UNIVERSITY OF CALIFORNIA, SAN DIEGO

SAN DIEGO STATE UNIVERSITY

Child Physical Activity in Relation to School Physical Activity Practices

A dissertation submitted in partial satisfaction of the
requirements for the degree Doctor of Philosophy

in

Public Health (Health Behavior)

by

Jordan A. Carlson

Committee in charge:

University of California, San Diego

Professor James F. Sallis, Chair
Professor Jacqueline Kerr
Professor Gregory J. Norman

San Diego State University

Professor Elva M. Arredondo
Professor Hala Madanat
Professor Thomas L. McKenzie

2012

The Dissertation of Jordan A. Carlson is approved, and it is acceptable in quality and form for publication on microfilm and electronically:

Chair

University of California, San Diego

San Diego State University

2012

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ACKNOWLEDGEMENTS

Thank you to my mentors, past and current, for their support and guidance. Thank you to my committee members who provided helpful input and support on my project. Thank you to Alexandra for her hard work in helping collect the data for this project. Thank you to the NIK and Move research teams for allowing me to use the data they worked hard to obtain. To my family and friends, your support has been critical to my success and happiness. Most of all, thank you to Kristen, Louis and Henry for creating such a warm and supportive home environment and reminding me of what I love most in life.

VITA

EDUCATION

2009-2012 Doctor of Philosophy, Public Health (Health Behavior)
University of California, San Diego; La Jolla, California and
San Diego State University; San Diego, California
Primary mentors: Drs. James F. Sallis and Gregory J. Norman
Dissertation: Child Physical Activity in Relation to School Physical Activity Practices
GPA: 3.97

2007-2009 Master of Arts, Experimental/Health Psychology
San Diego State University; San Diego, California
GPA: 3.64

2000-2005 Bachelor of Arts, Psychology
University of Kansas; Lawrence, Kansas

AREAS OF CURRENT RESEARCH INTEREST

- Preventing chronic disease through physical activity
- Identifying and promoting environmental and policy approaches to increase opportunities for physical activity, particularly in youth.
- Developing and evaluating community-based physical activity programs, particularly through the use of innovative technology and advanced statistical methods.

EMPLOYMENT AND RESEARCH EXPERIENCE

2012-present *Doctoral Student; Center for Obesity and Health*. Departments of Pediatrics and Psychiatry, University of California, San Diego; La Jolla, CA. Supervised by Drs. Kerri Boutelle and David Strong.

2010-present *Doctoral Student; Institute for Behavioral and Community Health*. Graduate School of Public Health, San Diego State University; San Diego, CA. Supervised by Drs. John Elder, Thomas McKenzie and Donald Slymen.

2009-present **Main appointment.** *Doctoral Student; Center for Wireless and Population Health Studies*. Department of Family and Preventive Medicine, University of California, San Diego; La Jolla, CA. Supervised by Drs. Gregory Norman, Jacqueline Kerr and Kevin Patrick.

2008-present **Main appointment.** *Doctoral Student; Active Living Research.* Department of Family and Preventive Medicine, University of California, San Diego; La Jolla, CA. Supervised by Dr. James Sallis.

2007-2009 *Masters Student; Health Outcomes Research.* Department of Psychology, San Diego State University; San Diego, CA. Supervised by Drs. Terry Cronan and Terry Conway.

2007-2009 *Masters Student; Health Services Research Center.* Department of Family and Preventive Medicine; University of California, San Diego, La Jolla, CA. Supervised by Drs. Theodore Ganiats and Erik Groessl.

2005-2007 *Post-Baccalaureate Research Assistant*; *Obesity and Physical Activity Research Team*. Department of Preventive Medicine, University of Kansas Medical Center; Kansas City, KS. Supervised by Drs. Paula Rhode and Katherine Froehlich-Grobe.

2005-2006 *Student Research Assistant*; *Sleep and Stress Laboratory.* Department of Psychology, University of Kansas; Lawrence, KS. Supervised by Dr. Nancy Hamilton.

2004-2006 *Student Research Assistant; Behavioral Pharmacology and Smoking Cessation Laboratory.* Department of Psychology, University of Kansas; Lawrence, KS. Supervised by Drs. James Grobe and Kimberly Pulvers.

GRANTS AND CONTRACTS AWARDED

1/2012 – 6/2013 *The California Endowment;* $50K competitive grant to evaluate school physical activity practices and conduct related advocacy work (dissertation project). (Role: Co-PI with Sallis).

9/2011 – 3/2012 *San Diego County Health and Human Services Agency*; $5K invited subcontract to work in county office and assist with evaluation of San Diego County's CDC Communities Putting Prevention to Work (CPPW) $16M grant project. (Role: awardee and lead).

4/2010 – 2/2011 *California Department of Transportation*; $7K invited subcontract through Walk San Diego to evaluate Health Equity by Design which aimed to improve health equity in an underserved neighborhood through community-driven, transit-oriented development. (Role: awardee and lead).

11/2010 – 12/2010 *Kaiser Permanente*; $4K invited subcontract through Walk San Diego to evaluate Next Steps Project V which aimed to create more walkable, health-promoting neighborhood environments and policies, thereby increasing walking as a form of physical activity. (Role: awardee and lead).

6/2010 – 8/2010 *California Department of Public Health*; $3K competitive mini-grant from NIH funded project Leaders Encouraging Activity and Nutrition (LEAN) to assess statewide policies related to amount of physical activity during school. (Role: PI).

GRANTS AND CONTRACTS PENDING

1/2013 – 12/2014 *National Institutes of Health*; NHLBI T32 Postdoctoral Fellowship (University of California, San Diego institutional grant). (Role: Fellow).

3/2013 – 8/2014 *Robert Wood Johnson Foundation*; $70k competitive research grant. Title: Using GPS to estimate effects of neighborhood food environment policy changes on adolescents' energy intake and obesity. (Role: Co-PI with Kerr).

7/2013 – 6/2015 *National Institutes of Health*; NHLBI Pediatric Loan Repayment Program ($25k/year). Title: Advancing evidence on built environments and physical activity in youth. (Role: PI/applicant).

HONORS AND AWARDS

2013 Society of Behavioral Medicine Citation Abstract Award

2013 Society of Behavioral Medicine Meritorious Student Abstract Award

2012 Recipient of the Achievement Rewards for College Scientists Scholarship (ARCS). This $7500 scholarship was awarded to the top 17 doctoral student

	scientists at UCSD, nominated for their achievement in research, from a pool of 16 doctoral programs representing hundreds of students. Details at: https://www.arcsfoundation.org/san_diego/
2009	San Diego State University Graduate Equity Fellowship Award
2008	San Diego State University Graduate Equity Fellowship Award
2008	University of California San Diego Department of Family and Preventive Medicine Staff Award
2006	Above and Beyond Recognition Cottonwood, Inc (April, October, & November)
2005	Headquarters Counseling Center Outstanding Overnight Counselor Award

TEACHING AND LEADERSHIP

2012- present	*Graduate Student Mentor; Center for Obesity and Health*. Departments of Pediatrics and Psychiatry, University of California, San Diego. Description: Advise and assist graduate students and postdocs with statistical analyses and technical writing for manuscripts.
10/2012	*Invited Discussion Leader; Doctoral Student General Seminar*. Graduate School of Public Health, San Diego State University. Description: Led discussion with doctoral students on advancement to candidacy and dissertation planning.
2011-2012	*Intervention Leader; Multilevel Intervention on Physical Activity in Retirement Communities.* Department of Family and Preventive Medicine, University of California, San Diego. Description: Developed and conducted eight 1-hour educational and skill-based session on reducing sedentary time.
2010-present	*Undergraduate Student Mentor; Active Living Research.* Department of Family and Preventive Medicine, University of California, San Diego. Description: Supervise undergraduate students in planning and implementation of data collection as well as manuscript writing.
10/2011	*Invited Guest Lecturer; Developmental Psychology.* Department of Psychology, San Diego State University. Description: Prepared and conducted lecture on promoting physical activity in children.
3/2010	*Invited Guest Lecturer*; *Introduction to Public Health.* Department of Public Health, San Diego State University. Description: Prepared and conducted lecture on health behavior science.
2007-2009	*Undergraduate Student Mentor; Health Outcomes Research*. Department of Psychology, San Diego State University. Description: Supervised and taught three undergraduate students to develop research questions, run statistics, submit abstracts, and present at professional conferences.

COMMITTEE INVOLVEMENT

2012-present	*Public Health Stakeholder Group*. San Diego Association of Governments (SANDAG; Metropolitan Planning Organization); San Diego, CA.
2006-2007	*Selection Committee.* Headquarters Counseling Center; Lawrence, KS.

SERVICE

2012	*Manuscript Reviewer*. International Journal for Behavioral Nutrition and Physical Activity (1 paper), International Journal of Public Health (1 paper), and Preventive Medicine (1 paper).
2010-2012	*Abstract Reviewer*. Annual Scientific Sessions of the Society of Behavioral Medicine.
2009-2012	*Conference Volunteer*. Active Living Research Annual Conference; San Diego, CA.
2011	*Manuscript Reviewer*. American Journal of Health Promotion (1 paper), Evaluation and Program Planning (1 paper), International Journal for Behavioral Nutrition and Physical Activity (1 paper), Journal of School Health (1 paper), and Research Quarterly for Exercise and Sport (1 paper).
2008-2009	*Conference Volunteer.* Annual Scientific Sessions of the Society of Behavioral Medicine; San Diego, CA and Montreal, Quebec.
2006-2007	*Residential Manager for Individuals with Developmental Disabilities*. Cottonwood Incorporated; Lawrence, KS.
2004-2007	*Volunteer Crisis and Suicide Counselor*. Accrued over 1000 volunteer hours. Headquarters Counseling Center; Lawrence, KS.

PUBLICATIONS

Book Chapters:

2. **Carlson, J.A.** (2012). Encyclopedia entries: lifestyle general, lifestyle modification, lifestyle sedentary, and exercise general. In Gellmen, M.D. & Turner, R.J. (Eds.). *Encyclopedia of behavioral medicine*. New York: Springer Science+Business Media.
1. Sallis, J.F., Millstein, R.A., &. **Carlson, J.A.** (2011). Community design for physical activity. In Dannenberg, A., Frumkin, H., & Jackson, R. (Eds.). *Making healthy places: designing and building for health, well-being, and sustainability*. Washington DC: Island Press; 33-49.

Published Manuscripts:

20. Sallis, J.F., **Carlson, J.A.**, Mignano, A.M., Lemes, A., & Wagner, N. (In press). Trends in presentations of environmental and policy studies related to physical activity, nutrition, and obesity at society of behavioral medicine, 1995-2010: a commentary to accompany the Active Living Research supplement to Annals of Behavioral Medicine. *Annals of Behavioral Medicine*.
19. Sallis, J.F., **Carlson, J.A.**, & Mignano, A. (In press). Promoting youth physical activity through PE and after-school programs. *Adolescent Medicine: State of the Art Reviews*.
18. **Carlson, J.A.**, Sallis, J.F., Chriqui, J.F., Schneider, L., McDermid, L.C., & Agron, P. (In press). State policies about physical activity minutes in physical education or during the school day. *Journal of School Health.*
17. Dirige, O.V., **Carlson, J.A.**, Alcaraz, J.E., Moy, K.L., Rock, C.L., Oades, R., & Sallis, J.F. (In press). *Siglang Buhay*: Nutrition and physical activity promotion in Filipino Americans through community organizations. *Journal of Public Health Management and Practice*.
16. Sarkin, A.J., Groessl, E.J., **Carlson, J.A.**, Tally, S.R., Kaplan, R.M., Sieber, W.J.. & Ganiats, T.G. (2012). Development and validation of a mental health subscale from the Quality of Well-Being Self-Administered. *Quality of Life Research*, online first.

15. Kerr, J., Rosenberg, D., Nathan, A., Millstein, R.A., **Carlson, J.A.**, Crist, K., Wasilenko, K., Castro, C.M., & Marshall, S.J. (2012). Applying the Ecological Model of Behavior Change to a Physical Activity Trial in Retirement Communities. *Contemporary Clinical Trials*, online first.
14. Kerr, J., **Carlson, J.A.**, Rosenberg, D., & Withers, A. (2012). Identifying and Promoting Safe Walking Routes in Older Adults. *Health, 4*(Special Issue I), 720-724.
13. **Carlson, J.A.**, Sallis, J.F., Wagner, N., Calfas, K.J., Partick, K., Groesz, L.M., & Norman, G.J. (2012). Brief physical activity-related psychosocial measures: reliability and construct validity. *Journal of Physical Activity and Health, 9*(8), online first.
12. Norman, G.J., **Carlson, J.A.**, Omara, S., Sallis, J. F., Patrick, K., Frank, L.D., & Godbole, S. (2012). Neighborhood Preference, Walkability and Walking in Overweight/Obese Men. *American Journal of Health Behavior, 37*(2), 276-281.
11. Rhode, P.C., Froehlich-Grobe, K., Hockemeyer, J.R., **Carlson, J.A**., & Lee, J.H. (2012). Assessing stress among individuals with physical disabilities: development of the Disability Related Stress Scale (DRSS). *Disability and Health Journal, 5*(3),168-176.
10. **Carlson, J.A.**, Crespo, N.C., Sallis, J.F., Patterson, R.E., & Elder, J.P. (2012). Dietary-related and physical activity-related predictors of obesity in children: a 2-year prospective study. *Childhood Obesity, 8*(2), 110-115.
9. **Carlson, J.A.**, Sallis, J.F., Ramirez, E., Partick, K., & Norman, G.J. (2012). Physical activity and dietary behavior change in Internet-based weight loss interventions: comparing two multiple-behavior change indices. *Preventive Medicine, 54*(1), 50-54.
8. **Carlson, J.A.**, Sallis, J.F., Conway, T.L., Saelens, B.E., Frank, L.D., Kerr, J., Cain, K., & King, A.C. (2012). Interactions between psychosocial and built environment factors in explaining older adults' physical activity. *Preventive Medicine, 54*(1), 68-73.
7. **Carlson, J.A.**, Imberi, J.E., Cronan, T.A., Villodas, M.T., Brown, K.C., & Talavera, G.A. (2011). Factors related to the likelihood of using a health advocate. *California Journal of Health Promotion, 9*(1), 62-72.
6. Kerr, J., **Carlson, J.A.,** Sallis, J.F., Rosenberg, D., Leak, C.R., Saelens, B.E., Chapman, J.E., Frank, L.D., & King, A.C. (2011). Assessing health-related resources in senior living residences. *Journal of Aging Studies, 25*(3), 206-214.
5. Leek, D.N., **Carlson, J.A.**, Henrichon, S., Rosenberg, D., Cain, K., Patrick, K., & Sallis, J.F. (2011). Physical activity during youth organized sports: differences in minutes and intensity between baseball and soccer. *Archives of Pediatric and Adolescent Medicine,165*(4), 294-299.
4. **Carlson, J.A.**, Sarkin, A.J., Levack, A.E., Tally, S.R., Gilmer, T.P., & Groessl, E.J. (2011). Evaluating a measure of social health derived from two mental health recovery measures: the California Quality of Life (CA-QOL) and Mental Health Statistics Improvement Program Consumer Survey (MHSIP). *Community Mental Health Journal, 47*(4), 454-462.
3. Norman, G.J., **Carlson, J.A.**, Sallis, J.F., Wagner, N., Calfas, K.J., & Partick, K. (2010). Reliability and validity of brief psychosocial measures related to dietary behaviors. *International Journal of Behavioral Nutrition and Physical Activity, 7*, 56.
2. Sallis, J.F., Kerr, J., **Carlson, J.A.**, Norman, G.J., Saelens, B.E., Durant, N., & Ainsworth, B.E. (2010). Evaluating a brief self-report measure of neighborhood environments for physical activity research and surveillance: Physical activity neighborhood environment scale (PANES). *Journal of Physical Activity and Health, 7*(4), 533-540.
1. Cronan, T.A., **Carlson, J.A.**, Imberi, J.E., Villodas, M.T., Vasserman-Stokes, E., & Dowell, A. (2010). The effects of social support and confidence in the health care

system on the decision to hire a health advocate. *Psychology Research and Behavior Management, 3*, 41-50.

Manuscripts under Review:

Carlson, J.A., Sallis, J.F., Conway, T.L., Frank, L.D., Kerr, J., Cain, K., & Saelens, B.E. (Under review). Ecological correlates of active travel to school in youth age 12-15.

Norman, G.J., Huang, J.S., Davila, E.P., **Carlson, J.A.**, Covin, J.R., Gottschalk, M., & Patrick, K. (Under review). Outcomes of a one-year behavioral, stepped-care weight loss intervention for obese adolescent patients: PACE-PC.

McKenzie, T.L., Moody, J.S., **Carlson, J.A.**, Lopez, N.V., & Elder, J.P. (Under review). Neighborhood income matters: disparities in recreation facilities, amenities, and programs.

Bracy, N.L., Millstein, R.A., **Carlson, J.A.**, Conway, T.L., Sallis, J.F., Saelens, B.E., Kerr, J., Cain, K.L., Frank, L.D., & King, A.C. (Under review). Is the Relationship between the built environment and physical activity moderated by perceptions of crime and safety?

Lopez, N.V., **Carlson, J.A.**, Crespo, N.C., Corder, K., & Elder, J.P. (Under review). Validity of caregiver proxy report of children's sedentary behavior using accelerometers.

Boutelle, K.N., Peterson, C., Zucker, N., Rydell, S., **Carlson, J.A.**, & Harnack, L. (Under review). Regulation of cues: a description of the ROC intervention and pilot trial.

Other Publications and Major Reports:

4. **Carlson, J.A.**, & San Diego County Health and Human Services Agency. (2012). Evaluation of the 2011 Walk, Ride & Roll promotional campaign on active travel to school. Sponsored by the San Diego Association of Governments.
3. **Carlson, J.A.**, & Sallis, J.F. (2011). Evaluation report of the Health Equity by Design community advocacy intervention project. Sponsored by the California Department of Transportation.
2. **Carlson, J.A.**, Sallis, J.F., & Mignano, A. (2010). Evaluation report of Walk San Diego's 2010 Next Steps community advocacy project V. Sponsored by Kaiser Permanente of San Diego.
1. Joe, L., **Carlson, J.A.**, Sallis, J.F. (2010). Active Where? Individual item reliability statistics. Available at: http://www.drjamessallis.sdsu.edu/measures.html.

Oral Presentations:

6. **Carlson, J.A.**, Kerr, J., Sallis, J.F., Godbole, S., Lam, M., Saelens, B.E., Cain, K., Conway, T.L., Frank, L.D., & Glanz, K. (2013). GPS-measured time spent in vehicle, neighborhood walkability and BMI in adolescents. Presented at the 2013 Annual Meeting of the Society of Behavioral Medicine. March 20-23, San Francisco, CA.
5. **Carlson, J.A.**, Sallis, J.F., Norman, G.J., Saelens, B.E., Elder, J.P., Glanz, K., Frank, L.D., & Cain, K. (2013). School practices, economic disparities, and objectively measured MVPA during school in children aged 8-13. Presented at the 2013 Annual Meeting of Active Living Research. February 26-28, San Diego, CA.
4. **Carlson, J.A.**, Frank, L.D., Sallis, J.F., Conway, T.L., Cain, C., & Saelens, B.E. (2012). Contribution of perceived built environment attributes around the worksite to active transportation and physical activity. Presented at the 2012 Congress on Physical Activity and Public health. October 31- November 3, Sydney, Australia.
3. McKenzie, T.L., Moody, J.S., Lopez, N.V., & **Carlson, J.A.** (2012). Neighborhood income matters: disparities in recreation facilities, amenities, and programs. Presented at the

Annual Congress of the National Recreation and Park Association Leisure Research Symposium. October 16-18, Anaheim, CA.

2. Rhode, P.C., Froehlich-Grobe, K., Hockemeyer, J.R., & **Carlson, J.A.** (2009). Psychometric properties of the Disability Related Stress Scale (DRSS). Presented at the Annual Meeting of the Society of Behavioral Medicine. April 22-25, Montreal, Quebec.
1. Tally, S., Brunette, Y., **Carlson, J.A.**, Levack, A., & Ganiats, T. (2008). Comparison of general and health-related Quality of Life: the SEIQOL, SF36, and EQ5D. Presented at the Annual Meeting of the International Society for Quality of Life Research. October 22-25, Montevideo, Uruguay.

Poster Presentations:

24. **Carlson, J.A.**, McKenzie T.L., Lee, N.V.L., Corder, K., Sallis, J.F., & Elder, J.P. (2012). Are schools providing sufficient opportunities for physical activity? Objectively measured physical activity and sedentary time in- and out-of-school in children aged 7-10. Presented at the Annual Meeting of Active Living Research. March 12-14, San Diego, CA.
23. Ryan, S., Jovanovic, S., **Carlson, J.A.**, Delaney, T., Browner, D., & Vance, S. (2012). Evaluating the effectiveness of Bike to Work Month promotions: are we reaching low income – minority communities? Presented at the Annual Meeting of Active Living Research. March 12-14, San Diego, CA.
22. **Carlson, J.A.**, Sallis, J.F., Conway, T.L., Saelens, B.E., Frank, L.D., Kerr, J., Cain, K., & King, A.C. (2011). Psychosocial by built environment interactions associated with older adults' physical activity. Presented at the Annual Meeting of the Society of Behavioral Medicine. April 27-30, Washington, DC.
21. **Carlson, J.A.**, Omara, S., Godbole, S., Sallis, J.F., Frank, L.D., Patrick, K., & Norman, G.J. (2011). Neighborhood preferences moderate the relationship between neighborhood walkability and total walking in overweight/obese men. Presented at the Annual Meeting of the Society of Behavioral Medicine. April 27-30, Washington, DC.
20. Norman, G.J., Adams, M.A., Ramirez, E.R., **Carlson, J.A.**, Kerr, J., Godbole, S., Dillon, L., Palmer, N., & Marshall, S.J. (2011). Predictors of adolescent exergame play over four weeks. Presented at the Annual Meeting of the Society of Behavioral Medicine. April 27-30, Washington, DC.
19. **Carlson, J.A.**, Sallis, J.F., & Cox, L. (2011). Evaluation of statewide policies to increase physical activity in physical education and at school. Presented at the Annual Meeting of Active Living Research. February 22-24, San Diego, CA.
18. **Carlson, J.A.**, Norman, G.J., Sallis, J.F., Calfas, K.J., & Patrick, K. (2010). Evaluating brief psychosocial measures related to physical activity. Presented at the Annual Meeting of The Obesity Society. October 9-12, San Diego, CA.
17. Pulvers, K., Merchant, G., Pandzic, I., Potter, R., **Carlson, J.A.,** & Thode, L. (2010). Cognitive and affective correlates of distress tolerance and smoking relapse. Presented at the Annual Meeting of the American Psychological Association. August 12-25, San Diego, CA.
16. **Carlson, J.A.**, Kerr, J., Rosenberg, D., Sallis, J.F., Saelens, B.E., Leak, C.R., Frank, L.D., Chapman, J.E., & King, A.C. (2010). Development and evaluation of the Audit of Physical Activity Resources for Seniors (APARS) tool. Presented at the Annual Meeting of the Society of Behavioral Medicine. April 7-10, Seattle, WA.
15. **Carlson, J.A.**, Leek, D.N., Henrichon, S., Sallis, J.F., & Cain, K. (2010). Differences in minutes and intensity of children's physical activity between soccer and baseball

practices. Presented at the Annual Meeting of the Society of Behavioral Medicine. April 7-10, Seattle, WA.

14. Leek, D.N., **Carlson, J.A.**, Henrichon, S., Cain, K., & Sallis, J.F. (2010). Gender differences in physical activity during youth organized sports practices using accelerometers. Presented at the Annual Meeting of the Society of Behavioral Medicine. April 7-10, Seattle, WA.
13. **Carlson, J.A.**, Sallis, J.F., Kerr, J., Norman, G.J., Saelens, B.E., Durant, N., & Ainsworth, B.E. (2009). Evaluating the Physical Activity Neighborhood Environment Scale (PANES). Presented at the Annual Meeting of the Society of Behavioral Medicine. April 22-25, Montreal, Quebec.
12. **Carlson, J.A.**, Sarkin, A.J., Tally, S.R., Groessl, E.J., Sieber, W.J., Ganiats, T.G., Brody, B.L., & Kaplan, R.M. (2009). Development and validation of the Quality of Well-Being Self-Administered Mental Health Scale. Presented at the Annual Meeting of the Society of Behavioral Medicine. April 22-25, Montreal, Quebec.
11. **Carlson, J.A.**, O'Connor, M.E., Villodas, M.T., & Cronan, T.A. (2009). The role of health-related factors in using a patient advocate. Presented at the Annual Meeting of the Society of Behavioral Medicine. April 22-25, Montreal, Quebec.
10. Allbee, L.K., **Carlson, J.A.**, Villodas, M.T., & Cronan, T.A. (2009). The role of individual and health-related factors in ratings of healthcare confidence. Presented at the Annual Meeting of the Western Psychological Association. April 23-26, Portland, OR.
9. Calderón, N.E., Imberi, J.E., **Carlson, J.A.**, Villodas, M.T., & Cronan, T.A. (2009). Demographic characteristics in two age groups as predictors of the likelihood of hiring a health care advocate. Presented at the Annual Meeting of the Western Psychological Association. April 23-26, Portland, OR.
8. **Carlson, J.A.**, Levack, A., Tally, S., Ganiats, T. & Sarkin, A. (2008). Gender differences in responses to traditional and alternative time trade-off scenarios. Presented at the Annual Meeting of the Society of Behavioral Medicine. March 26-29, San Diego, CA.
7. Sarkin, A., **Carlson, J.A.**, Schatzle, D., Harvey, J., Tally, S., Groessl, E., Kaplan, R.M., & Ganiats, T. (2008). Influence of mood on self-rated health. Presented at the Annual Meeting of the Society of Behavioral Medicine. March 26-29, San Diego, CA.
6. **Carlson, J.A.**, Imberi, J.E., Conway, T.L., & Cronan, T.A. (2008). Self-efficacy and screening efficacy for colorectal cancer (CRC) screening in low-income Caucasion, African, and Mexican Americans. Presented at the Annual Meeting of the Society of Behavioral Medicine. March 26-29, San Diego, CA.
5. Rhode, P.C., Froehlich-Grobe, K., Hockemeyer, J.R., & **Carlson, J.A**. (2007). Development of the Disability Related Stress Scale (DRSS). Presented at the Annual Meeting of the Society of Behavioral Medicine. March 21-24, Washington, DC.
4. **Carlson, J.A.**, Karlson, C.W., Hamilton, N.A., Nelson, C.A., & Luxton, D.D. (2006). Relationship between subjective and objective measures of sleep duration and sleep efficiency. Presented at the Annual Meeting of the American Psychological Association. August 10-13, New Orleans, LA.
3. Rhode, P.C., **Carlson, J.A.**, Hockemeyer, J.R., & Greiner, A. (2006). Adherence to clinical practice guidelines for overweight and obesity among rural primary care physicians. Presented at the Annual Scientific Meeting of The Obesity Society. October 20-24, Boston, MA.
2. **Carlson, J.A.**, Pulvers, K.M., Selig, J.P., & Grobe, J.E. (2006). The role of positive outcome expectancies in the ability to resist smoking in a lab-based setting. Presented at

the Annual Meeting of the Society of Behavioral Medicine. March 22-25, San Francisco, CA.

1. Rhode, P.C., Davis Martin, P., Hockemeyer, J.R., **Carlson, J.A.**, & Brantley, P.J. (2006). Psychosocial predictors of blood pressure among African American weight loss participants. Presented at the Annual Meeting of the Society of Behavioral Medicine. March 22-25, San Francisco, CA.

Submitted Abstracts:

Rosenberg, D., Kerr, J., Poon, L., **Carlson, J.A.**, Crist, K., Marshall, S., & Wasilenko, K. (Under review). Relationship between sedentary time and emotional health among older adults in retirement facilities. Submitted for presentation at the 2013 Annual Meeting of the Society of Behavioral Medicine.

Sallis, J.F., Adams, M.A., **Carlson, J.A.**, Frank, L.D., Saelens, B.E., Cain, K., Conway, T.L., Ahn, D.K., Kerr, J., & King, A.C. (Under review). Neighborhood environments, physical activity, and function among US older adults: findings from the Senior Neighborhood Quality of Life Study (SNQLS). Submitted for presentation at the 2013 Annual Meeting of the International Society for Behavioral Nutrition and Physical Activity.

MEDIA COVERAGE

October 2012	Press Release. Sports Medicine Australia. "Is your commute making you fat?"
December 2010	Press Release. San Diego State University. "Youth sports doesn't net enough daily activity for kids".
December 2010	Interview. CBS Radio Dallas/Fort Worth. Live radio interview with Mitch Carr.
December 2010	Interview. MedPage Today. "Kids' sports strike out on exercise goals". Available at: http://www.medpagetoday.com/PrimaryCare/ExerciseFitness/23763
December 2010	Interview. Toronto Star. "Few kids get enough exercise by playing sports, study finds". Available at: http://www.parentcentral.ca/parent/familyhealth/children'shealth/article/902614--few-kids-get-enough-exercise-by-playing-sports-study-finds.

ADVANCED STATISTICAL AND TECHNICAL SKILLS

- GPS data processing and analysis, including complex syntax for time series and spatial data
- GIS data processing and analysis, including geoprocessing, geocoding and mapping
- Accelerometer data processing and analysis, including complex syntax for bout and time-of-day processing
- Multilevel modeling, including three-level models, centering techniques and cross-level interactions
- Longitudinal analysis, including parallel processes modeling and multiple-group intervention evaluation
- Latent variable modeling, including structural equation modeling and latent growth analysis

ABSTRACT OF THE DISSERTATION

Child Physical Activity in Relation to School Physical Activity Practices

by

Jordan A. Carlson

Doctor of Philosophy in Public Health (Health Behavior)

University of California, San Diego, 2012
San Diego State University, 2012

Professor James F. Sallis, Chair

Background. Schools provide an important opportunity for children to meet physical activity guidelines. However, physical activity during school is low, and more evidence is needed to support schools to adopt best practices related to physical activity.

Objective. The purpose of the present study was to investigate the relation of elementary school physical activity practices related to Physical Education (PE), recess,

classroom time, and after-school time to school SES and children's objectively measured physical activity.

Methods. Participants were 172 children from 97 elementary schools in the San Diego, CA and Seattle, WA regions. Children wore accelerometers to estimate physical activity for 3.7±1.7 school days. A survey was completed by school informants (PE teachers and principals) to assess physical activity-related school practices (63% response rate). Accelerometer data were scored based on individual school start and end times to derive in-school and after-school minutes/day of MVPA. ANOVAs with LSD post-hoc tests were used to investigate disparities in physical activity-related practices for low-, moderate-, and high-SES schools. Three-level linear mixed effects regression models were used to investigate the association between school practices and children's MVPA. The 5 most important practices, based on their relationship with in-school MVPA, were combined into a summary score.

Results. The 5-item school physical activity practice summary score was significantly associated with in-school MVPA, where children had 2.4 more minutes/day of in-school MVPA for every additional practice reflected in the summary score ($p = .037$). Having a PE teacher was the strongest practice correlated with in-school MVPA, where children at schools with a PE teacher had 6 more minutes/day of in-school MVPA ($p = .114$). Having someone other than a classroom teacher supervise recess was non-significantly related to 3 more minutes/day of in-school MVPA ($p = .363$).

Conclusions. The present study provides evidence for adopting a package of school physical activity practices to improve children's physical activity during school. Particularly, not having a PE teacher appears to be a leading contributor to low rates of physical activity. Attention should be paid to economically disadvantaged schools, because schools could be contributing to disparities in childhood obesity and inactivity.

INTRODUCTION

Physical Activity in Children Can Help Prevent Lifetime Risk for Disease

Physical inactivity in adults has been associated with a plethora of negative health outcomes, including premature death; diseases such as coronary heart disease, stroke, some cancers, type 2 diabetes, and osteoporosis; risk factors for diseases such as high blood pressure and blood cholesterol; functional aging; and mental health attributes such as depression and cognitive function (Blair, Kampert, & Kohl, 1996; Haskell, Blair, & Hill, 2009; US Department of Health and Human Services [USDHHS], 2008). In children, physical activity supports cardiovascular and metabolic health, cognitive development, learning, and bone health (USDHHS, 2008). Physical inactivity in children has been associated with cardiovascular risk factors such as high blood pressure, high cholesterol, triglyceride levels, and obesity (Anderson et al., 2006; Berenson et al., 1998; Gutin & Owens, 2011; Steinberger & Daniels, 2003; USDHHS, 2008). Some evidence suggests that physical inactivity and disease risk factors, especially obesity, can track throughout childhood, into adolescence and even adulthood, making inactive children especially vulnerable to disease (Guo et al., 2002; Kelder et al., 1994; Kristensen et al., 2008; Nader et al., 2006; Telama et al., 2005; USDHHS, 2008).

One often overlooked benefit of physical activity in children is increased academic performance. Studies have found that active children generally have better grades in school, achievement scores and cognitive performance than inactive children (Singh et al., 2012). Classroom physical activity breaks (i.e., 10-15 minutes of physical

activity in the classroom) have resulted in improvements in concentration and on-task behavior of 10-20% (Trost, 2007). These findings suggest physical activity is an important factor for schools to consider in child learning, not just health.

More recently, evidence has accumulated suggesting an association between sedentary time and cardiovascular disease in adults that is independent of physical activity (Hamilton et al., 2008; Healy et al., 2008; Owen et al., 2010). In children, time spent viewing television has been associated with obesity, high blood pressure, and metabolic syndrome in children (Salmon, Campbell, & Crawford, et al. 2006; Tremblay et al., 2011). Although findings on the relationship between objectively measured sedentary time and disease risk factors in children is mixed (Ekelund et al., 2012), some evidence suggests objectively measured sedentary time is positively related to blood pressure, triglycerides and other cardiovascular risk factors, and these relationships may be stronger in obese children (Healy & Owen, 2010; Martinez-Gomez et al., 2009; Martinez-Gomez et al., 2010; Salmon et al., 2011; Tremblay et al., 2011).

Children are Not Meeting Guidelines for Physical Activity

The Centers for Disease Control and Prevention (CDC) and United States Department of Health and Human Services (USDHHS), among others, recommend children engage in 60 minutes of moderate to vigorous physical activity every day for optimal health and disease prevention (USDHHS, 2008). The physical activity guidelines do not cover total sedentary time, but recommend children spend no more than 2 hours/day viewing television. Based on self-reports, children spend 2-4 hours/day

viewing television or other screen-based media (Salmon et al., 2006). Based on objective data, children aged 6-11 years are the most active age group and engage in an average of 95 minutes/day of moderate to vigorous physical activity. However, only 42% of children meet the recommended 60 minutes/day of physical activity and average sedentary time for children is 6-7.5 hours/day. Older children and girls engage in less physical activity and more sedentary time than their male counterparts, and adolescents have among the lowest rates (8%) of meeting guidelines compared to other age groups (Mathews et al., 2008; Troiano et al., 2008).

Increasing Physical Activity in Children can Reduce Health Disparities

Rates of disease and physical inactivity differ by race/ethnicity and SES (Cooper et al., 2000; Kington & Smith, 1997; Mathews et al., 2008; Troiano et al., 2008). Blacks have the highest age-adjusted all-causes death rate of all races/ethnicities and are more likely to die from heart disease, cancer and diabetes than their counterparts (Centers for Disease Control and Prevention [CDC], 2008). Latino children, particularly boys, and Black children, particularly girls, have the highest rates of obesity (Ogden et al., 2010). Over the past few decades, obesity rates have increased among all race/ethnicities, but most among Blacks and Latinos (Strauss & Pollack, 2001). Black children engage in the most minutes of daily physical activity, follow by Latino then White non-Hispanic children (Nyberg, Ramirez, & Gallion, 2011; Troiano et al., 2008). Black boys are slightly more sedentary than White and Latino boys, while Black girls are significantly less sedentary than Latino and White non-Hispanic girls (Mathews et

al., 2008). The percent of children meeting physical activity guidelines becomes slightly higher as SES increases, although the differences are small (Whitt-Glover et al., 2009).

Potential causes of differing rates of physical activity by race/ethnicity and SES include cultural (e.g., recreational activities, body image) and environmental factors (e.g., access to physical activity opportunities). For example, studies have found that neighborhoods with higher SES are safer for walking and have more physical activity opportunities (Gordon-Larsen et al., 2006; Zhu & Lee, 2008). A population increase in the number of children who meet physical activity guidelines could contribute to a reduction in health disparities, especially when carried out in a high-reach setting such as schools (Rose, 1992).

Schools are an Important Setting for Increasing Physical Activity in Children

Approaches to promoting physical activity are often based on behavioral theory. While many behavioral theories focus on one level of behavioral influence, typically the psychological or interpersonal level, ecological models predict that behavior results from the dynamic interplay among psychological, interpersonal, environmental and policy factors (Sallis, Owen, & Fisher, 2008). Numerous health agencies, including the Institute of Medicine and CDC, promote strategies based on ecological models, particularly environmental and policy interventions, as most promising for creating population-wide increases in physical activity (Institute of Medicine, 2001; Koplan & Dietz, 1999).

Programs to promote physical activity in children have been delivered through various settings, including schools, primary care clinics, communities and family homes. Results have varied across settings and approaches, but the school setting has generally been the most successful (Dobbins et al., 2009; Kahn et al., 2002; Marcus et al., 2002; Salmon et al., 2007; Timperio, Salmon, & Ball, 2004). Family- or home-based programs as well as primary care-based programs have had mixed results, whether focusing on psychological or environmental factors; success in these programs has typically been linked with more frequent contact and greater duration of follow-up. School-based programs that focus exclusively on educating children and/or parents to make changes related to physical activity, whether targeting psychological or environmental changes, have had little success. School-based programs that include environmental or policy changes within the school have had much greater success in increasing children's physical activity (Dobbins et al., 2009; Kahn et al., 2002; Marcus et al., 2002; Salmon et al., 2007; Timperio, et al., 2004). These programs have led to increases in school-based physical activity as well as total physical activity, and, in some cases, out-of-school physical activity (Salmon et al., 2007).

One potential reason for the success of school-based interventions is the opportunity to intervene at multiple levels, such as the individual (e.g., education to support confidence), social environment (e.g., social norms), physical environment (e.g., improve playgrounds), and policy environment (e.g., mandatory daily PE). Schools offer a unique opportunity for targeting environment and policy changes because of their standardization in routines and policy structure set forth by officials at the school,

district, state and national level (Story, Nanney, & Schwartz, 2009). In general, teachers can be expected to be held accountable to uphold the standards of the school (although accountability varies), which means that a policy change is likely to affect the daily practices of all or a majority of children in the school (Brownson et al., 2010).

School Policies can Lead to More Opportunities for Physical Activity

Physical activity policies can take various forms, such as formal written codes bearing legal authority, written recommendations that are not mandated, and ground-level practices (i.e., the practices that are implemented at the school) (Schmid, Pratt, & Witmer, 2006). School physical activity policies can exist at the national, state, district and school level. An example of a national policy related to school physical activity was the mandate that all schools adopt a written wellness policy by 2006, as part of the Child Nutrition and Women, Infants, and Children Reauthorization Act of 2004. Most school physical activity policies exist at the state, district and/or school level; PE requirements are one example.

Figure 2 depicts the processes linking school policies to physical activity and health, and was adapted from the physical activity policy model from Schmid et al. 2006. The relationship between physical activity and health (D-E) has long been established (USDHHS, 2008). The main focus of school physical activity policy research is to understand the determinants of adopting (A) and implementing (B) policies, how these policies affect the school environment (C), and in turn effect children's physical activity (D). Determinants of adopting and implementing school

physical activity policies have been less studied, but more focus is currently being paid to this area (e.g., Cox et al., 2011). Because written policies are not always implemented (Carlson et al., 2012), and ground-level practices are often not bound by written requirements, it is important to identify the relationship between both A-C and B-C.

Types of physical activity-related environmental changes (C) to which policies can lead include changes in the built environment (e.g., adding a playground), scheduling environment (e.g., frequency and duration of PE offered) and curriculum environment (e.g., using an evidence-based PE curriculum or incorporating physical activity into classroom lesson plans). Each of these environmental changes is believed to affect a large number of children attending the school (C-D), but there are likely person-level factors that lead some students to be more active than others (e.g., gender, attitudes).

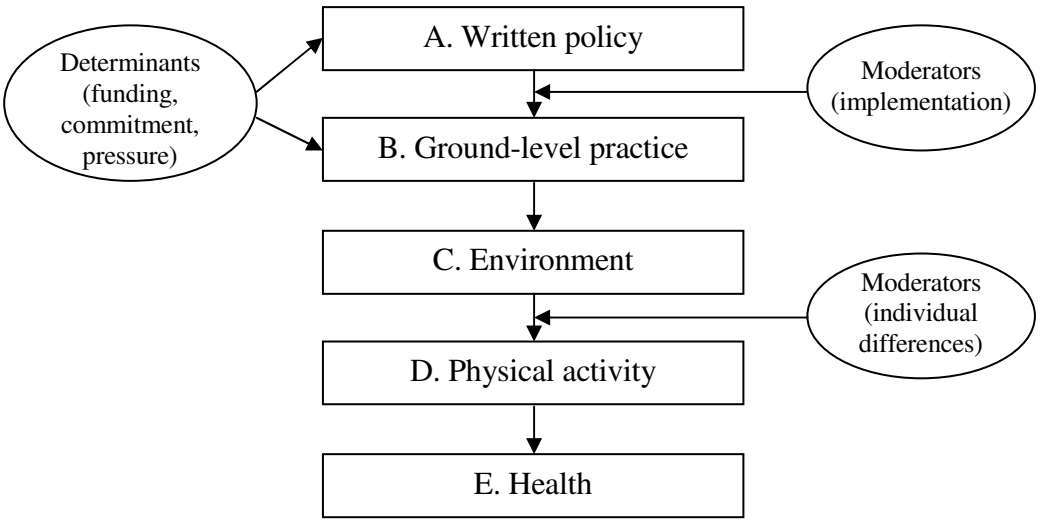

Figure 1: Foci of school physical activity policy research

School Policies and Practices are Not Providing Sufficient Opportunities for Physical Activity, although Several Evidence-Based Strategies have been Identified

Several strategies for increasing physical activity in schools have been supported through research and recommended by health authorities. These strategies generally fall within 6 domains: PE, recess, classroom activity, before- and after-school programs, intra- and extramural sports, and active travel to/from school (Ward, 2012). These domains vary in the number of students they reach, as presented in Figure 2. Recess and PE, for example, should affect most children at a school, while only a portion of children attend after-school programs and sports. Amount of physical activity gained by intervening on the aforementioned domains has been estimated to be 5 to 23 minutes/day, with PE, classroom activity and active travel to/from school leading to the greatest increases at 23, 19 and 16 minutes, respectively (Bassett et al., 2012). Policy approaches and related research are summarized below for each domain.

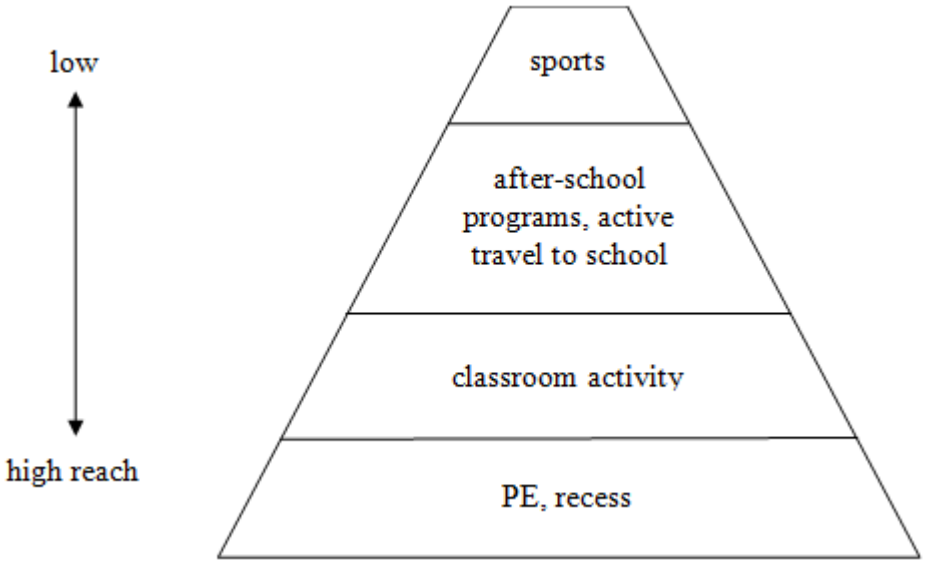

Figure 2: Strategies for increasing physical activity in school by percent of students reached

PE. Health organizations recommend 150 minutes/week of PE in elementary schools and 50% of PE time be spent in MVPA (CDC, 2011; National Association for Sport and Physical Education [NASPE], 2012; Pate et al., 2006; The Community Guide, 2012). In January 2012, the number of states (including DC) requiring PE in elementary school was 45; 6 (12%) of these states required at least 150 minutes of PE/week, while 4% of school districts required 150 minutes/week of PE (Slater et al., 2011; Turner et al., 2010). School-level data collected in 2008 showed that 20% of schools nationwide reported offering at least 150 minutes/week of PE (Turner et al., 2010). Schools in states that had a policy requiring 150 minutes/week of PE were almost 3 times as likely to report meeting the standard; schools in districts that had a policy requiring 150 minutes/week of PE were almost 2.5 times as likely to report meeting the standard (Slater et al., 2011). Since time in PE does not translate into time in physical

activity, 5 states (10%) have adopted a policy requiring at least 50% of PE time to be spent physically active (Carlson et al., 2012; UCLA Center to Eliminate Health Disparities et al., 2007). After a policy was adopted in Texas requiring at least 50% of PE time in physical activity, direct observation of PE classes showed that a majority of the schools sampled were meeting the standard (Kelder et al., 2009).

Thus, there is some evidence that state and district policies can lead to increases in school physical activity opportunities. However, written policies often are vague and do not specify evidence-based strategies (Carlson et al., 2012; Eyler et al., 2010). Several evidence-based policies have been identified and recommended by health organizations to increase physical activity in PE, particularly enhanced curriculum and teacher training (USDHHS et al., 2010). PE curricula like SPARK and CATCH have led to increases physical activity in PE from 37% at baseline to 52% post intervention (Luepker et al., 1996; McKenzie et al., 1996; Sallis et al., 1997). These programs replace less physically active games with those that are more active, use modified game rules that increase children's physical activity, maximize equipment use to prevent inactivity, and incorporate physical activity into otherwise sedentary activities like roll call and skill demonstrations (San Diego State University et al., 2007; USDHHS et al., 2010).

Recess. Health organizations recommend at least 20 minutes of daily recess, but only 4 states require daily recess and the required time duration does not meet the recommended 20 minutes standard (CDC, 2011; National Association for Sport and Physical Education [NASPE], 2012; Pate et al., 2006; National Cancer Institute, 2012;

The Community Guide, 2012). In 2009, an estimated 20% of school districts had a policy requiring recess and 30% reported offering the recommended 20 minutes/day of recess (Chriqui et al., 2010; Turner et al., 2010). Schools within states requiring daily recess were almost twice as likely to meet the standard (Slater et al., 2011). However, similar to PE, physical activity in recess is low, estimated to be less than 50% (Beighle, 2012; Stratton & Mullan, 2005; Verstaete et al., 2006). Several evidence-based policies exist for increasing physical activity in recess, such as using structured games (Connolly & McKenzie, 1995; Howe et al., 2012) painting school playgrounds with playground markings/games (Stratton & Mullan, 2005) and providing game equipment (Verstaete et al., 2006).

Classroom activity. Incorporating physical activity into the classroom has been recommended by health authorities as an evidence-based policy for increasing children's physical activity (CDC, 2011; National Association for Sport and Physical Education [NASPE], 2012; Pate et al., 2006; The Community Guide, 2012). These policies incorporate physical activity into learning (Donnelly et al., 2009; Kibble et al., 2011; Stewart et al., 2004) or create breaks from learning to engage in physical activity (Whitt-Glover, Ham, & Yancey, 2011). Implementing 10 minute activity breaks has increased children's daily physical activity by 12-16% (Donnelly et al., 2009; Mahar et al., 2006) and was associated with improvements in concentration and on-task behavior of 10-15% (Mahar et al., 2006). Implementing these breaks has been feasible on a large scale and seems to have great potential for increasing physical activity during school (Bassett et al., 2012; Stewart et al., 2004; Whitt-Glover et al., 2011).

After-school programs. After-school programs can be community- or school-based and provide a combination of scheduled activities rather than a single activity (e.g., music lessons, sports) (Beets, 2012a). Almost 40% of schools nationwide report providing after school activities (Turner et al., 2010). The National Institute on Out-of-School Time, among others, recommend at least 20% or 30 minutes of after-school program time be dedicated to physical activity programming and that children be active at least 50% of this time (Wiecha et al., 2011). Five states (10%) have policies addressing physical activity in after-school programs and the number of minutes required varies drastically (Beets, Wallner, & Beighle, 2010a). The few studies conducted on physical activity in after-school programs suggest that children attend the programs for an average of 110 to 125 minutes/day, and are physically active for 14 to 37% of this time (Beets et al., 2009; Beets et al., 2010b; Pate & O'Neill, 2009; Trost, Rosenkranz, & Dzewaltowski, 2008). Children were more active when more recreation facilities were present (Nicholas, Pickett, & Janssen, 2009; Nielsen et al., 2010). Physical activity in after-school programs may be increased using similar evidence-based policies to increasing physical activity in PE and recess, as mentioned above (Beets, 2012b; Beets et al., 2009).

Intramural and interscholastic sports. Few policies exist related to physical activity in school sports. Nationwide, 25% of elementary schools reported providing intramural sports and 19% reported providing extramural sports (Turner et al., 2010). Children spend an average of 46 to 57% of their time in sports physically active, with physical activity varying by sport (Bocarro et al., 2012; Katzmarzyk & Malina, 1998;

Leek et al., 2011; Weintraub et al., 2008; Wickel & Eisenmann, 2007). Children are more active in intramural (i.e., competitions within a school) than extramural sports (i.e., competitions between schools), with 53% vs. 46% of time spent in moderate to vigorous physical activity, respectively (Bocarro et al., 2012). School sports facilities are often underutilized and adding sports programs where none are offered has led to significant increases physical activity (Bocarro et al., 2012; Weintraub et al., 2008). Few evidence-based policies for increasing physical activity in sports have been identified, but recommendations have been made, such as training coaches to incorporate strategies similar to those used to increase physical activity in PE (Leek et al., 2011). Furthermore, improving access and de-emphasizing competition may lead to increases in the number of children participating in sports (National Council on Youth Sports, 2009).

Active travel to/from school. Few policies exist related to active travel to/from school, and the number of youth who walk or bicycle to school has dropped significantly over the past two decades to an estimated 5-20% (Martin, Lee, & Lowry, 2007; McDonald, 2007; McMillan, 2009; Turner et al., 2010). State and national grants have supported Safe Routes to School programs which consist of built environment changes and/or walking and biking safety education to increase the number of children who walk or bike to school (National Center for Safe Routes to School, 2011). Few evaluations of these programs exist, though one study found an 11% increase in active travel for children who passed by a built environment improvement and another study found a 64% increase in walking and 114% increase in biking after a Safe Routes to School educational program (Boarnet et al., 2005; Staunton, Hubsmith, & Kallins,

2003). A qualitative study identified specific policies and strategies that may lead to increases in active travel to school, including improving sidewalks, adding crosswalks/crossing guards, reducing traffic speed in school zones, and modifying school start/dismissal time and school choice policies (Eyler et al., 2008). However, the 3 aforementioned studies lacked rigor, so it can be concluded that active travel to school policies lack evidence regarding their impact on children's physical activity.

Disparities in School Physical Activity Policies and Practices

Economic and racial/ethnic disparities in school physical activity policies or practices have been investigated only in two studies. In one study, schools in low-income areas were less likely to offer recess (Beighle, 2012). A study in middle schools found that schools with a higher proportion of students eligible for free or reduced price lunch had lower scores on a school practice index which encompassed ten practices including whether there is a certified PE teacher, whether students receive daily PE, and whether sports are offered (Young et al., 2007). A more recent study in elementary schools found that predominately White schools had better recess practices, gymnasium facilities and playground facilities as compared to predominately Latino and predominately Black schools (Turner et al., 2010).

Physical Activity Practices Represent the Most Direct Measure of Physical Activity Opportunities

In many cases, policies may exist, but may not necessarily be implemented (Carlson et al., 2012; Eyler et al., 2010). The physical activity practices at a school represent the most direct measure of the opportunities that school provides for physical activity. That is, practices capture what is actually going on at a school, regardless of formal and informal policies. However, practices are often not documented in writing, thus making them difficult to assess.

Surveys have been developed to assess both policies and practices related to physical activity at schools. These surveys include the CDC's School Health Policies and Programs Study (SHPPS), Bridging the Gap's School Health Policies and Practices Questionnaire (SHPPQ), and the recently developed School Physical Activity Policy Assessment (S-PAPA). SHPPS and SHPPQ are sent to schools across the country on a regular basis to document policies and practices (Lee et al., 2007; Turner et al., 2010). However, these data have not been compared to objectively assessed physical activity. While the S-PAPA was designed to assess policies and practices that can be related to assessed physical activity, this has not been done as of yet (Lounsbery et al., 2012).

The Present Study Evaluated School Physical Activity Practices Across the Day using Objective Measures of Physical Activity

Understanding how practices are related to physical activity can inform policies. The purpose of the present study was to investigate the association between existing

school physical activity practices and objectively measured physical activity in children attending elementary schools in the San Diego, CA and Seattle, WA areas. The conceptual model used to design this study was based on ecological models of behavior change and suggests school practices influence physical activity during school, which contributes to overall physical activity and health outcomes (see Figure 3) (Sallis et al., 2008). In-school practices, such as those related to PE, recess and classroom activity, were investigated for their association with in-school MVPA. After-school practices, such as those related to active travel to school, after-school programs and school sports, were investigated for their association with after-school MVPA. In-school and after-school practices were also investigated for their association with total weekday MVPA (i.e., time in school, after school, and in the evenings). The rationale for investigating total weekday MVPA was if school practices were related to MVPA in-school, they would be expected to be related to total MVPA as well. Total MVPA is the basis for USDHHS physical activity guidelines because of its association with multiple health outcomes. The specific aims are outlined below.

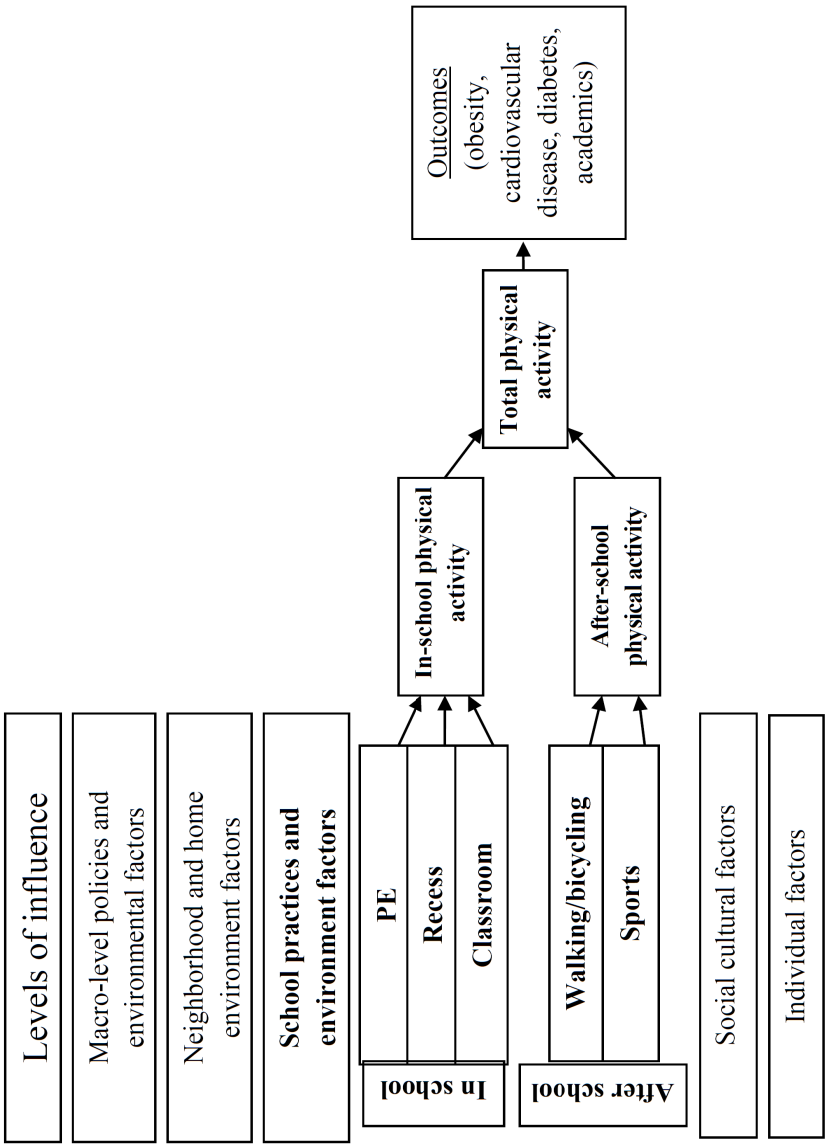

Figure 3: Conceptual model of present study (bolded boxes were examined)

Original study aims from proposal

Aim 1. To investigate summary scores of physical activity supportiveness derived from sums of physical activity-supportive policies at each school. In-school summary scores will be compared to in-school physical activity and sedentary time, while before- and after-school summary scores will be compared to before- and after-school physical activity and sedentary time.

Aim 2. To investigate individual school physical activity policies to identify the strongest policy (i.e., strongest relationship with physical activity). Individual in-school policies will be compared to in-school physical activity and sedentary time, while individual before- and after-school policies will be compared to before- and after-school physical activity and sedentary time.

Aim 3. To investigate whether ground-level policies (i.e., current practices) mediate the relationship between written policies and physical activity. For example, it is hypothesized that actual minutes of PE reported will mediate the relationship between minutes of PE required and in-school physical activity.

Aim 4. To investigate whether individual- and school-level factors, such as BMI, age, gender, race/ethnicity, and SES moderate the relation of a) the policy indices to activity outcomes and b) the individual policies to activity outcomes.

Rationale for revising aims

Aim 1 was changed to reflect one as opposed to multiple summary scores. The summary score reflected the sum of individual in-school practices that had associations

with physical activity in the expected direction (even if p=NS). Given that the survey was significantly shortened, multiple index scores were not warranted.

Aim 2 was split into three aims to make the research questions more clear (see new aims 2-4 below). Specifically, the aim was separated to make the three outcomes more distinct: in-school physical activity, after-school physical activity, and total weekday physical activity. Before-school time was also removed from the aim because monitoring time varied drastically during the hour before school, where a majority of the participants had < 20 minutes of monitoring time during this one-hour period.

Aim 3 was dropped. The survey was shortened significantly from its original version because some districts stated it was too burdensome and would not grant permission to study their schools unless the survey was shortened. It was believed that the "practice" questions, which reflected implementation of policies, would be most directly related to physical activity, rather than the written policy questions (because written policies may not be implemented or even known). What were believed to be the most physical activity-relevant practice questions were retained. The survey the committee provided feedback on during the proposal meeting was the shortened survey; feedback was incorporated.

Aim 4 was changed (see new aim 5 below) to specify that moderator analyses were conducted for the summary score only (not individual items). It was not feasible with the limited sample to explore moderators for individual items.

Three new aims were added. Aim 6 was to investigate the association between school SES and school practices to determine whether there were disparities in school

physical activity practices. Aim 7 was to stratify analyses by city because there appeared to be large differences in practices between the two cities. Aim 8 was to describe sedentary time and investigate differences in sedentary time by city and school SES. The rationale for describing sedentary time was that recent studies have found associations between sedentary time and negative health outcomes (Healy & Owen, 2010; Martinez-Gomez et al., 2009; Martinez-Gomez et al., 2010; Salmon et al., 2011; Tremblay et al., 2011), although findings have been mixed (Ekelund et al., 2012), and that sedentary time during school is unknown and likely high.

Revised study aims

Aim 1. To investigate the relation of a summary score of in-school physical activity practices to objectively measured in-school physical activity and total weekday physical activity. Individual in-school practices that were associated with in-school physical activity in the expected direction were summed to derive the summary score. The rationale for creating a summary score was that it would reflect multiple rather than single practices, which may be more related to physical activity. Hypothesis. Children at schools with higher summary scores (denoting more physical activity-supportive practices) will obtain more physical activity in school and during the overall week days.

Aim 2. To investigate the association between individual in-school physical activity practices and objectively measured in-school physical activity. Hypothesis. Physical activity-supportive in-school practices will be associated with more physical activity in school.

Aim 3. To investigate the association between after-school physical activity practices and objectively measured after-school physical activity. Hypothesis. Physical activity-supportive after-school practices will be associated with more physical activity after school.

Aim 4. To investigate the relation of in- and after-school physical activity practices to total weekday physical activity, where total weekday physical activity includes time in school as well as after school and in the evenings. Hypothesis. Physical activity-supportive practices will be associated with more total weekday physical activity.

Aim 5. To investigate whether individual-level factors, such as BMI, age, gender and race/ethnicity moderate the relation of the in-school physical activity practices summary score to objectively measured in-school physical activity and total weekday physical activity. This aim is exploratory.

Aim 6. To investigate whether school physical activity practices differ by school SES. Hypothesis. Schools with a greater percent of children from higher SES families will have more physical activity-supportive practices.

Aim 7. To investigate differences in physical activity and school practices between the two cities (Seattle and San Diego). This aim is exploratory.

Aim 8. To describe sedentary time during each time period (i.e., during school, after school, overall week day) and investigate differences in sedentary time by city and SES. This aim is exploratory.

METHODS

Description of the larger studies

Child participants had completed either the Neighborhood Impact on Kids (NIK) or Move study. NIK was an observational study that investigated the relation of neighborhood built environment attributes to physical activity, nutrition, and obesity and included 723 children initially aged 6-11 years, recruited by telephone from selected neighborhoods in the Seattle/King County, WA and San Diego County, CA metropolitan areas (Saelens et al., 2012). The study involved stratified recruitment of participants based on GIS-measured characteristics of physical activity and nutrition environments as described elsewhere (Frank et al., 2012). Move was a recreation center-based obesity prevention program that targeted Latino communities and included 541 children initially aged 6-7 years from San Diego County, CA (Elder et al., under review). Recruitment occurred around 30 public recreation centers using targeted phone calls, flyers, presentations, and staffed information booths. Both NIK and Move were longitudinal studies. Although Move was an intervention study and included both an intervention and control group, intervention effects were not found for the accelerometer outcome (Elder et al., under review).

The final NIK assessment was conducted at 18-24 months post baseline in 2009-2010 (school year 2009-2010) when participants were aged 8-14. The final Move assessment was conducted at 24 months post baseline in 2010 (school year 2009-2010) when participants were aged 8-11. The final NIK and Move assessment periods were chosen for inclusion in the present study because they were the most recent data

collection periods to the time of the school physical activity practice data collection which was completed in the Spring of 2012.

Exclusion criteria for the main NIK and Move studies were similar: participants could not have a medical and/or psychological condition that affected diet, physical activity, growth or weight. NIK participants were required to speak English, while Move participants were required to speak English or Spanish. No other eligibility criteria were required. Appropriate consent was obtained from parents and assent from children, and both studies were approved by the San Diego State University Institutional Review Board.

Inclusion in the present study

Together, NIK and Move included 1264 participants from 444 schools. NIK included some middle-school aged participants. The final study sample was determined through a series of processes, as outlined in Figure 4 and detailed below.

Removing middle school-aged participants. To derive a homogeneous sample of elementary-aged participants, participants attending middle schools were removed. Middle schools were easily identified because a majority of the school names contained the words "elementary" or "middle". If the school name did not include these words, the school website was visited to identify the school level. If the school included both elementary and middle school grade levels, participants were excluded from the study if they were $\geq$ 13 years old.

Removing participants with no accelerometer data when school was in session. District and school calendars were obtained from websites and compared to the dates of accelerometer wear. If the accelerometer was not worn for at least one day when school was in session, the participant was excluded from the study. A majority of participants excluded during this step wore the accelerometer during the summer, and a small number of participants did not have any valid week days of wear time and were excluded.

Obtaining district approval to conduct survey. A total of 28 districts were represented in the data. A request to conduct the physical activity practices survey was sent to an official at each district office, along with a description of the study and evidence of IRB approval. Three districts (all from San Diego County) declined to allow their schools to participate in the study. These three districts were the largest districts in San Diego County, and their refusal eliminated 116 schools from the study. The primary reason given for refusal was that the districts were not accepting any research requests because of poor financial climate and burden on teachers. School-level data, such as school SES, was not collected for districts or schools that declined to participate.

Change in sample size from original proposal. The anticipated sample size proposed was 428 participants from 132 schools (with estimated 80% response rate) in San Diego County. Since 116 schools in San Diego were eliminated from the pool of potential participants due to district refusal, Seattle schools were included in the study to increase the sample size. The estimated 80% response rate was ambitious, and the actual response rate was 63%. One possible reason for the lower-than-expected response rate

could be because schools were contacted towards the end of the school year, particularly in Seattle, when school officials were very busy and less likely to participate. The reason for the large decrease in child participants/school was because the large districts in San Diego had a large number of child participants/school, so not having these districts decreased the number of child participants/school in this study.

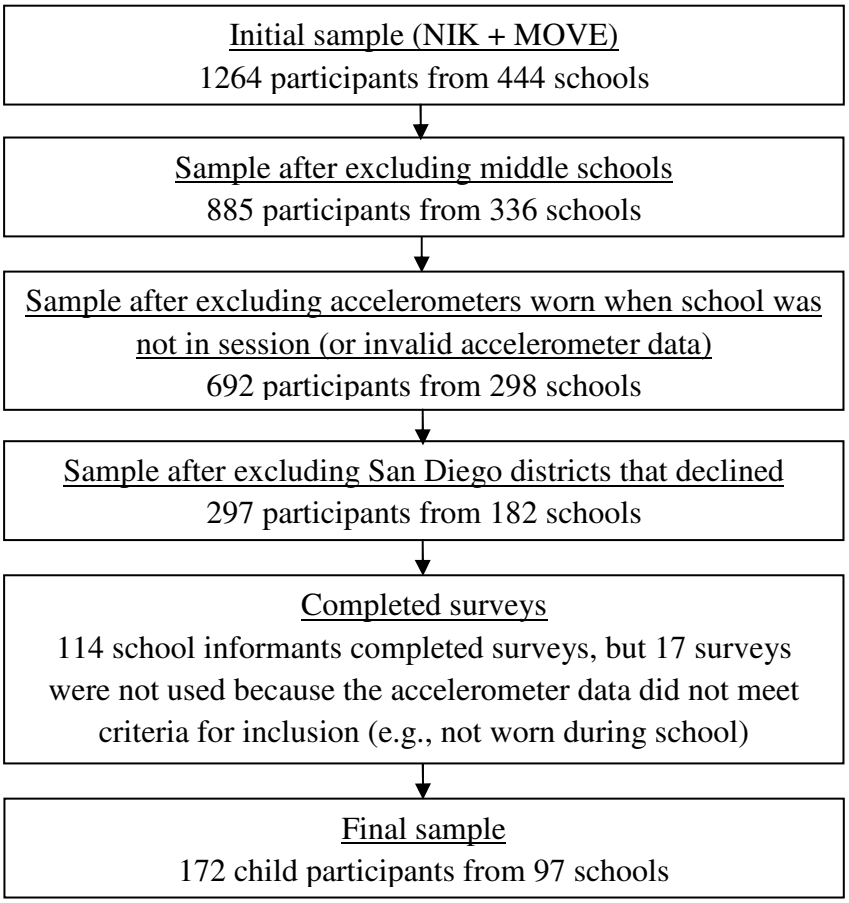

Figure 4: Study sample size

Data collection

Identifying contact information for potential school informants. Informants from 182 schools were asked to complete the study survey. School websites were browsed to identify contact information, including email address and phone number, for the PE teacher or the principal if the school did not appear to have a PE teacher. In circumstances when the school website did not list contact information for the PE teacher, the general school phone number was called and contact information for the PE teacher was requested.

Contacting informants. Next, an email was sent to all 182 (78 in San Diego and 104 in Seattle) PE teachers or principals that included a request to participate in the study as well as a link to the study survey and informed consent. The study survey was housed on a website so informants could complete the survey electronically and the data were transmitted to the investigator. Follow-up emails were sent approximately 10 days after the initial email. If a potential informant did not respond to the emails, they were contacted by phone within 10 days of the second email. If the person was reached by phone, they were given the opportunity to complete the survey over the phone. In most cases, a voicemail was left with information about the study and a request to contact the investigator. Approximately 10 days after the phone calls were conducted, surveys were mailed to informants via postal mail as a last attempt to request their participation. If a potential informant stated that they were not interested or declined to participate in the study, they were thanked for their time and removed from the contact list.

Completed surveys. A total of 114 (63% overall response rate) school informants completed the survey; 82 surveys were completed online and another 32 were returned via postal mail. Of the 78 San Diego school informants contacted, 54 completed the survey (69% response rate). In Seattle, 60 of the 104 school informants contacted completed the survey (58% response rate). Data collection in San Diego began in April 2012, and data collection in Seattle began in May 2012. The lower response rate in Seattle was likely due to the limited amount of time for follow up at the end of the school year.

Final sample. Seventeen completed surveys were not used because, after the accelerometer data were scored and processed, children from these 17 schools did not meet criteria for study inclusion. The reason for excluding these children was because they did not wear the accelerometer when school was in session (n = 12, usually worn during summer only) or they had more than 20 minutes of nonwear time during school (n = 5; see measures section). These accelerometer data were not excluded during the initial accelerometer screening process because the screening process overlapped with the beginning of survey data collection.

Acknowledging the retrospective nature of the study. Child accelerometer data were collected during the 2009-2010 school year, while the school survey was conducted during the Spring of 2012. Therefore, the survey included instructions for the informant to consider the 2009-2010 school year when answering the questions.

Incentives. School informants were given a $50 gift card to one of three sporting goods stores upon completion of the survey. The gift cards were sent to informants via

email or postal mail, whichever method they preferred. The store options were Sports Authority, Big 5 Sports, and Gopher Sport (online PE equipment store). Informants were encouraged to use the gift card to purchase physical activity equipment for their school.

Measures

Child participant demographic characteristics. Parents reported their education status and their child's school name, grade level, gender, and race/ethnicity via questionnaire.

Child participant anthropometrics. Children had their height and weight measured by a trained research assistant in both studies. Using a digital scale, weight was measured three or more times until three of four consecutive weight readings were within 0.1 kg of each other. The average of these readings was used. Using a stadiometer, height was measured three or more times to the nearest 0.1 cm until three of four consecutive measures were within 0.5 cm of each other. The average of the height and weight recordings was used. BMIz (z score) for age and gender was calculated using CDC 2000 growth charts (Centers for Disease Control and Prevention, 2012).

School demographic characteristics. School names were matched with state Department of Education data to identify the percent of students that were white non-Hispanic and percent of students eligible for free or reduced-price lunch (California Department of Education, 2012; State of Washington, 2012). School SES was split into

tertiles, where 33.3% of schools were categorized as low SES (35-100% FRPL), 33.3% as moderate SES (7-35% FRPL) and 33.3% as high SES (0-7% FRPL).

School physical activity practices. The content of the school physical activity practices survey is presented in Figure 5 (some constructs were assessed with multiple items; full survey is Appendix 1). The survey included 24 items covering practices related to PE, recess and as physical activity in the classroom and after school. Many of the items were adopted from existing measures such as CDC's School Health Policies and Programs Study (SHPPS) (Lee et al., 2007), Bridging the Gap's School Health Policies and Practices Questionnaire (SHPPQ) (Turner et al., 2010), and the School Physical Activity Policy Assessment (S-PAPA) (Lounsbery et al., 2012). However, many items were eliminated from the original survey as a contingency of approval from some districts. Sensitive items were removed, such as minutes/week of PE, because it was believed that districts would be uncomfortable reporting noncompliance with state law. The aforementioned existing surveys are also very long and burdensome, which would be expected to result in low response rates. Given the small pool of schools from which to survey for the present study, a priority was placed on minimizing burden to increase response rates. Participants were asked to consider 5th grade classes when responding to the survey questions, because this was the average grade represented in the existing data. The PE minutes/session item was multiplied by the PE sessions/week item to derive minutes/week of PE.

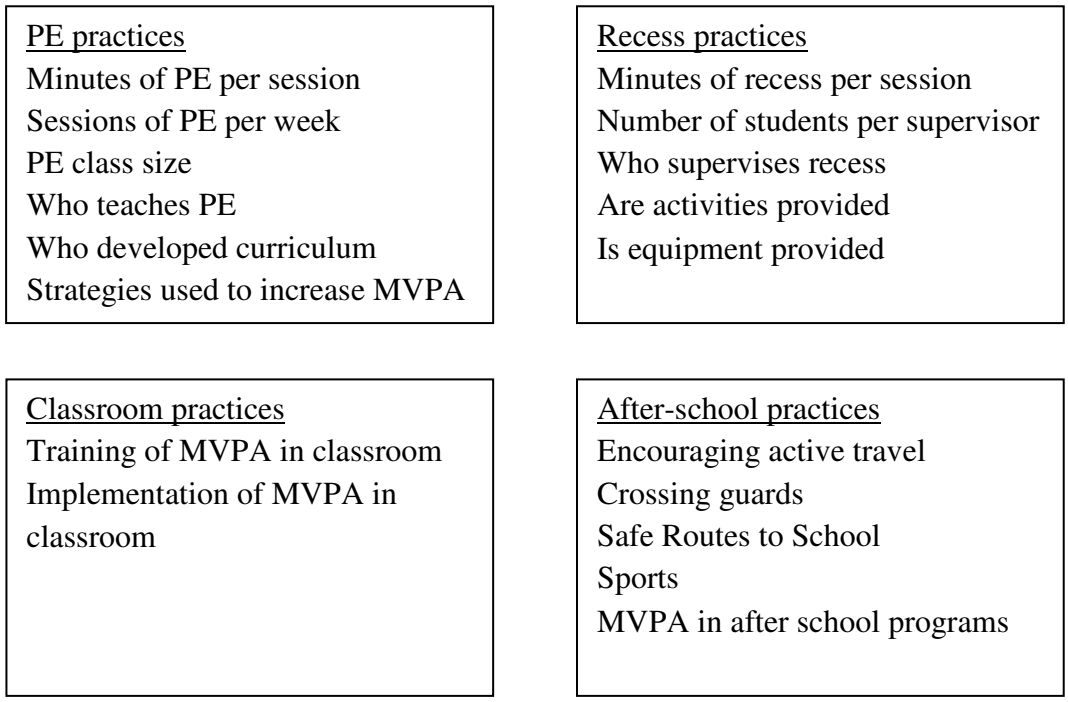

Figure 5: Constructs and items covered in School Physical Activity Practice Survey

School start and end times. The school survey included a question asking what time of day school started and ended. Because schools often have regularly occurring days (e.g., every Thursday, the first Friday of the month) where students are released early and teachers use the afternoon for planning time, another survey question asked what day of week, if any, there was early release. Days with early release were removed from the data, resulting in removal of 138 days (18% of all week days).

Physical activity. Actigraph accelerometers worn on the waist were used to measure children's physical activity during waking hours. The Actigraph has good validity for use among children (Janz, 1994; Welk, Corbin, & Dale, 2000). NIK used Actigraph model GT1M and Move used Actigraph models 7164 and GT1M, all set to

record acceleration at 30-second epochs. Participants were required to wear the accelerometer for a minimum of two 10-hour weekdays in both studies. Minutes of physical activity and sedentary time were calculated using the 4-MET Freedson age-based thresholds (Freedson, Pober, & Janz, 2005). The 4-MET threshold was chosen because it is the most commonly used and accepted equation for calculating MVPA in children (Cain, Sallis, & Conway, In Press) and was used for national prevalence estimates (Troiano et al., 2008). A threshold of < 100 counts/minute was used to define sedentary time. Although there is no consensus with regards to best threshold for defining sedentary behavior in children, < 100 counts/minute is the most commonly used threshold (Cain, Sallis, & Conway, In Press). Because these thresholds were based on minutes, they were divided by 2 to correspond to the 30-second epoch data used in the present study. School start and end times were used to calculate minutes/day for three time periods: 1) in-school time, 2) the 2-hour time period immediately after school and 3) total weekday time (this included time in-school, after-school and in the evening). Days were included only if nonwear time was ≤ 20 minutes during school, which is a somewhat conservative and commonly used threshold in children (Cain et al., In Press).

Raw accelerometer files were processed using the Personal Activity Location Measurement System (PALMS) to create a file that included all participants where each row of data represented one epoch (Personal Activity Location Measurement System, 2012). The PALMS software was used to combine all 172 accelerometer files into one data file, as opposed to scoring files individually in a software such as MeterPlus and

merging the individual files. SPSS was used to create a unique time filter for each participant, representing the start and end times of their specific school, and the number of epochs with activity counts meeting thresholds for MVPA and sedentary time were summed for each time period. Bouts (i.e., uninterrupted durations) of MVPA ≥ 10 minutes and of sedentary time ≥ 20 minutes were calculated using a lag function to identify the number of continuous rows (i.e., epochs) where activity counts met thresholds during each time period. For MVPA bouts, no epochs were allowed to be outside of the MVPA threshold; for sedentary bouts, 2 consecutive epochs outside of the sedentary threshold were required to break up the bout.

Analyses

Three levels of observation were represented in the data: schools, participants within schools, and days within participants. Days within participants was used as a level of observation to improve study power, rather than simply averaging days within a participant. Descriptive statistics were calculated for the total sample and broken out by city. School-level analyses included chi squared tests (for percentages), ANOVAs with LSD post-hoc tests (for continuous variables) and Mann–Whitney–Wilcoxon tests (for skewed continuous variables) to investigate differences in school practices by city (Aim 7) and school SES (Aim 6). San Diego schools were separated into two categories based on whether they had a PE teacher, creating a third category for the between city analyses (i.e., San Diego school without a PE teacher, San Diego schools with a PE teacher, and Seattle schools, which all had PE teachers). This separation was performed because

schools without PE teachers were hypothesized to have drastically different practices and physical activity opportunities than schools with PE teachers.

Day-level analyses included three-level mixed models to investigate the relation of school practices to in-school, after-school, and total weekday physical activity (Aims 2-4). A summary score was created using a statistical approach that involved summing the in-school practices (yes/no or median split) that were associated with in-school or total weekday physical activity in the hypothesized direction in the individual item analyses (Aim 1). The intention of creating a summary score was to reflect the number of practices each school had from a list of the most important practices assessed, where the most important practices were defined as those with the strongest relationships with in-school MVPA. Inter-item Spearman correlations for the individual items comprising the summary score were used to investigate whether schools that had one of the practices were more likely to have another. Multiple joint correspondence analysis was performed to explore the structure of the items comprising the summary score (similar to factor analysis but for dichotomous items). The summary score was investigated for its association with in-school and total weekday physical activity using three-level mixed models, and orthogonalized interaction terms were included to investigate the individual-level moderators BMIz, age, and gender (Aim 5). Participant race/ethnicity and family SES were not examined as moderators or included as a covariates because they were related to school SES and school practices and thus confounded. Analyses were conducted on the total sample as well as separately for each city so city could be explored as an effect moderator (Aim 7). The best and worst 15% of schools were

identified based on participants' MVPA (± 2 standard deviations from mean) and practices were compared between these two groups using t-tests.

All mixed models controlled for participant age, gender, accelerometer model, study (NIK vs. Move), and intervention condition (for MOVE participants). All independent variables were centered on zero (dichotomous variables) or grand mean centered (for continuous variables) so the intercept in the mixed models would approximate the overall mean in MVPA. Colinearity was assessed by observing bivariate correlations among the school practices; correlations were below r = .5 with the exception of the correlation between city and having a PE teacher (r = .63). Since city was a study design factor and having a PE teacher was an important variable of interest, the decision was made to retain both variables in the models. Because formal guidelines exist for PE minutes/week and recess minutes/session (CDC, 2011; National Association for Sport and Physical Education [NASPE], 2012; Pate et al., 2006), these variables were investigated as both continuous and dichotomous (±100 minutes/week for PE and ±20 minutes/session for recess) variables, and the strongest correlates of in-school MVPA were retained.

Unstandardized coefficients were reported because they can be interpreted as minutes/day of MVPA. Pseudo R squared was calculated for the models from aims 2-4 to determine the percent of variance explained by the school practices. Pseudo R squared was calculated by dividing the intercept + residual variance estimates from the full model by the intercept + residual variance estimates from the null model, where the null model included only study covariates. Intraclass correlation coefficients,

representing the proportion of variance between schools, was assessed for the MVPA outcome variables using the following formula: ICC = intercept / (residual + intercept) from empty model. Line graphs were created for school practice by participant characteristic interactions with a p-value < .2 by plotting predicted MVPA (in minutes/day) from the regression equation. Graphs included the effect of the practice summary score variable at -1 and +1 SD for each level of the participant-level variable (at -1 and +1 SD if continuous).

RESULTS

School informant and child participant characteristics

Descriptive and demographic characteristics of the study sample are presented in Table 1. The 97 schools were evenly divided between San Diego (48) and Seattle (49) and represented 172 child participants. There was an average of 1.8 (SD = 1.5) participants/school and each participant had an average of 3.7 (SD = 1.7) week days of monitoring when school was in session. One hundred fifty four participants (90%) had ≥ 2 week days of monitoring when school was in session. Seattle participants were significantly older, more likely to be white non-Hispanic, and more likely to have a parent with a college degree as compared to San Diego participants ($p < .05$).

Twenty-five school districts and 12 private schools were included, representing a total of 53,000 students. The average percent of students eligible for free or reduced price lunch (FRPL), indicating school SES, was 30.8 (SD = 24.5). Seattle schools were significantly smaller and had a larger proportion of students who were white non-Hispanic as compared to San Diego schools ($p < .05$). School start and end times are presented in Table 2. The average duration of the school day was 6 hours and 24 minutes (SD = 15 minutes).

Excluded survey items

The questions "is loose equipment provided during recess?"and "is physical activity included in after school programs?" were excluded from the analyses because all respondents reported "yes". The question "who developed the PE curriculum?" was

excluded because it appeared to be a proxy measure for whether the school had a PE teacher; 92% of schools with a PE teacher reported that the PE teacher developed the curriculum, while schools without a PE teacher reported that the district developed the curriculum.

Table 1. Descriptive and demographic characteristics of study sample

	Both cities	San Diego	Seattle	p value
Sample characteristics				
Number of schools	97	48	49	-
Number of children or students	172	83	89	-
Mean (SD) of participants/school	1.8 (1.5)	1.7 (1.2)	1.8 (1.7)	.776
Mean (SD) weekdays of monitoring/participant	3.7 (1.7)	3.2 (2.0)	4.2 (1.3)	.173
Percent of participants from Move study	20.3	41.7	-	-
Child characteristics (N = 172)				
Mean (SD) age	10.2 (1.5)	9.7 (1.2)	10.7 (1.5)	< .001
Percent of participants female	51.7	57.8	46.1	.123
Percent of white non-Hispanic	69.2	54.2	83.1	< .001
Percent of parents with college degree	63.8	54.4	72.6	.016
Percent of participants overweight or obese	27.3	33.7	21.3	.069
School characteristics[a] (N = 97 schools)				
Number of districts	25	13	12	-
Mean (SD) of schools/district	3.4 (2.3)	2.9 (2.4)	3.9 (2.2)	.332
Number of private schools	12	10	2	-
Mean (SD) of total number of students	549 (166)	609 (157)	497 (157)	.001
Mean (SD) of full time teachers	26.9 (6.5)	28.3 (5.4)	25.8 (7.1)	.072
Mean (SD) of percent of students white non-Hispanic	53.7 (21.0)	44.6 (20.9)	61.7 (17.9)	< .001
Mean (SD) of percent of students FRPL eligible	30.8 (24.5)	31.5 (28.6)	23.3 (20.6)	.109

[a]School characteristics were only obtainable for public schools
p value is from ANOVAs with LSD post-hoc test (continuous variables) or chi square (dichotomous variables)

Table 2: School bell schedule (N = 97 schools)

	Both cities	San Diego	Seattle
M (SD) of start times	8:32am (0:29)	8:11 (0:20)	8:54 (0:19)
M (SD) of end times	2:58pm (0:28)	2:38 (0:23)	3:18 (0:17)
M (SD) of time in school (hours:minutes)	6:24 (0:15)	6:26 (0:17)	6:23 (0:14)

Mean time in school was not different between cities (p = .277)

School physical activity practices

Descriptive statistics for the school physical practices are presented in Table 3 and were split by city and within San Diego by whether the school had a PE teacher. All 49 Seattle schools had a PE teacher, while 23 of the 48 (48%) San Diego schools had a PE teacher. San Diego schools with a PE teacher reported the most minutes/week of PE (110.8) and reported 11 more minutes/session of PE but 1.4 fewer days/week of PE than schools without a PE teacher ($p < .05$). Schools without a PE teacher were less likely to have training covering MVPA in PE than schools with a PE teacher ($p < .05$). Forty percent of schools in San Diego vs. 4% of schools in Seattle had classroom teachers supervise recess ($p < .05$).

School physical activity practices by SES

Differences in school practices by school SES, as measured by the percent of students eligible for free or reduced price lunch, are presented in Table 4. High-income schools had 6.5 more minutes/session of PE but 0.6-0.8 fewer sessions/week as compared to low- and moderate-income schools ($p < .05$). Ninety-seven percent of high-income schools had a PE teacher, while 63% of low- and moderate-income schools had a PE teacher ($p < .05$).

Table 3: Descriptive characteristics of variables from school practices survey (N = 97 schools)

	Both cities	San Diego (schools without PE teacher)	San Diego (schools with PE teacher)	Seattle (all schools had PE teacher)	Test of differences
Number of respondents	97	25	23	49	-
Respondent characteristics					
Percent of respondents at school 2009-2010	83.3	80.0	68.2	91.8	c
Percent of respondents PE teachers	67.0	0	78.3	100	a, b
Percent of respondents principals	28.9	92.0	21.7	0	a, b
PE characteristics					
M (SD) of PE minutes/session	35.6 (9.2)	31.9 (11.8)	42.8 (8.1)	34.0 (6.0)	a, b
M (SD) of PE session/week	2.4 (1.1)	3.4 (1.2)	2.0 (0.9)	2.0 (0.6)	a, c
M (SD) of PE minutes/week	81.4 (42.6)	110.8 (63.8)	80.8 (34.4)	66.7 (19.6)	a, b
M (SD) of PE class size	38.9 (63.7)	32.5 (4.0)	35.1 (16.4)	44.1 (89.0)	none
Percent of schools with PE taught by PE teacher	73.2	0	100	100	a, b
Percent of schools with PE training covering MVPA	57.4	28.0	60.9	75.5	a, b, c
Percent of schools modifying games in PE to increase activity	88.7	72.0	91.3	95.9	a, b
Percent of schools choosing PE games based on MVPA	60.8	48.0	60.9	67.3	none
Percent of schools reporting another MVPA in PE strategy	9.3	4.0	21.7	6.1	a, c
Recess characteristics					
M (SD) of recess minutes/session	19.4 (4.2)	20.0 (4.4)	19.1 (3.4)	19.2 (4.4)	none
M (SD) of recess students/teacher	69.1 (40.7)	68.2 (36.6)	54.2 (29.5)	77.8 (46.4)	c
Percent of schools with recess supervised by non-classroom teacher	77.8	52.0	68.2	95.7	b, c
Percent of schools with activities provided during recess	48.9	64.0	54.5	38.3	b
Classroom characteristics					
Percent of school with training covering classroom MVPA	16.5	28.0	36.4	0	b, c
Percent of schools with teachers implementing classroom MVPA	58.9	60.0	71.4	52.3	none
Before and after school characteristics					
Percent of schools encouraging active travel to school	53.8	60.0	42.9	55.3	none
Percent of schools participants in SRTS program	33.3	40.0	15.8	37.5	none
Percent of schools with crossing guards	76.3	64.0	61.9	89.4	b, c
Percent of schools with sports	38.0	32.0	47.6	37.0	none

p value is from ANOVAs with LSD post-hoc tests (normally distributed continuous variables), Mann–Whitney–Wilcoxon tests (for skewed continuous variables), or chi square (dichotomous variables)

[a]San Diego schools without PE teacher different from San Diego schools with PE teacher ($p < .05$)

[b]San Diego schools without PE teacher different from Seattle schools ($p < .05$)

[c]San Diego schools with PE teacher different from Seattle schools ($p < .05$)

Table 4: SES disparities in school physical activity practices across schools (N = 97 schools)

	Low-SES schools (35-100% FRPL eligible)	Moderate-SES schools (7-35% FRPL eligible)	High-SES schools (0-7% FRPL eligible)	Test of differences
n	32	33	32	-
PE characteristics				
M (SD) of PE minutes/session	33.5 (11.2)	33.5 (6.4)	39.7 (8.2)	b, c
M (SD) of PE sessions/week	2.5 (1.1)	2.7 (1.2)	1.9 (0.5)	b, c
M (SD) of PE minutes/week	84.2 (56.5)	85.6 (39.1)	74.4 (27.8)	none
M (SD) of PE class size	43.1 (59.2)	29.5 (7.3)	44.7 (94.1)	none
Percent of schools with PE taught by PE teacher	62.5	63.6	96.8	b, c
Percent of schools with PE training covering MVPA	65.6	54.5	59.4	none
Percent of schools modifying games in PE to increase activity	93.8	78.8	93.8	none
Percent of schools choosing PE games based on MVPA	65.6	57.6	59.4	none
Percent of schools reporting another MVPA in PE strategy	9.4	3.0	15.6	none
Recess characteristics				
M (SD) of recess minutes/session	20.7 (4.6)	18.2 (4.2)	19.4 (3.4)	a
M (SD) of recess students/teacher	71.1 (40.3)	70.1 (44.0)	65.1 (39.1)	none
Percent of schools with recess supervised by non-classroom teacher	75.0	84.4	73.3	none
Percent of schools with activities provided during recess	50.0	52.1	43.3	none
Classroom characteristics				
Percent of school with training covering classroom MVPA	25.0	16.1	7.1	none
Percent of schools with teachers implementing classroom MVPA	54.8	65.6	55.6	none
Before and after school characteristics				
Percent of schools encouraging active travel to school	53.1	62.5	44.8	none
Percent of schools participants in SRTS program	31.0	50.0	18.5	c
Percent of schools with crossing guards	81.3	87.5	58.6	b, c
Percent of schools with sports	46.9	28.1	39.3	none

p value is from ANOVAs with LSD post-hoc tests (normally distributed continuous variables), Mann–Whitney–Wilcoxon tests (for skewed continuous variables), or chi square (dichotomous variables)

[a]Low-income schools different from moderate-income schools ($p < .05$)

[b]Low-income schools different from high-income schools ($p < .05$)

[c]Moderate-income schools different from high-income schools ($p < .05$)

MVPA and sedentary time

Participants had an average of 29.4 (SD = 16.2) minutes/day of MVPA and 225.5 (SD = 39.7) minutes/day of sedentary time during the average 384 minute school day (see Table 5). Participants in the Move intervention group had 7 more minutes/day of MVPA during school than Move control participants and NIK participants ($p < .05$; data not presented in table). Forty percent of the variability in in-school MVPA was attributable to between-school effects (see Table 6). During the two-hour after school period, participants had an average of 23.0 (SD = 15.4) minutes/day of MVPA and 55.7 (SD = 20.3) minutes/day of sedentary time. Eleven percent of the variability in after-school MVPA was attributable to between-school effects. Average total weekday MVPA was 64.0 (SD = 33.7) minutes/day and sedentary time was 440.8 (SD = 99.9) minutes/day (these values were not adjusted for wear time). Twenty-eight percent of the variability in total weekday MVPA was attributable to between-school effects. The correlation between MVPA during school and MVPA after school and in the evening (total weekday MVPA minus MVPA during school) was $r = .40$ ($p < .001$; not presented in table).

MVPA and sedentary time by city

There were no significant differences in MVPA and sedentary time between San Diego and Seattle schools (see Table 7). Patterns showed that participants in San Diego schools with a PE teacher had the highest levels of MVPA in school (estimated mean = 31.3 minutes/day), after school (estimated mean = 24.3 minutes/day) and total on

weekdays (estimated mean = 69.6 minutes/day). San Diego schools without a PE teacher had the lowest levels of MVPA in school (estimated mean = 26.7 minutes/day), while Seattle schools had the lowest levels of MVPA after school (estimated mean = 22.6 minutes/day) and total on weekdays (estimated mean = 63.5 minutes/day). Sedentary time differed only by 2-9 minutes/day in school, 0-2 minutes/day after school, and 0-4 minutes/day total on weekdays (adjusted for wear time) between the cities.

Table 5: Minutes/day of accelerometer MVPA and sedentary time during and before and after school, and all times not in school (N = 172 children)

During school	
M (SD) minutes/day of MVPA	29.4 (16.2)
M (SD) minutes/day of sedentary time	225.5 (39.7)
Percent of children with ≥ 1 bout of MVPA	25.2
M (SD) minutes in bouts of sedentary time	65.5 (55.6)
After school (2 hours)	
M (SD) minutes/day of MVPA	23.0 (15.4)
M (SD) minutes/day of sedentary time	55.7 (20.3)
Percent of children with ≥ 1 bout of MVPA	9.1
M (SD) minutes in bouts of sedentary time	10.4 (18.8)
Total on weekdays	
M (SD) minutes/day of monitoring time	792.4 (116.0)
M (SD) minutes/day of MVPA	64.0 (33.7)
M (SD) minutes/day of sedentary time	440.8 (99.9)
Percent of children with ≥ 1 bout of MVPA	34.3
M (SD) minutes in bouts of sedentary time	114.6 (85.8)

Table 6: Percent of variance in accelerometer MVPA outcomes between schools (N = 172 children)

	Percent of variance between schools[a]
Both cities	
During school MVPA	40.4
After school MVPA	10.9
Total weekday MVPA	28.4
San Diego	
During school MVPA	44.8
After school MVPA	5.6
Total weekday MVPA	33.2
Seattle	
During school MVPA	33.8
After school MVPA	11.6
Total weekday MVPA	11.1

[a]From empty model, intercept / (residual + intercept) * 100

Table 7: Differences in minutes/day of accelerometer MVPA and sedentary time across city (N = 172 children)

	Estimated Mean (SE)			p value[a]		
	San Diego (schools without PE teacher)	San Diego (schools with PE teacher)	Seattle (all schools had PE teacher)	SD without vs. SD with PE teacher	SD without PE teacher vs. Seattle	SD with PE teacher vs. Seattle
During school						
Minutes/day of MVPA	26.7 (2.2)	31.3 (2.3)	28.8 (1.5)	.152	.440	.367
Minutes/day of sedentary time	225.5 (5.0)	233.2 (5.5)	224.0 (3.4)	.297	.802	.161
After school (2 hours)						
Minutes/day of MVPA	22.8 (1.8)	24.3 (1.9)	22.6 (1.2)	.562	.907	.432
Minutes/day of sedentary time	54.6 (2.1)	54.9 (2.3)	57.3 (1.3)	.909	.289	.385
Total on weekdays						
Minutes/day of MVPA	64.5 (4.4)	69.6 (4.7)	63.5 (3.0)	.423	.854	.278
Minutes/day of sedentary time[b]	440.2 (8.9)	440.4 (9.8)	444.6 (6.0)	.988	.683	.717

[a]p value is from mixed model controlling for age, gender, accelerometer model, study, intervention condition (Move), number of participants nested within schools, and number of days of monitoring nested within participants
[b]Model also controlled for minutes of wear time

MVPA and sedentary time by school SES

Table 8 presents differences in MVPA and sedentary time by school SES. No significant effects were found, but many patterns were in the expected direction. Participants in high-SES schools had 5 more minutes/day of MVPA in school and total on weekdays, as compared to participants in low-SES schools ($p = .106$). After accounting for accelerometer wear time, participants in low-SES schools had the highest levels of sedentary time in school (estimated mean = 231.4 minutes/day), after school (estimated mean = 58.2 minutes/day) and total on weekdays (estimated mean = 550 minutes/day). Participants in moderate-income schools had the lowest levels of sedentary time in school (estimated mean = 220.5 minutes/day), after school (estimated mean = 54.3 minutes/day) and total on weekdays (estimated mean = 433.8 minutes/day), as well as the highest levels of MVPA after school (estimated mean = 12.2 minutes/day).

Table 8: Economic disparities in minutes/day of accelerometer MVPA (4-METS) and sedentary time across schools (N = 172 children)

	Estimated Mean (SE)			p value[a]		
	Low-SES schools (35-100% FRPL eligible)	Moderate-SES schools (7-35% FRPL eligible)	High-SES schools (0-7% FRPL eligible)	Low vs. moderate	Low vs. high	Moderate vs. high
During school						
Minutes/day of MVPA	27.3 (2.0)	30.0 (1.7)	32.2 (2.2)	.787	.106	.142
Minutes/day of sedentary time	231.4 (4.5)	220.5 (3.6)	224.0 (4.4)	.072	.256	.545
After school (2 hours)						
Minutes/day of MVPA	10.5 (1.3)	12.2 (1.0)	11.5 (1.1)	.297	.549	.649
Minutes/day of sedentary time	58.2 (2.1)	54.3 (1.6)	57.0 (1.7)	.139	.648	.258
Total on weekdays						
Minutes/day of MVPA	62.6 (4.1)	64.9 (3.4)	67.5 (3.7)	.666	.381	.612
Minutes/day of sedentary time[b]	449.9 (8.9)	433.8 (6.8)	447.7 (7.3)	.157	.851	.171

[a]p value is from mixed model controlling for age, gender, accelerometer model, study, intervention condition (Move), number of participants nested within schools, and number of days of monitoring nested within participants

[b]Model also controlled for minutes of wear time

Relation of individual school physical activity practices to in-school and after-school MVPA

Table 9 presents the relation of school physical activity practices to minutes/day of in-school and after-school MVPA after controlling for age, gender, accelerometer model, study, intervention condition, and nesting of participants within schools and days within participants. The dichotomous PE minutes/week (≥ 100 vs. < 100) and recess minutes/session (≥ 20 vs. < 20) variables had stronger relationships with in-school MVPA than their continuous counterparts and thus the dichotomous variables were retained in the analysis. Twenty percent of the schools studied had ≥ 100 minutes/week of PE. 63% of schools had ≥ 20 minutes/session of recess.

In the model, no practices were significantly associated with in-school MVPA, but some patterns were in the expected direction. Having a PE teacher (B = 6 minutes/day; p = .114), providing ≥ 100 minutes/week of recess (B = 5.1 minutes/day; p = .149), having someone other than a classroom teacher supervise recess (B = 2.7 minutes/day; p = .381), and providing ≥ 20 minutes/session of recess (B = 3.8 minutes/day; p = .125) were among the strongest correlates of in-school MVPA. Training covering MVPA in PE, modifying game rules, choosing active games, and classroom teacher training or implementation of MVPA in the classroom were inversely associated with in-school MVPA (B's = -3.7 to -0.3; p's = .117 to .935). The 14 in-school practices assessed explained 7% of the variance in in-school MVPA over and above participant age and gender.

For after-school MVPA, offering intra- or extra-mural sports was associated with 1.7 fewer minutes/day of after-school MVPA (p = .019). Although not significant, encouraging active travel to school was associated with 1.9 fewer minutes/day of after-school MVPA (p = .174). The four after-school practices assessed explained 5% of the variance in after-school MVPA over and above participant age and gender.

School physical activity practices and in-school MVPA by city

Within San Diego, students who had a PE teacher had 10.1 more minutes/day of in-school MVPA (p = .048). Results were similar between cities with some exceptions. San Diego participants seemed to benefit from smaller PE classes (B = -1.3 minutes/day of in-school MVPA for every additional 10 students/class; p = .452) and larger recess classes (B = 1.2 minutes/day of in-school MVPA for every additional 10 students/supervisor; p = .111). In Seattle, participants seemed to benefit from larger PE classes (B = 0.3 minutes/day of in-school MVPA for every additional 10 students/class; p = .030) and smaller recess classes (B = -0.2 minutes/day of in-school MVPA for every additional 10 students/supervisor; p = .391). Providing activities during recess was positively associated with in-school MVPA in San Diego (B = 6.1 minutes/day; p = .187) but inversely associated with in-school MVPA in Seattle (B = -1.6 minutes/day; p = .558), although findings were not significant.

Table 9: Multivariate relations of school practices to minutes/day of accelerometer MVPA during and after school[a] (N = 172 children)

	Minutes/day of MVPA during school		
R squared = .07	B	95% CI	p
Intercept[b]	33.3	25.9, 40.7	-
PE characteristics			
PE minutes/week (≥ 100 vs. < 100)	5.1	-1.9, 12.0	.149
PE class size (/10)	0.2	-0.2, 0.5	.263
PE taught by PE teacher (vs. classroom teacher)	6.0	-1.5, 13.5	.114
Training covering MVPA in PE (yes vs. no)	-1.6	-6.7, 3.5	.530
Modifying games in PE to increase activity (yes vs. no)	-0.3	-8.5, 7.8	.935
Choosing PE games based on MVPA (yes vs. no)	-3.7	-8.4, 0.9	.117
Using another MVPA in PE strategy (yes vs. no)	3.0	-4.6, 10.6	.435
Recess characteristics			
Recess minutes/session (≥ 20 vs. < 20)	3.8	-1.1, 8.8	.125
Recess students/teacher (/10)	0.2	-0.4, 0.8	.605
Recess supervised by non-classroom teacher (vs. classroom teacher)	2.7	-3.4, 8.9	.381
Activities provided during recess (yes vs. no)	0.7	-4.1, 5.5	.779
Classroom characteristics			
Training covering classroom MVPA (yes vs. no)	-0.7	-8.3, 6.9	.864
Teachers implementing classroom MVPA (yes vs. no)	-0.9	-5.4, 3.6	.701
	Minutes/day of MVPA after school		
R squared = .05	B	95% CI	p
Intercept[b]	13.9	9.1, 13.1	-
Before and after school characteristics			
Encouraging active travel to school (yes vs. no)	-1.5	-4.4, 1.3	.288
Participants in SRTS program (yes vs. no)	0.2	-3.0, 3.4	.911
Crossing guards (yes vs. no)	2.3	-0.9, 5.5	.161
Sports (yes vs. no)	-1.7	-3.1, -0.3	.019

[a]Controlling for age, gender, accelerometer model, study, intervention condition (Move), number of participants nested within schools, and number of days of monitoring nested within participants

[b]Continuous variables were grand mean centered and dichotomous variables centered on zero (i.e., -.5, .5)

B = unstandardized coefficient representing minutes

Table 10: Multivariate relation of school practices to minutes/day of accelerometer MVPA during school within each city (N = 172 children)

	Minutes/day of MVPA during school					
	San Diego			Seattle		
	B	95% CI	p	B	95% CI	p
Intercept[b]	31.7	20.0, 43.4	-	35.0	22.4, 47.6	-
PE characteristics						
PE minutes/week (≥ 100 vs. < 100)	5.9	-4.2, 16.0	.237	9.8	-6.7, 26.3	.241
PE class size (/10)	-1.3	-4.7,2.2	.452	0.3	0, 0.6	.030
PE taught by PE teacher (vs. classroom teacher)	10.1	-0.1, 20.1	.048	-	-	-
Training covering MVPA in PE (yes vs. no)	-3.5	-13.9, 6.8	.492	-1.2	-7.5, 5.0	.692
Modifying games in PE to increase activity (yes vs. no)	-0.5	-11.0, 12.0	.930	-2.9	-19.9, 14.2	.733
Choosing PE games based on MVPA (yes vs. no)	-1.3	-9.8, 7.1	.753	-5.4	-11.1, 0.3	.063
Using another MVPA in PE strategy (yes vs. no)	1.2	-11.6, 14.1	.845	8.1	-1.8, 18.1	.104
Recess characteristics						
Recess minutes/session (≥ 20 vs. < 20)	5.0	-4.3, 14.4	.280	3.1	-2.6, 8.8	.274
Recess students/teacher (/10)	1.2	-0.2, 2.8	.111	-0.2	-0.9, 0.4	.391
Recess supervised by non-classroom teacher (vs. classroom teacher)	3.6	-6.0, 13.2	.454	7.5	-4.2, 19.3	.205
Activities provided during recess (yes vs. no)	6.1	-3.2, 15.4	.187	-1.6	-7.1, 3.9	.558
Classroom characteristics						
Training covering classroom MVPA (yes vs. no)	-0.2	-9.4, 9.9	.962	-	-	-
Teachers implementing classroom MVPA (yes vs. no)	-2.2	-11.7, 7.4	.647	-2.1	-7.3, 3.0	.408

[a]Controlling for age, gender, accelerometer model, study, intervention condition (Move), number of participants nested within schools, and number of days of monitoring nested within participants

[b]Continuous variables were grand mean centered and dichotomous variables centered on zero (i.e., -.5, .5)

B = unstandardized coefficient representing minutes

Relation of individual school physical activity practices to total weekday MVPA

Associations between school practices and total weekday MVPA were similar to those from the model investigating associations between school practices and in-school MVPA, with most effect sizes being larger for the model investigating total weekday MVPA. The strongest correlates of total weekday MVPA were providing ≥ 100 minutes/week of PE (B = 12.5 minutes/day; p = .098), having a PE teacher (B = 8.4 minutes/day; p = .299), and having someone other than a classroom teacher supervise recess (B = 6.5 minutes/day; p = .334), although these findings were non-significant. Providing ≥ 20 minutes/session of recess was non-significantly and slightly inversely associated with total weekday MVPA (B = -1.9 minutes/day; p = .727), which is different from the finding with in-school MVPA.

Table 11: Multivariate relation of school practices to weekday minutes/day of accelerometer MVPA (N = 172 children)

	Minutes/day of weekday MVPA		
R squared = .08	B	95% CI	p
Intercept[b]	79.0	63.2, 94.9	.000
PE characteristics			
PE minutes/week (≥ 100 vs. < 100)	12.5	-2.4, 27.3	.098
PE class size (/10)	0	-0.7, 0.7	.958
PE taught by PE teacher (vs. classroom teacher)	8.4	-7.6, 24.3	.299
Training covering MVPA in PE (yes vs. no)	-2.9	-14.0, 8.2	.606
Modifying games in PE to increase activity (yes vs. no)	3.0	-14.4, 20.3	.734
Choosing PE games based on MVPA (yes vs. no)	-1.8	-11.8, 8.2	.724
Using another MVPA in PE strategy (yes vs. no)	5.5	-10.9, 21.8	.507
Recess characteristics			
Recess minutes/session (≥ 20 vs. < 20)	-1.9	-12.4, 8.7	.727
Recess students/teacher (/10)	0.4	-1.0, 1.8	.552
Recess supervised by non-classroom teacher (vs. classroom teacher)	6.5	-6.8, 19.8	.334
Activities provided during recess (yes vs. no)	0.3	-10.1, 10.4	.957
Classroom characteristics			
Training covering classroom MVPA (yes vs. no)	0	-16.2, 16.3	.996
Teachers implementing classroom MVPA (yes vs. no)	-2.1	-11.7, 7.6	.673
Before and after school characteristics			
Encouraging active travel to school (yes vs. no)	-7.1	-16.6, 2.4	.143
Participants in SRTS program (yes vs. no)	-3.0	-13.6, 7.7	.582
Crossing guards (yes vs. no)	1.4	-9.2, 12.0	.797
Sports (yes vs. no)	-3.0	-7.8, 1.8	.220

[a]Controlling for age, gender, number of participants nested within schools, and number of days of monitoring nested within participants
[b]Continuous variables were grand mean centered and dichotomous variables centered on zero (i.e., -.5, .5)
B = unstandardized coefficient representing minutes

School physical activity practice summary score and school SES

The summary score ranged from 0 to 5 and included having a PE teacher, providing ≥ 100 minutes/week of PE, having someone other than a classroom teacher supervise recess, providing ≥ 20 minutes/session of recess minutes/session, and providing activities during recess. Inter-item correlations among the five items ranged from r = -.171 to .360. The only significant correlation was observed between having a PE teacher and having someone other than a classroom teacher supervise recess (r = .360; $p < .001$). The multiple joint correspondence analysis indicated that having a PE teacher, having someone other than a classroom teacher supervise recess, and providing activities during recess had the largest correlations with the 1-dimension solution (item-dimension correlations were 1.0, 0.91, and 0.51, respectively). Item-dimension correlations for providing ≥ 100 minutes/week of PE and providing ≥ 20 minutes/session of recess were 0.26 and 0.43, respectively.

Schools provided an average of 3.1 (SD = 1.1) of the 5 practices. San Diego schools with a PE teacher had a higher summary score by 1.5 practices (including having a PE teacher) as compared to San Diego schools without a PE teacher ($p < .001$), and a non-significantly higher summary score by 0.5 practices as compared to Seattle schools (p = .067). High-income schools had the highest summary scores (mean = 3.5 practices), while moderate-income schools had the lowest summary scores (mean = 2.7 practices; different from high-income schools p = .014). Low-income schools had non-significantly lower summary scores than high-income schools (mean = 3.0; p = .079).

School physical activity practice summary score and MVPA

The school physical activity practice summary score was significantly associated with in-school MVPA (see Table 13). Participants had 2.4 more minutes/day of in-school MVPA for every additional practice reflected in the summary score ($p = .037$). The practice summary score was not related to total weekday MVPA ($B = 0.1$ minutes/day; $p = .987$).

Table 12: Descriptive statistics for school physical activity practices summary score and differences by city and school SES (N = 97 schools)

	Summary score[a]	p value from t-test		
	Mean (SD)	a vs. b	a vs. c	b vs. c
Overall (0-5)	3.1 (1.1)	-	-	-
By city				
a. San Diego (schools without PE teacher)	2.2 (1.1)			
b. San Diego (schools with PE teacher)	3.7 (1.0)	< .001	< .001	.067
c. Seattle (all schools have PE teacher)	3.2 (0.9)			
By school SES				
a. Low-income schools (35-100% FRPL eligible)	3.0 (1.1)			
b. Moderate-income schools (7-35% FRPL eligible)	2.7 (1.1)	.496	.079	.014
c. High-income schools (0-7% FRPL eligible)	3.5 (1.0)			

[a]Summary score = PE teacher + PE minutes/week (≥ 100 vs. < 100) + recess teacher + recess minutes/session (≥ 20 vs. < 20) + recess activities provided

Table 13: Multivariate relation of school practices summary score to in- school and weekday minutes/day of accelerometer MVPA and participant-level moderators[a] (N = 172 children)

	Minutes/day of MVPA during school			Minutes/day of weekday MVPA		
	B	95% CI	p	B	95% CI	p
Intercept[b]	29.4	27.0, 31.7	-	67.3	62.5, 72.2	-
Summary score[c]	2.4	0.1, 4.6	.037	0.1	-4.6, 4.6	.987
BMIz	0.8	-1.1, 2.6	.421	0.3	-3.7, 4.2	.901
Age	-4.4	-5.7, -3.0	< .001	-10.7	-13.7, -7.8	< .001
Gender (male vs. female)	5.1	1.6, 8.7	.005	11.2	3.5, 18.9	.005
Summary score X BMIz	1.2	-0.5, 2.9	.182	2.6	-1.0, 6.2	.160
Summary score X Age	-0.9	-2.3, 0.4	.168	-0.9	-3.8, 2.0	.527
Summary score X Gender	-0.3	-3.8, 3.2	.869	-4.7	-12.2, 2.8	.215

[a]Controlling for city, number of participants nested within schools, and number of days of monitoring nested within participants

[b]Continuous variables were grand mean centered and dichotomous variables centered on zero (i.e., -.5, .5)

[c]Summary score = PE teacher + PE minutes/week (≥ 100 vs. < 100) + recess teacher + recess minutes/session (≥ 20 vs. < 20) + recess activities provided

B = unstandardized coefficient representing minutes

Participant-level moderators of the association between school practice summary score and MVPA

Of the three interactions tested (BMIz, age, and gender by practice summary score), none were significant at $p < .05$ (see Table 13). Two interactions had a p value < .2 for the in-school MVPA outcome (BMIz and age) and one interaction had a p value < .2 for the total weekday MVPA outcome (BMIz). The interactions with a p value < .2 were graphed to visualize the direction of the interaction (see Figure 6). The relationship between school practices and in-school MVPA, as well as total weekday MVPA, tended to be stronger for participants with a higher BMIz as compared to those with a lower BMIz. The relationship between school practices and in-school MVPA tended to be stronger for younger participants as compared to older participants

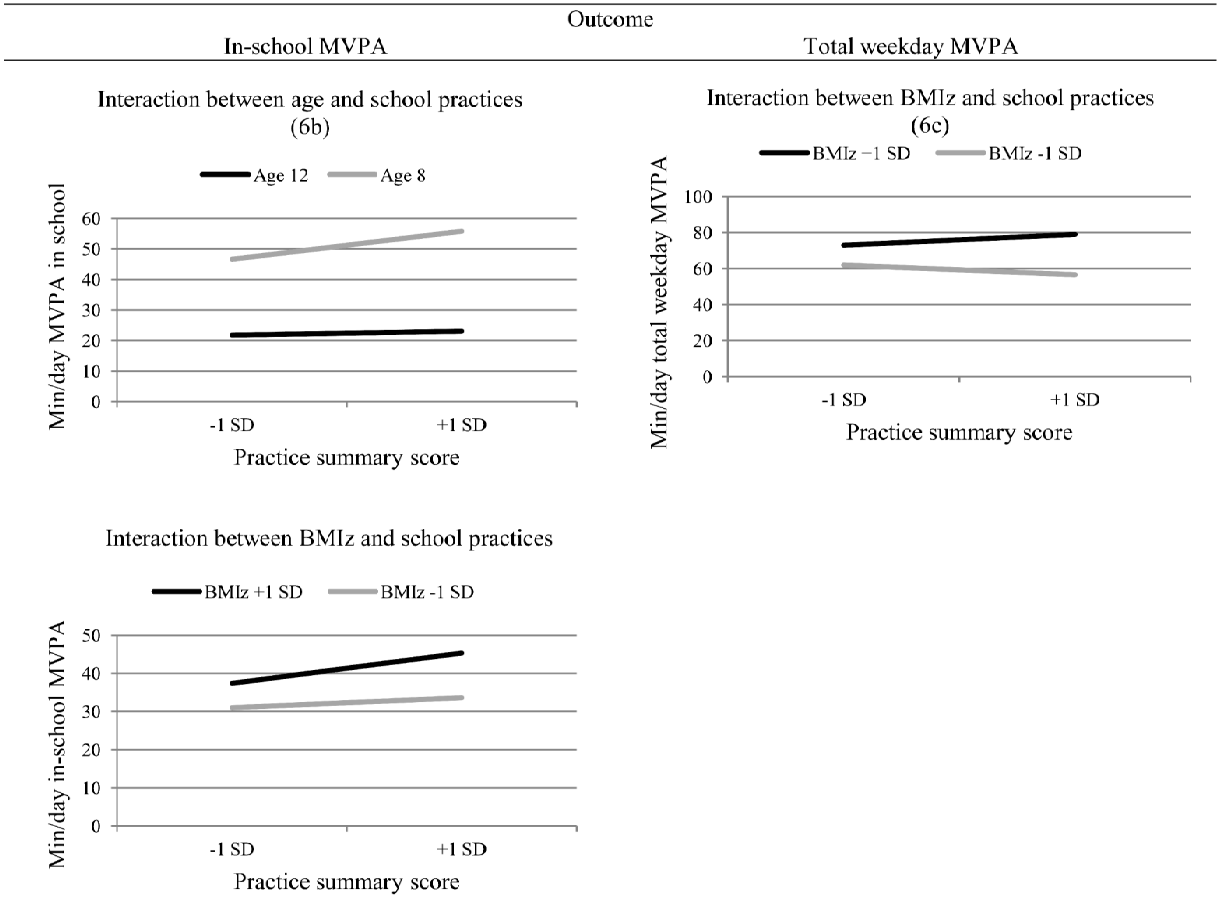

Figure 6: Interactions between school physical activity practices and participant factors (N = 172 children)

Characteristics of the schools with the most and least MVPA

Based on minutes/day of in-school MVPA aggregated at the school level, participants at the best 15% of schools had 53.5 (SD = 10.4) minutes/day of in-school MVPA, while participants at the worst 15% of schools had 11.9 (SD = 4) minutes/day of in-school MVPA ($p < .001$). The high-MVPA and low-MVPA schools were evenly divided between San Diego and Seattle. High-MVPA schools had an average summary score of 3.8 (SD = 0.8), while the low-MVPA schools had an average summary score of 2.5 (SD = 1.5; $p = .014$). The percent of schools providing ≥ 100 minutes/week of PE did not differ between the high- and low-MVPA groups. In the high-MVPA schools, 86% of schools had PE teachers, 93% had recess supervised by a non-classroom teacher, 92% provided ≥ 20 minutes/session of recess, and 50% provided activities during recess, compared to 64%, 71%, 64% and 36%, respectively, for low-MVPA schools (p's = .190, .139, .085, and .445). The high-MVPA schools had non-significantly larger PE class sizes as compared to low-MVPA schools (70 vs. 28; $p = .288$).

Table 14: Characteristics of the schools with the most and least accelerometer MVPA (N = 97 schools)

	Worst 15% of schools for MVPA	Best 15% of schools for MVPA	p value
Mean (SD) minutes/day of MVPA	11.9 (4.0)	53.5 (10.4)	< .001
City (percent of schools in San Diego)	50	50	.705
PE characteristics			
M (SD) of PE minutes/session	32.3 (13.9)	37.3 (7.5)	.266
M (SD) of PE sessions/week	2.4 (1.3)	2.0 (0.7)	.383
M (SD) of PE minutes/week	76.9 (71.5)	76.2 (34.8)	.972
Percent of schools with ≥ 100 minutes/week of PE	7.7	15.4	.539
M (SD) of PE class size	28.1 (5.5)	70.0 (138.9)	.288
Percent of schools with PE taught by PE teacher	64.3	85.7	.190
Percent of schools with PE training covering MVPA	71.4	57.1	.430
Percent of schools modifying games in PE to increase activity	92.9	100	.309
Percent of schools choosing PE games based on MVPA	64.3	57.1	.699
Percent of schools reporting another MVPA in PE strategy	0	21.4	.067
Recess characteristics			
M (SD) of recess minutes/session	19.0 (2.5)	20.1 (1.3)	.145
Percent of schools with ≥ 20 minutes/session of recess	63.6	92.3	.085
M (SD) of recess students/teacher	71.7 (27.5)	72.6 (46.1)	.951
Percent of schools with recess supervised by non-classroom teacher	71.4	92.9	.139
Percent of schools with activities provided during recess	35.7	50.0	.445
Classroom characteristics			
Percent of school with training covering classroom MVPA	14.3	14.3	1.00
Percent of schools with teachers implementing classroom MVPA	50.0	28.6	.256
Five item summary score M (SD)	2.5 (1.5)	3.8 (0.8)	.014

p value is from t-tests (for normally distributed continuous variables), Mann–Whitney–Wilcoxon tests (for skewed continuous variables), or chi square (dichotomous variables)

DISCUSSION

Five school physical activity practices stood out as being important to children's MVPA: having a PE teacher, providing ≥ 100 minutes/week of PE, having someone other than a classroom teacher supervise recess, providing ≥ 20 minutes/session of recess, and providing activities during recess. These 5 practices were combined into a summary score that was significantly related to MVPA during school, where each additional practice was related to 2.4 more minutes of MVPA. Higher-SES schools were significantly more likely to have more of these practices than moderate-SES schools. These 5 practices were more well-defined than many of the other practices assessed, such as modifying game rules to increase MVPA which can be ambiguous. Thus, these practices were likely easier for respondents to know the answer to and less likely to elicit response bias than other items.

While in the individual item analysis, the associations between the aforementioned 5 practices and in-school MVPA were not significant, but the effect sizes were meaningful (Bs = 2.7 to 6.0 minutes/day for 4 of the 5 practices). The main difference between San Diego and Seattle schools was that all Seattle schools had PE teachers and someone other than classroom teachers supervising recess. San Diego schools with a PE teacher had students who were significantly more active during school in the present study, by 5-10 minutes/day, than San Diego schools without a PE teacher. San Diego schools with a PE teacher also emerged as having the most physical activity-supportive school practices and most minutes of MVPA during school, while San Diego schools without a PE teacher had the least physical activity-

supportive school practices and fewest minutes of MVPA during school. Seattle schools were in the middle with regards to physical activity-supportive practices and minutes of MVPA during school. Findings suggest that adding PE teachers to schools without one may increase MVPA during school by 5-10 minutes/day.

Children's physical activity

During school, children received approximately half of the recommended 60 minutes/day of MVPA on average (U.S. Department of Health and Human Services, 2008). When considering the whole weekday, average MVPA was just above the recommended 60 minutes/day. However, these averages suggest that approximately half of the sample met MVPA guidelines during the weekdays, which is comparable to findings from national studies estimating that 42% of children age 6-11 meet physical activity guidelines (Troiano et al., 2008). The moderate and positive correlation between in-school and out-of-school weekday physical activity suggests that children do not compensate for high activity levels during school by being less active after school and in the evenings. This is a promising finding, suggesting that school physical activity opportunities have the potential to affect children's total physical activity levels.

There was substantial variation in MVPA, with 15% of participants (2 standard deviations below the mean) obtaining fewer than 15 minutes of MVPA during school and less than 30 minutes of MVPA across the whole day. Low activity levels during

school could be a primary reason these children were not meeting physical activity guidelines.

Over 40% of the variation in MVPA during school was attributable to school-level factors, particularly in San Diego, where 45% of the variance in MVPA during school was attributable to school-level factors. These findings suggest disparities among opportunities for MVPA during school, where some schools are not providing many opportunities for students to be physically active. However, some caution should be used when interpreting these ICCs because with some schools only having 1 participant, some of this between-school variance could actually be between participants.

Studies using accelerometers to assess physical activity during school were conducted in other countries and used thresholds for scoring MVPA that were different than those used in the present study. These studies found similar levels of MVPA during school (after adjusting for differences in scoring thresholds) and similar but slightly less variance in MVPA attributable to between school effects (Fairclough et al., 2012; Nettlefold et al., 2011; Nilsson et al., 2009). This suggests that activity levels in the schools included in the present study were similar to activity levels in schools included in other studies, and that the large differences in physical activity practices between San Diego and Seattle schools (and particularly having vs. not having a PE teacher) provided substantial variability in MVPA and school practices in the present study.

Some of the variation in children's MVPA during school was attributable to school SES as measured by the percent of students eligible for free or reduced price lunch. Participants were more active in higher SES schools by 5 minutes/day during school as well as total on weekdays, as compared to lower income schools. This is not surprising given that there was a high correlation between having a PE teacher and school SES in the San Diego schools, and participants at schools with a PE teacher had more MVPA.

Children's sedentary time

Children were sedentary for an average of 226 minutes during the 385 minute school day, equating to 59% of their time in school. For total weekdays, children were sedentary for an average of 441 of the 792 minutes (56%) of monitoring time. This suggests that children engaged in slightly fewer minutes of sedentary time outside of school as compared to in school, but that sedentary time was high both in- and out-of-school. Between 25% and 30% of children's sedentary time was accumulated in bouts $\geq$ 20 minutes, suggesting children sit for long periods of time without standing up.

It was not surprising that sedentary time in school was fairly high, given that children are encouraged to sit still during academic lessons. However, it seems alarming that children were almost as sedentary outside of school as they were during school. Children attending low-SES schools were slightly but not significantly more sedentary than children attending high-SES schools, suggesting sedentary time may be a contributor to health disparities. Recommendations for sedentary time do not

currently exist, aside from TV time, and the relationship between sedentary time and health is unclear in children (Ekelund et al., 2012). Thus, it is difficult to draw conclusions from these data. Although further evidence is needed in this area, reducing sedentary time appears to be an important topic for intervention, at least from an energy expenditure standpoint.

PE

Half the schools in San Diego did not have a PE teacher, and having a PE teacher was the strongest correlate of MVPA during school, although this finding was only significant in the model investigating only San Diego schools. Having a PE teacher was related to 6 additional minutes/day of MVPA in the total sample and 10 minutes/day in the model investigating only San Diego schools, suggesting that substantial increases in MVPA may be accomplished by adding a PE teacher to schools that do not have one.

Schools offered an average of 81 minutes/week of PE, well below the recommended 150 minutes/week (CDC, 2011; NASPE, 2012; Pate et al., 2006; The Community Guide, 2012). Only 20% of schools reported providing the 100 minutes/week of PE required by California and Washington state law. Although schools without a PE teacher reported offering more minutes/week and sessions/week of PE (albeit fewer minutes/session) than schools with a PE teacher, other studies in San Diego suggest that it is possible classroom teachers are counting recess as PE or not adhering to the PE schedule reported by the school informant (County of San

Diego, 2012). For example, one study was unable to observe PE at San Diego elementary schools because PE was not occurring (County of San Diego, 2012). Furthermore, it is important to note that principals completed the survey in the present study at schools that did not have a PE teacher, which could have led to differences in responses. Thus, direct observations may be needed to accurately assess minutes/week of PE rather than relying on reports from principals or teachers, particularly at schools that do not have a PE teacher. It is also important to note that when 1 PE teacher is shared across an entire school, they have limited time to spend with each class. Thus, multiple PE teachers may be needed or PE may need to be supplemented by classroom teachers to ensure schools meet the 100 minutes/week state law or 150 minutes/week national guideline.

Having a PE teacher was significantly related to school SES, where 63% of low- and moderate-income schools had a PE teacher and 97% of high-income schools had a PE teacher. San Diego schools have faced severe financial hardship which led to layoffs of PE teachers in many schools. This is especially problematic because having vs. not having a PE teacher could contribute to racial/ethnic and income disparities in children's physical activity and obesity risk. It is important to note that children benefit from PE teachers in more ways than just physical activity, including physical fitness and skills development.

The finding that larger class size in PE and recess was non-significantly related to more minutes/day of MVPA in the model including both cities was contrary to previous studies that found minutes of MVPA to be lower in larger classes (Barroso

et al., 2005; McKenzie et al., 2001; UCLA et al., 2007). It is possible that larger classes in the present study had multiple teachers or aides, particularly in Seattle schools; this question was not asked in the survey. When considering San Diego schools only, the association between class size and MVPA was in the expected direction, where every 10 additional students/class in PE was related to 1.2 fewer minutes/day of MVPA.

It is unclear why training on MVPA in PE was related to fewer minutes/day of MVPA during school, albeit non-significant. It is possible that the training was being offered because the teachers were less qualified, so the measure could have been a proxy for teacher qualification, where less qualified teachers are receiving more training on MVPA. It is also possible that the question was ambiguous and could have been improved by defining MVPA training and providing examples.

The specific strategies for increasing MVPA in PE included in the survey were modifying game rules to increase MVPA and exclusively selecting games based on MVPA. These strategies have been associated with increased MVPA in PE in other studies and are emphasized in PE programs such as SPARK and CATCH (Luepker et at., 1996; McKenzie et al., 1996; Sallis et al., 1997). An unexpectedly high number of schools reported using these strategies in the present study (89% and 61%, respectively), but the strategies were non-significantly related to fewer minutes/day of MVPA during school. Further research is needed to understand these relationships. It is possible that these questions stimulated more social desirability bias as compared to other questions, or that these questions required knowledge that principals did not

have, thus leading to inaccuracies in responses. The open ended question allowing participants to report any other strategies they used for increasing MVPA in PE was non-significantly positively associated with MVPA during school. The strategies listed included using pedometers and offering rewards. This survey item may be a measure of teacher dedication to MVPA, which appears to be important in children's activity.

Recess

Providing ≥ 20 minutes/session of recess was associated with almost 4 additional minutes/day of in-school MVPA. Thus, 20 minutes may be a minimum duration for recess to serve as a sufficient opportunity for youth to be physically active. The 20 minute/day guideline for recess seems appropriate given this finding (CDC, 2011; National Association for Sport and Physical Education [NASPE], 2012; Pate et al., 2006). Previous studies have found that children spend 15-50% of recess time in MVPA on average (Beighle, 2012; Stratton & Mullan, 2005; Verstaete et al., 2006). Low-income schools reported offering significantly more minutes/session of recess as compared to high-income schools, but the difference was only 1 minute/day.

Whether recess was supervised by a classroom or non-classroom teacher was not related to school SES but was related to minutes/day of MVPA during school (non-significant). In Seattle, only 4% of schools had a classroom teacher supervise recess, whereas half of the San Diego schools without a PE teacher and 68% of San Diego school with a PE teaches had classroom teachers supervise recess. The mechanism linking recess supervisor to minutes/day of MVPA is unknown, but it

could be that classroom teachers are less likely to adhere to the recess schedule or encourage physical activity during recess because they are overworked or focused more on academic learning. Many low-income schools had volunteers supervise recess, suggesting that relieving classroom teachers of recess duty is feasible even in low-income schools and can lead to increases in MVPA. Previous studies have not investigated differences in students' MVPA in recess when supervised by classroom vs. non-classroom teachers, but studies have found that students are more active when recess supervisors have training and skills for encouraging MVPA (Beighle, 2012).

Providing activities during recess was non-significantly related to 6 more minutes/day of MVPA during school in San Diego schools but 2 fewer minutes/day of MVPA during school in Seattle schools. The finding in San Diego schools was similar to that of other studies that found providing structured activities during recess was associated with more minutes of MVPA in recess (Beighle, 2012; Connolly & McKenzie, 1995; Howe et al., 2012). Since only half of the schools surveyed were providing activities during recess, and providing activities during recess was not related to school SES, this is a potential area to target for increasing MVPA. All schools in the present study reported providing loose equipment during recess, which has been related to MVPA in recess in previous studies (Verstraete et al., 2006).

Classroom physical activity

A high number of school officials, 59%, reported that teachers were implementing classroom MVPA. However, teacher training and implementation of

MVPA in the classroom were associated with 1 fewer minute/day of MVPA during school (non-significant), which is contrary to previous studies that found classroom physical activity breaks and incorporating physical activity into academic lesson plans can lead to increases in MVPA (Donnelly et al., 2009; Mahar et al., 2006). These unexpected findings could be because it is difficult for PE teachers and principals to know whether classroom teachers are implementing classroom MVPA, the implementation may vary widely across teachers at the school, or teachers' efforts to increase MVPA may simply not be working. For example, breaks could be mostly stretching or very short activity sessions. Previous studies that have found classroom physical activity breaks to be beneficial used a pre-post research design and included training of teachers. It is not clear what type of training on classroom MVPA teachers in the present study received, but better training is likely needed, as well as better assessment of implementation. The item may be too ambiguous and could be improved by adding that teachers should be trained and use a specific program or curriculum to guide classroom activity sessions. Assessment of classroom MVPA could also be improved by having teachers record in a log when classroom MVPA is provided.

After school practices

The after school practices assessed included sports and factors expected to be related to active travel to school. It was expected that relationships between after school practices and MVPA would be more difficult to detect because after school

practices would only reach a portion of students, whereas in-school practices were expected to reach a majority of students. High-income schools were significantly less likely to have crossing guards and bike racks than other schools. This could be because higher-income schools tend to be in less urban (more suburban) areas where children are less likely to walk or bike (Martin et al., 2007). Having crossing guards was non-significantly related to 2 more minutes/day of MVPA during school, suggesting that more participants may have been walking or biking home from school at schools with crossing guards.

Unexpectedly, participants at schools that offered sports had significantly fewer minutes/day of MVPA after school. Since only a portion of students within a school are likely to participate in sports and sports are seasonal, it is unknown whether the children were actually involved in sports at the time of accelerometer data collection. It is also possible that they removed the accelerometers while participating in sports and this was the reason for the inverse association. Previous studies suggest that MVPA in youth sports is low, so this is a potential area of intervention (Bocarro et al., 2012; Katzmarzyk & Malina, 1998; Leek et al., 2011; Weintraub et al., 2008; Wickel & Eisenmann, 2007).

School physical activity practice summary score

The school practice summary score represented the five seemingly most important physical activity practices based on their relationships with minutes/day of MVPA during school in the initial analysis. The five practices were: having a PE

teacher, providing ≥ 100 minutes/week of PE, having someone other than a classroom teacher supervise recess, providing ≥ 20 minutes/session of recess, and providing activities during recess. The correspondence analysis revealed item-dimension correlations > 0.40 for 4 of the 5 items, suggesting these items could be considered part of a "package" of practices. The providing ≥ 100 minutes/week of PE item had an item-dimension correlation < 0.40 but was retained in the summary score based on its conceptual importance to physical activity and positive association with in-school MVPA in Seattle schools. Schools that had a PE teacher were more likely to have a non-classroom teacher supervise recess, suggesting that some of these important practices co-occur. Having a PE teacher and having a non-classroom teacher supervise recess may indicate having more resources or commitment to physical activity.

The summary score was significantly associated with minutes/day of MVPA during school, where each additional practice was associated with 2.4 more minutes/day of MVPA. Findings suggest that children at schools with 1 of the 5 practices (10% of schools) obtained just over 30 minutes/day of MVPA during school on average, while children at schools with all 5 practices (8% of schools) obtained over 40 minutes/day of MVPA during school on average. These differences could account for approximately 1 hour of additional MVPA per week, or 1 extra day of meeting physical activity guidelines (USDHHS, 2008). This significant finding suggests that schools need to implement multiple strategies for providing physical activity opportunities. The summary score was not associated with minutes/day of

total weekday MVPA, suggesting that the physical activity opportunities children have in the evenings may be independent of the opportunities they have at school.

The summary score differed significantly by city and by school SES, suggesting that there are disparities among schools in the most important physical activity practices. Variation in school practices may be one explanation for economic disparities in physical activity and obesity. Two previous studies have had similar findings, with high-SES schools having more supportive physical activity practices than low-SES schools (Turner et al., 2010; Young et al., 2007). Reducing disparities in childhood obesity may require greater equity in school physical activity resources and opportunities.

Moderators of the association between school practices and MVPA

The moderator analyses suggested that children with a higher BMIz and those that were younger may benefit more from physical activity-supportive practices than their counterparts (non-significant finding), but intervention studies are needed to confirm this. The finding related to BMI is promising because it suggests school physical activity practices could benefit children in most need of increasing their physical activity. High priority should be placed on investigating whether this finding is replicable. Previous intervention studies found slightly greater rates of improvement in MVPA in PE for elementary- as compared to middle-school youth, but it is difficult to assess across studies because of differences in measurement (Leupker et al., 1996;

McKenzie et al., 1996; McKenzie et al., 2004; Pate et al., 2005; Sallis et al., 1997; Webber et al., 2008).

Contribution to literature

Individual policies and practices have been investigated for relationships with MVPA in specific settings such as PE and recess, usually using an intervention study design (Beets et al., 2009; Connolly & McKenzie, 1995; Donnelly et al., 2009; Howe et al., 2012; Leupker et al., 1996; Mahar et al., 2006; McKenzie et al., 1996; Sallis et al., 1997; Stratton & Mullan, 2005; Verstaete et al., 2006). No studies have examined how multiple practices across the day relate to accelerometer-assessed physical activity during school and total on weekdays. Findings from the present study provide an evaluation of a package of existing school physical activity practices and suggest that the package of practices is more important than any individual practice in relation to children's physical activity. While over 40% of the variation in MVPA during school was attributable to school-level factors, only 8% of this variance was explained by the practices assessed in this study. Future studies should use or develop more accurate measures of school practices, such as direct observation. This is because unclear associations were found in the present study between some reported practices and children's MVPA, particularly when the practice was ambiguous (e.g., whether the school has a PE teacher is straight forward, whereas whether classroom teachers implement MVPA in the classroom is more difficult for a PE teacher or principal to report accurately).

Limitations

Since the survey was kept brief, it was not able to provide an in-depth assessment of school practices. The time discrepancy between the accelerometer data collection (2009-2010) and the school practices survey (Spring 2012) may have contributed to error because practices can change over time and PE teachers and principals may not have been able to recall the exact practices during the 2009-2010 school year. However, a majority (83%) of respondents were employed at the same school as their current school during the 2009-2010 school year, and the survey included specific instructions to report practices for the 2009-2010 school year as opposed to the current year. Another potential source of error was social desirability bias, which may have occurred due to school officials aiming to promote their or their school's reputation and prevent litigation, particularly with regards to required minutes of PE. Respondents were reminded that their and their school's name would be kept anonymous, and that the data would be aggregated across a large number of schools. Despite this care to reduce reporting bias, it is possible and even likely that respondents answered some survey questions inaccurately. Some respondents may have had a lack of knowledge of physical activity practices in their school, particularly principals, making their responses unreliable. Some survey items may have been ambiguous, as previously mentioned, and these items tended to have unclear associations with physical activity. Direct observations may be needed to better assess practices that are more prone to response bias (e.g., number of minutes per week of PE when there is a state law).

The small sample size of 172 children and 97 schools led to low statistical power for detecting effects. It is likely that large variability in physical activity practices and MVPA existed between classes and grade levels, which could have contributed to error. Few findings were significant with regard to associations between practices and MVPA, with the exception of the summary score which was significantly related to in-school MVPA. Large confidence intervals were a result of the small sample size and large amount of variation. However, some effect sizes were large (e.g., difference of 5-10 minutes/day of MVPA) and appeared to be robust, although not statistically significant, such as the effect sizes for having a PE teacher, having someone other than a classroom teacher supervise recess, and providing activities during recess. It is important to note that this was a study of association and was not able to determine whether changes in school practices would lead to changes in children's physical activity (i.e., causation). A better understanding of causation could come from evaluations of changes in school practices in naturalistic settings (e.g., a school without a PE teacher hires a PE teacher and a researcher assesses student MVPA before and after the change in practice).

Several factors limit this study's generalizability, including the refusal of the large districts in San Diego and the statistical approach used to derive the summary score that was based on the present sample. It is important to note that the school informant survey used 5th grade as a reference for the questions, so findings may not generalize past 5th graders. Furthermore, with 10% of child participants having only 1 day of accelerometer monitoring, and many schools only having 1 participant, the

MVPA data collected may not be representative of other children in the school. It is important to note that 2 different samples (NIK and Move), with one of the samples being from an intervention study with a control and intervention group, were used in the present study. This could have biased results due to systematic differences in the samples, although this bias was minimized by controlling for sample and intervention group, and the samples had similar inclusion/exclusion criteria.

Strengths

Despite shortening the survey and the limited sample size due to refusal of the largest San Diego districts, this study had several strengths. It filled a gap in school policy research by using accelerometers to investigate associations between a full spectrum of school practices and physical activity. It involved original data collection which required designing a survey and communicating with school district officials, school principals and PE teachers to collect data. It involved complex accelerometer data cleaning and processing to remove non-school days and score physical activity specific to individual school start and end times, which was designed to reduce error. The statistical analyses were thorough and included a comprehensive depiction of differences in study variables and research questions by city, as well as complex three-level (to improve statistical power) mixed models to investigate the primary study aims. Adding Seattle schools to the sample increased variability in study variables, and a range in school SES was represented. This study was among the first to examine SES disparities in school physical activity practices. Over 30% of chlidren were of

racial/ethnic minority and 27% were overweight or obese, which is comparable to the general population in these areas (US Census Bureau, 2012). This investigation can serve as a pilot study to inform future studies investigating school practices and objectively measured physical activity. The study findings are relevant to policy because there are specific school policies that do or could govern each of the practices studied.

Implications for policy

The practices assessed in the present study are indicators of policies, written or unwritten. Findings generally were in line with previous studies showing large amounts of between-school variation in children's MVPA during school (Fairclough et al., 2012; Nettlefold et al., 2011; Nilsson et al., 2009). This suggests that some schools are providing more or better-quality opportunities for physical activity than others. However, this was the first study to investigate how multiple school practices explain this between-school variation in MVPA.

A key lesson is that schools should implement multiple evidence-based strategies for providing physical activity opportunities. Practices related to having a PE teacher, providing ≥ 100 minutes/week of PE, having someone other than a classroom teacher supervise recess, providing ≥ 20 minute/session of recess, and providing activities during recess stood out as being most important. Implementing these physical activity practices could reach large numbers of students and provide even greater benefits to children in most need of increasing their physical activity,

such as overweight/obese children. Children at schools without PE teachers were particularly vulnerable to low levels of MVPA, and it is possible that some of these children were receiving little to no PE, despite what principals reported in the survey (County of San Diego, 2012). Adding a PE teacher or improving training and accountability of classroom teachers' implementation of PE should be a first task for decision makers. Another promising strategy decision makers should consider is hiring staff or seeking volunteers and training them to supervise recess in schools where classroom teachers currently have recess supervision duties. The present study, as well as others, suggests training staff or volunteers to encourage MVPA and provide activities during recess can lead to increases in the number of minutes of MVPA children obtain during recess (Beighle, 2012; Connolly & McKenzie, 1995; Howe et al., 2012).

Health and professional organizations recommend children receive at least 30 minutes/day (150 minutes/week) of PE and 20 minutes/day of recess (CDC, 2011; National Association for Sport and Physical Education [NASPE], 2012; Pate et al., 2006; The Community Guide, 2012), and that at least half (30 minutes/day) of the recommended 60 minute/day of MVPA should be obtained during school (Institute of Medicine, 2001). Furthermore, California and Washington have requirements, embedded in state law, for elementary schools to provide at least 100 minutes/week of PE (California State Board of Education, 1999; National Cancer Institute, 2011). The low rates of PE and MVPA during school found in the present study, where only 20% of schools provided ≥ 100 minutes/week of PE, half of participants had less than 30

minutes/day of MVPA, and 15% of participants had under 15 minutes/day of MVPA, suggest that many schools are not meeting national recommendations or state mandates.

Particular attention should be paid to lower income schools because MVPA and physical activity practices were poorer in these schools. Best practices for providing physical activity opportunities have been indentified in some low-income schools, such as obtaining supplemental funds and identifying PE games that are culturally appropriate and that children enjoy (San Diego State University, 2007). Schools may be able to use monitoring of students' MVPA as a strategy for gauging improvements.

Conclusions

The most important finding was that a package of 5 high-reach physical activity-supportive school practices was significantly associated with children's MVPA during school. These findings suggest that implementing multiple evidence-based practices may be more beneficial than implementing any 1 individual practice. Each of these five practices had meaningful associations with physical activity during school (3-6 minutes/day for 4 of the 5 practices), and particularly having a PE teacher which was associated with between 5 and 10 minutes/day of additional MVPA during school. Schools are in a unique position to support children's physical activity and reverse obesity trends. Although some evidence-based strategies for increasing physical activity in school exist, such as enhanced PE and classroom breaks (Donnelly

et al., 2009; Luepker et al., 1996; Mahar et al., 2006; McKenzie et al., 1996; Sallis et al., 1997), the present study provides evidence for a specific package of policies. Not having PE teachers appears to be a leading contributor to low rates of physical activity in children. Particular attention should be paid to economically disadvantaged schools, because limited opportunities for PA at schools could be contributing to disparities in childhood obesity and inactivity. Some schools do not appear to be meeting current guidelines or laws regarding school physical activity opportunities; more support, monitoring, and accountability of physical activity opportunities may be needed in these schools to improve children's physical activity. Further research is needed to better understand how school practices influence total weekday MVPA, but sufficient evidence exists to inform and improve current efforts. Schools play an important role in child development, and adding physical activity to schools' priorities is essential to reducing obesity and disease rates and improving children's attention, mental and physical health, and quality of life.

APPENDIX A: SCHOOL INFORMANT SURVEY

School Physical Activity Opportunities

Instructions

Thank you for taking the time to complete this survey. Please be as open and honest as possible in answering the questions so that our data will be as accurate as possible. If you need to seek out the answer to a question, you may come back to the survey at another time. You may skip any question that you do not know the answer to or prefer not to answer.

Please consider grades 4-5 when answering the questions.

For questions or to complete this survey over the phone, please contact Jordan Carlson at jacarlson@ucsd.edu or 619-260-5542.

If you wish not to complete this survey electronically, you may print it and mail the completed survey to:
Jordan Carlson
University of California, San Diego
3900 Fifth Avenue, Suite 310
San Diego, CA 92103

1. What is your title/position at your school?

2. Which gift card would you like? (please allow a few days for me to email it to you)

- ◯ $50 to Sports Authority
- ◯ $50 to www.usgames.com

3. We are conducting a retrospective study. Please think back to the 2009-2010 school year when answering all survey questions. If you are unable to remember or were not at the school during this time frame, please provide your best guess or provide answers for the current school year.
Were you employed at this school during the 2009-2010 school year?

- ◯ Yes
- ◯ No

4. What time of day did school start and end in 2009-2010? If you don't know, please put the start and end times for the current school year.

Start time (am)	
End time (pm)	
If any days start and end at different times, please list them here	

PE Practices and Procedures

School Physical Activity Opportunities

5. Who chose or developed your school's physical education curriculum?

- [ ] Not applicable (do not use curriculum)
- [ ] District
- [ ] School
- [ ] PE teacher
- [ ] Consultant
- [ ] Purchased (e.g., SPARK)

Other (please specify)

6. Do those who teach physical education at your school use any of the following strategies to engage students in physical activity during physical education?

- [ ] Modifying game rules to increase activity
- [ ] Physical activity during role call
- [ ] Exclusively choosing games that are highly active

Other (please specify)

7. What is the typical number of students in a physical education class at your school?

Provide the average class size

8. Who primarily teaches physical education?

- ◯ Certified PE teacher
- ◯ Non-certified PE teacher (e.g., PE Aide)
- ◯ Classroom teacher

Other (please specify)

9. If your school has a PE teacher or PE aide, is that person's job at YOUR school

- ◯ Full time
- ◯ Half time
- ◯ Less than half time

School Physical Activity Opportunities

10. How often do those who teach physical education receive professional development on PE?

- ◯ At least 2 times per year
- ◯ At least 1 time per year
- ◯ At least 1 time per 2 years
- ◯ Less than 1 time per 2 years

11. Do professional development sessions on PE emphasize providing moderate to vigorous physical activity during physical education classes?

- ◯ Yes
- ◯ No
- ◯ Not applicable, no professional development for PE

12. What is the typical length of a PE class at your school?

Minutes of typical PE class

13. Who primarily oversees your school's physical education program?

- ◯ School physical education teacher
- ◯ School principal
- ◯ District physical education lead
- ◯ Other district official

Other

14. How many days per week of physical education do students receive on average?

- ◯ 0
- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5

Recess Practices and Procedures

School Physical Activity Opportunities

15. Who primarily supervises recess?

- ◯ PE teacher
- ◯ Classroom teacher
- ◯ Paraprofessional
- ◯ Volunteer

Other (please specify)

16. What is the typical length of recess at your school?

Minutes of typical recess

17. What is the typical number of students per every 1 supervisor during recess?

Students per every 1 supervisor

18. Do children have access to organized activities during recess (e.g., walking or running programs)?

- ◯ Yes
- ◯ No

19. Do children have access to loose equipment during recess (e.g., balls, jump ropes)?

- ◯ Yes
- ◯ No

20. How many days per week of recess do students receive on average?

- ◯ 0
- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5

Other Practices and Procedures

School Physical Activity Opportunities

21. Regarding walking and biking to school, does your school

- ◯ Prohibit it (e.g., for safety reasons)
- ◯ Encourage it
- ◯ Allow but not encourage

22. Does your school participate in a Safe Routes to School program?

- ◯ Yes
- ◯ No

23. Are there crossing guards for children who walk or bike to school?

- ◯ Yes
- ◯ No

24. Does your school have bike racks for students to lock their bikes?

- ◯ Yes
- ◯ No

25. Do classroom teachers receive training on incorporating physical activity into the classroom (aside from PE and recess)?

- ◯ Yes
- ◯ No

26. Do more than 2 classroom teachers regularly hold classroom physical activity breaks (e.g., Instant Recess) aside from PE and recess?

- ◯ Yes
- ◯ No

27. Do more than 2 classroom teachers regularly incorporate physical activity into academic lesson plans?

- ◯ Yes
- ◯ No

28. Is physical activity included in after school programs at your school?

- ◯ Not applicable - no after school programs
- ◯ Yes
- ◯ No

School Physical Activity Opportunities

29. Does your school offer organized sports to 1st through 5th graders?

- ☐ Yes, interscholastic sports (compete against other schools)
- ☐ Yes, intramural sports (compete against others within the school)
- ☐ No organized sports

End of Survey

30. Thank you for completing the survey! Don't forget to click the "done" button before exiting. If you have any additional comments, please type them in the box below.

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