in all tables, compared across race/ethnic and sex subgroups. The findings for preferred activities demonstrated surprising consistency, with walking being the most preferred physical

activity across all subgroups and seasons. This is a clear indication that walking should be a major focus of interventions. Exercise (perhaps interpreted as dance exercise) and running were highly rated by all race/ethnic groups, and girls showed strong preferences for water play.

Current and preferred places for physical activity also tended to be similar across subgroups. With just a few exceptions, the most frequent current places for physical activity were inside the home or in the yard or common area for all subgroups during the school year and summer. School grounds was another frequently-used location by virtually every subgroup, with the expected lower frequency of use in the summer. Nearby parks were not among the most-used locations, except for American Indians.

When asked where they would ideally like to do physical activity, in the home and around the home still rated highly regardless of season, but school grounds dropped out of the top choices for all subgroups except Latinos and White non-Hispanics. There was more variety across subgroups in top choices. The most preferred places included playing fields/courts by African Americans, American Indians, and boys in the school year; biking/hiking/walking paths by Asian/Pacific Islanders in the school year; and swimming pools by Latinos, White non-Hispanics, and girls, regardless of season. Nearby parks were among the highly-rated locations in the summer by Asian/Pacific Islanders and Latinos, but American Indians' top-rated location for the summer was parks outside the neighborhood.

4.4. Strengths and limitations

Strengths of the study included the focus on recruiting diverse adolescents from lower-income areas, analysis of all results by race/ethnic subgroups, use of device-based and reported physical activity and sedentary behavior, and inclusion of psychosocial variables. The formative assessment of preferred physical activities and places to be active can be used to tailor physical activity interventions for subgroups of adolescents at high risk for reduced physical activity in the summer and obesity in general.

Limitations of the study largely stemmed from challenges of recruitment described in the present paper and an accompanying paper on recruitment from all the PARC research groups (Botchwey et al., in press). Because of this, several of the samples were smaller than planned, Asian and Pacific Islander youth had to be combined for analyses, and it was not feasible to summarize or analyze data by sex for each race/ethnic subgroup. Race/ethnic group was partially confounded by state of residence, so these effects cannot be separated. There was a wide range of parent education levels across race/ethnic groups. Almost all American Indian participants were recruited from one school. The sample cannot be considered generalizable, and though participants were recruited from multiple geographies to produce a more diverse sample, it was not possible to evaluate regional or urban/suburban/rural differences. Present results showing important race/

ethnic, sex, and seasonal differences justify larger studies with more representative samples. Although weather and temperature are related to youth physical activity (Ridgers et al., 2015), weather data were not collected, and it is possible that hot summer weather plays an important role in lower physical activity in the summer. Measurement dates were based on child availability and time of recruitment rather than being randomly assigned. Some participants had fewer than the recommended number of accelerometer wearing days, which may have produced imprecise measures of habitual activity. Additional accelerometer data collection periods during each season would be expected to produce more precise physical activity and sedentary behavior estimates. Parent/guardian physical activity was not assessed in the present study, so it was not possible to determine whether adult patterns of school-year versus summer physical activity comparisons were similar to adolescent patterns. A review concluded adults were generally more active in summer (Tucker and Gilliland, 2007), but studies of parents from specific race/ethnic groups might yield different findings. Because some youth were measured first in the school-year and others were measured first in the summer, it was not possible to analyze BMI changes.

5. Conclusion

The diverse sample of adolescents, though not ideal in composition, allowed comparisons across five race/ethnic subgroups that are rarely possible with such detailed data related to physical activity. Results clearly showed a substantial summer decline in total physical activity that generalized across all the race/ethnic groups studied, so population-wide interventions seem to be needed. The study also identified higher-risk subgroups, with American Indians, Asian/Pacific Islanders, Latinos, and boys having the largest declines in overall physical activity from the school-year to the summer. Some findings were particularly useful in identifying reasons for the summer decline overall or in specific subgroups that could be used to design subgroup-tailored interventions. Enjoyment of physical activity was generally lower in the summer, and screen time was generally higher, so these patterns could help explain the summer decline and are worthy of further study. Walking was the most preferred physical activity in all subgroups, providing a justification for population-wide efforts to promote walking among adolescents, though specific intervention approaches can be tailored using results from the psychosocial variables and preferred locations. The significant variations across race/ethnic groups found in the present study justify studies with larger samples of adolescents to explore subgroup-specific barriers to, and opportunities for, physical activity. Because declines in physical activity during the summer could be contributing to excessive summer weight gain, additional evidence is needed to inform subgroup-tailored interventions that could be evaluated.

Disclosures

This work was supported by a grant from The Robert Wood Johnson Foundation grant number (73742) as part of the Physical Activity Research Center. The funder had no role in the study design; in the collection, analysis and interpretation of data; in the writing of the report; or in the decision to submit the article for publication.

James F Sallis receives royalties and honoraria for SPARK physical activity programs through Gopher Sports Inc. He is employed by Australian Catholic University. All other authors report no disclosures.

References

Baranowski, T., O'Connor, T., Johnston, C., Hughes, S., Moreno, J., Chen, T.A., et al., 2014. School year versus summer differences in child weight gain: a narrative review. *Child. Obes.* 10 (1), 18–24. <https://doi.org/10.1089/chi.2013.0116>.

Beets, M.W., 2015. Does summertime weight gain undermine youth obesity prevention efforts?

Research Brief. Active Living Research, San Diego, CA May. Available from. <http://activelivingresearch.org/does-summertime-weight-gain-undermine-youth-obesity-prevention-efforts>.

Bleich, S.N., Segal, J., Wu, Y., Wilson, R., Wang, Y., 2013. Systematic review of community-based childhood obesity prevention studies. *Pediatrics* 132, e201–e210. <https://doi.org/10.1542/peds.2013-0886>.

Botchwey, N., Conway, T.L., Floyd, M.F., Hipp, A., Kim, A., Pollack Porter, K.M., Umstادت Meyer, R., Burnett, J., & Sallis, J.F. (in press, this issue). Challenges recruiting diverse youth for physical activity research. *Preventive Medicine*.

Cain, K.L., Sallis, J.F., Conway, T.L., Van Dyck, D., Calhoun, L., 2013a. Using accelerometers in youth physical activity studies: a review of methods. *J. Phys. Act. Health* 10, 437–450. <https://doi.org/10.1123/jpah.10.3.437>.

Cain, K.L., Conway, T.L., Adams, M.A., Husak, L.E., Sallis, J.F., 2013b. Comparison of older and newer generations of ActiGraph accelerometers with the normal filter and the low frequency extension. *Int. J. Behav. Nutr. Phys. Act.* 10, 51. <https://doi.org/10.1186/1479-5868-10-51>.

Cain, K.L., Bonilla, E., Conway, T.L., Schipperijn, J., Geremia, C.M., Mignano, A., Kerr, J., Sallis, J.F., 2017. Defining accelerometer nonwear time to maximize detection of sedentary time in youth. *Pediatr. Exerc. Sci.* 30 (2), 288–295. <https://doi.org/10.1123/pes.2017-0132>.

Carson, V., Staiano, A.E., Katzmarzyk, P.T., 2015. Physical activity, screen time, and sitting among US adolescents. *Pediatr. Exerc. Sci.* 27 (1), 151–159. <https://doi.org/10.1123/pes.2014-0022>.

Ding, D., Bracy, N.L., Sallis, J.F., Saelens, B.E., Norman, G.J., Harris, S.K., Durant, N., Rosenberg, D., Kerr, J., 2012. Is fear of strangers related to physical activity among youth? *Am. J. Health Promot.* 26 (3), 189–195. <https://doi.org/10.4278/ajhp.100701-QUAN-224>.

Evenson, K.R., Catellier, D.J., Gill, K., Ondrak, K.S., McMurray, R., 2008. Calibration of two objective measures of physical activity for children. *J. Sports Sci.* 26 (14), 1557–1565. <https://doi.org/10.1080/02640410802334196>.

Franckle, R., Adler, R., Davison, K., 2014. Accelerated weight gain among children during summer versus school year and related racial/ethnic disparities: a systematic review. *Preventing Chronic Diseases* 11, E101. <https://doi.org/10.5888/pcd11.130355>.

Fu, Y., Brusseau, T.A., Hannon, J.C., Burns, R.D., 2017. Effect of a 12-week summer break on school day physical activity and health-related fitness in low-income children from CSPAP schools. *J. Environ. Public Health* 7, 9760817. <https://doi.org/10.1155/2017/9760817>.

Gutin, B., Yin, Z., Johnson, M., Barbeau, P., 2008. Preliminary findings of the effect of a 3-year after-school physical activity intervention on fitness and body fat: the medical College of Georgia Fitkid Project. *Int. J. Pediatr. Obes.* 3 (Suppl. 1), 3–9. <https://doi.org/10.1080/17477160801896457>.

Health Resources and Services Administration, 2018. National Survey on Children's Health 2018. <https://www.rwjf.org/en/library/articles-and-news/2018/10/nearly-one-in-six-young-people-nationwide-has-obesity-new-data-show.html>.

von Hippel, P.T., Powell, B., Downey, D.B., Rowland, N.J., 2007. The effect of school on overweight in childhood: gain in body mass index during the school year and during summer vacation. *Am. J. Public Health* 97 (4), 696–702. <https://doi.org/10.2105/AJPH.2005.080754>.

Ickes, M.J., Sharma, M., 2013. A systematic review of community based childhood obesity prevention programs. *J. Obes. Weight Loss Ther.* 3, 5. <https://doi.org/10.4172/2165-7904.1000188>.

Joe, L., Carlson, J.A., Sallis, J.F., 2012. Active where? Individual Item Reliability Statistics Adolescent Survey. http://sallis.ucsd.edu/Documents/Measures_documents/ActiveWhere_item_reliability_Adolescent.pdf, Accessed date: 13 February 2019.

Larouche, R., Saunders, T.J., Faulkner, G., Colley, R., Tremblay, M., 2014. Associations between active school transport and physical activity, body composition, and cardiovascular fitness: a systematic review of 68 studies. *J. Phys. Act. Health* 11 (1), 206–227. <https://doi.org/10.1123/jpah.2011-0345>.

Moreno, J.P., Johnston, C.A., Woehler, D., 2013. Changes in weight over the school year and summer vacation: results of a 5-year longitudinal study. *J. Sch. Health* 83 (7), 473–477. <https://doi.org/10.1111/josh.12054>.

Norman, G., Schmid, B., Sallis, J., Calfas, K., Patrick, K., 2005. Psychosocial and environmental correlates of adolescent sedentary behavior. *Pediatrics* 116, 908–916. <https://doi.org/10.1542/peds.2004-1814>.

Ogden, C.L., Fryar, C.D., Hales, C.M., Carroll, M.D., Aoki, Y., Freedman, D.S., 2018. Differences in obesity prevalence by demographics and urbanization in US children and adolescents, 2013–2016. *JAMA* 319 (23), 2410–2418. <https://doi.org/10.1001/jama.2018.5158>.

Ridgers, N., Salmon, J., Timperio, A., 2015. Too hot to move? Objectively assessed seasonal changes in Australian children's physical activity. *Int. J. Behav. Nutr. Phys. Act.* 12, 77. <https://doi.org/10.1186/s12966-015-0245-x>.

Rosenberg, D., Sallis, J.F., Kerr, J., Maher, J., Norman, G.J., Durant, N., Harris, S.K., Saelens, B.E., 2010. Brief scales to assess physical activity and sedentary equipment in the home. *Int. J. Behav. Nutr. Phys. Act.* 7, 10. <http://www.ijbnpa.org/content/7/1/10>.

Sallis, J.F., McKenzie, T.L., Alcaraz, J.E., Kolody, B., Faucette, N., Hovell, M.F., 1997. The effects of a 2-year physical education program (SPARK) on physical activity and fitness in elementary school students. *Am. J. Public Health* 87, 1328–1334. <https://doi.org/10.1016/j.yjmed.2018.02.00>.

Sallis, J.F., Prochaska, J.J., Taylor, W.C., 2000. A review of correlates of physical activity of children and adolescents. *Med. Sci. Sports Exerc.* 32, 963–975. <https://doi.org/10.1097/00005768-200005000-00014>.

Sallis, J.F., Conway, T.L., Cain, K.L., Carlson, J.A., Frank, L.D., Kerr, J., Glanz, K., Chapman, J.E., Saelens, B.E., 2018. Neighborhood built environment and socioeconomic status in relation to physical activity, sedentary behavior, and weight status of adolescents. *Prev. Med.* 110, 47–54. <https://doi.org/10.2105/AJPH.87.8.1328>.

- Skinner, A.C., Ravanbakht, S.N., Skelton, J.A., Perrin, E.M., Armstrong, S.C., 2018. Prevalence of obesity and severe obesity in US children, 1999–2016. *Pediatrics* 141 (3), e20173459. <https://doi.org/10.1542/peds.2017-3459>.
- Stalsberg, R., Pedersen, A.V., 2010. Effects of socioeconomic status on the physical activity in adolescents: a systematic review of the evidence. *Scand. J. Med. Sci. Sports* 20, 368–383. <https://doi.org/10.1111/j.1600-0838.2009.01047.x>.
- Strauss, W.J., Nagaraja, J., Landgraf, A.J., Arteaga, S.S., Fawcett, S.B., Ritchie, L.D., John, L.V., Gregoriou, M., Frongillo, E.A., Loria, C.M., Weber, S.A., 2018. The longitudinal relationship between community programmes and policies to prevent childhood obesity and BMI in children: the healthy communities study. *Pediatric Obesity* 13, 82–92. <https://doi.org/10.1111/ijpo.12266>.
- Trost, S.G., Pate, R.R., Freedson, P.S., Sallis, J.F., Taylor, W.C., 2000. Using objective physical activity measures with youth: how many days of monitoring are needed? *Med. Sci. Sports Exerc.* 32, 426–431. <https://doi.org/10.1097/00005768-200002000-00025>.
- Tucker, P., Gilliland, J., 2007. The effect of season and weather on physical activity: a systematic review. *Public Health* 121 (12), 909–922. <https://doi.org/10.1016/j.puhe.2007.04.009>.
- Van Ekris, E., Altenburg, T.M., Singh, A.S., Proper, K.I., Heymans, M.W., Chinapaw, M.J.M., 2016. An evidence-update on the prospective relationship between childhood sedentary behaviour and biomedical health indicators: a systematic review and meta-analysis. *Obes. Rev.* 17 (9), 833–849. <https://doi.org/10.1111/obr.12426>.
- Wang, X., Conway, T.L., Cain, K.L., Frank, L.D., Saelens, B.E., Geremia, C., Kerr, J., Glanz, J., Carlson, J.A., Sallis, J.F., 2017. Interactions of psychosocial factors with built environments in explaining adolescents' active transportation. *Prev. Med.* 100, 76–83. <https://doi.org/10.1016/j.ypmed.2017.04.008>.
- Wang, Y., Cai, L., Wu, Y., Wilson, R.F., Weston, C., Fawole, O., Bleich, S.N., Cheskin, L.J., Showell, N.N., Lau, B.D., Chiu, D.T., 2015. What childhood obesity prevention programmes work? A systematic review and meta-analysis. *Obes. Rev.* 16 (7), 547–565. <https://doi.org/10.1111/obr.12277>.
- Yin, Z., Moore, J.B., Johnson, M.H., Vernon, M.M., Gutin, B., 2012. The impact of a 3-year after-school obesity prevention program in elementary school children. *Child. Obes.* 8 (1), 60–70. <https://doi.org/10.1089/chi.2011.0085>.