Evaluating correlates of adolescent physical activity duration towards National Health Objectives: analysis of the Colorado Youth Risk Behavioral Survey, 2005

Stephen Nkansah-Amankra1, Abdoulaye Diedhiou2, Harry L.K. Agbanu3, Mariana Toma-Drane4, Ashish Dhawan5

1School of Human Sciences, University of Northern Colorado, 501-20th Street, Campus Box 93, Greeley, CO 80639, USA
2South Carolina Public Health Consortium, University of South Carolina, Columbia, SC 29208, USA
3Department for the Study of Religions, University of Ghana, Legon-Accra, Ghana
4Hazard and Vulnerability Research Institute, University of South Carolina, Columbia, SC, USA
5Monmouth Medical Center, Long Branch, NJ 07740, USA

Address correspondence to Stephen Nkansah-Amankra, E-mail: Stephen.Namankra@unco.edu

ABSTRACT

Background While numerous studies have examined the relationships among correlates of physical activity (PA), less attention has been given to identifying the correlates of low PA duration. The main objective of the current study was to examine correlates of low PA duration, team sports participation and smoking behaviors among adolescents.

Methods Data from the 2005 Colorado Youth Behavioral Risk Survey were analyzed using Cox proportional hazard models. We evaluated associations between two measures of low PA duration, assessed as per Healthy People 2010 (HP2010) objectives and 2008 Physical Activity Guidelines (PAG) for Americans, and smoking behaviors, participation in the physical education (PE) and team sports, controlling for age, gender and other behavioral characteristics.

Results Forty percent and 70%, respectively, of adolescents did not meet the 2008 PAG and HP2010 objectives. After adjustment, smoking remained associated with failure to meet the 2008 PAG. However, no significant relationship was found with low PA duration as per the HP2010 objectives. The risk of low PA was higher among girls for both outcome measures. Likewise, adolescents who reported no participation in team sports presented a 7-fold higher risk of low PA as per the 2008 PAG and 51% higher risk of low PA as per the HP2010 objectives compared with the group with team sports participation.

Conclusions Regular participation in school PE and team sports may represent an important avenue for increasing PA duration and reducing smoking behaviors among adolescents.

Keywords health promotion, public health, smoking

Introduction

Benefits of physical activity (PA) and deleterious effects of cigarette smoking on numerous health outcomes have been consistently reported in different population groups across a variety of contexts.1–5 Adolescents are a population group for which PA maintenance is reported to be associated with self-body image, improved interpersonal relationships, high academic achievements and improved mental health functioning.6,7 According to the Healthy People 2010 (HP2010) and the 2008 PAG for Americans, regular PA over a period of time produces enduring health benefits to the individuals.
and further leads to overall improved population health. The 2008 PAG specifically recommends that adolescents are engaged in at least 60 min of daily moderate or vigorous-intensity PA to achieve the optimal health benefits. Additional findings from these national guidelines indicate that adolescents also gain substantial benefits if, as part of their 60 min daily activity, they are involved in any combination of vigorous-intensity, and muscle and bone strengthening activities for at least 3 days/week.\(^8\) In 2005, only 36% of students in Grades 9–12 in the USA met this recommendation in the week prior to the survey.\(^9\) Similarly, according to the HP2010 objective, benefits from PA are also achieved with 30 min of moderate leisure time aerobic activity for 5 or more days/week.\(^10\) One of the national goals for the HP2010 is to increase the proportion of adolescents meeting the recommended levels of PA to at least 85%. In 2005, only 69% of adolescents in Grades 9–12 in the USA met the HP2010 requirements. Gender and racial/ethnic differences exist to suggest that males and non-Hispanic white students are more likely to adhere to the recommended PA level than females or non-Hispanic black students.\(^11–15\)

A thorough understanding of how adolescent smoking behaviors and participation in team sports or in-school PE might be related to the recommended PA is crucial to designing successful smoking cessation programs and interventions to increase duration of PA or participation in team sports. The purpose of this study was to evaluate factors associated with low PA duration, and the extent to which adolescent smoking is related to lower PA duration. In addition, we assessed whether those relationships are modified by gender.

**Methods**

**Study design and data source**

We analyzed the cross-sectional data from the 2005 Colorado Youth Risk Behavior Survey (YRBS). In Colorado, the YRBS is a biannual survey conducted as a joint effort of the Centers for Disease Control and Prevention with several state agencies and other implementing partners. Further details of survey design and psychometric properties of questionnaire items of the YRBS are available in other publications.\(^16–18\) In 2005, the survey’s response rate was approximately 60%. The questionnaire items for different years were different, and only the 2005 survey data contained consistent items relevant for the current analysis. The University of Northern Colorado (UNC) Institutional Review Board (IRB) approval was obtained before the analysis.

**Measures**

**Dependent variable**

We measured the **PA duration** based on the number of days had been moderately or vigorously active in the 7 days prior to the survey. Vigorous PA was defined in the survey as exercise or PA ‘that made respondents sweat and breathe hard, such as basketball, soccer, running, swimming laps, fast bicycling, fast dancing, or similar aerobic activities’. Moderate PA referred to activity ‘that did not make (respondents) sweat or breathe hard, such as fast walking, slow bicycling, skating, pushing a lawn mower or mopping floors’. The validity of the PA survey items in the YRBS is consistent with recommendations of PA for youth.\(^10,16,19\) To establish categories of PA duration, we used recommendations from the 2008 PAG for Americans and the HP2010 objectives. As per the HP2010 objectives, PA duration was ‘low’ when adolescents did not meet the recommended 30 or more minutes of moderate PA at least 5 days/week or 20 or more minutes of vigorous PA at least 3 days/week and ‘high’ otherwise. As per the 2008 PAG, PA duration was categorized as ‘low’ when adolescents did not report any combination of vigorous-intensity, and muscle and bone strengthening activities totaling at least 180 min, and ‘high’ otherwise.

**Independent variables**

The main predictor was **smoking status**, defined based on respondents’ current cigarette smoking in the 30-day period to the survey. Consistent with Gilliland et al.,\(^20\) respondents were categorized into the following three groups according to the number of days students reported smoking cigarettes in the month preceding the interview: non-smokers (never tried to smoke), infrequent smokers (smoked 1–5 days) and regular smokers (continuous smoking for at least 6 days).

**Participation in PE** combined two survey items asking the number of days in an average school week a student attended PE classes, and the actual time spent exercising while in PE. Consistent with an earlier study,\(^21\) participation in the PE was categorized as ‘low’ (0–1 day of PE class and/or <10 min of exercise), ‘moderate’ (2–3 days of PE class and/or 10–30 min of exercise) and ‘high’ (4–5 days of PE class and/or >30 min of exercise). **Participation in team sports** was categorized as ‘low’ (did not participate in any team sports), ‘moderate’ (participated in one or two team sports) and ‘high’ (participated in three or more team sports). **Perception of body image** was assessed from responses to a question asking adolescent how they will describe their weight; and was categorized as ‘low weight’ (very underweight and slightly underweight), ‘normal weight’ (about the
right weight) and ‘overweight’ (slightly overweight and very overweight). Psychological health was dichotomously assessed as sadness or hopelessness present or absent based on respondent’s response to a questionnaire item.21,22

Data analysis

Analyses were performed with SAS Callable SUDAAN version 10.0 (RTI, Research Triangle Park, NC). Data analyses incorporated survey weights to account for the complex survey design, and to ensure estimation of appropriate variances. The Rao–Scott $\chi^2$ test was used to compare categorical variables while the adjusted association between duration of PA (time to event) and smoking and other risk behaviors was evaluated using Cox proportional hazard models. Variable selection into the multivariable hazard models was based on criteria suggested by Hosmer and Lemeshow.23 Effects were measured as relative risks (hazard ratios). Adolescents meeting or exceeding the recommended combination of number of days and minutes per day of PA were considered censored at the time of the survey. Covariates for the Cox proportional hazard regression models were included via a series of steps. First, we adjusted for age; variables that were not significantly associated with low PA duration were not considered for inclusion in subsequent steps. In a second step, all variables were simultaneously included in the model to assess independent relationships with low PA duration. Various combinations of interactions between smoking and gender, age and expression of sadness were tested. Model fit was evaluated under proportional hazard assumptions using the Wald test for individual predictors and the partial likelihood ratio test for the global test. Finally we performed analyses stratified by gender because previous studies have shown differences in PA duration levels between boys and girls.11,24 Due to limited statistical power, regression analyses were not stratified by race/ethnicity. Statistical significance was set as $P < 0.05$.

Results

Sample description and bivariate relationships

Table 1 shows that, regardless of gender, adolescent smokers were more likely to be Hispanic, older (15–18 years), to have a high participation in school PE, but limited or no participation in team sports, and to watch TV more than 2 h on an average school day. Smokers were also more likely to describe themselves as overweight and to express feelings of sadness or hopelessness. Table 2 shows weighted percentage distribution of low PA duration determined by either standard. Using the 2008 PAG, more than 40% of high school students in the state (consisting of 24% of females and 16% of males) were classified as not meeting the recommended guidelines. However, this proportion rose to 70% when considering HP2010 objectives (made of 34% of boys and 36% of girls). Generally, females, Hispanics, students viewing TV 2 or more h/day, students reporting limited to no participation in team sports or school PE, and student reporting feelings of sadness/hopelessness or describing themselves as overweight were more likely to have low PA duration as per either standard.

Multivariate associations

After controlling for adolescent demographic and behavioral characteristics (Table 3), smoking remained significantly associated with failure to meet the 2008 PAG. However, no significant relationship was found between smoking and low PA duration as per the HP2010 objectives. Other association patterns between covariates and low PA duration were found. The risk of low PA was higher among girls compared with boys for both measures of PA duration. While Hispanic adolescents were at 32% higher risk of not meeting the 2008 PAG, non-Hispanic blacks and other minorities were at a higher risk for low PA as per the HP2010 standards. Low participation in school PE classes was associated with a 65% higher risk of low PA as per the 2008 PAG and a 15% risk of low PA as per the HP2010 objectives but the latter was not statistically significant. The most consistent factor associated with low PA duration was non-participation in team sports. Compared with their peers who reported higher levels of participation in team sports, adolescents who reported moderate and no participation presented respective risks of 3- and 7-folds of low PA as per the 2008 PAG. Using the HP2010 objectives, risks of low PA duration were only 25 and 51% higher, respectively, for adolescents with moderate and no participation in team sports.

Gender differences in PA duration

In adjusted gender-stratified analyses (Table 4), smoking was not significantly associated with low PA for either guideline. Among boys, the risk of low PA duration as per the 2008 PAG for Hispanics was 48% higher than for non-Hispanic whites. However, this relationship was not found for low PA per the HP2010. The risks of low PA (per HP2010) among Latino and other non-Hispanic black and other minority girls were, respectively, 65 and 44% higher when compared with their non-Hispanic white peers. When comparing boys not participating in school PE classes with peers...
participating fully in PE classes, the relative risk for low PA
as per the 2008 PAG was more than 2.5-folds. Limited to
no participation in team sport showed consistent relation-
ships with low PA for either standard.

**Discussion**

**Main findings of this study**

Our study found that a higher proportion of adolescents
were classified as physically inactive based on HP2010 guide-
lines than on the 2008 PAG. This discrepancy may be related
to the absence of duration and frequency requirements for
the 2008 PAG; instead the guideline puts much emphasis on
the total volume of PA in order to achieve the desired health
benefits. Thus, the 2008 PAG allow adolescents to meet the
guidelines with various combinations of aerobic activities
that add up to at least 180 min/week of vigorous-intensity, and
muscle and bone strengthening activities. The 2008 PAG
represent the most recent evidence of the health benefits of
PA. Smoking appeared to be significantly associated with low
PA duration as per the 2008 PAG but not with low PA as per
the HP2010 guideline.

### Table 1

Selected demographic and behavioral characteristics of adolescents in 2005 Colorado YRBS, according to gender and smoking status

<table>
<thead>
<tr>
<th>Variables</th>
<th>Female sample, n = 700&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Male sample, n = 798&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes (%)</td>
<td>No (%)</td>
</tr>
<tr>
<td>------------------------------------</td>
<td>----------------------------------</td>
<td>----------------------------------</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12–140</td>
<td>37.1</td>
<td>62.9</td>
</tr>
<tr>
<td>15–18</td>
<td>50.5</td>
<td>49.5</td>
</tr>
<tr>
<td>Race/ethnicity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hispanic</td>
<td>54.1</td>
<td>45.9</td>
</tr>
<tr>
<td>Non-Hispanic White</td>
<td>44.8</td>
<td>55.2</td>
</tr>
<tr>
<td>Non-Hispanic black and others</td>
<td>50.0</td>
<td>50.0</td>
</tr>
<tr>
<td>PE participation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>48.8</td>
<td>51.2</td>
</tr>
<tr>
<td>Moderate</td>
<td>47.5</td>
<td>52.5</td>
</tr>
<tr>
<td>Low</td>
<td>47.6</td>
<td>52.4</td>
</tr>
<tr>
<td>Team sports (number)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥3</td>
<td>25.2</td>
<td>74.8</td>
</tr>
<tr>
<td>1–2</td>
<td>47.8</td>
<td>52.2</td>
</tr>
<tr>
<td>0</td>
<td>55.0</td>
<td>45.0</td>
</tr>
<tr>
<td>TV viewing (hours)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>42.3</td>
<td>57.7</td>
</tr>
<tr>
<td>1–2</td>
<td>39.3</td>
<td>60.7</td>
</tr>
<tr>
<td>&gt;2</td>
<td>55.9</td>
<td>44.1</td>
</tr>
<tr>
<td>Self-body image</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal weight</td>
<td>45.6</td>
<td>54.4</td>
</tr>
<tr>
<td>Low weight</td>
<td>44.4</td>
<td>55.6</td>
</tr>
<tr>
<td>Overweight</td>
<td>54.0</td>
<td>46.0</td>
</tr>
<tr>
<td>Feeling sadness/hopelessness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>40.1</td>
<td>59.9</td>
</tr>
<tr>
<td>Yes</td>
<td>61.3</td>
<td>38.7</td>
</tr>
</tbody>
</table>

<sup>a</sup>Weighted percentage representative of all high school students in Colorado and adjusted for the complex survey design of the YRBS. Totals may not add to 100% due to rounding errors.

<sup>b</sup>Unweighted sample distribution of students participating in the 2005 Colorado YRBS.

*All <i>P</i>-values associated with the Rao–Scott <i>χ</i><sup>2</sup> test are <0.001.
These findings are generally consistent with a number of cross-sectional and longitudinal studies examining cognitive competence beliefs, PA and smoking behaviors among adolescents. In at least three of these studies, smoking has been found to be inversely related to PA duration.

Table 2 Unadjusted correlates of PA duration among adolescents participating in 2005 Colorado YRBS, by standard of PA

<table>
<thead>
<tr>
<th>Covariates</th>
<th>PA level</th>
<th>Per 2008 PA guidelines (%)</th>
<th>Per HP2010 recommendations (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td></td>
<td>67.7</td>
<td>32.3</td>
</tr>
<tr>
<td>Female</td>
<td></td>
<td>51.4</td>
<td>48.6</td>
</tr>
<tr>
<td>Race/ethnicity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-Hispanic white</td>
<td></td>
<td>63.8</td>
<td>36.2</td>
</tr>
<tr>
<td>Non-Hispanic black and others</td>
<td></td>
<td>60.1</td>
<td>39.9</td>
</tr>
<tr>
<td>Hispanic</td>
<td></td>
<td>46.2</td>
<td>53.8</td>
</tr>
<tr>
<td>Smoking status</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td></td>
<td>65.6</td>
<td>34.4</td>
</tr>
<tr>
<td>Yes</td>
<td></td>
<td>54.0</td>
<td>46.0</td>
</tr>
<tr>
<td>Number of days smoked cigarettes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
<td>65.6</td>
<td>34.4</td>
</tr>
<tr>
<td>1–5</td>
<td></td>
<td>59.8</td>
<td>40.2</td>
</tr>
<tr>
<td>6–30</td>
<td></td>
<td>55.4</td>
<td>44.6</td>
</tr>
<tr>
<td>PE participation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High</td>
<td></td>
<td>65.3</td>
<td>34.7</td>
</tr>
<tr>
<td>Moderate</td>
<td></td>
<td>70.9</td>
<td>29.1</td>
</tr>
<tr>
<td>Low</td>
<td></td>
<td>53.8</td>
<td>46.2</td>
</tr>
<tr>
<td>Team sports (number)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥3</td>
<td></td>
<td>88.9</td>
<td>11.1</td>
</tr>
<tr>
<td>1–2</td>
<td></td>
<td>66.2</td>
<td>33.8</td>
</tr>
<tr>
<td>0</td>
<td></td>
<td>39.5</td>
<td>60.5</td>
</tr>
<tr>
<td>Self-body image</td>
<td></td>
<td></td>
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<tr>
<td>Normal weight</td>
<td></td>
<td>62.8</td>
<td>37.2</td>
</tr>
<tr>
<td>Underweight</td>
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<td>58.4</td>
<td>41.6</td>
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<td>Overweight</td>
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<td>53.0</td>
<td>47.0</td>
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<tr>
<td>Feeling sadness/hopelessness</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td></td>
<td>62.0</td>
<td>38.0</td>
</tr>
<tr>
<td>Yes</td>
<td></td>
<td>53.0</td>
<td>47.0</td>
</tr>
<tr>
<td>Television viewing (hours)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
<td>61.5</td>
<td>38.5</td>
</tr>
<tr>
<td>1–2</td>
<td></td>
<td>63.0</td>
<td>37.0</td>
</tr>
<tr>
<td>≥2</td>
<td></td>
<td>56.9</td>
<td>43.1</td>
</tr>
</tbody>
</table>

HP, healthy people.

*Based on the 2008 PAG for Americans (at least 180 min/week of any combinations of vigorous-intensity, and muscle and bone strengthening activities).

*Based on the 2010 YRBS, Colorado, and are adjusted for the complex survey design of the YRBS.

Totals may not add to 100% due to rounding errors.

*All P-values associated with the Rao–Scott $\chi^2$ test are < 0.001.
among adolescents. However, these effects were independent of participation in school PE lessons or inter-schools scholastic sports participation.

The epidemiological evidence supporting the association of smoking with PA duration has been mixed.29 – 31 Direct comparisons of studies are particularly problematic because of differences in study designs, PA measurements, variables operationalized, types of activities measured (leisure time, active commuting to school, household activities) and the fact that most activities among adolescents are often unplanned and sporadic, which some studies do not account for in assessing these relationships.29 Prochaska et al.19 found smoking relapses to be associated with low PA duration between control and intervention groups in a randomized trial of 407 adult smokers from San Francisco Bay area.

A study by Kujala et al.32 tracking Finnish adolescents to adulthood found persistent physical inactivity as the strongest predictor of smoking in young adulthood. An earlier prospective study found a decline in the PA among non-Hispanic black and white adolescent girls with increasing age, but the decline was higher among non-Hispanic white smokers.33 Two other studies found moderately active or inactive adolescents to be more susceptible to smoking initiation.34,35 However, a study by Tao et al.36 among a Chinese adolescent cohort, did not find a protective relationship between PA and risk of smoking. In a systematic review of the long-term impact of a school-based smoking cessation programs Wiehe et al.30 found no evidence of long-term effectiveness of smoking cessation programs on PA duration.

### Table 3  Likelihood of low PA duration among adolescents participating in 2005 Colorado YRBS, by standard of PA

<table>
<thead>
<tr>
<th>Variable</th>
<th>Low PA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>As per the 2008 PAG&lt;sup&gt;a&lt;/sup&gt; (n = 513)</td>
</tr>
<tr>
<td></td>
<td>HR (95% CI)</td>
</tr>
<tr>
<td>Gender</td>
<td>Reference</td>
</tr>
<tr>
<td>Male</td>
<td>Reference</td>
</tr>
<tr>
<td>Female</td>
<td>1.51 (1.20, 1.91)**</td>
</tr>
<tr>
<td>Race</td>
<td>Reference</td>
</tr>
<tr>
<td>non-Hispanic white</td>
<td>Reference</td>
</tr>
<tr>
<td>non-Hispanic black and others</td>
<td>1.04 (0.79, 1.38)</td>
</tr>
<tr>
<td>Hispanic</td>
<td>(1.10, 1.86)*</td>
</tr>
<tr>
<td>Smoking status</td>
<td>Reference</td>
</tr>
<tr>
<td>Non-smoker</td>
<td>Reference</td>
</tr>
<tr>
<td>Smoker</td>
<td>1.36 (1.08, 1.75)*</td>
</tr>
<tr>
<td>PE participation</td>
<td>Reference</td>
</tr>
<tr>
<td>High</td>
<td>Reference</td>
</tr>
<tr>
<td>Moderate</td>
<td>1.22 (0.79, 1.57)</td>
</tr>
<tr>
<td>Low</td>
<td>1.65 (1.13, 2.42)*</td>
</tr>
<tr>
<td>Number of team sports</td>
<td>Reference</td>
</tr>
<tr>
<td>≥3</td>
<td>Reference</td>
</tr>
<tr>
<td>1 – 2</td>
<td>3.31 (2.12, 5.16)**</td>
</tr>
<tr>
<td>0</td>
<td>7.20 (4.67, 11.08)**</td>
</tr>
<tr>
<td>Feeling sadness/hopelessness</td>
<td>Reference</td>
</tr>
<tr>
<td>No</td>
<td>Reference</td>
</tr>
<tr>
<td>Yes</td>
<td>0.90 (0.76, 1.07)</td>
</tr>
</tbody>
</table>

Significant interactions exist between age and smoking for both PA standards: HR for low PA as per the 2008 PAG: 2.89; 95% CI: 1.55, 5.41 and HR for low PA as per the HP2010: 1.87; 95% CI: 1.06, 3.28). HR, hazard ratio; CI, confidence interval.

*Based on the 2008 PAG for Americans (at least 180 min/week of any combinations of vigorous-intensity, and muscle and bone strengthening activities).

<sup>a</sup>Based on the Healthy People 2010 objectives (30 min of PA/day, at least 5 days/week).

*P < 0.05; **P < 0.01. All models are adjusted for age, body image perception and TV viewing.
What this study adds

In this study, the most important correlates of low PA duration are limited or lack of participation in school PE and team sports. These findings suggest that the decline in-school PE attendance and non-participation in extracurricular activities related to team sports might constitute important reasons for physical inactivity and student involvement in behaviors unimimal to improved health among this population. Thus, in spite of longstanding intuitive benefits of in-school PE towards improved child health and positive health outcomes in adulthood, the capacity of school PE curricula to meet the national health objectives has been questioned in recent studies.29,37,38 Most contentious in this discourse is the failure of school PE curricula to improve the quality and quantity of students’ PA in a manner that responds effectively to the national public health objectives.29,39,40 For example, some studies demonstrate a precipitous decline in the PE participation among 9th–12th grade students across the USA to the extent that in some instances <25% are regularly engaged in daily PA.29,37 Evidence also suggests that more emphasis on competitive sports in PE curricula reduces enthusiasm and deters the non-athletic and less gifted students from participation, even though a recent national policy statement attempts to de-emphasize the role of competitive team sports in school PE.39 Nonetheless, adolescents engaged in PA or team sports might appear to be self-motivated and conscious of other health risks that are potentially detrimental to health.6,38 In addition, rules of team sports may prohibit young people from engaging in behaviors that compromises health.41,42 However, further investigations are needed to delineate the explicit causal pathways.39 It is clear from this and other studies that PA and participation in team sports probably provide rewards that could potentially prevent sustenance of adolescent smoking behaviors.

Table 4 Likelihood of low PA duration among adolescents participating in 2005 Colorado YRBS, by gender and standard of PA.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Adolescent males (n = 704)</th>
<th></th>
<th></th>
<th></th>
<th>Adolescent females (n = 632)</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low PA as per 2008</td>
<td>Low PA as per PAG (n = 225)</td>
<td>Low PA as per HP2010 (n = 228)</td>
<td>Low PA as per 2008</td>
<td>Low PA as per PAG (n = 288)</td>
<td>Low PA as per HP2010 (n = 163)</td>
<td>Low PA as per 2008</td>
<td>Low PA as per PAG (n = 288)</td>
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<tr>
<td>Race</td>
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<tr>
<td>Non-Hispanic white</td>
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<td>Reference</td>
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<tr>
<td>Non-Hispanic black and others</td>
<td>1.27 (0.98, 1.63)</td>
<td>1.17 (0.91, 1.51)</td>
<td>0.97 (0.57, 1.65)</td>
<td>1.65 (1.11, 2.46)*</td>
<td>1.17 (0.88, 1.57)</td>
<td>1.44 (1.20, 1.72)**</td>
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<tr>
<td>Hispanic</td>
<td>1.48 (1.02, 2.15)**</td>
<td>1.03 (0.76, 1.42)</td>
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<tr>
<td>Smoker</td>
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<tr>
<td>Yes</td>
<td>1.36 (0.94, 1.99)</td>
<td>0.90 (0.75, 1.07)</td>
<td>1.30 (0.94, 1.80)</td>
<td>0.98 (0.77, 1.24)</td>
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<td>PE participation</td>
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<td>High</td>
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<td>Moderate</td>
<td>1.52 (0.94, 2.45)</td>
<td>1.22 (0.95, 1.56)</td>
<td>1.02 (0.70, 1.49)</td>
<td>1.37 (1.08, 1.76)*</td>
<td>1.22 (0.82, 1.82)</td>
<td>1.18 (0.93, 1.50)</td>
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<td>Low</td>
<td>2.61 (1.64, 4.14)**</td>
<td>1.17 (0.92, 1.48)</td>
<td>1.22 (0.82, 1.82)</td>
<td>1.18 (0.93, 1.50)</td>
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<td>Team sports</td>
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<td>≥ 3</td>
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<tr>
<td>1–2</td>
<td>2.52 (1.65, 3.85)**</td>
<td>1.23 (0.91, 1.68)</td>
<td>4.17 (1.87, 9.32)**</td>
<td>1.28 (0.93, 1.50)</td>
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<tr>
<td>0</td>
<td>6.31 (3.88, 10.27)**</td>
<td>1.67 (1.16, 2.42)**</td>
<td>7.92 (3.41, 18.38)**</td>
<td>1.34 (1.01, 1.78)*</td>
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<td>Feeling sadness</td>
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<tr>
<td>Yes</td>
<td>0.74 (0.44, 1.26)</td>
<td>0.90 (0.75, 1.07)</td>
<td>1.00 (0.87, 1.15)</td>
<td>1.00 (0.66, 1.51)</td>
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</tbody>
</table>

HR, hazard ratio; CI, confidence interval.
*Based on the 2008 PAG for Americans (at least 180 min/week of any combinations of vigorous-intensity, and muscle and bone strengthening activities).
**Based on the Healthy People 2010 objectives (30 min of PA/day, at least 5 days/week).
*P < 0.05; **P < 0.01. All models are adjusted for age, body image perception and TV viewing.
There are no statistically significant interactions among variables.
**Limitations**

First, PA duration and smoking patterns were self-reported and therefore could be subject to biases associated with social desirability and memory losses. In addition, PA entails a complex set of behaviors involving bodily movement, which are often spontaneous and intermittent among children. Therefore, capturing these varied activities with a high degree of accuracy using survey instruments is very challenging. Such inaccuracies in measuring PA would result in a systematic outcome misclassification. Using salivary or blood nicotine levels for smoking exposure and accelerometers for PA would provide a more objective measure. Nonetheless, moderate levels of concordance between YRBS PA items and Actigraph accelerometer readings have been reported. Second, our data were from an observational cross-sectional study, thus we could only assess associations, not causation. Indeed, findings from other studies suggest that parental social class or social status and neighborhood contexts (including crime, violence and incivilities) are significant factors in children’s participation in organized sports and PA. We did not have information available with our data to assess these relationships, and therefore could not rule out completely the possibility of confounding effects associated with these contexts. Assessment of these contextual effects on adolescent PA duration should be the focus of future studies. The National Longitudinal Study of Adolescent Health (Add Health) in the USA might provide a unique opportunity to explore these relationships prospectively in future studies than was available in the current study. Third, smoking status used in the analysis only reflects smoking in the past 30 days prior to the survey, and thus could not capture lifelong smokers in the 12 months period as well as ex-smokers. Therefore, smoking prevalence presented in the analysis likely underestimates smoking prevalence among adolescents participating in this study. Fourth, the response rate of 60% might have limited the study’s ability (statistical power) to detect other significant relationships in the current analysis. Wide confidence intervals around many of the OR estimates was evidence of generally low precision. Information gathered (and analyzed) is likely subject to error and bias due to reduced response rate, thus a caution is needed in making generalization to the underlying population of adolescents across the state of Colorado, USA. However, a survey response rate of 60–69% is considered acceptable by experts. Nonetheless, the strength of the study is its population base. In addition we used Cox proportional hazard modeling, a statistical technique that is more powerful than other methods of non-parametric data analysis, and controlled for a relatively large number of potential confounders.

**Implications**

Physical inactivity is a significant determinant of obesity, while smoking is incontrovertibly related to numerous poor health outcomes. Achieving increased PA duration to meet the recommended guidelines among this population is contingent upon generating the needed enthusiasm rather than focusing on health benefits per se. School PE programs may be necessary for increasing PA duration among this population, but might not be sufficient to address critical national objectives of improved adolescent health due to over-emphasis of PE as competitive sports. More involvement of parents, as role models, and adult mentors, particularly in after-school programs, would encourage greater participation in the PA by adolescents to meet these recommended national standards. Contextual factors influencing adolescents’ greater use of PA could be assessed prospectively. The Add Health survey data provides tremendous opportunities to assess these relationships in the future studies. Finally, from a measurement and surveillance standpoint, public health professionals should be aware that, when applied to current survey data, the two sets of PA standards (HP2010 and 2008 PAG) yield different results. Thus, an alignment of the upcoming set of national goals for PA, namely Healthy People 2020, with the current evidence outlined in the 2008 PAG for Americans is an imperative.

**Human subjects approval statement**

The conduct of this study was with the prior approval of UNC, at Greeley (CO), IRB for human subjects in research. All relevant documentation was made available to the Board before the approval for the study.

**Funding**

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**References**


