

Compliance with Physical Activity Guidelines: Prevalence in a Population of Children and Youth

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PURPOSE: To use objective monitoring of physical activity to determine the percentages of children and youth in a population that met physical activity guidelines.

METHODS: A total of 375 students in grades 1–12 wore an accelerometer (CSA 7164) for seven consecutive days. Bouts of continuous activity and accumulation of minutes spent in physical activity at various intensities were calculated to determine how many students met three physical activity guidelines.

RESULTS: Over 90% of students met Healthy People 2010, Objective 22.6 and nearly 70% met the United Kingdom Expert Consensus Group guideline, both of which recommend daily accumulation of moderate physical activity. Less than 3% met Healthy People 2010, Objective 22.7, which calls for bouts of continuous vigorous physical activity. For the United Kingdom Expert Consensus Group guideline, compliance decreased markedly with age, but gender differences were not statistically significant.

CONCLUSIONS: Prevalence estimates for compliance with national physical activity guidelines varied markedly for the three guidelines examined. Objective monitoring of physical activity in youth appears to be feasible and may provide more accurate prevalence rates than self-report measures.

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INTRODUCTION

Physical inactivity is a well-documented risk factor for coronary heart disease (1) and is associated with increased risk for other chronic diseases, including obesity, Type II diabetes mellitus, hypertension, colon cancer, depression, and osteoporosis (2). Accordingly, promoting physical activity has become a public health priority in the United States (3). Although the chronic diseases associated with physical inactivity rarely manifest before middle adulthood, promotion of physical activity in children and youth is important because lower levels of activity early in life are associated with less favorable physiological risk factor status (3). Limited physical activity may also predispose youth to developing a sedentary lifestyle later in life (4, 5). Because of the growing awareness of the health benefits of regular physical

activity, public health guidelines for physical activity have been established (6). Several of these guidelines focus on youth (7–9).

To track compliance with these guidelines, measures of physical activity have been incorporated into several public health surveillance systems, including the Youth Risk Behavior Surveillance System (YRBS) (10, 11), the National Health Interview Survey (NHIS) (12), and the National Health and Nutrition Examination Survey (NHANES). Each of these systems relies exclusively on self-report methods, the applicability and validity of which are in considerable question (13–15). Self-report measures of physical activity are considered inappropriate for use with children under age 12, and are known to have limitations with people of all ages (13, 14, 16). Consequently, there is uncertainty concerning the true prevalence of compliance with physical activity guidelines in American children and youth.

Recently, increasing use has been made of accelerometers for measurement of physical activity (17–19). These devices provide objective and highly detailed information on physical activity as observed over relatively long periods, and they have been shown to be useful in children of all ages (17, 18, 20–22). To date, however, accelerometers have been used primarily in research settings with small

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Selected Abbreviations and Acronyms

YRBS = Youth Risk Behavior Surveillance
 NHIS = National Health Interview Survey
 NHANES = National Health and Nutrition Examination Survey
 CSA monitor = Computer Science and Applications, Inc. model 7164 accelerometer
 HP 2010 = Healthy People 2010
 UK Group = United Kingdom Expert Consensus Group
 MET = metabolic equivalent; the equivalent energy cost of 1 MET is approximately 1 kcal·kg⁻¹·hr.⁻¹

groups of subjects. To our knowledge, accelerometers have not been used previously to measure physical activity in a population. Hence, the purpose of this study was to use objective monitoring of physical activity to determine the percentages of children and youth in a defined population that met recommended physical activity guidelines.

METHODS

Subjects

Subjects for this study ($n = 400$) were randomly selected from the pool of participants in the Amherst Health and Activity Study, a cross-sectional observational study that examined determinants of physical activity in school-age children and youth. Subjects were recruited from seven elementary schools, one junior high school, and one senior high school in and near Amherst, MA. All 3648 students enrolled in physical education in those schools were invited to participate. Thirty-eight percent of the students ($n = 1379$) returned an informed consent form signed by a parent or guardian. Only one child per household was included in the study, for a final sample of 1110 (51.4% female, 75.1% white). The final sample was categorized according to grade groups: grades 1-3, grades 4-6, grades 7-9, and grades 10-12.

For the present study, 50 female and 50 male subjects in each grade group were randomly selected to wear a physical activity monitor. If a student refused to participate ($n = 4$), a replacement was randomly selected from the same grade and gender group. Following deletions for monitor failure ($n = 14$), monitor loss ($n = 1$), tampering ($n = 4$), and outliers ($n = 6$), the final sample consisted of 375 students. Subject characteristics are summarized in Table 1.

Procedure

Physical activity was objectively measured for seven days using the Computer Science and Applications, Inc. (CSA, Shalimar, FL) model 7164 accelerometer. The use of this monitor to measure physical activity in children has been described previously (20, 23). The instrument has been shown to be valid and reliable in both children and adolescents (18, 20, 24).

Monitors were provided to students by study staff during the school day. Students received oral and written instructions for using the CSA monitor, which was securely fastened directly above the right hip using an adjustable elastic strap. Students were asked to wear the monitor during all waking hours, except when swimming or bathing. After seven days, the activity monitors were collected. Stored activity counts were downloaded to an IBM-compatible computer for data reduction and analysis.

Data were collected in two waves. The first wave ($n = 267$) took place in the fall of 1996 (late October to mid December); the second wave ($n = 108$) took place in the spring of 1997 (April). Equal numbers of children in each age group were monitored each week. The coldest weather months were avoided because activity levels may be particularly low in the winter (3).

Data Reduction

Because the study was designed to examine compliance with physical activity guidelines, the monitor data were reduced to allow comparison with operational definitions of the selected guidelines (Table 2). Bouts of continuous activity and accumulation of minutes spent in activity at various intensities were calculated to determine the percentage of students who met two guidelines included in Healthy People 2010 (HP 2010), Objectives 22.6 and 22.7, and the guideline advanced by the United Kingdom Expert Consensus Group (UK Group) (8).

Minute-by-minute activity counts were uploaded to a QBASIC data reduction program to determine time spent in moderate (3-5.9 METs), vigorous (6-8.9 METs), and very vigorous (> 9 METs) activity during each 60-min segment of the 7-day monitoring period. (The equivalent energy cost of 1 MET is approximately 1 kcal · kg⁻¹ · hr.⁻¹.) Age-specific count cutoffs for each intensity level were derived from the energy expenditure prediction equation developed by Freedson and coworkers (25). Daily totals for the physical activity variables were calculated by summing the twenty-four 60-min time blocks for each of the seven days.

To examine compliance with HP 2010, Objective 22.7 (≥ 20 continuous minutes, ≥ 3 d/wk, ≥ 6 METs), the daily number of 20-min bouts with an intensity of ≥ 6 METs was calculated. Within the 20-min bouts, subjects were permitted a brief interruption interval or "break in the action" of no more than 2 min. Thus, to be considered a bout, during a 20-min period at least 18 of the minutes had to be at or above the count cutoff corresponding to 6 METs.

Statistics

The percentage of students who met the three guidelines was calculated for each grade and gender group. Chi-square tests were used to determine gender differences in the per-

TABLE 1. Subject characteristics across gender and grade groups; mean (SD)

Grade group	Males				Females			
	1–3	4–6	7–9	10–12	1–3	4–6	7–9	10–12
N	42	51	48	44	48	46	48	48
Age (yr)	7.2 (0.9)	10.1 (1.0)	12.0 (1.0)	15.7 (1.0)	7.3 (0.9)	10.4 (1.0)	12.8 (1.0)	15.5 (1.1)
Height (cm)	128.3 (10.9)	141.7 (10.8)	159.5 (10.4)	176.6 (7.5)	126.4 (10.4)	144.3 (8.6)	159.3 (8.7)	164.9 (5.4)
Body mass (kg)	27.3 (7.2)	39.6 (9.2)	50.7 (11.5)	66.2 (11.6)	25.8 (6.9)	37.7 (8.3)	49.4 (11.0)	57.7 (7.4)
% white	66.0	79.6	85.4	73.3	65.9	67.4	85.4	77.3

centage of children meeting the guidelines. Mantel-Haenszel tests for trends were used to determine differences in the percentages of children who met the guidelines at each grade level. All statistical procedures were performed using SAS statistical software with a significance level of $p = 0.05$.

RESULTS

Table 3 presents the distributions for time spent in moderate-to-vigorous and vigorous physical activity by boys and girls in each grade group. Medians for physical activity were consistently higher for boys than girls, but more distinctly so for vigorous than moderate-to-vigorous activity.

Over 90% of the students in this study met the Healthy People 2010, Objective 22.6 guideline (≥ 30 min, ≥ 5 d/wk, ≥ 3 METS) (Table 4). Compliance with this guideline was not significantly different across the three youngest age groups; however, students in grades 10–12 were significantly less likely than those in the younger groups to meet this guideline (76.1%, $p = 0.001$). The percentage of girls meeting this guideline did not differ from that of boys.

In contrast, very few students (less than 3%) met the requirements of HP 2010, Objective 22.7 (≥ 20 continuous minutes, ≥ 3 d/wk, ≥ 6 METS) (Table 4). Compliance with the guideline did not differ significantly across grade groups. Approximately twice as many boys as girls met the guideline, but the difference was not statistically significant.

More than two thirds (69.3%) of students met the United Kingdom Expert Consensus Group guideline (≥ 60

min, ≥ 5 d/wk, ≥ 3 METS). Compliance with this guideline, however, declined from 100% to 29.4% from the youngest to the oldest grade groups ($p < 0.01$). More boys than girls met the guideline, although the difference was not significant.

DISCUSSION

This is the first study of youth physical activity using objective measures to evaluate compliance with national guidelines in a population-based sample. Our major finding was that prevalence estimates for compliance with the guidelines were dramatically different for the three guidelines examined. Virtually all elementary school-age subjects met Healthy People 2010, Objective 22.6 for moderate physical activity (≥ 30 min, ≥ 5 d/wk, ≥ 3 METS), though a significant decline was observed in grades 10–12. At the other extreme, very few students of any age met Healthy People 2010, Objective 22.7 for vigorous physical activity (≥ 20 continuous minutes, ≥ 3 d/wk, ≥ 6 METS). Yet, another pattern was observed for the United Kingdom Expert Consensus Group guideline (≥ 60 min, ≥ 5 d/wk, ≥ 3 METS), for which overall compliance was 69% with marked differences across age groups. Clearly, conclusions regarding the physical activity status of a population are heavily dependent on the specific guideline selected.

Like most previous descriptive studies (3, 10, 26), we observed higher levels of physical activity in boys than girls. As demonstrated by the data in Table 3, median time spent

TABLE 2. Selected physical activity guidelines and operational definitions established for the present study

Source	Guideline	Operational Definition
HP 2010, goal 22.6	Engage in moderate physical activity for at least 30 minutes per day on five or more days per week.	On five or more days during the week, physical activity at an intensity of three or more METS observed during 30 or more one-minute periods.
HP 2010, goal 22.7	Engage in vigorous physical activity that promotes the development and maintenance of cardiorespiratory fitness three or more days per week for 20 or more minutes.	On three or more days during the week, physical activity at an intensity of six or more METS observed during 20 or more continuous minutes.
United Kingdom Expert Consensus Group	Participate in physical activity that is of at least moderate intensity for an average of one hour per day.	On five or more days during the week, physical activity at an intensity of three or more METS observed during 60 or more one-minute periods.

TABLE 3. Distribution of moderate-to-vigorous and vigorous physical activity by gender and grade group

Grade Group	Males				Females			
	1–3	4–6	7–9	10–12	1–3	4–6	7–9	10–12
N	42	51	48	44	48	46	48	48
MVPA (min/day)								
Percentile								
5th	158	65	40	33	145	51	38	2
25th	199	110	66	46	186	81	53	36
50th	243	146	88	61	206	111	75	55
75th	267	180	111	82	247	132	101	70
95th	343	230	163	107	306	182	147	105
VPA (min/day)								
Percentile								
5th	9	3	2	1	7	2	1	0
25th	18	10	5	3	15	4	3	1
50th	32	20	13	6	21	9	6	2
75th	47	32	19	15	28	13	11	5
95th	66	53	28	28	50	19	23	21

in both moderate-to-vigorous and vigorous physical activity was higher in boys than girls in all grade groups. Interestingly, however, these differences did not translate into a consistent gender difference in the prevalence of meeting physical activity guidelines. Only in grades 10–12 were boys consistently more likely than girls to meet physical activity guidelines. Consistent with previous studies, we observed a strong age-related decline in physical activity (10, 26–28). In grades 1–3 all students exhibited ≥ 1 h of physical activity of at least moderate intensity on five or more days of the week. In grades 10–12, however, only 34.1% and 25.1% of males and females, respectively, met this guideline. These results support the need for physical activity interventions that are designed to reduce the age-related decline in physical activity in young people of both genders. Given that prevalence rates for the UK Group guideline fell from 100% in primary grade students to less than 30% in high school students, our findings also suggest that the middle school years may be a particularly important time to initiate such intervention programs.

In 1997, the United Kingdom Expert Consensus Group adopted the guideline that all young people should participate in physical activity of at least moderate intensity for one hour per day. This guideline was adopted because the

prevalence of obesity was increasing (29), even though available studies indicated that a majority of young people were engaging in 30-min of moderate physical activity on most days of the week (8, 30). The UK Group guideline is consistent with a children's guideline developed by the National Association for Sport and Physical Education (31). The findings of the present study support the appropriateness of the UK Group guideline because, out of the three guidelines examined, compliance with the UK Group guideline clearly showed the age-related decline in physical activity that is consistently documented in physical activity studies of children and adolescents. Since virtually all the young people met HP 2010 22.6, and very few of any age met HP 2010 22.7, these guidelines did not reveal age-related trends and have shortcomings as guidelines for physical activity in youth.

Because prevalence estimates affect public health policy related to youth physical activity, it is essential that prevalence rates be as accurate as possible. Consequently, it is instructive to compare the percentage of students in the present study who met guidelines with the results of national surveillance studies that use self-report methods. One such system is the Youth Risk Behavior Surveillance System (YRBS) of the U.S. Centers for Disease Control and Prevention. According

TABLE 4. Percent of children meeting national/international guidelines and recommendations

(N)	Gender and Grade Groups														
	Gender			Grade Group				Male				Female			
	All	Male	Female	1–3	4–6	7–9	10–12	1–3	4–6	7–9	10–12	1–3	4–6	7–9	10–12
	(375)	(185)	(190)	(90)	(97)	(96)	(92)	(42)	(51)	(48)	(44)	(48)	(46)	(48)	(48)
Guideline															
Healthy People 2010 22.6	91.7	91.9	91.6	100	97.9	92.7	76.1 ^a	100	98	89.6	79.6 ^a	100	97.8	95.8	72.9 ^a
United Kingdom Expert Consensus Group	69.3	72.4	66.3	100	89.7	58.3	29.4 ^a	100	92.2	62.5	34.1 ^a	100	87	54.2	25.1 ^a
Healthy People 2010 22.7	2.4	3.2	1.6	3.3	2.1	1.0	3.3	4.8	3.9	0	4.6	2.1	0	2.1	2.1

^aTrend for age related decline ($p = 0.001$).

to the 1999 YRBS, 72.3% of high school-age males and 57.1% of high school-age females meet the vigorous physical activity guideline HP 2010 22.7 (≥ 20 continuous min, ≥ 3 d/wk, ≥ 6 METs) (10). In stark contrast, we observed the prevalence of meeting the same vigorous physical activity guideline to be less than 5% in high school students. Because of differences in sampling methods, procedures for assessment of physical activity, observation periods, and subject characteristics, such comparisons must be interpreted cautiously. The YRBS question on vigorous physical activity is phrased: "On how many of the past seven days did you participate in physical activity for at least 20 min that made you sweat and breathe hard?" It seems likely that many respondents tend to include all the time they were in a physical activity setting, rather than the time they were actually vigorously active (for example, they may count basketball practice which lasted for 60 min but during which they were actually vigorously playing basketball for fewer than 20 min).

The dramatic discrepancies in prevalence rates between self-reported national estimates and objectively measured estimates in the current sample raise the possibility that self-reported surveys produce prevalence rates that are grossly inflated. Previous studies have shown that children and adolescents tend to overestimate their physical activity behavior when completing self-report instruments (15). The feasibility of using objective physical activity measures for national surveillance studies should be considered. Our results indicate that one week of physical activity monitoring is acceptable to youth throughout the school-age range and is logistically feasible. Monitor failure rate was low (3.5%, $n = 14$), and subject non-compliance with the protocol (lost monitor, tampering, and outliers) comprised only 2.8% ($n = 11$) of the sample. Additionally, the 7-day monitoring period has been shown to produce reliable estimates of usual physical activity in children and youth ($R = 0.76\text{--}0.87$) (21). It is acknowledged, however, that accelerometers underestimate activities that do not involve vertical movement of the trunk (e.g., cycling, weight lifting) and cannot be worn during aquatic activities such as swimming (32). Thus, prior to use in national studies, the limitations of objective monitors should be fully documented. Also, the strengths and limitations of objective measures of physical activity should be carefully weighed against those of self-report measures.

Strengths of the present study include the large age range, inclusion of both genders, a large sample size relative to previous studies, and the extensive one-week data collection with objective monitors. Weaknesses include the restriction to one geographic region, inability to examine ethnic differences, limitations of the accelerometer, and low recruitment rate into the study.

In summary, objective monitoring of physical activity among youth appears to be feasible on a large scale. This methodology should be considered for population studies

because prevalence estimates based on self-report may be inflated. Three physical activity guidelines for children and youth were evaluated. The Healthy People 2010, Objective 22.6 moderate physical activity guideline (≥ 30 min, ≥ 5 d/wk, ≥ 3 METS) appears to be too low a standard because the vast majority of youth meet the recommendation. The Healthy People 2010, Objective 22.7 vigorous physical activity guideline (≥ 20 continuous minutes, ≥ 3 d/wk, ≥ 6 METS) appears to be an inappropriate standard for youth because it may prescribe a form of physical activity that is common for adults but uncharacteristic of children and youth. The UK Group recommendation of accumulating 60 min per day of moderate intensity physical activity (≥ 60 min, ≥ 5 d/wk, ≥ 3 METS) was supported as the best existing guideline for youth and has been adopted for the U.S. dietary guidelines (33). The prevalence of meeting the UK Group guideline decreased dramatically with age, indicating the need for physical activity interventions for boys and girls of all ages.

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