# Scientific Contributions of the Children's Physical Activity Research Group

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## Introduction

The Children's Physical Activity Research Group (CPARG) at the University of South Carolina (USC) is an interdisciplinary research team that is based in the Arnold School of Public Health's Department of Exercise Science. The group is comprised of faculty investigators, staff, post-doctoral fellows and graduate students. Faculty investigators are drawn from multiple academic units across the USC campus and from a number of other institutions. The members of the team bring diverse areas of expertise, but they share a common interest in physical activity in children and youth. The research activities of CPARG are directed by Russell R. Pate, Ph.D., a Professor of Exercise Science at USC.

The research team that is currently configured as CPARG had its origin in the early 1990's when Pate brought together a group of investigators to pursue studies on promotion of physical activity in youth. Initially, the group was funded by the U.S. Centers for Disease Control and Prevention and the American Heart Association. In 1993 the group received its first grant from the National Institutes of Health (NIH), and since then CPARG has been funded continuously by NIH to undertake a series of studies addressing a wide range of issues related to physical activity in young people. As stated on the group's website, the purpose of CPARG is to expand the body of knowledge on physical activity and its promotion in children and adolescents and to generate the knowledge needed to design and implement effective public health policies. The group's research interests include measurement of physical activity in children and adolescents, interventions to increase physical activity in young people, influences on physical activity behavior during childhood and adolescence, relationships between physical activity and other health parameters in youth, surveillance of physical activity in populations of young people, and the impact of physical activity on body weight status in youth.

In 2014, Dr. Pate was recognized by the South Carolina Academy of Science with its Excellence in Scientific Research and Excellence in Scientific Awareness Awards. These awards provide an opportunity to reflect on the history of the research team that has supported Pate's work. Accordingly, the purpose of this article is to summarize the products of the research conducted by CPARG since the mid-1990's. The work will be reviewed in categories corresponding closely to the group's areas of interest. Numerous collaborators have contributed to the work of CPARG, and in Table 1 we list and acknowledge the important contributions of those persons.

## Measurement of Physical Activity in Children

In order to understand the physical activity behaviors and patterns of children, and develop effective programs that will help them become more physically active, researchers and health professionals need accurate ways to measure children's physical activity. The CPARG research team has been studying measurement of children's physical activity for more than 30 years, and has been at the forefront of efforts to develop and test measurement tools. These tools include objective measures of physical activity, direct observation systems, and self-report instruments.

### Objective Measures

A number of devices can be used to measure physical activity objectively. CPARG uses accelerometers, small devices worn on the hip or wrist, to determine the amount of time children spend in physical activity at different intensities (sedentary, light, moderate, and vigorous). Accelerometers provide accurate measurements of physical activity in children and youth, although they have some limitations. One of the challenges of using accelerometers is that analyzing and interpreting the data they provide requires the development of data "cutpoints" that are specific to the population being measured. In response to this challenge, CPARG has conducted studies that established valid accelerometer cutpoints for measuring physical activity in young children and adolescents.[1-4] The development of these cutpoints has enabled the CPARG team and other research groups throughout the country to use accelerometers to measure physical activity in large-scale observational studies and interventions. CPARG also has contributed to the field of physical activity measurement by describing best practices for accelerometer use, including conducting cutpoint comparisons and determining the number of days and hours of accelerometer wear needed to assess physical activity levels.[5-9]

### Direct Observation and Self-Report Instruments

At times, using accelerometers or other objective measures may not be realistic (because of the cost or technical expertise required) or ideal (because accelerometers do not provide the type of information needed). In those cases, direct observation or self-report of physical activity may be used. Direct observation methods allow researchers to document the moment-to-moment characteristics of children's physical activity.[10] The CPARG team has developed an important tool for measuring physical activity of children by direct observation, the Observational System for Recording Physical Activity in Children (OSRAC).

Table 1. CPARG Contributors

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Table 1 (continued). CPARG Contributors

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OSRAC can be used to measure the type, intensity, and context of children's physical activity in a number of settings, including preschools, elementary schools, homes and youth sports activities.[10-12]

In some studies, children are asked to self-report their physical activity. These studies need valid and reliable self-report measures, in order to insure that the data obtained are accurate. The CPARG team has developed and validated a number of self-report measures of children's physical activity. Two of these measures, the Previous Day Physical Activity Recall (PDPAR) and the 3-Day Physical Activity Recall (3DPAR), ask children or adolescents to recall the type, intensity, and frequency of physical activity they participated in during the previous day (PDPAR) or previous three days (3DPAR).[13,14] These measures have been used in a number of studies by CPARG investigators and other research groups. Additionally, CPARG also has studied the ability of children to recall and report their physical activity behavior accurately.[15-18] Theses studies have resulted in two main findings: 1) children are capable of recalling the types and duration of their physical activity;[17,18] and 2) using a chronological format, a shorter recall interval, and a single-focus recall (e.g., physical activity) rather than an integrated recall (e.g., physical activity and diet) improves children's accuracy of recalling physical activity.[15,16,18]

In summary, the physical activity measurement studies conducted by CPARG researchers have created tools and provided information that physical activity researchers in South Carolina, across the country and around the world are using to study physical activity in children and youth.

## Factors Related to Children's Physical Activity

The national physical activity recommendation for children in the United States is 60 or more minutes per day of moderate-to-vigorous physical activity (MVPA). Research shows, however, that a majority of American children do not meet this recommendation. The low rate of physical activity among children and youth has heightened public health interest in developing effective physical activity programs that will help children and adolescents meet the recommendation. In order to develop these programs, however, researchers and health professionals need to understand the factors that influence children's physical activity, both positively and negatively. Over the past 25 years, the CPARG team has examined and identified important social-cognitive and environmental factors that influence physical activity in young people from preschool-age through high school.

### Social-cognitive Factors

CPARG researchers have conducted studies examining associations between a set of social-cognitive factors, including attitudes, beliefs, enjoyment, perceived benefits, perceived barriers, self-efficacy, and social support, and physical activity in children and adolescents. Their findings show a consistent positive association between barriers self-efficacy and MVPA in children. Barriers self-efficacy refers to people's beliefs about their capabilities to perform physical activity when encountering barriers (e.g., lack of time). Children who report higher levels of barriers self-efficacy are more likely to have higher levels of MVPA, and this association does not differ by gender.[19-23]

Among adolescents, CPARG studies have found that physical activity is related to a wider range of factors, and that these factors appear to differ for boys and girls. For boys, the studies found that attitude toward physical activity, peer support, and perceived coordination are positively associated with MVPA, while enjoyment and self-efficacy are positively associated with vigorous physical activity.[24,25] For girls, enjoyment,[26] self-efficacy, and social support from peers and family are positively associated with MVPA.[23,27-30] In addition to the direct effect, findings show that self-efficacy also has indirect effects on MVPA in adolescent girls. It has a mediating effect on the positive association between enjoyment of physical activity and MVPA,[31] and a moderating effect on MVPA through the mediation of social support.[32]

### Physical Environment Factors

Over the years, CPARG has examined physical features in preschools, schools, homes, neighborhoods, and community settings to determine their influence on children's physical activity levels. Among preschool-age children, the team found that greater access to physical activity equipment at home, living closer to a park[33,34], and attending preschools with more open spaces, more portable playground equipment, larger playgrounds,

and lower exposure to electronic media (i.e., TV, video games) are associated with higher levels of physical activity.[33,35-37]

Among middle school children, the team found that participating in community organizations/programs that promote physical activity, participating in community-based sports, and using less electronic media are associated with increases physical activity levels.[21,22,38,39] In high school girls, the number of physical activity facilities (e.g. parks, churches, commercial physical activity facilities) in proximity to a girl's home or school was positively associated with physical activity levels.[40-43] Perceived accessibility to physical activity equipment at home and neighborhood had a significant indirect effect on high school girls' physical activity through the mediation of barriers self-efficacy[28,44] Across all studies, the group's findings suggest that increased access to physical activity facilities/resources across multiple settings is associated with increased levels of physical activity.

### Social Environment Factors

The social ecological model of health behavior[45] posits that health behaviors, such as physical activity, are influenced not only by personal characteristics but also by factors within boarder contexts, including proximal social influences and institutional factors, as well as more distal influences, such as community characteristics and public policies. CPARG has examined the impact of these social environments on children's physical activity levels in preschools, schools, and neighborhoods settings.

For preschool children, who have limited autonomy over their daily routine, their physical activity levels are largely dependent on their parents or primary caregivers. CPARG studies have found that parents who enjoy physical activity and who perceive playing sports as important for their child are more likely to support their child's physical activity, which positively affects MVPA in preschool children.[33] In addition to the family setting, the preschool/childcare center a child attends influences important aspects of his/her life, including physical activity. The social environment within a preschool includes factors such as organizational norms, policies and practices related to physical activity, and interaction with teachers and peers. Studies by CPARG researchers suggest that children attending preschools with the following social environment characteristics participate in more MVPA: 1) the culture and norms of the preschool support physical activity (e.g., Montessori preschools believe that "the best learning is active")[46] 2) the preschool takes more field trips than do preschools in which children are less active, and 3) the preschool employs more college-educated teachers.[47] Additionally, children are more likely to participate in MVPA during outdoor free play when they are given the autonomy to engage in activities that are child-initiated and without the involvement of an adult.[37]

Other CPARG studies have shown that a supportive family environment also promotes physical activity in elementary-age children,[23,48,49] and that a supportive social environment outside the home may play a more significant role in promoting physical activity in minority girls.[50] Among adolescent girls, CPARG studies have demonstrated that a supportive family[28,44] was associated with increased physical activity. Girls also tend to perform physical activity with a companion (either families or friends).[51] However, an unexpected finding was that higher levels of perceived neighborhood safety do not appear to promote higher levels of physical activity.[28,44]

## Intervention and Process Evaluation

CPARG has developed and implemented several interventions to increase children's physical activity in preschools, schools, and community settings. The team's studies are based on the intervention literature and best practices in the field, and always include two important features: theory-based intervention components and comprehensive program monitoring and process evaluation. This section describes briefly the physical activity interventions carried out by CPARG and demonstrates the application of program monitoring and process evaluation in children's physical activity intervention studies.

### Preschool Interventions

*The Study of Health and Activity in Preschool Environments (SHAPES)*[52,53] was a group-randomized nested cohort trial that involved 8 intervention and 8 comparison preschools. Based on the Social Ecological Model, SHAPES hypothesized that creating an instructional and social environment that supported physical activity would increase MVPA in children during the preschool day. The intervention included three components: Move Inside (adult–led structured physical activity), Move Outside (physical activity opportunities during recess), and Move to Learn (physical activity opportunities during daily classroom lessons). The University-based intervention team provided training and technical support designed to help teachers implement the intervention in their four-year-old classrooms for three consecutive academic years. One unique feature of the SHAPES intervention was using process evaluation data to adapt and improve the program over time. For instance, the goal for Move Outside was changed from 60 min/day outdoor time to a more realistic goal (40 min/day) after the first year, based on interventionists' and teachers' feedback collected as part of the process evaluation.

### School Interventions

*Lifestyle Education for Activity Program (LEAP)* [54,55] was a 2-year experimental cohort design involving 12 intervention and 12 comparison high schools. Based on the Social Ecological Model, LEAP hypothesized that modifying the instructional program and school environment in high schools could create an environment that supported girls' physical activity and would increase the percentage of girls engaging in vigorous physical activity (VPA). The intervention included LEAP physical education classes, which focused on making physical education fun and active for girls, health education, faculty/staff health promotion activities, and family and community involvement. The investigative team provided training and technical support to help school personnel implement the intervention. Process evaluation data revealed that >50% of the intervention schools had a high level of implementation.[56,57] At post-intervention, the percentage of girls

who reported regular participation in VPA was significantly higher in the intervention schools (45%) than the comparison schools (36%).[54] Stratified analyses showed that only girls in the high implementation schools had a higher prevalence of participation in VPA.[57] Sustainability data collected three years after the active phase of the intervention (12th grade) showed that high implementation schools tended to maintain the LEAP elements post-intervention. Stratified analyses found that girls in the intervention schools with high levels of implementation and maintenance were more likely than girls in the other schools to participate in regular VPA.[55,58] These findings indicate that high levels of implementation had positive effects on program effectiveness, as well as on program sustainability.

*The Trial of Activity for Adolescent Girls (TAAG)* was a 3-year school- and community-based intervention.[59] The study was a group-randomized nested cohort trial involving 36 middle schools from six field centers. One of the field centers was based at the University of South Carolina and managed by CPARG. TAAG hypothesized that creating environmental and organizational changes supportive of physical activity and providing cues, messages, and incentives to be more physically active would reduce the decline in MVPA in middle school girls. The 3-year intervention had two components. During Years 1 and 2, the intervention staff trained and worked with school teachers to help them deliver the TAAG activities (i.e., physical education for girls; health education with activity challenges; partnerships among TAAG investigators, schools, and community agencies for physical activity and promotional activities). Year 3 was a champion-directed intervention, in which a TAAG "champion" in each intervention school sustained the efforts in continuing TAAG activities. After the staff-directed intervention, girls' MVPA was not significantly different between the intervention and comparison schools, but it was higher in the intervention schools following the program champion–directed intervention.

### Community-based Interventions

Active Winners was an 18-month quasi-experimental design involving two rural, predominantly African American communities in South Carolina (one intervention and one comparison community).[60] The intervention was guided by Social Cognitive Theory and Pender's Health Promotion Theory. It hypothesized that providing opportunities to participate in enjoyable physical activities and increasing physical activity self-efficacy would increase afterschool physical activity in fifth grade children. It included an afterschool/summer program and home, school and community components. The intervention was implemented by the investigative team. Process data indicated that the afterschool/summer program was implemented with optimal dosage and good fidelity, but the reach was very limited (only 5% of the students attended half of the total sessions). The home, school, and community components were not fully implemented. The results showed no significant difference in children's afterschool physical activity between the intervention and comparison groups, likely due to inadequate levels of implementation.

## Health Effects of Physical Activity in Children

### Weight Status

CPARG has conducted several studies that evaluated the impact of MVPA on health and weight status in children, including effects on body mass index,[61-64], percent body fat,[63] and waist circumference.[64] The results of these studies show a consistent inverse association between physical activity and markers of body fat among preschool- and school-age children and adolescents.[61,62] Specifically, children who engaged in more MVPA had lower BMI z-scores than their less-active counterparts. Also, girls who engaged in higher levels of MVPA had lower levels of percent body fat.[63] For preschool-age children, the inverse association between MVPA and BMI z-score was significant for boys, but not for girls. However, MVPA was found to be negatively associated with waist circumference at the 90th percentile in girls.[64]

### Cardiorespiratory Fitness

In addition to the health benefits provided by participation in physical activity, evidence indicates that higher levels of cardiorespiratory fitness are associated with lower risks of all-cause mortality. However, most of the evidence supporting this association was found among adults. Over the past several years, the CPARG group has conducted studies among adolescents to understand the health benefits that may be associated with cardiorespiratory fitness.[65,66] In a study of girls, CPARG researchers found that those who participated in team sports had higher levels of cardiorespiratory fitness than those did not.[62] Other studies examined a range of health outcomes, including cardiovascular disease risk score (i.e., systolic blood pressure, percent body fat, insulin resistance, triglyceride, and atherogenic lipid profile)[65] and alanine aminotransferase, a biomarker for non-alcoholic fatty liver disease (NALFD)).[66] These studies found that adolescents with the lowest level of cardiorespiratory fitness have higher cardiovascular disease risk scores, compared to adolescents with a higher level of fitness. Additionally, adolescents with the lowest level of cardiorespiratory fitness had the highest levels of alanine aminotransferase, especially among youth with greater amounts of central adiposity.

### Academic Achievement

Additionally, an experimental study[67] demonstrated that five to 20 minutes of classroom exercise breaks had an acute effect on children's positive affect (i.e., individual subjectively experiences positive moods such as joy and happiness) which may in turn improve cognitive performance and academic achievement.

## Sedentary Behavior

Independent of physical activity levels, participation in sedentary behaviors (e.g., prolonged sitting, television viewing) negatively affects health.[68,69] Sedentary behavior refers to activities that do not elicit energy expenditures substantially above resting levels.[70] Because of growing concern about the negative health effects of

being sedentary, the CPARG team investigated the relationship between sedentary behaviors and several health outcomes in youth, including BMI,[46,64,71,72] obesity risk,[72] waist circumference,[64] cardiorespiratory fitness,[73] and cardiovascular disease risk score.[74] Among preschool children, sedentary time was associated with waist circumference at the 90$^{th}$ percentile in girls. However, sedentary time was not associated with BMI z-score or waist circumference in boys.[64] Among children and adolescents, participation in sedentary behaviors was associated with increased adiposity,[74] BMI,[71,72] and risk of being obese[72] in children and adolescents. Interestingly, the positive association between sedentary behavior and the risk of obesity was negated among children who participated in at least 15 minutes of MVPA per day. Additionally, sedentary behavior was negatively associated with cardiorespiratory fitness, and the effect was more profound among those with the highest levels of cardiorespiratory fitness.[73]

In summary, the research studies carried out by CPARG have provided valuable scientific evidence regarding the association between physical activity, cardiorespiratory fitness, and sedentary behavior and health outcomes among youth. As a whole, these findings indicate that participating in MVPA, achieving a high level of cardiorespiratory fitness, and reducing time spent in sedentary behaviors may provide substantial health benefits for children and adolescents.

## Conclusion

The Children's Physical Activity Research Group at the University of South Carolina has functioned for nearly twenty-five years as an interdisciplinary research team that is committed to expanding the body of knowledge on physical activity behavior in children and adolescents. CPARG's research products have been widely cited by scientists and professionals from across the globe, and the team has achieved worldwide recognition for its contributions to understanding the health implications of physical activity in young people. The team has benefitted from the expertise, experience and hard work of many individuals. In closing this article we recognize the contributions of four persons who have been important members of CPARG throughout its years of operation. They are Ruth Saunders, whose expertise in process evaluation of interventions has greatly enhanced the productivity of the group's intervention studies; Rod Dishman of the University of Georgia, whose knowledge of health psychology has brought great sophistication to the group's studies of factors influencing physical activity behavior in children; Marsha Dowda, who has managed and analyzed virtually all of the data generated by CPARG's studies; and Gaye Christmus, whose editorial skills and grant writing expertise have tremendously enhanced the group's productivity. Sincerest thanks are expressed to them and to all who have contributed to CPARG's work.

## Notes and references

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(1) Pate RR, Almeida MJCA, McIver KL, Pfeiffer KA, Dowda M. Validation and calibration of an accelerometer in preschool children. *Obesity.* 2006;14:200-206.
(2) Pfeiffer KA, McIver KL, Dowda M, Almeida MJCA, Pate RR. Validation and calibration of the Actical accelerometer in preschool children. *Med Sci Sports Exerc.* 2006;38:157.
(3) Sirard JR, Trost SG, Pfeiffer KA, Dowda M, Pate RR. Calibration and evaluation of an objective measure of physical activity in preschool children. *J Phys Act Health.* 2005;2:345-357.
(4) Treuth MS, Schmitz K, Catellier DJ et al. Defining accelerometer thresholds for activity intensities in adolescent girls. *Med Sci Sports Exerc.* 2004;36:1259-1266.
(5) Addy CL, Trilk JL, Dowda M, Byun W, Pate RR. Assessing preschool children's physical activity: How many days of accelerometry measurement? *Pediatr Exerc Sci.* 2014;26:103-109.
(6) Kim Y, Beets MW, Pate RR, Blair SN. The effect of reintegrating Actigraph accelerometer counts in preschool children: Comparison using different epoch lengths. *J Sci Med Sport.* 2013;16:129-134.
(7) Trost SG, Pate RR, Freedson PS, Sallis JF, Taylor WC. Using objective physical activity measures with youth: How many days of monitoring are needed? *Med Sci Sports Exerc.* 2000;32:426-431.
(8) Trost SG, McIver KL, Pate RR. Conducting accelerometer-based activity assessments in field-based research. *Med Sci Sports Exerc.* 2005;37:S531-S543.
(9) Bornstein DB, Beets MW, Byun W et al. Equating accelerometer estimates of moderate-to-vigorous physical activity: In search of the Rosetta Stone. *J Sci Med Sport.* 2011.
(10) McIver KL, Brown WH, Pfeiffer KA, Dowda M, Pate RR. Assessing children's physical activity in their homes: The Observational System for Recording Physical Activity in Children - Home. *J Appl Behav Anal.* 2009;42:1-16.
(11) Brown WH, Pfeiffer KA, McIver KL, Dowda M, Almeida MJCA, Pate RR. Assessing preschool children's physical activity: An Observational System for Recording Physical Activity in Children - Preschool Version (OSRAC-P). *Res Q Exerc Sport.* 2006;77:167-176.
(12) Cohen A, McDonald S, McIver K, Pate R, Trost S. Assessing physical activity during youth sport: The Observational System for Recording Activity in Children: Youth Sports. *Pediatr Exerc Sci.* 2014;26:203-209.
(13) Pate RR, Ross R, Dowda M, Trost SG, Sirard J. Validation of a three-day physical activity recall instrument in female youth. *Pediatr Exerc Sci.* 2003;15:257-265.
(14) Trost SG, Ward DS, McGraw B, Pate RR. Validity of the Previous Day Physical Activity Recall (PDPAR) in fifth-grade children. *Pediatr Exerc Sci.* 1999;11:341-348.
(15) Baxter SD, Hitchcock DB, Guinn CH et al. A pilot study of the effects of interview content, retention interval, and grade on accuracy of dietary information from children. *J Nutr Educ Behav.* 2013;45:368-373.
(16) Baxter SD, Hitchcock DB, Guinn CH et al. A validation study concerning the effects of interview content, retention interval, and grade on children's recall accuracy for dietary intake and/or physical activity. *J Acad Nutr Diet.* 2014.
(17) Dowda M, Pate RR, Sallis JF et al. Agreement between student-reported and proxy-reported physical activity questionnaires. *Pediatr Exerc Sci.* 2007;19:310-318.
(18) Wilson DK, Baxter SD, Guinn C, Pate RR, McIver K. A qualitative study of interviewer-administered physical activity recalls by children. *J Phys Act Health.* 2013;10:833-849.
(19) Trost SG, Pate RR, Saunders RP, Ward DS, Dowda M, Felton GM. A prospective study of the determinants of physical activity in rural fifth-grade children. *Prev Med.* 1997;26:257-263.
(20) Pate RR, Trost SG, Felton G, Ward DS, Dowda M, Saunders R. Correlates of physical activity behavior in rural youth. *Res Q Exerc Sport.* 1997;68 (Suppl):241-248.

(21) Trost SG, Pate RR, Ward DS, Saunders R, Riner W. Determinants of physical activity in active and low-active sixth grade African-American youth. *J Sch Health.* 1999;69:29-34.
(22) Trost SG, Pate RR, Ward DS, Saunders R, Riner W. Correlates of objectively measured physical activity in preadolescent youth. *Am J Prev Med.* 1999;17:120-126.
(23) Taylor WC, Sallis JF, Dowda M, Freedson PS, Eason K, Pate RR. Activity patterns and correlates among youth: Differences by weight status. *Pediatr Exerc Sci.* 2002;14:418-431.
(24) Sallis JF, Taylor WC, Dowda M, Freedson PS, Pate RR. Correlates of vigorous physical activity for children in grades 1 through 12: Comparing parent-reported and objectively measured physical activity. *Pediatr Exerc Sci.* 2002;14:30-44.
(25) Bungum T, Dowda M, Weston A, Trost SG, Pate RR. Correlates of physical activity in male and female youth. *Pediatr Exerc Sci.* 2000;12:71-79.
(26) Motl RW, Dishman RK, Saunders R, Dowda M, Felton G, Pate RR. Measuring enjoyment of physical activity in adolescent girls. *Am J Prev Med.* 2001;21:110-117.
(27) Kelly EB, Parra-Medina D, Pfeiffer KA et al. Correlates of physical activity in black, Hispanic, and white middle school girls. *J Phys Act Health.* 2010;7:184-193.
(28) Motl RW, Dishman RK, Saunders RP, Dowda M, Pate RR. Perceptions of physical and social environment variables and self-efficacy as correlates of self-reported physical activity among adolescent girls. *J Pediatr Psychol.* 2007;32:6-12.
(29) Bungum TL, Pate RR, Dowda M, Vincent M. Correlates of physical activity among African-American and Caucasian female adolescents. *Am J Health Behav.* 1999;23:25-31.
(30) Motl RW, Dishman RK, Saunders RP, Dowda M, Pate RR. Measuring social provisions for physical activity among adolescent black and white girls. *Educ Psychol Meas.* 2004;64:682-706.
(31) Dishman RK, Motl RW, Saunders RP et al. Enjoyment mediates effects of a school-based physical activity intervention. *Med Sci Sports Exerc.* 2005;37:478-487.
(32) Dishman RK, Saunders RP, Motl RW, Dowda M, Pate RR. Self-efficacy moderates the relation between declines in physical activity and perceived social support in high school girls. *J Pediatr Psychol.* 2009;34:441-451.
(33) Dowda M, Pfeiffer KA, Brown WH, Mitchell JA, Byun W, Pate RR. Parental and environmental correlates of physical activity of children attending preschool. *Arch Pediatr Adolesc Med.* 2011;165:939-944.
(34) Pfeiffer KA, Dowda M, McIver KL, Pate RR. Factors related to objectively measured physical activity in preschool children. *Pediatr Exerc Sci.* 2009;21:196-208.
(35) Taverno Ross SE, Dowda M, Saunders R, Pate RR. Double dose: The cumulative effect of TV viewing at home and in preschool on children's activity patterns and weight status. *Pediatr Exerc Sci.* 2013.
(36) Dowda M, Brown WH, McIver KL et al. Policies and characteristics of the preschool environment and physical activity of young children. *Pediatrics.* 2009;123:e261-e266.
(37) Brown WH, Pfeiffer KA, McIver KL, Dowda M, Addy CL, Pate RR. Social and environmental factors associated with preschoolers' nonsedentary physical activity. *Child Dev.* 2009;80:45-58.
(38) Lobelo F, Dowda M, Pfeiffer KA, Pate RR. Electronic media exposure and its association with activity-related outcomes in female adolescents: Cross-sectional and longitudinal analyses. *J Phys Act Health.* 2009;6:137-143.
(39) Trost SG, Kerr LM, Ward DS, Pate RR. Physical activity and determinants of physical activity in obese and non-obese children. *Int J Obes Relat Metab Disord.* 2001;25:822-829.
(40) Pate RR, Colabianchi N, Porter D, Almeida MJ, Lobelo F, Dowda M. Physical activity and neighborhood resources in high school girls. *Am J Prev Med.* 2008;34:413-419.
(41) Trilk JL, Ward DS, Dowda M et al. Do physical activity facilities near schools affect physical activity in high school girls? *Health Place.* 2011;17:651-657.
(42) Pfeiffer K, Colabianchi N, Dowda M, Porter D, Hibbert J, Pate RR. Examining the role of churches in adolescent girls' physical activity. *J Phys Act Health.* 2011;8:227-233.
(43) Dowda M, Dishman RK, Porter D, Saunders RP, Pate RR. Commercial facilities, social cognitive variables, and physical activity of 12th grade girls. *Ann Behav Med.* 2009;37:77-87.
(44) Motl RW, Dishman RK, Ward DS et al. Perceived physical environment and physical activity across one year among adolescent girls: self-efficacy as a possible mediator? *J Adolesc Health.* 2005;37:403-408.
(45) Bronfenbrenner U. *The Ecology of Human Development: Experiments by Nature and Design.* Cambridge, MA: Harvard University Press; 1979.
(46) Byun W, Liu J, Pate RR. Association between objectively measured sedentary behavior and body mass index in preschool children. *Int J Obes (Lond).* 2013;epub ahead of print.
(47) Dowda M, Pate RR, Trost SG, Almeida MJCA, Sirard J. Influences of preschool policies and practices on children's physical activity. *J Commun Health.* 2004;29:183-195.
(48) Dowda M, Dishman RK, Pfeiffer KA, Pate RR. Family support for physical activity in girls from 8th to 12th grade in South Carolina. *Prev Med.* 2007;44:153-159.
(49) Trost SG, Sallis JF, Pate RR, Freedson PS, Taylor WC, Dowda M. Evaluating a model of parental influence on youth physical activity. *Am J Prev Med.* 2003;25:277-282.
(50) Taverno Ross SE, Dowda M, Colabianchi N, Saunders R, Pate RR. After-school setting, physical activity, and sedentary behavior in 5th grade boys and girls. *Health Place.* 2012;18:951-955.
(51) Kuo J, Schmitz KH, Evenson KR et al. Physical and social contexts of physical activities among adolescent girls. *J Phys Act Health.* 2009;6:144-152.
(52) Howie EK, Pate RR. Physical activity and academic achievement in children: An historical perspective. *Journal of Sport and Health Science.* 2012;1:160-169.
(53) Pfeiffer KA, Saunders RP, Brown WH, Dowda M, Addy CL, Pate RR. Study of Health and Activity in Preschool Environments (SHAPES): Study protocol for a randomized trial evaluating a multi-component physical activity intervention in preschool children. *BMC Public Health.* 2013;13:728.
(54) Pate RR, Ward DS, Saunders RP, Felton G, Dishman RK, Dowda M. Promotion of physical activity in high school girls: A randomized controlled trial. *Am J Public Health.* 2005;95:1582-1587.
(55) Pate RR, Saunders R, Dishman RK, Addy C, Dowda M, Ward DS. Long-term effects of a physical activity intervention in high school girls. *Am J Prev Med.* 2007;33:276-280.
(56) Ward DS, Saunders RP, Felton GM, Williams E, Epping JN, Pate RR. Implementation of a school environment intervention to increase physical activity in high school girls. *Health Educ Res.* 2006;21:896-910.
(57) Saunders RP, Ward DS, Felton GM, Dowda M, Pate RR. Examining the link between program implementation and behavior outcomes in the Lifestyle Education for Activity Program (LEAP). *Evaluation and Program Planning.* 2006;29:353-364.
(58) Saunders RP, Pate RR, Dowda M, Ward DS, Epping JN, Dishman RK. Assessing sustainability of the Lifestyle Education for Activity Program (LEAP). *Health Educ Res.* 2012;27:319-330.
(59) Webber LS, Catellier DJ, Lytle LA et al. Promoting physical activity in middle-school girls: Trial of Activity for Adolescent Girls. *Am J Prev Med.* 2008;34:173-184.
(60) Pate RR, Saunders RP, Ward DS, Felton GM, Trost SG, Dowda M. Evaluation of a community-based intervention to promote physical activity in youth: Lessons from Active Winners. *Am J Health Promot.* 2003;17:171-182.
(61) Mitchell JA, Pate RR, Espana-Romero V, O'Neill JR, Dowda M, Nader PR. Moderate-to-vigorous physical activity is associated with decreases in body mass index from ages 9 to 15 years. *Obesity (Silver Spring).* 2013;21:E280-E293.
(62) Sirard JR, Pfeiffer KA, Dowda M, Pate RR. Race differences in activity, fitness, and BMI in female eighth graders categorized by sports participation status. *Pediatr Exerc Sci.* 2008;20:198-210.
(63) Stevens J, Murray DM, Baggett CD et al. Objectively assessed associations between physical activity and body composition in middle-school girls: The Trial of Activity for Adolescent Girls. *Am J Epidemiol.* 2007;166:1298-1305.

(64) Espana-Romero V, Mitchell JA, Dowda M, O'Neill JR, Pate RR. Objectively measured sedentary time, physical activity and markers of body fat in preschool children. *Pediatr Exerc Sci.* 2013;25:154-163.
(65) Lobelo F, Pate RR, Dowda M, Liese AD, Daniels SR. Cardiorespiratory fitness and clustered cardiovascular disease risk in U.S. adolescents. *J Adolesc Health.* 2010;47:352-359.
(66) Trilk JL, Ortaglia A, Blair SN, Bottai M, Church TS, Pate RR. Cardiorespiratory fitness, waist circumference, and alanine aminotransferase in youth. *Med Sci Sports Exerc.* 2012;epub ahead of print.
(67) Howie EK, Newman-Norlund RD, Pate RR. Smiles count but minutes matter: Responses to classroom exercise breaks. *Am J Health Behav.* 2014;38:681-689.
(68) Hamilton MT, Healy GN, Dunstan DW, Zderic TW, Owen N. Too little exercise and too much sitting: Inactivity physiology and the need for new recommendations on sedentary behavior. *Curr Cardiovasc Risk Rep.* 2008;2:292-298.
(69) Tremblay MS, Colley RC, Saunders TJ, Healy GN, Owen N. Physiological and health implications of a sedentary lifestyle. *Appl Physiol Nutr Metab.* 2010;35:725-740.
(70) Pate RR, O'Neill JR, Lobelo F. The evolving definition of "sedentary". *Exerc Sport Sci Rev.* 2008;36:173-178.
(71) Mitchell JA, Pate RR, Beets MW, Nader PR. Time spent in sedentary behavior and changes in childhood BMI: A longitudinal study from ages 9 to 15 years. *Int J Obes (Lond).* 2013;37:54-60.
(72) Mitchell JA, Mattocks C, Ness AR et al. Sedentary behavior and obesity in a large cohort of children. *Obesity (Silver Spring).* 2009;17:1596-1602.
(73) Mitchell JA, Pate RR, Blair SN. Screen-based sedentary behavior and cardiorespiratory fitness from age 11 to 13. *Med Sci Sports Exerc.* 2012.
(74) Mitchell JA, Pate RR, Liese AD. Changes in cardiovascular disease risk factors from age 9 to 19 and the influence of television viewing. *Obesity (Silver Spring).* 2013;21:386-39