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Developmental Trends and Determinants of Physical Activity from Adolescence to Adulthood differ by Ethnicity/Race and Sex

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Abstract

Background—Interventions to raise population physical activity generally show modest effects; one possible reason is that trends and determinants of moderate to vigorous physical activity (MVPA) differ between population subgroups. This study examined differences in trends in and determinants of reported MVPA by ethnicity/race and sex in a 15-year longitudinal study.

Methods—Participants (n=2092) in the Project EAT study were surveyed on MVPA behavior and potential determinants from adolescence to young adulthood. Generalized estimating equations were used to model age trends in MVPA and associations with determinants.

Results—Mean MVPA declined by 2.1 hours per week over 15 years of follow-up from adolescence to young adulthood. Asian males reported the lowest levels of MVPA at each age. Non-white females reported less MVPA than white females at each age. The association of body mass index (BMI) with MVPA differed by sex and ethnicity/race. Asian males and females showed lower levels of MVPA at both low and high BMI.

Conclusions—Interventions to increase MVPA may need to begin earlier among Asian men and non-white women than among other groups. Asian adolescents with lower BMI show lower MVPA, and may benefit from additional intervention efforts compared to Asian adolescents with normal BMI.

Keywords

physical activity; health disparities; epidemiology; health determinants

INTRODUCTION

In much of the world, physical activity is declining as advances in technology and shifts to sedentary forms of employment reduce activity at work, at home and for transportation. Lack of physical activity is linked to obesity, heart disease and cancer,¹ and is implicated in over three million preventable deaths per year globally.^{2,3} Therefore, it is a high public health priority to promote life-long physical activity.

In the United States, 40% of children under 12 years of age achieve the recommended 60 minutes of moderate to vigorous physical activity (MVPA) per day.⁴ By adolescence (13 to 18 years) only 8% of Americans are meeting MVPA recommendations and only 5% of adults in the United States meet MVPA recommendations.⁴ There is a clear need to intervene to increase population levels of MVPA in the United States. However, the modifiable determinants of MVPA are poorly understood, and determinants of MVPA may differ across groups within a population. Determinants of physical activity like screen-time and confidence in overcoming barriers differ by sex.⁵⁻⁷ Barriers to MVPA, like low parent knowledge of MVPA recommendations or neighborhood design barriers, differ by ethnicity/race.^{8,9}

Yet, few studies have quantified determinants of, or trends in MVPA, both across ethnicity/race and between the sexes at the same time. To our knowledge, 13 longitudinal studies have examined determinants of physical activity in subgroups of both ethnicity/race and sex.^{6,10-21} Of these studies, only two studies examined determinants in stratified subgroups of both sexes and more than one ethnicity/race.^{10,11} This gap in the literature may reflect that intersectionality theory – which proposes that health behaviors are determined by the interactions among social variables like ethnicity/race and sex, and not simply each of the social variables independently – is relatively new.²² Improved understanding of differences in determinants of MVPA and trends over time in population subgroups may be crucial for targeting appropriate interventions to increase life course MVPA. Therefore, the current analysis aimed to examine the following questions: 1. What are the trends of MVPA from adolescence to young-adulthood? 2. Do the trends of MVPA differ by ethnicity/race and sex? 3. Do longitudinal determinants of MVPA differ between these groups, for example: does a relatively high BMI predict subsequent lack of MVPA differently in African American young adults than in white young adults? Specifically, six variables that have previously been associated with physical activity were assessed for differences by sex and ethnicity/race: body mass index (BMI) has been negatively associated with physical activity;²³ screen-time has been negatively associated with physical activity;^{6,7} sports participation has been positively associated with physical activity;²⁴ substance use has been negatively associated with physical activity;^{12,23} depression has been negatively associated with physical activity;²⁴ parent fitness concerns have been positively associated with physical activity.²⁵

METHODS

Study Design

Project EAT (Eating and Activity in Teens and Young Adults) is a 15 year longitudinal study with four waves of follow-up and a large, diverse sample that allows examination of trends in and determinants of MVPA from adolescence to adulthood in subgroups of ethnicity/race and sex. The Project EAT surveys examined dietary intake, physical activity, weight-control behaviors, weight status, and associated factors among young people. Surveys at EAT-I (1998 – 1999) were completed by 4746 participants during classes at 31 public junior and senior high schools in the Minneapolis-St. Paul metropolitan area of Minnesota.^{26,27} At each wave of follow-up (EAT-II: 2003 – 2004, EAT-III: 2008 – 2009 or EAT-IV: 2015 – 2016) participants completed online or mailed paper surveys. Prior to EAT-II, 1075 participants could not be contacted and were lost to follow-up. Of the 3671 invited to participate in EAT-II, 2516 completed surveys. Between EAT-II and EAT-III, 229 participants could not be contacted and were lost to follow-up. Of the 3442 invited to participate in EAT-III, 2287 completed surveys. Between EAT-III and EAT-IV, 672 participants could not be contacted and were lost to follow-up. Of the 2770 invited to participate in EAT-IV, 1830 completed surveys. All surveys can be accessed at <http://www.sphresearch.umn.edu/epi/project-eat/#survey>.

The sample for this analysis included 2902 participants in the Project EAT-I survey who completed at least one of the three follow-up surveys. The analysis sample was relatively evenly split between the sexes and among levels of baseline SES (Table 1). All ethnicity/race by sex groups had sample sizes over 80, meaning that stratified models could reasonably be run (Table 1). The University of Minnesota's Institutional Review Board approved all protocols for Project EAT at each time point. All participants gave informed consent at each time point.

Variables

Moderate to Vigorous Physical Activity (MVPA)—MVPA was assessed using questions modified from Godin and Shepard at each wave of follow-up.²⁸ The questions ask about hours per week spent in mild, moderate or strenuous exercise. Moderate and strenuous exercise were summed to obtain hours per week of MVPA. This self-report measure was validated with accelerometers in a sub-sample of 121 respondents at EAT-III.²⁹ Sirard et al found a correlation of 0.43 between the self-report and accelerometer measured MVPA at EAT-III, and self-report did not systematically over or underestimate MVPA compared to accelerometer measurements.²⁹ Two week test-retest correlations are 0.52 to 0.63 at EAT-I, 0.85 at EAT-III and 0.76 at EAT-IV.

Ethnicity/race was self-reported at EAT-I. Respondents chose one or more categories with which they identified: White, Black or African American, Hispanic or Latino, Asian American, Hawaiian or Pacific Islander, or American Indian or Native American (kappa reliability coefficients ranged from 0.7 to 0.83). Respondents who reported Hispanic or Latino ethnicity were classified as Hispanic or Latino regardless of racial identity. Non-Hispanic respondents who reported two races with one race being “white” were classified as

the non-white race they reported. Because of small sample sizes of Hawaiian or Pacific Islander and American Indian or Native American, these groups were included in the mixed/other race category.

Sex was self-reported at EAT-I as male or female (kappa reliability coefficient = 1.0).

Socioeconomic Status (SES) was created from the maximum parent education attainment reported at EAT-I (baseline) (kappa reliability coefficient = 0.78). Level of SES was adjusted down if the respondent was on public assistance, free or reduced lunch or neither parent was employed.²⁷ The five categories were ordered with the highest category representing highest SES and the lowest category representing lowest SES.

Age in years at each follow-up was self-reported or calculated by subtracting the respondent's birthdate from the survey-completion date (test-retest reliability = 0.99 at EAT-I, EAT-III and EAT-IV). To account for possible non-linearity in MVPA over the life course, age was categorized to mutually exclusive categories: middle school (11 to 13 years), high school (13.1 to 18 years), college-age (18.1 to 22 years), young adult (22.1 to 30 years), 30+ (30.1 to 36 years). Categories were chosen to reflect ages where major life changes may change MVPA behavior.

Determinants—Six variables – BMI, screen-time, sports participation, substance use, depression, and parent fitness concerns— were modeled as potential determinants of MVPA. All determinants except sports participation and parent fitness concerns (measured only at baseline) were lagged by five years. To assess reliability of these constructs, a test-retest reliability study was conducted prior to administering the EAT-I and EAT-III studies; the test re-test samples consisted of 161 adolescents at EAT-I and 66 young adults at EAT-III. Surveys for the test-retest study were completed two weeks apart and reliability coefficients were calculated for all survey items.^{26,30} The reliabilities of individual survey items varied from poor to perfect, and reliabilities for the items used in this analysis are presented below.

BMI—Height and weight were measured by trained research staff at baseline (EAT-I) and used to calculate body mass index (BMI) in kg/m² for 4240 of the 4746 baseline participants.²⁷ Height and weight were also self-reported at EAT-I and these values were used to calculate BMI for an additional 357 of the baseline participants who did not have a measured BMI. The correlations between measured and self-reported heights and weights at baseline were high (females: 0.85, males: 0.89). BMI was calculated from respondents' self-reported height and weight at each wave of follow-up. The test-retest correlation at EAT-III was 0.99 for both height and weight.

Depression was measured at each wave of follow-up from responses to the Kandel and Davies depression scale.³¹ This scale was categorized into high depressive symptoms (scores over 23), moderate depressive symptoms (scores between 18 and 22) and low depressive symptoms (scores 17 and below) as previously described.^{31,32} Cronbach's alpha for these items was 0.82 at EAT-I and EAT-II and 0.83 at EAT-III.

Sports Participation—At baseline, sports participation was assessed using the question, “During the past 12 months, on how many sports teams did you play?” Sports participation was dichotomized to compare respondents who participated on any teams to respondents who participated on no teams. The test-retest correlation was 0.84 at EAT-I.

Screen-time—Participants were asked about daily hours of TV and video use and daily hours of computer use separately for weekdays and weekends. Total weekly hours of screen-time were calculated. The test-retest correlations ranged from 0.69 to 0.81 at EAT-I and from 0.74 to 0.90 at EAT-III.

Substance Use—Participants were asked about past-year cigarette, alcohol and marijuana use. Substance use was dichotomized to compare participants who never used any substance in the past year to participants who ever used any substance in the past year. The test-retest correlations ranged from 0.77 to 0.81 at EAT-I and from 0.91 to 0.94 at EAT-III.

Parent Fitness Concerns—At baseline, participants were asked how much their mother and father care about staying fit and exercising. There were four response options from “Not at all” to “Very Much.” Parent fitness concerns were modeled as the average over the parents for whom this variable was reported. The test-retest correlation at EAT-I ranged from 0.68 to 0.70.

Analysis

Statistical tests comparing the analysis sample ($n = 2902$) to those lost to follow-up ($n = 1844$) showed significant differences between these groups on SES, ethnicity/race, gender, and baseline MVPA. To address differential loss to follow-up, data were weighted using the response propensity method in all analyses.³³ Response propensities (the probability of responding to any of the follow-up surveys) were estimated using a logistic regression on a large number of predictor variables from the baseline (EAT-I) survey. The weighting method resulted in estimates representative of the demographic make-up of the original sample, addressing the potential bias from differential loss to follow-up.

Generalized estimating equations (GEE) were used to estimate the association of age with MVPA over the 15 years of follow-up. To allow for potential non-linearity of the association, age was modelled as a five-level categorical variable except when testing for trends. To account for correlation of MVPA over follow-up within individuals, GEE models were fit using an auto-regressive working correlation matrix. Models were run in two steps. First, a model was run on the entire sample, adjusted for ethnicity/race, sex and SES, with a three-way interaction for ethnicity/race and sex with age on MVPA to test for heterogeneity of the associations. When the test for three-way interaction was statistically significant, models were run separately in eight strata defined by ethnicity/race and sex. For all models, tests for linear, quadratic and cubic trends in MVPA with age were run by sequentially adding age, age², and age³ as continuous variables to the model. Trends were considered significant at $p < 0.05$. Each model was run on respondents from the sample of 2902 that were not missing any of the variables modeled.

Generalized estimating equations were used next to estimate lagged (longitudinal) associations of the six determinants with MVPA at five-year intervals. Since sports participation and parent fitness concerns were only measured at baseline (1999 – 2000), these determinants were modeled as baseline only; all other determinants were lagged five years and modeled as time-varying. To explore possible non-linearity in the association with MVPA, BMI was modelled both as a linear and as a quadratic determinant. All GEE models were fit with an auto-regressive working correlation matrix, and run on the entire sample and stratified by sex. Two-way interactions for each determinant with ethnicity/race on MVPA, and with sex on MVPA and a three-way interaction for ethnicity/race and sex with each determinant on MVPA were used to test for heterogeneity of the associations on the additive scale. If a determinant had a significant ($p < 0.05$) three-way interaction with ethnicity/race and sex, models stratified to eight strata of ethnicity/race and sex were run. All models were also adjusted for age, SES and previous (five-year lagged) MVPA. Models run on the whole sample were also adjusted for ethnicity/race and sex. Analyses were conducted with SAS, version 9.4 (2013, SAS Institute, Cary, NC, USA).

RESULTS

Trends in MVPA from Adolescence to Young Adulthood

Mean reported MVPA declined by 2.1 hours per week over 15 years of follow-up in the overall sample from a mean of 6.4 hours per week at baseline (Table 1). The test for the three-way interaction of ethnicity/race and sex with age on MVPA was statistically significant ($p < 0.001$). Age trends in MVPA were, therefore, examined stratified by sex and ethnicity/race (Figures 1–3).

Compared to females, males showed higher MVPA at each age. A test for a cubic trend in MVPA with age was significant ($p < 0.001$) in males, indicating two periods of stability in MVPA with a period of more rapid change between the periods of stability. The trend in males showed stable MVPA over middle school and high school (7.4 hours per week [95% CI: 6.9 to 7.8]) before a comparatively steep decline at college age and stability at a lower level in young adulthood (5.2 hours per week [95% CI: 4.8 to 5.6]) (Figure 1).

Females showed a decline in MVPA from middle school (6.1 hours per week [95% CI: 5.4 to 6.7]) into college age and stabilized at lower levels during young adulthood (3.4 hours per week [95% CI: 2.9 to 3.9]) (Figure 1). The test for a quadratic trend in MVPA with age was significant ($p < 0.0001$) in females, providing evidence for this U-shaped curve, or period of rapid change followed by a period of stability.

Trends in MVPA with age also differed by ethnicity/race within each sex (Figures 2 and 3). Asian males, primarily Hmong ethnicity, reported significantly lower levels of MVPA than white males ($p < 0.05$) at each age except for high school. There was a significant cubic, or S-shaped, trend in MVPA over age in white males, with stability from middle school to high school followed by relatively steep decrease in MVPA at college age and stability at a lower level in young adulthood (Figure 2). Tests for linear trends in MVPA with age were not significant in African-American and Hispanic males, giving no evidence for change in

MVPA with age in these groups likely because smaller sample sizes allow less precision in MVPA estimates and greater possibility of type II errors (Figure 2).

In middle school, white females report significantly greater levels of MVPA (6.8 hours per week [95% CI: 6.2 to 7.4]) than African-American (5.3 hours per week [95% CI: 4.1 to 6.5], test for difference from white participants: $p = 0.03$) and Asian females, again primarily Hmong (5.5 hours per week [95% CI: 4.5 to 6.4], test for difference from white participants: $p = 0.03$). A significant quadratic trend in MVPA with age among white, African-American and Asian females indicates a steeper decline in MVPA from middle school to college age before stabilizing at lower levels as young adults. A significant linear trend in MVPA with age among Hispanic females indicates steady declines in MVPA from adolescence to adulthood (Figure 3).

Longitudinal Determinants of MVPA and their Differences by Sex and by Ethnicity/Race

In both males and females, the associations of five-year lagged depression and baseline parent fitness concerns showed little evidence for any association. Participating in any sports at baseline was associated with 0.46 more hours per week of MVPA per week at follow up in males and 0.44 more hours per week of MVPA per week females. Five-year lagged screen-time showed a weak negative association with MVPA in both males and females. Five-year lagged substance use showed a negative association with MVPA among females ($\beta = -0.38$) compared to a weaker, though slightly positive association with MVPA among males ($\beta = 0.27$) (Table 2).

The only determinant that differed significantly in its association with MVPA both by ethnicity/race and sex was BMI modeled as a quadratic or U-shaped association (test for interaction: $p < 0.05$). Therefore, models of the association of BMI with MVPA were stratified by ethnicity/race within each sex.

To further explore the form of the association of BMI *as a determinant of* MVPA, the sample was stratified into subgroups of ethnicity/race and sex and models of five-year lagged linear and quadratic BMI on MVPA were run. If quadratic terms were not statistically significant in these models ($p < 0.05$), they were dropped. Figure 4 shows the best fitting associations of five-year lagged BMI with MVPA in males and females respectively. Tests for trends for these associations were statistically significant at $p < 0.05$ in all subgroups except for African-American females.

White, African-American and Hispanic males show a linear decline in MVPA with increasing five-year lagged BMI. The steepest decline in MVPA with increasing five-year lagged BMI was among African-American males ($\beta = -0.25$ [95% CI: -0.41 to -0.09]) Among Asian males, the quadratic association of five-year lagged BMI with MVPA showed the best fit. In this group, MVPA was lower at both low and high BMI, and higher MVPA was observed at five-year lagged BMI between 25 and 30 kg/m² (Figure 4).

Among females there was a linearly decreasing association of five-year lagged BMI with MVPA in white females and no significant relationship of MVPA with five-year lagged BMI in African-American females. As with Asian males, in Asian females there was a quadratic

relationship of five-year lagged BMI with MVPA, with lower MVPA at both low and at high BMI, and higher MVPA at five-year lagged BMIs between 23 and 27 kg/m². The quadratic relationship of five-year lagged BMI with MVPA in Hispanic females showed sharp declines in MVPA with BMI until it reaches a fairly low and stable level at BMI of 30 kg/m² (Figure 4).

DISCUSSION

This study found that MVPA declined from adolescence to adulthood, and trends differed significantly by ethnicity/race and sex. Specifically, males showed later declines in MVPA than females. African-American and Hispanic males showed little evidence of change in MVPA behavior over follow-up, though this could reflect lower statistical power to see changes due to smaller samples sizes of these groups. Asian males, and females of non-white ethnicity/race, started at lower levels of MVPA at middle school and declined into adulthood. The different trends in MVPA across subgroups in our study provide some guidance about possible mechanisms for the decline in MVPA and about when to target interventions.

The later decline in MVPA among males may be evidence of a mix of social and biological mechanisms leading to lower MVPA following puberty, and further studies will need to disentangle these mechanisms. The relatively sharp drop in MVPA among white males after high school indicates that the transition to college or work may be the optimal timing for interventions; while the relatively low activity among Asian males as early as middle school may mean that interventions need to be sustained from grade school through high school. MVPA starts at a lower level in adolescence among non-white females and declines quickly from adolescence to adulthood. Earlier interventions may, therefore, also be useful among non-white females. Previous work in college students by Nelson et al has similarly shown that while college may be an appropriate intervention point for white males and females, it may be too late for Asian males and non-white females.³⁴

This study also found associations with determinants of MVPA that may be useful in understanding mechanisms and targeting interventions. Sports participation at baseline showed strong positive association with MVPA over follow-up in both males and females. Reported substance use was associated with less MVPA five years later among females, but there was little evidence of a similar association among males. BMI was the only determinant that differed significantly in its association with MVPA by ethnicity/race and sex.

While BMI is often considered as an *outcome* of MVPA, the possible feedback loop makes it important to consider BMI also as a *determinant* of MVPA. We found 11 longitudinal studies that examined BMI as a determinant of physical activity.^{6,12,14,19,35–41} Yet, none of these examined this association within subgroups of both sexes and multiple ethnicities/races. Examining these associations by ethnicity/race and sex showed that most racial and ethnic groups show lower MVPA at higher BMI. Among these groups, targeting interventions to increase MVPA to individuals with higher BMI may be useful. However, stratified models showed that Asian males and females at *lower* BMI also show lower levels

of MVPA. Asian participants in this study were mostly Hmong ethnicity: a group largely comprised of families that immigrated to the United States relatively recently.⁴² A potential mechanism for the association of low BMI with low MVPA in this group that should be studied further is that smaller Asian adolescents may not be participating in popular American team sports that favor larger individuals. This mechanism would also help explain previous findings in the Project EAT sample that Hmong participants were more likely to report steroid use.⁴³ Interventions to increase MVPA should not overlook participants with lower BMI.

Other determinants of MVPA did not differ by ethnicity/race. Substance use inversely predicted MVPA among females, in line with findings by Kimm et al, which found cigarette use inversely predicted physical activity in white adolescent females.¹² Interestingly, this association did not exist among males but the estimate and confidence interval among males slightly favored a *positive* association. The association of substance use with physical activity should be examined in more detail in future studies, particularly looking for non-linearity in the association and sex differences. Further, the strength of the association of sports participation in adolescence with MVPA into adulthood was similar for males and females and across racial and ethnic groups, indicating that interventions to promote participation on sports teams may have lasting benefits for meeting recommended levels of MVPA in all adolescents.

Strengths and Limitations

A major strength of this study is its 15 years of longitudinal data collection. Following participants from adolescence to young adulthood allowed us to examine the shape of trends in MVPA over this period of rapid change. Further, having four waves of data collection allowed us to lag potential determinants of MVPA to establish evidence for temporality of any associations.

The diversity of this sample allowed us to examine trends and determinants of MVPA stratified by ethnicity/race and sex. Stratified analyses not only support previous longitudinal studies by clearly demonstrating that the decrease in MVPA occurs earlier among females than among males,^{4,36} but also found that trends differ by ethnicity/race within strata of sex, expanding on previous cross-sectional work.⁴ We are aware of only one other study that examined MVPA trends over development from adolescence to young adulthood longitudinally within multiple subgroups of race and sex, though it only examined linear trends in physical activity.⁴⁴ Yet, as with any stratified analysis, results should be interpreted with care due to the reduced sample sizes when stratifying, particularly among the Hispanic participants ($n = 176$, 6.1% on analysis sample).

Since our sample ranged from 11 to 18 years of age at baseline, our analyses could not completely separate cohort effect from the age effect. Further, selection bias may exist in these data due to differential loss to follow-up. Our sample of 2902 represents 61% of the original sample of 4746, and had a higher proportion of female and white participants than the original sample. Our analyses used sampling weights to address selection bias due to loss to follow up to the best of our ability. In addition, demographic covariates and five-year lagged measurements of the outcome (MVPA) were added to models to address potential

further bias due to confounding. However, it is possible that some residual bias from these sources remains. Since MVPA was self-reported in this study, measurement bias may exist. However, a validation sub-study at EAT-III showed that this self-report measure did not systematically over or underestimate MVPA when compared to accelerometer measures.²⁹ This finding was consistent even at high reported levels of MVPA. Measurement bias in the determinants may also exist. A further limitation is that BMI as a measure of adiposity may have different relationships to MVPA than other measures like waist circumference or DXA measured central adiposity, particularly since BMI is not as sensitive a measure of muscle to fat ratios. Finally, although comparing between ethnicities/races within the same geographic area allows better control of other environmental variables, the results from this study may not be generalizable to other geographic areas, particularly as lifestyles are likely to vary between regions within the United States as well as between other countries. Future work will be needed to replicate and expand on these findings.

Implications for Public Health

The results of this study can help target and tailor interventions to increase MVPA. Specifically, this study shows that interventions at earlier ages (for example, in grade school) may be needed for Asian males and non-white females. Many trials like GEMS,^{45–48} TAAG,⁴⁹ and others^{50–54} have focused on increasing MVPA among females, especially African American females. Yet, to our knowledge few trials have been developed to increase MVPA in Asian-American males. The relatively low levels of MVPA at low BMIs among Asian males and females may mean that these groups should be targeted for tailored MVPA interventions – which are more commonly targeted at overweight individuals. Taken together with the association of sports participation in adolescence with greater MVPA into adulthood, interventions that increase the diversity of sports offered at middle schools and high schools, especially focusing on sports that favor different body types, may engage more individuals and have a lasting impact on population levels of physical activity.

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Figure 1. Age Trends in Population Mean MVPA for Males and Females, adjusted for SES and race

a: Test for cubic trend is significant at $p < 0.01$

b: Test for quadratic trend is significant at $p < 0.01$

Figure 2. Age Trends in Population Mean MVPA for Males by Race, adjusted for SES

a: Test for cubic trend is significant at $p < 0.01$

Figure 3. Age Trends in Population Mean MVPA for Females by Race, adjusted for SES

a: Test for quadratic trend is significant at $p < 0.01$

b: Test for linear trend is significant at $p < 0.01$

Figure 4.
Predicted Forms of the relationship of Five-Year Lagged BMI on Physical Activity

Table 1

Sample Demographics

	Participants by Wave
EAT-I	4746
EAT-II	2516
EAT-III	2287
EAT-IV	1830
	Analysis Sample (n = 2902)
<i>Age (Years): Mean (SD)</i>	
EAT-I	14.8 (2.2)
EAT-II	19.4 (2.2)
EAT-III	25.2 (2.1)
EAT-IV	31.0 (2.1)
<i>MVPA (Hours/Week): Mean (SD)</i>	
EAT-I	6.4 (6.0)
EAT-II	5.3 (5.7)
EAT-III	4.2 (5.0)
EAT-IV	4.3 (4.6)
<i>BMI (kg/m²): Mean (SD)</i>	
EAT-I	23.2 (6.4)
EAT-II	24.3 (6.3)
EAT-III	26.4 (7.3)
EAT-IV	27.8 (8.0)
<i>Race-Gender Groups: n (weighted %)</i>	
Male	1341 (50.0%)
White	853 (25.1%)
African American	122 (8.4%)
Hispanic	83 (4.3%)
Asian	221 (9.1%)
Mixed or Other	62 (3.0%)
Female	1561 (50.0%)
White	866 (22.4%)
African American	195 (10.4%)
Hispanic	93 (3.4%)
Asian	306 (10.0%)
Mixed or Other	101 (3.8%)
<i>Socioeconomic Status (SES) at Baseline (EAT-I): n (weighted %)</i>	
Low	388 (17.3%)
Low Middle	475 (18.8%)
Middle	726 (26.7%)
High Middle	772 (23.8%)
High	465 (13.5%)

TABLE 2

GEE ESTIMATES OF THE ASSOCIATION OF PERSONAL AND SOCIAL PREDICTORS WITH MVPA (HOURS/WEEK)^a

	Males (n = 1341)	Females (n = 1561)
TIME VARYING 5-YEAR LAGGED PREDICTORS		
	Estimate	Estimate
<i>Screen-time (Unstandardized Beta [95% CI])</i>		
Hours of Screen-time/week	-0.02 [-0.03 to -0.01]	-0.01 [-0.02 to -0.004]
<i>Substance Use (Unstandardized Beta [95% CI])</i>		
(2) Any	0.27 [-0.17 to 0.71]	-0.38 [-0.70 to -0.06]
(1) None	0 [Ref]	0 [Ref]
<i>Depression (Unstandardized Beta [95% CI])</i>		
High Symptoms	-0.20 [-0.84 to 0.44]	-0.38 [-0.73 to -0.03]
Moderate Symptoms	-0.06 [-0.48 to 0.36]	-0.11 [-0.41 to 0.19]
Low Symptoms	0 [Ref]	0 [Ref]
BASELINE DETERMINANTS		
<i>Sports Participation (Unstandardized Beta [95% CI])</i>		
Any Sports	0.46 [0.02 to 0.90]	0.44 [0.16 to 0.74]
No Sports	0 [Ref]	0 [Ref]
<i>Parent Fitness Concerns (Unstandardized Beta [95% CI])</i>		
(4) Very Much	0.37 [-0.63 to 1.38]	0.42 [-0.19 to 1.03]
(3) Much	0.27 [-0.73 to 1.26]	0.12 [-0.46 to 0.70]
(2) Some	-0.04 [-1.06 to 0.99]	0.13 [-0.49 to 0.74]
(1) Little	0 [Ref]	0 [Ref]

^aModels adjusted for race, age, SES and 5 year lagged MVPA