Depressive Symptoms and Physical Activity in Adolescent Girls

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[1]Tulane University School of Public Health & Tropical Medicine, New Orleans, LA; [2]The Ohio State University, Columbus, OH; [3]San Diego State University, San Diego, CA; [4]National Heart, Lung, and Blood Institute, Bethesda, MD; [5]Klein Buendel, Inc., Golden, CO; [6]University of Minnesota, Minneapolis, MN; [7]University of Maryland, College Park, MD; and [8]University of Arizona, Tucson, AZ

ABSTRACT

JOHNSON, C. C., D. M. MURRAY, J. P. ELDER, J. B. JOBE, A. L. DUNN, M. KUBIK, C. VOORHEES, and K. SCHACHTER. Depressive Symptoms and Physical Activity in Adolescent Girls. *Med. Sci. Sports Exerc.*, Vol. 40, No. 5, pp. 818–826, 2008. **Purpose:** To evaluate the relationship between depressive symptoms and physical activity in a geographically and ethnically diverse sample of sixth-grade adolescent girls. **Methods:** The Trial of Activity for Adolescent Girls (TAAG) baseline measurement included a random sample (N = 1721) of sixth-grade girls in 36 schools at six field sites. Measurements were accelerometry and the 3-d Physical Activity Recall (3DPAR) for physical activity, and the Center for Epidemiological Studies-Depression scale (CES-D) for depressive symptoms. **Results:** Girls with complete data (N = 1397), mean age 12 yr, had an average CES-D score of 14.7 (SD = 9.25) and engaged in an average of about 460 min of sedentary activity, < 24 min of moderate to vigorous physical activity (MVPA), and < 6 min of vigorous physical activity (VPA) in an 18-h day. Thirty-minute segments of MVPA ranged in number from 3.9 to 1.2, and METS for these segments ranged from > 3.0 to > 6.5. Mixed-model regression indicated no relationship between depressive symptoms and physical activity; however, a significant but modest inverse relationship between sedentary activity and depressive symptoms was observed. **Conclusion:** A sufficient sample size, standardized procedures, and validated instruments characterized this study; however, a relationship between depressive symptoms and physical activity was not observed for sixth-grade girls from diverse geographic locations. The average CES-D score was lower than is considered clinically meaningful for either adolescents or adults, and MET-minutes of sedentary activity were high. This combination of data may be different from other studies and could have contributed to the unexpected finding. This unexpected finding is informative, however, because it shows the need for additional research that includes a wider range of possible combinations of data, especially with young adolescent girls. **Key Words:** SIXTH GRADERS, ACCELEROMETRY, 3DPAR, SEDENTARY BEHAVIOR

A physically inactive lifestyle is associated with the development of obesity, chronic physical disorders, and certain mental and emotional conditions (37). Despite evidence that physical activity has multiple health benefits and is associated with reductions in morbidity and mortality, physical inactivity among the U. S. population continues to be widespread (37). National studies have shown that almost two thirds of U.S. adults are either sedentary or irregularly active (19,23), and children's levels of physical activity, although initially higher than adults, decline as children grow into adolescence and young adulthood (37). Indeed, by middle-school age, more than one third of adolescents are not reaching recommended physical activity levels, and just a little over one third of adolescents participate in daily physical activity programs (37). Multiple studies have reported that the decrease in adolescent physical activity is much more pronounced for girls than for boys (29,37), and that the proportion of adolescent boys versus adolescent girls who are consistently active is about two to one (23).

Major depressive disorder is one of the most common mental disorders among adults in industrialized countries

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(2). Major depressive disorder and expressions of depressive symptomatology can begin during adolescence and are associated with morbidity and mortality in the adolescent population (28). Depression in its variant forms is now occurring earlier in life than it did in the past (28), and, surprisingly, the annual rate of depression among adolescents and young adults is almost twice that of older adults (40). A recent study by Kessler et al. (2005) found that half of all lifetime cases of mental disorders, including depression, start at about 14 yr of age (15).

The above studies suggest that adolescence is a developmental period when physical activity levels decrease, especially for girls, and depressive symptoms begin or increase, especially for girls (1). Both adult and adolescent females have a higher probability than males of depressive symptom expression (1), with adolescent girls being twice as likely as adolescent boys to develop depression, a gender ratio similar to that for physical inactivity.

Although not all studies agree, both cross-sectional and longitudinal population-based studies have shown a link between depression or depressive symptoms and physical activity levels (4,5,13,29). For example, attendance in physical education (PE) class has been inversely related to feelings of sadness (4). Calfas and Taylor (1994) reviewed adolescent physical activity studies and concluded that physical activity was consistently related to improvements in depressive symptoms, with an effect size of 0.38 for depressive symptoms (5). In a review of 102 studies of correlates of physical activity for children and adolescents, Sallis et al. (2000) indicated that, although beneficial effects of physical activity in youth are less well documented than in adults, positive effects have been demonstrated in youth on both physical and psychological health, that is, depression (29). Again, child and adolescent males were consistently more physically active than females. Of the 54 adolescent studies reviewed by Sallis et al. (29), the majority indicated that depression was inversely correlated with physical activity. Physical activity measurement was almost always self-report, with only six studies using objective measures such as pedometers or accelerometers.

Some studies, however, have *not* found an inverse relationship between physical activity and depression and/or depressive symptoms (12,17,21,22). For example, Norris, Carroll, and Cochrane found that high-intensity, but not moderate-intensity, physical training resulted in positive effects on psychological well-being for adolescents (22). Fulkerson also found that moderate-to-vigorous physical activity (MVPA) and depressive symptoms were negatively associated for males but not for females (12). As Sallis et al. (2000) have noted, these inconsistencies could be the result of studies using mixed-sex and -age samples, measuring physical activity with possibly unreliable and/or invalid self-report instruments, and/or other methodological differences, including the nonmeasurement of other important covariates that could be linked to depression or physical activity (29).

Trial of Activity for Adolescent Girls

Because physical inactivity is an independent risk factor for coronary heart disease (10), and a decline in MVPA accelerates for girls during adolescence, the National Heart, Lung, and Blood Institute (NHLBI) initiated a randomized controlled multicenter trial, the Trial of Activity for Adolescent Girls (TAAG) (31). The primary aim of TAAG was to design and evaluate a school- and community-linked intervention to reduce by half the decline in physical activity (primarily measured by Actigraph accelerometers) in middle school girls. The intervention, based on the Social Ecological Model (32), was intended to affect the physical and social environment through programs in health education and PE that link schools with community organizations to increase opportunities for physical activity, along with promotional efforts to enhance motivation. TAAG is a collaborative trial among six field centers (Universities of Arizona, Maryland, Minnesota, and South Carolina; San Diego State University; and Tulane University), the coordinating center at the University of North Carolina, Chapel Hill, and the NHLBI. A data and safety monitoring board provided oversight and performed an advisory role. Six schools per field center (N = 36 schools) were randomized to either intervention (N = 18) or control (N = 18) conditions after baseline measurement.

In the current study, participants were sixth-grade adolescent girls representing multiple ethnicities in six geographically diverse areas of the United States who participated in the TAAG baseline cross-sectional measurements prior to randomization to experimental conditions. Physical activity was measured with both accelerometry and self-report. The objective of the current study was to evaluate the relationship of depressive symptoms with levels of physical activity measured by both accelerometry and self-report in a free-living geographically and ethnically diverse sample of sixth-grade girls.

METHOD

TAAG Study Design

TAAG recruitment of both schools and students followed standardized protocols at all field sites. Schools eligible for participation in TAAG were publicly funded, with no magnet or special populations and with a less than 28% student dropout rate during any given year. Districts with middle schools meeting eligibility criteria were identified. Sixty-eight schools were contacted, 41 agreed to participate, and 36 schools, representing 19 districts, were finally selected based on inclusion criteria, one of which was willingness to accept random assignment. Girls were recruited based on random sampling within each school. A total of 1721 girls provided written parental consent for a baseline participation rate of 80% of all eligible girls. The measurement design consisted of a series of three cross-sectional measurements, with the first providing baseline data and the last two providing follow-up data. The data reported here represent baseline assessment and will not be reported by intervention or control condition, but in the aggregate. The TAAG study design is described in more detail elsewhere (31).

Data Collection Procedures

At baseline, the goal was to recruit 60 girls from each school to participate in baseline measurement, which included 1) Mediators and Moderators Student Questionnaire (MSQ), which incorporated the Center for Epidemiological Studies–Depression scale (CES-D); 2) accelerometry for measurement of physical activity; 3) a 3-d physical activity recall (3DPAR); and 4) body composition (height, weight, and triceps skinfolds). All measurement protocols were reviewed and approved by the respective human subjects institutional review boards for each of the seven universities engaged in the study. Written informed consent was obtained from the parents of the participants, and the participants had the right of assent or refusal at time of measurement. Data collection documents were prelabeled prior to field use with either a unique identification (ID) number for each student or a bar code representing the ID. All data were collected by TAAG staff trained according to standardized protocols and certified for data collection only after practice administrations met specified standards. Periodic recertification ensured that performance standards were met continuously.

Measurement

CES-D. Depressive symptoms were measured with the 20-item CES-D, a self-report measure intended for research applications in general nonpsychiatric populations. The majority of items (N = 16) assess cognitive, affective, behavioral, and somatic symptoms associated with depression; the remaining four items are included to minimize biases attributable to response sets, as well as for their intrinsic value (26). Frequency responses are recorded on a four-point Likert scale and range from "rarely" to "almost always." The instrument has been well standardized and used extensively with both adults and adolescents (26,27). Numerous interview and self-administration field tests have found the CES-D acceptable and understandable by a wide range of general population respondents (38). High to adequate levels of internal consistency (alpha = 0.85), split-half (alpha = 0.87), and test–retest correlations (range from 0.51 to 0.67) were found in all groups studied (26). Correlations of the scale with other mental health measures and clinical ratings of depression have produced reasonable evidence of both construct and discriminant validity (0.73–0.89) (38). Acceptability and internal consistency have been demonstrated across age, sex, and race (white, African American, Mexican Americans, and Hispanics), as well as with adolescent populations (27). Although the CES-D is not a diagnostic instrument, a score of > 16 has been used to indicate a "presumption of depression" with adults (21) and > 24 to indicate clinically meaningful symptoms of depression in adolescents (7).

MTI ActiGraph accelerometer. The MTI ActiGraph accelerometer is an objective measure of MVPA, the primary outcome variable for TAAG. The accelerometer records acceleration and deceleration of movement, resulting in activity counts, intensities of physical activity, and time of day for accelerations. The monitor has demonstrated high reliability, validity, and sensitivity to different intensities of physical activity, and has been used in several studies to assess physical activity in children (14,39). Correlations between heart rate and activity counts have ranged from 0.64 to 0.57. Reliability correlations over time have ranged from 0.87 to 0.42 (7,14). At baseline each girl wore the activity monitor against the right hip bone for six complete days except while sleeping or during any water activity (e.g., bathing, swimming). Official data collection for the study began at 6:00 a.m. on the day after the monitors were distributed. Downloading of data from the ActiGraph to laptops occurred immediately upon removal of the monitor or within the next 24 h, and data were transmitted to the Coordinating Center according to standardized procedures using the TAAG Data Management System (DMS).

Accelerometer readings were processed using methods similar to those reported by Puyau et al. (25). Cut points for sedentary (< 50 counts/30 s), light (51–1499), moderate (1500–2600), and vigorous (> 2600) activity were based on an earlier pilot study that related accelerometer counts to MET levels across a range of activities (34). Half-minute counts were used instead of full-minute counts based on the expectation that they would be more sensitive to fluctuations in activity levels. Occasional missing accelerometry data within a girl's 6-d record were replaced via imputation based on the expectation maximization (EM) algorithm (6). On average, approximately 12 h (11%) of data per person were imputed. For the MET-minutes of MVPA measure, counts above 1500 per half minute were converted into metabolic equivalents (METs) using a regression equation developed from a second pilot study for TAAG (30). The METs were summed over the 6:00 a.m. to midnight day to provide MET-minutes per day of MVPA, where 1 MET·min represented the metabolic equivalent of energy expended sitting at rest for 1 min.

3DPAR. The primary objective of the 3DPAR is to measure the types and contexts of physical activity as self-reported by participants. Immediately on completion of accelerometry, participants were administered the 3DPAR in a group setting that took about 45 min. For each of the past 3 d, the students were asked to recall what activity they did for every 30-min interval throughout the day. Codes for the girls to use in recording "activity number," "with whom" and "where" were provided in a coding instruction sheet. In addition to the 3-d recall, students were asked how frequently they rode their bike to and from school and/or walked to and from school during the previous 7 d. Forms were reviewed by

TAAG staff for completeness and clarity, and girls were asked to correct any noted problems. Test–retest reliability of the 3DPAR among girls was 0.707 for MVPA and 0.771 for VPA (18). The 3DPAR has also been validated against pedometer counts, accelerometer counts, and heart rate monitors. These validity measures were 0.88 for step counts, 0.77 for accelerometer counts, and 0.53–0.63 for heart rate monitors (24).

BMI. Both height and weight were measured twice using a Shorr height board and a Seca Model 880 weight scale. Triceps skinfolds were measured three times with Lange skinfold calipers. Height measurements were repeated if the difference between the two measurements was > 1 cm. Weight measurements were repeated if the difference was > 0.5 kg, and the three triceps measurements were repeated if (maximum − minimum)/minimum was > 0.20. Girls were evaluated in their bare feet or socks after removing all excess clothing and any heavy accessories.

MSQ. The MSQ was developed by a TAAG working group for the purpose of measuring mediators, moderators, and secondary outcomes as specified by the TAAG theoretical model. Variables included in the MSQ were initially pilot tested for timing, readability, and adequacy of questions. Another pilot study tested the revised version of the MSQ using confirmatory factor analyses, Cronbach alpha, test–retest reliability, and intraclass correlations (3). Because the CES-D is a published instrument with adequate psychometric data for adolescent girls, it was not included in pilot testing. MSQ variables measured at TAAG baseline that could be associated with or mediate physical activity levels and/or depressive symptoms and selected for this study were: demographic data (7 items); enjoyment of PE (1 item with Likert scale response from *disagree a lot* to *agree a lot*); enjoyment of physical activity (7 items with Likert scale responses ranging from *disagree a lot* to *agree a lot*); participation in sports teams and/or lessons in and outside of school (checklist of 15 and 18 items, respectively); social support for physical activity (4 items for friends and 5 items for family with Likert scale responses ranging from *never* to *every day*); home alone without adult supervision (2 frequency items); barriers to physical activity (10 items with Likert scale responses ranging from *never* to *very often*); and change strategies for physical activity (9 items with 5-point Likert scale responses from *never* to *very often*). Internal consistency coefficients for enjoyment, social support, barriers and change strategies ranged from 0.46 (barriers) to 0.86 (enjoyment). Factor validity for these variables ranged from 0.96 (social support) to 0.99 (enjoyment and change strategies). Confirmatory factor analyses indicated that the theoretical relations among the items from each variable were similar across racial groups.

Statistical Analysis Methods

Simple descriptive statistical methods were used to characterize the sample with regard to the independent and dependent variables. Descriptive statistics were calculated by site, as well as for the overall sample, to provide some indication of variability among the sites. Methods included sample means with standard deviations and frequency distributions.

Mixed-model linear regression analyses were used to evaluate the relationship between physical activity and CES-D score modeled as a continuous variable, with separate analyses for each of nine measures of physical activity (five based on accelerometry, four based on self-report). We fit a crude model first, predicting CES-D from physical activity. Second, we added seven demographic variables: race, mother's education, father's education, household structure, participation in the free or reduced lunch program, mother's employment status, and father's employment status. Nonsignificant terms were removed until all remaining terms were significant at $P < 0.10$. The third model added the following variables: enjoyment of physical education, enjoyment of physical activity, body mass index, participation in sports programs in school, participation in sports programs out of school, participation in physical activity lessons, social support for physical activity, barriers to physical activity, time spent home alone after school, and strategies to change physical activity. Again, nonsignificant terms were removed until all remaining terms reached a P value of < 0.10.

Mixed-model logistic regression analyses were used to evaluate the relationship between physical activity and the likelihood of having a CES-D score of 24 or higher. The model-building process for the logistic models followed the same pattern as for the linear models.

For both models, site and school within site were included in all analyses as random effects to account for correlation among observations taken on girls who lived in the same city and among girls who attended the same school. SAS version 8.2 was used for all analyses.

RESULTS

Sample Characteristics

A total of 1721 sixth-grade girls participated in the TAAG baseline measurement. Only the girls who completed measurement of the main variables of interest, the CES-D, the 3DPAR, and accelerometry, were selected for this study (N = 1397). The sociodemographic descriptors of this sample are presented in Table 1. Overall, 46.7% of participants were white, with an average age of 12.0 yr. Average ages were fairly consistent across sites ranging from 11.7 yr at the Maryland site to 12.2 yr at the Louisiana site. A measure of socioeconomic status for the school was the percentage of girls on free or reduced lunch, which overall was 41.1%, with the Louisiana site having the largest percentage of girls on free or reduced lunch (75.4%). The majority of girls (72.2%) lived with both parents, and both mothers and fathers were generally well educated, with 34.1% of mothers and 30.8% of fathers having a college

TABLE 1. Demographic characteristics of sixth-grade girls participating in Trial of Activity for Adolescent Girls baseline measurement by site.

Demographic Characteristic	AZ (*N* = 216)	CA (*N* = 267)	MD (*N* = 204)	MN (*N* = 262)	SC (*N* = 175)	LA (*N* = 273)	Overall (*N* = 1397)
	Study Site						
Mean (SD) age (yr)	11.9 (0.35)	11.8 (0.38)	11.7 (0.39)	12.0 (0.36)	12.0 (0.41)	12.2 (0.71)	12.0 (0.50)
				***N* (%)**			
Race/ethnicity							
White	117 (54.2)	99 (37.1)	97 (47.6)	205 (78.2)	92 (52.6)	42 (15.4)	652 (46.7)
Black	7 (3.2)	16 (6.0)	44 (21.6)	5 (1.9)	55 (31.4)	148 (54.4)	275 (19.7)
Latino	78 (36.1)	107 (40.1)	32 (15.7)	26 (9.9)	8 (4.6)	52 (19.1)	303 (21.7)
Asian	6 (2.8)	12 (4.5)	14 (6.9)	9 (3.4)	4 (2.3)	10 (3.7)	55 (3.9)
American Indian	3 (1.4)	1 (0.4)	2 (1.0)	—	2 (1.1)	—	8 (0.6)
Multiracial	5 (2.3)	32 (12.0)	15 (7.4)	17 (6.5)	14 (8.0)	20 (7.4)	103 (8.1)
Free/reduced lunch							
Yes	74 (34.4)	105 (39.6)	60 (29.6)	60 (23.3)	65 (37.6)	205 (75.4)	569 (41.1)
No/don't know	141 (65.6)	160 (60.4)	143 (70.4)	198 (76.7)	108 (62.4)	67 (24.6)	817 (59.0)
Household structure							
Both parents	169 (80.5)	189 (72.7)	143 (71.9)	210 (83.0)	113 (69.3)	137 (55.5)	961 (72.2)
Mother only	35 (16.7)	60 (23.1)	49 (24.6)	39 (15.4)	45 (27.6)	89 (36.0)	317 (23.8)
Father only	4 (1.9)	5 (1.9)	2 (1.0)	3 (1.2)	4 (2.5)	4 (1.6)	22 (1.7)
Neither	2 (1.0)	6 (2.3)	5 (2.5)	1 (0.4)	1 (0.6)	17 (6.9)	32 (2.4)
Mother's education							
< High school	14 (6.5)	24 (9.1)	6(2.9)	9 (3.5)	11 (6.3)	30 (11.0)	94 (6.76)
High school/GED	25 (11.6)	35 (13.3)	32 (15.7)	27 (10.4)	23 (13.1)	44 (16.1)	186 (13.4)
Vocational tech/some							
College	20 (9.3)	26 (9.9)	13 (6.4)	40 (15.4)	13 (7.4)	38 (13.9)	150 (10.8)
> College degree	85 (39.5)	84 (31.8)	91 (44.6)	102 (39.2)	68 (38.9)	44 (16.1)	474 (34.1)
Other[1]	71 (33.0)	95 (36.0)	62 (30.4)	82 (31.5)	60 (34.3)	117 (42.9)	487 (35.0)
Father's education							
< High school	11 (5.2)	22 (8.4)	12 (5.9)	6 (2.3)	13 (7.5)	30 (11.1)	94 (6.8)
High school/GED	18 (8.5)	36 (13.7)	20 (9.8)	32 (12.5)	28 (16.1)	32 (11.8)	166 (12.0)
Vocational tech/some							
College	15 (7.0)	22 (8.4)	12 (5.9)	23 (9.0)	15 (8.6)	23 (8.5)	110 (8.0)
> College degree	89 (41.8)	71 (27.0)	74 (36.3)	102 (39.7)	46 (26.4)	44 (16.2)	426 (30.8)
Other[a]	80 (37.6)	112 (42.6)	86 (42.2)	94 (36.6)	72 (41.4)	142 (52.4)	586 (42.4)
Mother's employment							
Full-time	86 (40.0)	111 (42.2)	117 (57.4)	132 (50.8)	95 (55.9)	128 (47.6)	669 (48.4)
Part-time	50 (23.3)	62 (23.6)	48 (23.5)	74 (28.5)	33 (19.4)	68 (25.3)	335 (24.3)
Home	25 (11.6)	25 (9.5)	13 (6.4)	19 (7.3)	10 (5.9)	10 (3.7)	102 (7.4)
Unemployed	21 (9.8)	27 (10.3)	10 (4.9)	14 (5.4)	19 (11.2)	20(7.4)	111 (8.0)
Other[b]	33 (15.4)	38 (14.5)	16 (7.8)	21 (8.1)	13 (7.7)	43 (16.0)	164 (11.9)
Father's employment							
Full-time	161 (76.7)	156 (60.0)	152 (75.3)	196 (76.6)	112 (66.3)	162 (61.4)	939 (69.0)
Part-time	12 (5.7)	41 (15.8)	21 (10.4)	21 (8.2)	18 (10.7)	29 (11.0)	142 (10.4)
Other[c]	37 (17.6)	63 (24.23)	29 (14.4)	39 (15.2)	39 (23.1	73 (27.7)	280 (20.6)

[a] *Other* includes don't know or missing.
[b] *Other* includes disabled, retired, and don't know.
[c] *Other* includes not working outside the home, unemployed, disabled/not working, retired, and don't know.

degree and/or education beyond college. A near majority of mothers (48.4%) and a majority of fathers (69.0%) worked full-time. Two thirds of the girls reported either very little or no time home alone; however, more than one third were home alone at least one or more hours a day.

Depressive Symptomatology

The CES-D was analyzed for internal consistency, and the resulting Cronbach's alpha was 0.88. The means and standard deviations for the CES-D (Table 2) are presented both for CES-D as a continuous score as well as after categorizing the CES-D using a cut point of 24, with 0 = less than 24, and 1 = greater than or equal to 24. The mean overall CES-D score for the continuous presentation was 14.7 and ranged across sites from 12.2 (Minnesota) to 17.9 (Louisiana). The average proportion of participants with scores greater than or equal to 24 was 18%, with a range of 11% to 29% for the Minnesota and Louisiana sites, respectively.

Physical Activity

Table 2 also presents the means and standard deviations for physical activity measured by accelerometry and self-reported with the 3DPAR. Accelerometry data were skewed with an overall average of almost 460 $min{\cdot}d^{-1}$ spent in sedentary behavior and an average of about 342 min for light physical activity. Fewer than 24 (23.8) minutes per day were spent in moderate to vigorous physical activity (MVPA), and fewer than 6 (5.6) minutes per day were spent in vigorous physical activity (VPA).

The 3DPAR was analyzed in 30-min segments, which were categorized according to the MET level assigned to the intensity-weighted activity in those segments (Table 2). The criterion for MVPA was METs = 3.0, and any segments with MET activities less than 3.0 were excluded. The average number of segments with METs greater than 3.0 was 3.9 while only 1.2 segments had METs greater than 6.5.

TABLE 2. Means and standard deviations for measurements of physical activity (3DPAR and CSA) and depressive symptoms (CES-D) by site.

	Site						
Variable Mean (SD)	**AZ**	**CA**	**MD**	**MN**	**SC**	**LA**	**Overall**
3DPAR* (30-min segments)							
MVPA (METs > 3.0)	3.82 (2.5)	3.92 (2.7)	3.85 (2.8)	3.85 (2.7)	3.28 (2.6)	4.17 (2.9)	3.85 (2.7)
MVPA (METs > 4.6)	2.03 (1.8)	1.66 (1.6)	1.83 (2.3)	1.71 (2.0)	1.59 (1.8)	1.84 (2.2)	1.78 (2.0)
VPA (METs > 6.0)	1.57 (1.5)	1.22 (1.4)	1.46 (2.0)	1.50 (1.8)	1.21 (1.7)	1.47 (1.9)	1.41 (1.7)
VPA (METs > 6.5)	1.33 (1.4)	1.09 (1.3)	1.23 (1.7)	1.29 (1.7)	1.09 (1.6)	1.19 (1.6)	1.21 (1.5)
Accelerometer (average)							
Min·d^{-1}	438.14 (66.1)	453.59 (61.7)	471.30 (75.3)	457.70 (65.0)	473.20 (75.4)	467.05 (69.5)	459.65 (69.3)
Sedentary	346.14 (55.3)	347.36 (48.7)	332.04 (53.4)	349.89 (53.2)	317.84 (62.0)	350.53 (63.1)	342.33 (57.0)
Light	27.88 (13.3)	7.23 (11.2)	22.33 (12.5)	22.78 (10.3)	19.94 (10.1)	21.69 (11.9)	23.78 (11.9)
MVPA	6.97 (5.8)	6.78 (4.1)	5.09 (4.5)	4.69 (3.5)	4.82 (4.1)	5.23 (4.6)	5.62 (4.6)
VPA	174.78 (96.8)	167.78 (74.1)	136.88 (83.8)	134.63 (63.7)	25.59 (77.9)	135.69 (82.4)	146.58 (81.7)
MET MVPA							
CES-D mean score (SD)	*N* = 216	*N* = 267	*N* = 204	*N* = 262	*N* = 175	*N* = 273	*N* = 1397
Continuous	14.38 (8.52)	14.10 (8.28)	15.42 (10.17)	12.21 (8.56)	14.23 (9.59)	17.89 (9.56)	14.74 (9.25)
Categorical > 24	0.15 (0.36)	0.15 (0.35)	0.21 (0.41)	0.11 (0.32)	0.15 (0.36)	0.29 (0.45)	0.18 (0.38)
BMI	19.93 (4.6)	20.56 (4.5)	20.90 (5.2)	19.84 (3.6)	21.61 (5.8)	21.83 (5.1)	20.77 (4.8)

3DPAR, time-based approach to physical activity recall from the previous 3 d; MVPA, moderate to vigorous physical activity; VPA, vigorous physical activity; BMI, body mass index.

Relationship between Physical Activity and Depressive Symptoms

BMI (Table 2) has been associated with physical activity (36). Other variables measured at TAAG baseline that could be associated with or mediate physical activity levels and/or depressive symptom scores are presented in Table 3. Participation in sports teams, social support for and enjoyment of physical activity, barriers and change strategies are all related to physical activity. It was expected that enjoyment of physical activity would be compromised when depressive symptoms are present. Additionally, adolescents who are experiencing depressive symptoms would not be expected to initiate strategies to overcome barriers or make changes to increase physical activity (2). Based on the theoretical and behavioral expectations for these variables, they were used to build both the linear and logistic regression models.

As stated previously, a mixed-model linear regression model was used to predict CES-D (dependent variable) separately from each of nine measures of physical activity (independent variables). Only sedentary behavior, as measured by accelerometry, was statistically significant in the crude model fit for each activity variable. All of the sociodemographic variables in Table 1 were then included as additional predictors with the intention of retaining only those variables with a P value of < 0.10. Father's education ($P = 0.07$), family structure ($P = 0.03$), and participation in the free/reduced lunch program ($P = 0.09$) were related to CES-D within the specified P value. These three variables were retained in the model and the additional variables were then added. Of these, the variables that remained at $P < 0.10$ were enjoyment of physical education ($P = 0.09$), enjoyment of physical activity ($P < 0.0001$), BMI ($P < 0.0001$), number of sports participated in outside of school ($P = 0.0002$), social support ($P < 0.0001$), number of barriers to physical activity ($P < 0.0001$), and time home alone ($P = 0.004$).

Consistent with the crude model, only sedentary behavior measured by accelerometry was significant in the adjusted models. The regression coefficients and P values from the adjusted model are presented in Table 3. The data show that higher sedentary behavior was significantly, but modestly, associated with lower CES-D scores; that is, for every additional minute of sedentary behavior measured by accelerometry, the average CES-D score decreased by 0.00978 points. Inasmuch as the overall mean for sedentary behavior in this sample is 460 and the SD is 69.3, a 2-SD increase in sedentary behavior would predict a 1.35-point decline in CES-D scores. The overall mean BMI was 20.8

TABLE 3. Predicting CES-D score from sedentary behavior and other factors.

	CES-D	
	Estimate	***P* Value**
Sedentary behavior	−0.00978	0.0036
Father's education		0.0744
≥ College degree	0	
< High school	1.6825	0.0972
Graduated high school/GED	1.4812	0.0561
Vocational tech/some college	0.9519	0.2932
Other	1.5672	0.0059
Household structure		0.0269
Both	0	
None	0.2962	0.8424
Mother only	1.6798	0.0026
Father only	0.8657	0.6283
Free/reduced lunch program		
No/don't know	0	
Yes	0.8596	0.0879
Enjoyment of physical education	−0.3603	0.0898
Enjoyment of physical activity	−0.261	< 0.0001
BMI	0.1951	< 0.0001
Sports outside school	0.3842	0.0002
Social support	−0.1416	< 0.0001
Barriers to physical activity	0.353	< 0.0001
Time home alone		0.0036
None	0	
< 1 h·d^{-1}	1.3124	0.0206
1–2 h·d^{-1}	1.4614	0.0363
> 2 h·d^{-1}	2.8026	< 0.0001

Coefficients and P values for sedentary behavior were measured by accelerometry.

and the SD is 4.8; therefore, a 2-SD increase in BMI would predict an increase in CES-D of 1.89. Compared with girls who have no time home alone after school, those girls who spent more than 2 $h \cdot d^{-1}$ home alone had CES-D scores that were 2.8 units higher. The coefficients for enjoyment of physical education and physical activity, sports participation, support and barriers to physical activity were quite small and, therefore, not very meaningful.

A logistic regression model using CES-D scores greater than or equal to 24 was developed using the same model-building approach as for the linear regression model. The results from the logistic regression model were similar to those from the linear regression model, indicating no relationship between physical activity and CES-D greater than or equal to 24.

BASIC SCIENCES

DISCUSSION

The purpose of this study was to evaluate the relationship between depressive symptoms and levels of physical activity. The sixth-grade girls randomly recruited from the 36 TAAG schools showed comparable levels of depressive symptoms with a sample of approximately 1900 seventh-grade girls who participated in the TEENS Study (20), with a mean CES-D score of 14.7 in TAAG and 14.8 in TEENS. The mean score for TAAG, however, was slightly higher than that for the AddHealth Study in which the average CES-D was 12.2. This slightly lower average may be reflective of a very large sample in the AddHealth study of 13,568, which included both boys and girls, and symptoms in males are generally lower than in females (28).

Some 18% of the TAAG girls had a CES-D score greater than 24. This is twice as high as the 9% found in the AddHealth Study, but not as great as the 29% observed in another sample of girls 16–18 yr of age (11). These data are alarming because there is increasing evidence that even subsyndromal symptoms of depression are associated with significant psychosocial impairment and increased likelihood of developing major depressive disorder (16).

In this sample of sixth-grade girls, no association between depressive symptoms and physical activity levels was observed. The methods used in this study were rigorous, and state-of-the-science sampling, measurement, and related methods were used. The CES-D is a widely used and respected instrument for measuring depressive symptoms and has been shown to be reliable and valid in a variety of population groups, including adolescents. Physical activity levels were measured using both accelerometry and self-report, and neither of these methods indicated a relationship between physical activity and depressive symptoms. The information that emerged from these data, however, was that physical activity levels for these sixth-grade girls were well below public health recommendations of 60 min of MVPA daily. On average, this sample of girls engaged in less than 24 min of moderate-intensity physical activity daily and less than 6 $min \cdot d^{-1}$ of vigorous physical activity.

Other studies have reported similar results. After participants in their study initiated a physical activity course, Mack et al. observed that mood state scores did not change, with participants remaining "fairly happy throughout the length of the course" (17). There may be a higher probability of finding an inverse relationship between physical activity and depression in clinical samples than in population-based samples, although, as mentioned previously, other population-based studies have found such a relationship (29).

It should be noted that the present sample of girls was young (mean age 12 yr), and two possibilities could be associated with such a young age. First, it is possible that they generally did not have symptoms associated with depression, or, secondly, had difficulty identifying and documenting the emotions, feelings, and symptoms listed in the CES-D.

In this study, the inverse relationship noted between depressive symptoms and sedentary behavior was unexpected; however, this is most likely a statistical anomaly given that the size of the correlation coefficient was quite small and the sample size was large. Additionally, baseline values showed that sedentary behavior was high and generally CES-D scores were not.

A variable that was significantly predictive of increases in CES-D scores was BMI. The overall BMI in this study was 20.8. When there is no statistical relationship between physical activity and depressive symptoms and a population-based measurement of BMI is not low, as is the case in this study, other possible factors may be involved, such as negative self-image or dissatisfaction with one's weight or size (8). Some studies have even evaluated weight-teasing and shame among adolescents as predictive of negative mood states (9), as well as failed attempts to weigh less (33,35).

Another variable that was significantly predictive of CES-D scores was being home alone more than 2 h each day after school. Some studies have indicated that individuals who engage in more social interactions, and who enjoy those interactions, do not experience the levels of depression or depressive symptoms of those who are less socially active (23). Adolescents who are home alone most evenings obviously have limited opportunities to be socially interactive with others.

The absence of a significant association between depressive symptoms and physical activity in this and other studies is indicative of the complex nature of that relationship, its possible dependence on other variables (some known and some yet to be examined), and the sociodemographic factors within specific subgroups. Within some subgroups, the relationship may simply not exist. Additionally, the combination of data in this study, low physical activity levels and high BMI, may not have existed in studies reporting an inverse relationship between physical activity and depressive symptoms. All of the possibilities discussed result in the conclusion that additional research on this issue is warranted that includes a wider range of combinations of data, as well as measurement of other factors that could be involved when depressive symptoms are present, specifically with girls at middle school ages.

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