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Integration of Short Bouts of Physical Activity Into Organizational Routine

A Systematic Review of the Literature

Daheia J. Barr-Anderson, PhD, MSPH, Mona AuYoung, MS, MPH, Melicia C. Whitt-Glover, PhD, Beth A. Glenn, PhD, Antronette K. Yancey, MD, MPH

Context: Recommended daily physical activity accumulated in short intervals (e.g., <10 minutes) may be more feasible and appealing to the relatively sedentary populace than longer bouts. The purpose of this paper is to present a systematic review of the evidence for the effectiveness of short activity bouts incorporated into organizational routine as part of the regular "conduct of business."

Evidence acquisition: PubMed, MEDLINE, and Google Scholar databases were searched in August 2009 (updated search in February and July 2010) to identify relevant, peer-reviewed journal articles and abstracts on school-, worksite-, and faith-based interventions of short, structurally integrated physical activity breaks.

Evidence synthesis: The majority of interventions implemented daily physical activity bouts of 10–15 minutes in length. Schools were the most common settings among the 40 published articles included in this review. The rigor of the studies varied by setting, with more than 75% of worksite versus 25% of school studies utilizing RCT designs. Studies focused on a broad range of outcomes, including academic/work performance indicators, mental health outcomes, and clinical disease risk indicators, in addition to physical activity level. Physical activity was the most commonly assessed outcome in school-based studies, with more than half of studies assessing and observing improvements in physical activity outcomes following the intervention. About a quarter of worksite-based studies assessed physical activity, and the majority found a positive effect of the intervention on physical activity levels. About half of studies also observed improvements in other relevant outcomes such as academic and work performance indicators (e.g., academic achievement, cognitive performance, work productivity); psychosocial factors (e.g., stress, mood); and clinical disease risk indicators (e.g., blood pressure, BMI). The average study duration was more than 1 year, and several reported outcomes at 3–6 years.

Conclusions: Interventions integrating physical activity into organizational routine during everyday life have demonstrated modest but consistent benefits, particularly for physical activity, and these are promising avenues of investigation. The proportionately longer-term outcomes available in these studies compared with individual-level studies suggest that physical activity promotion strategies at the organizational level may be more sustainable.

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Introduction

Physical activity is an underutilized,[1] yet potent, tool in our prevention arsenal. Regular physical activity participation positively influences almost every human physiologic system.[2] Physical *in*activity, on the other hand, is increasingly becoming identified with metabolic dysregulation and dysfunction.[3] There is growing recognition[4,5] that interrupting prolonged periods of sitting and other sedentary behaviors, as well as increasing engagement in moderate-to-vigorous physical activity (MVPA), will be necessary to promote well-being and prevent chronic disease. For example, both the overall volume and numbers of bouts of daily physical activity recently have been found[6] to be associated with weight status in children and adolescents.

Physical activity promotion interventions could have a considerable impact on population health given the inordinately low levels of physical activity observed when data are gathered through objective monitoring versus self-report. Fewer than 50% of elementary students, 10% of

From the School of Kinesiology, University of Minnesota (Barr-Anderson), Minneapolis, Minnesota; UCLA Kaiser Permanente Center for Health Equity, Division of Cancer Prevention and Control Research, and Department of Health Services, University of California Los Angeles School of Public Health (AuYoung, Glenn, Yancey), Los Angeles, California; and Gramercy Research Group (Whitt-Glover), Winston-Salem, North Carolina

Address correspondence to: Antronette K. Yancey, MD, MPH, UCLA School of Public Health, 650 Charles Young Drive South, Los Angeles CA 90095. E-mail: ayancey@ucla.edu.

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adolescents, and 5% of adults meet current physical activity guidelines according to recent estimates based on accelerometer data.[1] The average adult gets only 6–10 minutes/day of MVPA.[1] Population-based estimates of adherence to physical activity guidelines among adults based on self-report are considerably higher (51%), although likely a substantial overestimation. The need for innovative physical activity promotion efforts is especially great in underserved communities with few active recreation facilities, little park acreage, neighborhood safety concerns, and subpar physical education and recess opportunities[7,8] and in population segments culturally dissuaded from participating in physical activity, (e.g., immigrant girls and women from conservative Latin American or Middle Eastern countries).[8,9]

Recommended daily physical activity that may be accumulated in short intervals of 10 or more minutes may be more feasible and appealing than longer bouts, especially for sedentary populations.[2,10,11] A recent review[12] of the literature compared the benefits of accumulated to continuous exercise and found equivalent longer-term effects on cardiovascular fitness improvements and blood pressure normalization as well as short-term effects on reducing postprandial lipemia. Available evidence was insufficient to determine whether accumulated exercise was as effective as continuous exercise for other outcomes such as adiposity, blood lipids, and psychological well-being indicators.[12] Another recent study[5] found that MVPA accumulated in bouts of 10 minutes or more was associated independently and inversely with BMI and waist circumference after controlling for other covariates.

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New and innovative ways to increase physical activity across a wide range of settings, sectors, and population segments must be identified. Organizational contexts offer unique opportunities to expose people to physical activity promotion efforts. Institutional practice and policy changes within organizational settings can readily expand opportunities for physical activity.[11,13] Organizational leadership and management usually have the decisional latitude to modify practices and policies to promote physical activity. Changes made at the level of the organization may ultimately lead to upstream and widespread policy changes needed to arrest the obesity and chronic disease epidemics—changes that will require considerable political will and financial resources (e.g., prioritizing mass transit over personal transportation).

One such institutional policy is integrating short activity bouts into organizational routine. This policy has been implemented across a number of settings, including worksites, schools, and religious institutions. The short activity bouts (typically 10 minutes or less) have taken the form of brief aerobic routines held during meetings or events or at certain times during the workday, restrictions on nearby parking and elevator use, or walking meetings. Engaging captive audiences convened for other purposes in group physical activity provides built-in social support and relies less on individual initiative and motivation than other strategies (e.g., gym membership subsidies).

In a systematic review,[14] the U.S. Preventive Services Task Force found strong evidence supporting the effectiveness of such interventions aimed at increasing social support for physical activity within community settings. Enhancing the impact and sustainability of societal physical activity promotion efforts is critical, as the enormous prevention potential of physical activity cannot be fully realized until the vast majority of the population gets moving. The purpose of this paper is to present a systematic review of the evidence for the effectiveness of short activity bouts incorporated into organizational routine as part of the regular "conduct of business."

Evidence Acquisition

Data Source

In August 2009, PubMed, MEDLINE, and Google Scholar databases were searched to identify relevant, peer-reviewed journal articles and abstracts on organization-based interventions that utilized short structured physical activity breaks, which are defined as episodes of activity lasting 20 minutes or less. Although "brief" bouts were here conceptualized as those lasting approximately 10 minutes, studies were included that implemented bouts of at least 3 minutes and up to 20 minutes in length. Studies that implemented bouts of physical activity designed to be 20 minutes or more in duration were excluded, given bouts of this length begin to resemble typical exercise prescriptions, have been evaluated in prior research, and are less feasible to integrate into organizational routine. The search terms included were *10 minute*, *15 minute*, *20 minute*, *exercise*, *physical activity*, *physical activity break*, *short bouts*, *brief bouts*, *school-based*, *workplace-based*, *worksite-based*, *church-based*, and *faith-based*. Additionally, bibliographies of relevant review articles related to school-based and worksite-based interventions were searched. In February and July 2010, the electronic search was updated.

Study Inclusion and Exclusion Criteria

A total of 2720 citations were identified from the electronic searches. Individual article titles and abstracts were reviewed independently by three of the authors (MA, DBA, MWG) to exclude duplicates and nonrelevant publications (i.e., non-English publications, news reports,

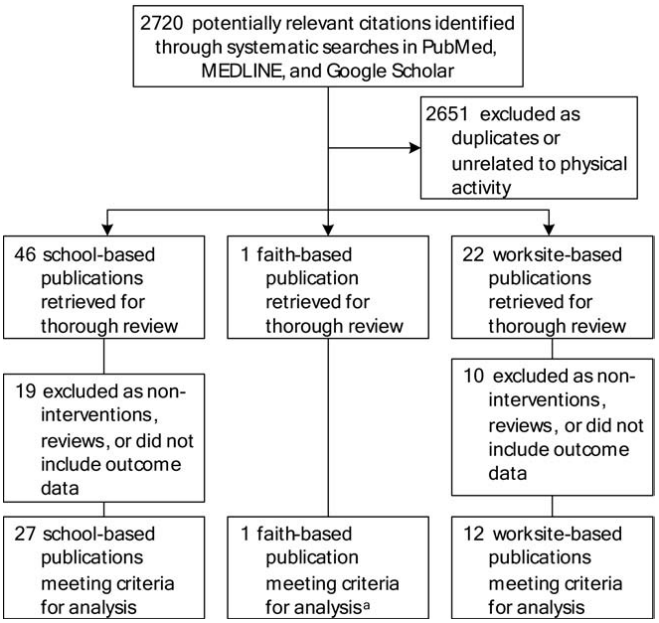

Figure 1. Flowchart of systematic search findings
[a]The faith-based study identified reported on results of brief bout interventions conducted in both school and faith-based settings, and thus was included with school-based studies.

review articles, and articles from non–peer-reviewed publications). The remaining articles ($n=133$) then were downloaded and reviewed independently by the same authors. Articles and abstracts had to meet the following inclusion criteria: (1) school-, worksite-, or faith-based; (2) brief exercise bouts as single or primary physical activity intervention; (3) published in English-language literature between 1960 and July 2010; and (4) included outcomes data related to the intervention.

Identification of Eligible Studies

Sixty-nine articles and abstracts were identified initially (46 school-based, 22 worksite-based, 1 faith-based, and 0 other settings). After careful review, 19 school-based and 10 worksite-based articles were eliminated because they did not fully meet the inclusion criteria. In addition, the faith-based study identified reported on results of brief bout interventions conducted in both school- and faith-based settings, and thus was included with school-based studies. Outcome results for some of the interventions appeared in more than one published article. The final number of published articles included in this review is 40 (28 school-based, 12 worksite-based) resulting from 34 unique intervention studies (23 school-based; 11 worksite-based, Figure 1).

Data Extraction and Calculation of Effect Size

Data extracted from each article were as follows: study population; study setting (including country of origin); study design; description of the intervention; duration of the intervention and follow-up period; assessment of physical activity; and research findings related to the outcome variables. Table 1 provides descriptive information about studies and physical activity outcome findings. Tables 2 and 3 provide information regarding all other study results organized by outcome. Study results were categorized as "positive" when increases in the outcome of interest were observed in the intervention group relative to the control condition or between baseline and follow-up, when no comparison group was available. Conversely, results were classified as "negative" when decreases in the outcome of interest were observed among intervention group participants relative to the control condition or between baseline and follow-up. In order to provide an estimate of the magnitude of the impact of brief bout interventions on physical activity outcomes, effect sizes were estimated (Cohen's d) when the necessary details (e.g., post-test means and SDs for intervention and control participants) were included in the published manuscript (Table 1).[55]

Evidence Synthesis

Schools

Characteristics of school-based interventions and participation. Of the 23 published articles reporting on school-based interventions included in this systematic review, the majority reported on interventions implemented in elementary/primary schools,[15–29,31–33,36–42] one in junior high,[34] and one in a preschool.[35] Another study evaluated the effect of an intervention implemented among adult staff at three schools as well as within several faith-based organizations.[30] These studies were conducted in several countries, predominantly in the U.S.,[17–21,27–33,35,39–42] but also in Canada,[16,23–26,36–38] Australia,[34] China,[22] and the Netherlands.[15] Sample sizes for the studies ranged from 28[40] to 1914.[29]

Six of the publications did not report assessing physical activity[20,21,28,31,33,39]; the remaining publications measured this behavior by self-reported questionnaire[15,16,22–26,30,34,36,37,40]; pedometer[19,27,32,38,42]; teacher report[35,36]; direct observation[17,29,41]; accelerometer.[18,30,32] One study[33] assessed physical activity knowledge rather than behavior. Although the majority of school-based studies assessed physical activity, a number of studies used only physical activity as a covariate (e.g., studies focused on bone-related outcomes). In addition to reporting on physical activity, studies included data on body composition,[18,20–22,26,34,42] academic-related outcomes,[17–21,27–29,31,33,36–39,41] and bone-related outcomes.[16,23–26,34,36–38]

Details on the description, duration, and study design for the school-based interventions are in Table 1. The majority of the interventions were implemented in classroom settings,[15–22,28–33,35–40,42] some during physical education

Table 1. Description of interventions and summary of PA outcomes

Study	Intervention	Length of bout	Duration of intervention	Study design	Population/setting	Measure of PA	Change in PA	Effect size on PA (if known)
School-based interventions								
Jurg (2006)[15]	Jump-In: six component program including 3 minutes of jumping in classroom setting, afterschool sports programs, and parental involvement	<10 minutes	1 school year (~9 months)	Quasi-experimental; pre- and post-test	6 Dutch elementary schools (N=510 students)	Self-report questionnaire	+ (Daily PA time: control= 26-minute decline; intervention=n.s. decline; β=0.11 for PA time intervention effect)	Not reported
McKay (2009)[16]	10 jumps (~1 minute) completed when bell rings three times a day	<10 minutes	9 months	Quasi-experimental; pre- and post-test	3 Canadian elementary schools (N=51 students)	Self-report questionnaire	0	Not reported
Gibson (2008)[17]; Donnelly (2009)[18]	Physical Activity Across the Curriculum (PAAC): 10 minutes of PA in classroom setting nine times per week	10–15 minutes	3 years	Cluster RCT, pre- and post-test	24 U.S. elementary schools (N=454 students)	Direct observation with SOFIT (Gibson); Accelerometer (Donnelly)	+	SOFIT: PA level intervention vs control: 3.04 Accelerometer: mean accelerometer minutes of MVPA intervention vs control: 0.65
Grieco (2009)[19]	10–15 minutes of PA in classroom setting	10–15 minutes	1 school year (~9 months)	Quasi-experimental, pre- and post-test	1 U.S. elementary school (N=97 3rd-grade students)	Pedometer	0	Not reported
Hollar (2010)[20]	10–15 minutes of PA in classroom setting	10–15 minutes	20 months	Quasi-experimental, pre- and post-test	5 U.S. elementary schools (N=1197 students)	PA not assessed	N/A	N/A
Katz (2010)[21]	ABC for Fitness: Five 6-minute intervals of PA in classroom setting	10–15 minutes	8 months	Quasi-experimental, pre- and post-test	5 U.S. elementary schools) (N=1216)	PA not assessed	N/A	N/A
Liu (2008)[22]	Happy 10: 10 minutes of PA in classroom setting daily	10–15 minutes	8 months	Quasi-experimental; pre- and post-test	2 Chinese elementary schools (N=753 students)	Self-reported questionnaire	+ (Daily PA time: intervention=30-minute increase at posttest; control=decline in PA time)	Not reported
MacKelvie (2001)[23]; MacKelvie (2002)[24]	10–12 minutes of weight-bearing PA during twice-a-week PE class and on one other day	10–15 minutes	7 months	Cluster RCT; pre- and post-test	14 Canadian elementary schools (N=157 girls and 121 boys)	Self-report questionnaire	0	Not reported

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Table 1. Description of interventions and summary of PA outcomes *(continued)*

Study	Intervention	Length of bout	Duration of intervention	Study design	Population/setting	Measure of PA	Change in PA	Effect size on PA (if known)
MacKelvie (2003)[25]; MacKelvie (2004)[26]	10–12 minutes of weight-bearing PA during twice-a-week PE class and on one other day	10–15 minutes	20 months	Cluster RCT; pre- and post-test	14 Canadian elementary schools (N=80 girls and 64 boys)	Self-report questionnaire	0	Not reported
Mahar (2006)[27]	Energizers: 10 minutes of PA in classroom setting	10–15 minutes	12 weeks	Quasi-experimental; pre- and post-test	1 U.S. elementary school (N=243 students)	Pedometer only	+	In-School Step Count Effect Size/Cohen's d intervention vs control: 0.49
Metzler (2006)[28]	TAKE 10!: 10 minutes of PA in classroom setting once or twice daily times	10–15 minutes	10 weeks	Uncontrolled trial; pre- and post-test	38 U.S. elementary schools	PA not assessed	N/A	N/A
Mitchell (peer-reviewed conference abstract)[29]	Instant Recess: 10-minute DVD or CD with stretches and exercises in classroom setting	10–15 minutes	5 months	Cluster RCT with delayed intervention; pre- and post-test	7 U.S. elementary schools (N=1914 students)	Direct observation with SOFIT	0	Not reported
Richardson (peer-reviewed conference abstract)[30]	Instant Recess: 10-minute DVD or CD with stretches and exercises incorporated at the discretion of organizations but encouraged to be used within routine organizational practices	10–15 minutes	8–12 weeks	Pretest/posttest dissemination project	3 schools and 7 churches (N=199 participants)	Self-report questionnaire; accelerometer	+ (Questionnaire: no control group, significant increase in MET-minutes per week [185 MET-min/week] from baseline to follow-up among intervention participants Accelerometer: intervention effect for accelerometer measured decrease in sedentary bouts and increase in light PA bouts)	Not reported
Sibley (2008)[31]	Making the Grade with Diet and Exercise (MGDE): three-component program including 10–20-minute PA period before start of school	10–15 minutes	6 years	Uncontrolled; pre- and post-test	1 U.S. elementary school (N=435 students)	PA not assessed	N/A	N/A

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Table 1. *(continued)*

Study	Intervention	Length of bout	Duration of intervention	Study design	Population/setting	Measure of PA	Change in PA	Effect size on PA (if known)
Stewart (2004)[32]	TAKE 10!: 10 minutes of PA during classroom lesson once or twice daily times	10–15 minutes	5 months	Uncontrolled; post-test only	1 U.S. elementary school (N=71 students)	Pedometer, accelerometer	+ (In-class pedometer step counts by grade: 1st grade=743; 3rd grade=946; 5th grade=1022, no control group)	Not reported
Tsai (2009)[33]	TAKE 10!: 10 minutes of PA in classroom setting once or twice daily	10–15 minutes	1 year (does not specify academic or calendar)	Uncontrolled; pre- and post-test	1 U.S. elementary school (N=717 students)	PA not assessed	N/A	N/A
Weeks (2008)[34]	POWER PE: twice-weekly, 10 minutes of jumping activities at the beginning of PE class	10–15 minutes	8 months	RCT; pre- and post-test	1 Australian junior high school (N=81 9th-grade students)	Self-report questionnaire	− (Control group showed higher PA at follow-up, girls only)	Not reported
Williams (2009)[35]	Animal Trackers: daily 10 minutes of PA in classroom setting daily	10–15 minutes	10 weeks	Uncontrolled; pre- and post-test	9 U.S. preschools (N=273 students, N=32 teachers)	Teacher report	+ (No control group: 47-minute increase in PA time during school week per teacher report)	Not reported
Ahamed (2007)[36]; Macdonald (2007)[37]; Naylor (2008)[38]	Action School! British Columbia: six-component program including daily jumping program when bell rings and 15 minutes of PA in classroom setting daily	15–20 minutes	16 months	Cluster RCT, pre- and post-test	10 Canadian elementary schools (N=515 students)	Self-report (Ahamed, Macdonald); Pedometer (Naylor); Teacher report (Ahamed)	+ (Pedometer: liaison condition vs usual practice: boys=1175 step-count difference; Girls=n.s.)	Teacher report: weekly PA time intervention vs control schools=0.87, 47-minute difference
Caterino (1999)[39]	15 minutes of stretching and walking in classroom setting	15–20 minutes	1 day	Uncontrolled trial, pre- and post-test	1 U.S. elementary school (N=177 students)	PA not assessed	N/A	N/A
Ernst (1999)[40]	Promoting Lifestyle Activity for Youth (PLAY): 15 minutes of PA during school day and self-monitoring of outside-of-school activity	15–20 minutes	12 weeks	Quasi-experimental, pre- and post-test	1 U.S. elementary school (N=28 students)	Self-report	+	Posttest effect size/Cohen's d for PAQ-C intervention vs control: boys=0.63; girls=0.85

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Table 1. Description of interventions and summary of PA outcomes *(continued)*

Study	Intervention	Length of bout	Duration of intervention	Study design	Population/setting	Measure of PA	Change in PA	Effect size on PA (if known)
Jarrett (1998)[41]	15–20 minutes of weekly recess	15–20 minutes	Length of intervention not given	Quasi-experimental; post-test only	1 U.S. elementary school (N=43 fourth-graders from 2 classrooms)	Direct observation	0	Not reported
Pangrazi (2003)[42]	Promoting Lifestyle Activity for Youth (PLAY): 15 minutes of PA during school day and self-monitoring of outside-of-school activity	15–20 minutes	12 weeks	Quasi-experimental; pre- and post-test	5 U.S. elementary schools (N=28 students)	Pedometer only	+	(Effect size/Cohen's d for step counts: PLAY only vs no treatment=0.34, or 1418 steps)
Worksite-based								
Balci (2003)[43]	3 different work–rest schedules (60-minute work/10-minute rest , 30-minute work/5-minute rest, 15-minute work/micro breaks) using stretching breaks during rest	<10 minutes	1 day (acute effects only)	RCT with 3 intervention groups (no control)	Male college students (N=10)	PA not assessed	N/A	Not reported
Daniel (2007)[44]	5-minute light PA, 5-minute moderate PA, or no activity during a specific time of work day	<10 minutes	15 minutes; measurements: before PA, 2.5 minutes into PA, immediately after PA, after 5-minute rest, after 10-minute rest (acute effects only)	RCT with 2 intervention groups	Sedentary smokers who volunteered (N=84)	PA not assessed	N/A	Not reported
Galinsky (2007)[45]	Randomly assigned workers to (1) "stretch breaks" and (2) "no stretching during breaks." Those randomized to "stretch breaks" were given 4 additional breaks per day (5 minutes each)	<10 minutes	8 weeks	RCT	Seasonal employees who volunteered (N=51)	PA not assessed	N/A	Not reported

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Table 1. *(continued)*

Study	Intervention	Length of bout	Duration of intervention	Study design	Population/setting	Measure of PA	Change in PA	Effect size on PA (if known)
Nicoll (2009)[46]	Installation of "skip-stop" elevators and open, nested stairwells	<10 minutes	24 weeks; follow-up 12 weeks	Controlled trial (natural experiment, with redesigned south end of building compared to traditional north end)	Office employees (N=299)	PA not assessed	N/A	Not reported
Crawford (2004)[47]	Organizational changes, including 10-minute PA breaks and healthy foods during meetings	10–15 minutes	3 years (1 year baseline, 1 year intervention, 1 year evaluation)	RCT	6 sites of California WIC staff (N=51)	PA not assessed	N/A	Not reported
Dishman (2009)[48]; Dishman (2009)[49]	Self-set personal and team goals to accumulate 10-minute blocks of PA, and increase weekly pedometer steps; included organizational support and environmental prompts	10–15 minutes	12 weeks	RCT	8 sites of Home Depot staff without chronic disease (N=664)	Self-report questionnaire	+	Weekly MET hours calculated from IPAQ of intervention vs control=0.34 for VPA; 0.18 for MPA
Gilson (2009)[50]	Route-based walking group (at least 10 minutes); incidental walking (during work); or control (no behavior change)	10–15 minutes	10 weeks (United Kingdom, Australia, Spain)	RCT with 2 intervention groups	3 sites white-collar university employees who volunteered (N=179)	Pedometer	+	Daily steps: 0.26 for incidental condition vs control; 0.41 for route condition vs control
Lara (2008)[51]	10-minute PA breaks, stair prompts, written materials, encouragement by leadership	10–15 minutes	1 year	Natural experiment	Office workers (N=335)	PA not assessed	N/A	Not reported
Pronk (1995)[52]	10-minute flexibility and strength exercises during company time	10–15 minutes	6 weeks (pilot), then 6 months (main)	Pretest/posttest demonstration project	Manufacturing plant employees for pilot (N=19) and main study (N=210)	PA not assessed	N/A	Not reported

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Table 1. Description of interventions and summary of PA outcomes *(continued)*

Study	Intervention	Length of bout	Duration of intervention	Study design	Population/setting	Measure of PA	Change in PA	Effect size on PA (if known)
Yancey (2004)[53]	One 10-minute exercise break during work time	10–15 minutes	1 day (acute effects only)	Cluster RCT, post-test only	County health department employees (N=499)	PA not assessed	N/A	Not reported
Yancey (2006)[54]	30-minute weekly training sessions on organizational wellness with 10-minute exercise break	10–15 minutes	6 weeks and 12 weeks; follow up at 6 months and 1 year	Pretest/posttest demonstration project	Public and private, nonprofit agencies (N=35 for 12-week program), (N=11 for 6-week program)	Self-report questionnaire	+ (Days of vigorous activity/week increased from 1.6 to 1.9 in 6-week program, no control group) 0 (VPA in 12 program participants)	Not reported

Note: (+) = Significant increase in outcome observed over time or relative to control group (−) = Significant decrease in outcome observed over time or relative to control group IPAQ, International Physical Activity Questionnaire; MPA, moderate physical activity; MVPA, moderate-to-vigorous physical activity; PA, physical activity; PAQ-C, Physical Activity Questionnaire–Children; SOFIT, System for Observing Fitness Instruction Time; VPA, vigorous physical activity; WIC, Women, Infants, & Children program.

class,[23–26,34] and one during recess.[41] One intervention[39] reported only acute effects of the bouts immediately after conclusion of the activity. In other studies, the intervention duration ranged from 2 weeks to 6 years (M=13.0 months, with 1 school year = 9 months), with no information about duration of implementation for one of the interventions.[41] The majority of school-based interventions implemented physical activity bouts of 10–15 minutes on average. Fewer interventions utilized shorter (<10 minutes) or longer bouts (15–20 minutes).

Physical activity outcomes. Twelve of the 15 school-based publications with physical activity outcomes reported improvements in physical activity following the intervention. Although not available for all studies, effect sizes were moderate to large in most studies for which effect size estimates could be calculated, based on self-reported physical activity (e.g., PAQ-C)[40]; direct observation (e.g., SOFIT)[17]; pedometer or accelerometer data[18,27]; and teacher report.[36] Another study,[22] which did not provide the detailed information necessary to calculate effect sizes, reported a 30-minute increase in daily physical activity in the intervention group, with a decline observed among control group participants during the study period.

Compared to the control group, participants in the Physical Activity Across the Curriculum (PAAC) intervention[18] reported significantly greater levels of physical activity both during the school day and outside of school on the weekends. Several studies found significant intervention effects among subgroups of participants (i.e., girls,[42] boys,[38] sixth-graders[15]), whereas the majority reported overall intervention effects.[15,17,18,22,27,30,36,40,42] Students engaged in Instant Recess[29] breaks during the school day significantly increased the proportion of their class time spent in physical activity breaks compared to control, but they showed no significant increases in the proportion of time spent in moderate-to-vigorous physical activity; however, unanticipated funding constraints precluded individual data collection in this trial, so outcomes were based on only an observational classroom-level audit instrument.

Body composition and physiology. Results were somewhat mixed for body composition outcomes in school-based settings. A publication resulting from Happy 10! (an intervention adapted from TAKE 10!)[22] reported a decrease in BMI among girls, and a study[26] aimed at improving bone-related outcomes saw a similar effect in boys. A school-based obesity intervention[20] utilizing a quasi-experimental design observed a protective effect of the intervention on BMI with children in the intervention group maintaining BMI over the study period while significant BMI increases were observed among children in control schools. A dose–response effect was observed in the PAAC study[18]: Those who par-

Table 2. Summary of findings of non-PA outcomes: school-based studies

Outcome	+ (Positive)	0 (Null)	− (Negative)
Body composition and physiology			
BMI	Katz (ABC)[21]	PLAY (Pangrazi)[42] MacKelvie (boys only)[26] Weeks[34] PAAC[18] Richardson[30]	Hollar[20] Happy 10! (girls only)[22]
Lean mass	Weeks[34] MacKelvie (boys only)[26]		
Blood pressure		Richardson[30] (systolic only)	Richardson[30] (diastolic only)
Academic/performance outcomes			
Academic achievement	PAAC[17,18] Sibley[31] Hollar[20]	ASBC[36–38]	
Knowledge	PA—TAKE 10! (Tsai)[33]	Nutrition—TAKE 10! (Tsai)[33]	
Concentration	Caterino (4th grade only)[39]		
Time-on-task behavior	Jarrett[41] Mahar[27] Mitchell[29]	Grieco[19] TAKE 10! (Metzler)[28]	
Inattentive behavior (fidgeting)			TAKE 10! (Metzler)[28] Jarrett[41]
Student use of medication for attention-deficit/ hyperactivity disorder and asthma			Katz[21]
Missouri academic performance scores		Katz[21]	
District work/social skills progress report		Katz[21] (behavior changes)	Katz[21] (Control group performance improved relative to intervention for reading and math)
Other PA-related outcomes			
Engagement in fitness skills/ drills during class time	Mitchell[29]		
Determinants of PA	Jurg (4th grade only)[15]		
Attraction to PA	PLAY (Ernst) (girls only)[40]		

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Table 2. Summary of findings of non-PA outcomes: school-based studies *(continued)*

Outcome	+ (Positive)	0 (Null)	− (Negative)
Abdominal strength	Katz[21]		
Upper body strength	Katz[21]		
Trunk extensor strength	Katz[21]		
Flexibility			Katz[21]
Attitudes toward PA		Katz[21]	
Bone-related outcomes			
Bone area		MacKelvie[25,26]	McKay[16]
Bone mass content	MacKelvie (femoral neck and lumbar spine; early pubertal girls only)[23]; MacKelvie (lumbar spine and total body; boys only)[24]; MacKelvie (femoral neck and lumbar spine)[25,26]; McKay (proximal femur and intertrochanteric region)[16] Weeks (femoral neck, trochanter and whole body)[34]	MacKelvie (other regions; boys only)[26]; MacKelvie (femoral neck and lumbar spine; prepubertal girls only)[23]	
Bone mineral density	MacKelvie (femoral neck and lumbar spine areal and femoral neck volumetric; early pubertal girls only)[23]; MacKelvie (proximal femur area and trochanteric area; boys only)[24]	MacKelvie (femoral neck and lumbar spine areal and femoral neck volumetric; prepubertal girls only)[23]	McKay (total body, bone mineral content)[16]
Broadband ultrasound attenuation	Weeks[34]		
Bone strength index	ASBC (prepubertal boys only)[36–38] Weeks (lumbar spine)[34]	ASBC (girls only)[36–38]	
Polar strength strain index	ASBC (boys only)[36–38]	ASBC (girls only)[36–38]	

Note: Study sites include combination of schools and faith-based organizations. Outcome data were collected from adults only.
ABC, Activity Bursts in the Classroom for Fitness; ASBC, Action School! British Columbia; PA, physical activity; PAAC, Physical Activity Across the Curriculum; PLAY, Promoting Lifestyle Activity for Youth

Table 3. Summary of findings of non-PA outcomes: worksite-based studies

Outcome	+ (Positive)	(Null)	− (Negative)
Worksite-level outcomes			
Changes in work environment	Crawford[47]		
Perceived workplace support PA	Crawford[47]	Dishman[48,49]	
Perceived workplace support healthy food choices	Crawford[47]		
Healthier foods served at staff meetings	Crawford[47]		
PA higher priority at worksite	Crawford[47]		
Staff "very comfortable" encouraging parents to do PA with kids	Crawford[47]		
Change in how staff discuss weight issues with parents	Crawford[47]		
Use of skip-stop vs enclosed stairs	Nicoll[46]		
INDIVIDUAL-LEVEL OUTCOMES			
Body composition and physiology			
Blood pressure			Lara[51]
BMI			Lara (men)[51]
Resting heart rate	Yancey[53]		
Waist circumference			Lara[51]
Weight			Lara (men)[51]
Work-related/performance outcomes			
Data entry speed	Balci (30-minute work/5-minute rest, 15-minute work/micro breaks only)[43]		
Data entry accuracy	Balci (30-minute work/5-minute rest, 15-minute work/micro breaks only)[43]		
Discomfort in shoulder, upper back, chest, knee			Balci (60-minute work/10-minute rest schedule only)[43]
Grip strength	Pronk[52]		
Productivity		Galinsky[45]	
Work performance	Balci (30-minute work/5-minute rest, 15-minute work/micro breaks only)[43]		
Wrist flexion	Pronk (right wrist only)[52]		
Wrist extension	Pronk (left wrist only)[52]		
Nutrition			
Fruit and vegetable intake	Yancey (12 weeks only)[54]		

(continued on next page)

Table 3. Summary of findings of non-PA outcomes: worksite-based studies *(continued)*

Outcome	+ (Positive)	(Null)	– (Negative)
Mood and psychosocial factors			
Anger			Pronk[52]
Commitment	Dishman[48,49]		
Desire to smoke			Daniel (moderate PA after rest only)[44]
Difficulty concentrating			Daniel[44]
Fatigue			Balci (30-minute work/5-minute rest schedule only)[43] Pronk[52]
Feeling state		Galinsky[45]	
Feelings of sadness/depression			Pronk[52] Yancey (12 weeks only)[54]
Goal setting	Dishman[48,49]		
Intention	Dishman[48,49]		
Irritability			Daniel (moderate PA after rest only)[44]
Perceived health status	Yancey[53]		
Restlessness			Daniel (moderate PA after rest only)[44]
Satisfaction	Dishman[48,49] Yancey[53]		
Self-efficacy	Dishman[48,49]		
Self-esteem	Pronk[52]		
Stage of change			
Stress			Daniel (moderate vs light PA only)[44]
Tension			Daniel (after rest only)[44] Pronk[52]

Note: (+) = Significant increase in outcome observed over time or relative to control group; (–) = Significant decrease in outcome observed over time or relative to control group
PA, physical activity

ticipated in ≥75 minutes of the intervention per week reported a significantly lower increase in BMI than those who participated for <75 minutes per week, although no overall effect on BMI was observed. Short, structured physical activity breaks had no effect on BMI among participants of the larger trial for the PLAY intervention[42] or on participants of two bone studies.[26,34] Lean mass was found to increase among intervention participants in the two randomized school-based trials in which it was reported as an outcome.[26,34] Richardson found a significant improvement in diastolic blood pressure over time although no improvements were observed for systolic blood pressure or BMI.

Other physical activity–related outcomes. Short, structured physical activity breaks significantly influenced determinants of physical activity: perceived benefits and strength of habit (i.e., a history of repetition, automatic in nature, and expressing identity) in fourth-graders[15] and increased attraction to physical activity in girls.[40] Another study[21] found that brief activity bursts in the classroom led to significant improvements in a number of fitness measures, including abdominal, upper body, and trunk extensor strength.

Academic/performance outcomes. Of the 17 publications that assessed these outcomes (e.g., achievement, concentration, time-on-task behavior), more than half[17,18,20,21,27–29,31,33,39,41] found that short, structured physical activity breaks led to improvements in at least one outcome, including academic achievement, knowledge, concentration, and time-on-task behavior. The re-

maining publications[19,21,28,33,36–38] reported finding no effect of the intervention on academic-related outcomes. One study[21] found an unexpected decrease in student use of attention-deficit/hyperactivity disorder and asthma medications following brief bout intervention implemented in the classroom. Only one study[21] found a negative effect of a brief bout intervention, with children in the control group showing greater improvements across time in reading and math compared to the intervention group.

Bone-related outcomes. Short, structured physical activity were found in a number of studies to enhance a variety of bone-related outcomes, including femoral neck,[23,25,26,34] lumbar spine,[23–26] trochanter,[34] whole body,[24,34] and proximal femur bone mass content.[16] However, intermittent physical activity did not have an effect on other regions of bone mass content in boys[26] or bone area,[25,26] and in one study had a negative impact on total body bone mineral content.[16] Action Schools! British Columbia[36–38] reported a significant increase in bone strength index and polar strength strain index in boys but no significant effect in girls.

Worksite-Based Studies

Characteristics of workplace-based interventions and participants. The 11 unique worksite interventions we analyzed were implemented in a variety of work settings, with the number of participating employees ranging from 10[43] to 664[48,49] per study. The majority of these studies were based in the U.S. ($n=9$),[43–49,52–54] with one intervention conducted in Mexico[51] and another conducted collaboratively within the United Kingdom, Australia, and Spain.[50] Participating employees were primarily volunteers, although a few studies[48,49,51,52] described physical activity interventions that were conducted as company-wide activities for all employees. Participants were primarily office workers, but settings ranged from a manufacturing plant to a university.

Most of the worksite-based studies analyzed were RCTs except four—an evaluation of a natural experiment,[46] a pre–post evaluation of an intervention implemented across an entire worksite,[51] and two demonstration projects.[52,54] Program characteristics also varied, both in length of time of the exercise bout (ranging from 5 to 15 minutes) and the level of intensity for physical activity (from stationary stretching to aerobic exercise). One program[47] had multiple secondary components, incorporating nutrition education or organizational-level policy changes on nutrition. The duration of the programs also varied; three[43,44,53] were limited to studying the acute effects of exercise in 1 day, but all other interventions lasted between 6 weeks and 3 years, averaging 10.1 months. Interventions structurally integrating physical activity in worksites ranged from set times for activity breaks during the workday to promoting stair use through a change in building design to include a skip-stop elevator and open staircase design. The majority of worksite-based interventions utilized bouts lasting 10–15 minutes, with the rest implementing shorter bouts.

Worksite-level outcomes. Only three studies reported organizational-level outcomes in terms of social support or other sociocultural environmental influences and physical environmental changes. In one study,[47] among the employees from the intervention group, 96% felt their workplace supported their efforts to be physically active, compared to 58% of the control group ($p<0.01$). Similarly, 84% of intervention group employees felt workplace support in making healthy food choices, compared to 28% of the control group ($p<0.001$).[47] Additionally, 72% of those from the intervention group noticed a change in the types of food served at staff meetings, compared to 24% from the control group ($p<0.01$).[47] Another study[48] found significant improvements in management support for physical activity within the intervention group from baseline to follow-up, but these changes were not significantly greater than those observed in the control condition. In one study,[46] the introduction of a nested, carpeted stairwell with an open design combined with a skip-stop elevator (stopping on Floors 1, 4, 7, and 11 only) at one end of an office building found that 72% of surveyed employees used the stairs daily, and the open stairwell registered users 33 times more often than the older, enclosed stairwell and unrestricted elevators at the other end of the building.

Individual-Level Outcomes

Physical activity and sedentary behavior measures. Interventions increased the overall level of physical activity among participants in all studies in which it was assessed, although findings varied in terms of physical activity intensity. Two studies[48,49,54] reported an increase in vigorous physical activity. Studies[48–50] that examined daily pedometer steps also found an increase, with the greatest amount of change among employees categorized as "inactive" at baseline. In general, the magnitude of improvement in physical activity observed were relatively modest. Another study[50] did not observe a reduction in minutes per day spent sitting in a worksite-based walking intervention, although significant increases in daily steps were observed based on pedometer data.

Body composition and physiology. Relatively few studies reported the effect of worksite-based interventions on body composition or physiologic outcomes. One study reported physiologic changes among intervention participants, with some gender-specific results. Another study[51] found small but significant decreases in blood pressure and waist circumference for all study partici-

pants, whereas significant improvements in BMI and weight were observed only for men.

Work-related and performance outcomes. Results were mixed for employee work performance as well. Work ability sometimes was improved by exercise breaks, including an improvement in data entry speed and accuracy that varied by the ratio of time spent working to time spent resting (stretching).[43] However, one study[45] found no significant intervention effect on worker productivity. Several studies[43,52] observed improvements in other occupational health outcomes such as grip strength; wrist flexion and extension; and shoulder, back, chest, and knee discomfort.

Mood and psychosocial factors. Studies reported on a broad range of mood and psychosocial factors that are relevant in worksite settings. Overall, studies[44,48,49,52,54] found an improvement in self-efficacy or self-esteem, improved perception of health status, and decreases in feelings of stress or depression. Interestingly, these findings held in one study population undergoing tobacco withdrawal symptoms,[44] where participants also felt less irritability and less of a desire to smoke.

Discussion

Summary

Elementary, junior high, and preschools were the most common setting for studies included in this review. The quality of the studies varied by setting, with three quarters of worksite studies, but only one quarter of school studies, using an RCT design. Another one quarter of school-based designs were controlled but nonrandomized (quasi-experimental). Physical activity commonly was assessed, with the majority of studies finding a significant increase in physical activity, in most cases with moderate to large effect sizes. Weight-related outcomes (i.e., BMI, lean mass) were assessed less commonly, with about half finding significant improvements in BMI and lean mass and the other half observing no intervention effect or an effect in only certain subgroups (e.g., by age or gender) or dependent on the intensity of the intervention implementation. Outcomes relevant to academic performance were assessed in a large number of studies, with more than half of publications finding positive effects on at least some academics-related outcomes, such as academic achievement, cognitive performance, and on-task behavior.

Worksite-based interventions were designed more rigorously (as earlier noted, 75% were RCTs), yielding generally positive findings, particularly with regard to physical activity. Most studies that assessed physical activity observed modest but significant improvements in this outcome. Improvements in worksite-level outcomes such as social support for physical activity from peers and employers as well as changes in policies related to healthy food offerings were observed in one of the two studies that assessed these outcomes. Fewer studies reported physiologic outcomes such as BMI, blood pressure, waist circumference, or fitness measures. Results of these studies were inconsistent, with some studies finding overall improvements in intervention participants whereas other studies found no effects or improvements among only subgroups of participants. Improvements in mood and a wide range of psychosocial factors commonly were observed in studies reporting on these outcomes. The effect of short exercise bouts on work performance outcomes were mixed, although no adverse effects (e.g., increases in injuries or lowered productivity) were observed in the studies included in this review. The greater potential for sustainability of these interventions is notable, compared with traditional low-cost, individual-level worksite physical activity promotion efforts (e.g., Green et al.[56]).

Only one study was identified that met the inclusion criteria that integrated short physical activity bouts into faith-based settings. That demonstration project found significant improvements in most outcomes, including self-reported and accelerometer-assessed physical activity and diastolic blood pressure. Interestingly, another faith-based intervention[57] in African-American churches, one of the few targeting physical activity, produced no main effect on physical activity; although this project[58] included exercise breaks as a minor element (Exercise Your Faith for 10), the focus was on 8 Steps to Fitness,[59] a traditional, individual-level behavioral change intervention. This was one of several studies that were excluded from the current review because exercise breaks were not the main physical activity intervention (e.g., Racette et al.[60]) or because no outcome data were presented (e.g., Bellows and colleagues[61]).

Taken together and weighing more heavily data from more rigorously designed trials, these studies provide promising evidence to support the effectiveness of short bouts of physical activity on the accumulation of meaningful amounts of daily physical activity. The evidence for these interventions across other outcomes is promising but more tenuous in aggregate. Future research that uses randomized designs and long-term follow-up and assesses physical activity, attitudinal, body-composition, and physiologic outcomes is needed.

Limitations

This is a relatively "young" and emerging field of research, as is true for all policy and environmental physical activity promotion intervention. The majority of interventions to promote physical activity in the literature have used "exercise prescriptions," typically directing participants to engage in physical activity bouts of at least 20 minutes' duration a certain number of days per week. Relatively few studies have examined effects of physical activity accu-

mulated in short bouts or their effect on other relevant weight-related, physiologic, or performance-based outcomes. In addition, a number of published studies have included brief bouts as peripheral components of more comprehensive interventions, and thus were not included in the current review. Examples of such studies include the Health eAME project,[58] Shape Up Somerville,[62] Muevete Bogota,[63] Agita Sao Paolo,[64] and Food Friends Get Movin' With Mighty Moves.[61]

The quality of studies included this review varied by setting, particularly with regard to school-based interventions. In summarizing the literature regarding the effectiveness of brief bouts of physical activity, there is a balance to achieve between what can be learned from RCTs versus studies using more externally valid designs. Tightly controlled trials rarely inform us of how an intervention will ultimately improve population health when implemented widely. Uncontrolled trials or those with inadequate comparison groups may lead to inappropriate conclusions given selection biases or changes due to secular trends. Variability of study designs in school-based interventions is somewhat expected given the complexity of working in this setting, in terms of massive and highly prescriptive bureaucracies, human subjects constraints involving children, and contextual variations not adequately captured in available SES and geographic measures. The quality of studies was higher for workplace-based studies, where more scientific control may be feasible. The results of these studies in general were more positive across a variety of outcomes. To date, very little research has evaluated the effect of integrating brief physical activity bouts into faith-based settings; thus future research in this area is needed. There are a number of current ongoing studies that may shed light on these issues in the near future.

In addition, the interventions implemented within each study in this review varied widely, particularly with regard to intensity. The modal duration of physical activity bouts in studies in this review was 10 minutes, which is consistent with CDC and ACSM recommendations. However, the duration of physical activity delivered varied widely and had not always been readily measurable, precluding conclusions about the minimum dose needed to effect relevant outcomes.

This review was designed to be as inclusive as possible to better balance external and internal validity. The reigning dogma when conducting systematic reviews has typically directed the sacrifice of the former at the expense of the latter. However, the reductionist "medical model" premise that efficacious interventions may be plucked from the context in which they were developed and plopped in another, preserving effects with minimal adaptation, has little to no empirical support in applied public health research. Furthermore, these findings must be interpreted in light of the fact that most studies did not report process evaluation data. Thus, when null effects are observed, one cannot with confidence attribute the lack of the effect to the intervention itself versus the marketing of the intervention. For example, stair prompts did not work among African Americans in the first shopping mall study,[65] but this disparity was rectified subsequently by the inclusion of a photograph of an African American in the promotional poster.[66] Another challenge in identifying studies to be included in this review was the lack of consistent definitions or terminology to characterize this type of physical activity intervention.

Although data from well-conducted randomized trials promoting brief bouts of physical activity are limited, the result of the current review complements a growing body of observational literature that supports a link between reduced sedentary behavior and improvements in body composition (BMI, waist circumference); physiologic markers (triglycerides, glucose levels); and some health outcomes (i.e., metabolic syndrome) (Healy et al.[67]; Sisson et al.[68]), independent of physical activity levels. Sedentary behavior has been examined in several ways, including assessment of total sedentary behavior (time spent sitting, watching TV, computer work, commuting) as well as the length of periods of uninterrupted sedentary behavior. Another line of research has proposed that reductions in nonexercise activity thermogenesis or NEAT (energy expended on all physical activity except for purposeful exercise) resulting from increases in mechanization and automation of society over time may be an important contributor to the alarming increases in the prevalence of overweight and obesity observed in the past several decades (Levine et al.[69]; Levine and Kotz[70]).

Conclusion and Implications for Future Research

Given the failure of individually focused education and counseling to stem the tide of the chronic disease and obesity epidemics, interventions that aim to reintegrate physical activity into organizational routine in everyday life are promising avenues of practice and policy change and research investigation.

Widespread modifications to the built environment and macro-level policy changes hold the greatest potential to improve population health; however, these strategies will take decades to implement and enormous political will to realize. Additional studies utilizing more rigorous methodology are needed to more definitively quantify the effects of brief bouts of physical activity on relevant outcomes. It is particularly important that studies collect and report process data about how the intervention was developed and implemented and by whom. This information is necessary in understanding not only

intervention effectiveness but also feasibility and sustainability of approaches across time and diverse settings.

However, the academic pitfall of making "the perfect the enemy of the good" must be avoided. This evidence is arguably as strong or stronger than, for example, that supporting the effectiveness of stair-use prompts in increasing population physical activity levels at the time this strategy was deemed an evidence-based physical activity promotion practice,[14] and markedly stronger than that undergirding smoking bans 20 years ago, or trans fat bans, restaurant menu labeling, or soda excise taxes today. As the recent IOM childhood obesity reports[71–73] strongly have advocated, we must act on the best available evidence, and rigorously evaluate the results.

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