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Comparison of three measures of physical activity and associations with blood pressure, HDL and body composition in a sample of adolescents

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Abstract

Background—The association of physical activity (PA), measured three ways, and biomarkers were compared in a sample of adolescents.

Methods—PA data were collected on two cohorts of adolescents (N=700) in the Twin Cities, Minnesota, 2007–2008. PA was measured using two survey questions (Modified Activity Questionnaire (MAQ)), the 3-Day Physical Activity Recall (3DPAR), and accelerometers. Biomarkers included systolic (SBP) and diastolic blood pressure (DBP), lipids, percent body fat (%BF) and body mass index (BMI) percentile. Bivariate relationships among PA measures and biomarkers were examined followed by generalized estimating equations for multivariate analysis.

Results—The three measures were significantly correlated with each other (r=0.22–0.36, $P<0.001$). Controlling for study, puberty, age and gender, all three PA measures were associated with %BF (MAQ=-1.93, $P<0.001$; 3DPAR=-1.64, $P<0.001$; accelerometer=-1.06, $P=0.001$). The MAQ and accelerometers were negatively associated with BMI percentile. None of the three PA measures were significantly associated with SBP or lipids. The percentage of adolescents meeting the national PA recommendations varied by instrument.

Conclusions—All three instruments demonstrated consistent findings when estimating associations with %BF, but were different for prevalence estimates. Researchers must carefully consider the intended use of PA data when choosing a measurement instrument.

Background

Physical activity (PA) levels suffer a marked decline during adolescence with the most dramatic decline occurring in early adolescence.[1] Low PA and high sedentary behavior may have serious proximal and distal health and psychosocial implications for adolescents including elevated blood pressure, unhealthy blood lipid profiles and increased risk for obesity.[2–4] Adiposity, particularly central adiposity, obesity and other biomarker changes are associated with an increase in cardiovascular disease risk factors tracking into adulthood.[5–7]

A National Expert Panel recommends that adolescents participate in 60 minutes of MVPA daily,[8] however, current data suggest that few adolescents are meeting that benchmark.[9] The two most common ways to measure PA levels are through self-report surveys and an objective measure of movement, such as accelerometers; all were designed to reflect 'usual' activity. Self-report surveys are relatively inexpensive to administer and are important as part of national surveillance of PA levels. The 2007 Youth Risk Behavior Surveillance

Survey (YRBSS) used self-report questions and found that only 35% of high school students participated in moderate-to-vigorous physical activity (MVPA) on five or more of the seven days preceding the survey.[10] Yet, there is evidence that self-report instruments overestimate adolescents' PA behavior and the measurement error associated with self-report PA appears to attenuate the association between PA and percent body fat (%BF) as compared to direct observation.[5]

The use of accelerometers provides an objective measure of PA. As part of the most recent National Health and Nutritional Examination Survey (NHANES 2003–2004), Troiano and colleagues (2008) reported on accelerometer-measured PA in a representative sample of children and adolescents in the US. In contrast to the higher levels reported in the YRBSS, [10] NHANES reported that 42% of 6–11-year-olds, 8% of 12–15-year-olds, and 7.6% of 16–19-year-olds accumulated 60 minutes of daily MVPA.[9] Despite the potential for less error in measurement and subsequent improved strength of the association with a biologic outcome, accelerometer data have other unique challenges in terms of compliance and in interpretation of the data themselves.[11] In many studies it is logistically and financially prohibitive to distribute accelerometers to all participants. While one would expect that the more objective measure of activity would correspond most strongly with biologic markers since the bias associated with self-report is eliminated, it would be helpful for researchers to know how these PA assessment instruments compare.

The purpose of this analysis was to compare three measures of PA (two survey-based, one accelerometer) and the association with biological markers among adolescents. This study is unique in that, as opposed to meta-analysis methods, this study collected all three measures of PA, biomarkers and body composition on healthy weight and overweight/obese adolescents during the same ten-day period, providing a comparison of the relationship between PA and biomarkers by different instruments. Specifically, we sought to evaluate if the relationship between PA and biomarkers was observed regardless of the instrument used and to assess to what extent the assessment method impacted the strength of the association observed. Secondarily, we observed the differences in the proportion of adolescents who met national recommendations of PA for each of the three PA instruments.

Methods

Subjects or Sample

Data for this analysis came from two etiologic studies of adolescent obesity from the same location and during the same time period. The Transdisciplinary Research on Energetics and Cancer – Identifying Determinants of Eating and Activity (TREC-IDEA) study is a 3-year longitudinal study aimed at understanding the social and environmental influences on unhealthy weight gain in adolescences (blinded for review). Youth were recruited from a preexisting cohort, [12] a permit application listing from the Minnesota Department of Motor Vehicles, and a convenience sample from the St. Paul-Minneapolis metropolitan area. Participants in this study (n=349) were adolescents (ages 10.8—17.7 years at baseline) and one parent/guardian living in the Twin Cities Metropolitan Area, Minnesota. Baseline data were collected in 2006–2007. Exclusion criteria included: 1) youth with a BMI less than or equal to the 15th percentile for age and sex; 2) a medical condition affecting growth (e.g. diagnosed with a genetic or metabolic disease/syndrome associated with obesity, Type 1 or Type 2 diabetes, chronic GI disease, anorexia or bulimia nervosa, AIDS or HIV infection; 3) use of medication that affects growth (e.g. steroids taken more than 2 weeks in the past year, thyroid hormones, growth hormones); 4) youth not fluent in English; and 5) plans to move from the geographical area within three years.

The second sample was from the Etiology of Childhood Obesity (ECHO) study (n=374). Baseline data were collected on adolescents (ages 11.0—17.6) and one parent/guardian from 2007–2008. The participants were recruited from the membership of HealthPartners® (HP) health plan within the seven-county metropolitan area of Minneapolis, St. Paul, Minnesota. The recruitment plan was designed to recruit an ethnically and racially diverse sample and to sample youth and parents that represented both healthy weight and overweight individuals. To be eligible for enrollment, youth were required to be current HP members, in grades 6th through 11 in the fall of 2007, residing in one of the randomly selected middle or high-school districts included in the sample, have a parent willing to participate and be willing to allow their names and contact information to be sent from HP to the study team at University of Minnesota for further eligibility screening, consent and measurement. Only one parent/child dyad per family were allowed to enroll. Parent/child dyads were excluded from eligibility if they planned to move from the area in the next three years, had a medical condition that affected their growth, were non-English speaking or otherwise had difficulty comprehending English, or had any other physical or emotional condition that would affect their diet/activity levels or make it difficult to complete measurements.

The TREC-IDEA and ECHO studies collected the same measures on all participants from the same target population. Appending the data from the two studies provided a larger and more diverse sample. Appending, data management and analyses were done using v.9.1 of the SAS System for Windows.[13] Both studies were approved by the University of Minnesota Institutional Review Board (IDEA IRB protocol number: 0505S69869; ECHO IRB protocol number: 0609S92886)

The total sample size for the main study was n=723. However, one of the measures included in the measurement battery was an optional blood draw. Therefore, the full sample for blood-based measures included a total of n=367 adolescents (TREC-IDEA=198, ECHO=178). The sample of adolescents who participated in the blood draw was comparable to the full sample for age, percent Caucasian, SES, and physical activity ($P \geq 0.05$).

Measures

Body Mass Index (BMI) and Percent Body Fat—Trained clinic staff measured the height of each youth and parent using a Shorr height board (Irwin Shorr, Olney, MD), and body mass and body composition were determined using a bioelectrical impedance device that assesses body lean and fat masses (Tanita TBF-300A Body Composition Analyzer, Arlington Heights, IL). Percent body fat calculated using this method can be found in the published literature [14–16], although with limitations particularly in multiethnic populations [17]. BMI was calculated using the measured height and weight with the formula BMI=weight (kg)/ height (m)^2. Youth BMI percentiles were derived from data from the Centers for Disease Control and Prevention Growth Charts.[18]

Blood pressure was measured over the brachial artery in the right arm via an automated sphygmomanometry (Critikon Dinamap 8100 blood pressure monitor, GE Healthcare, Piscataway, NJ) after 5 minutes of seated rest in a quiet room. Three measurements of blood pressure were made and then averaged; if the three measures of systolic (SBP) and diastolic (DBP) blood pressure were not within 15% of each other a fourth measure was taken. The three measures within 15% of each other were then averaged. Data collection time period varied, occurring Monday-Thursday evenings (4:00 p.m. – 8:00 p.m.) or Saturdays (9:00 a.m. – 3:00 p.m.).

Fasting blood samples were obtained by venipuncture from the anticubital vein into chilled tubes containing ethylene diamine tetraacetic acid (EDTA) between 6:00 and 9:00 am, after a 12-hour overnight fast at the University of Minnesota General Clinical Research Center

(GCRC). Plasma was separated by centrifugation for 20 minutes at 2500 rpm and 4°C for the measurement of total cholesterol, low-density lipoproteins (LDL-C) and high-density lipoproteins (HDL-C). All plasma samples were assessed by standard colorimetric reflectance spectrophotometry at the Fairview Diagnostics Laboratories, Fairview-University Medical Center (Minneapolis, Minnesota), a Center for Disease Control and Prevention certified laboratory.

Two surveys (Modified Activity Questionnaire and the 3-Day Physical Activity Recall) and an accelerometer were used to assess MVPA. The student survey was a self-administered questionnaire asking demographic information, perceptions, knowledge, attitudes and behaviors related to energy balance. Two PA questions, based on the Modifiable Activity Questionnaire (MAQ) [19], asked participants to report, 1) "How many times in the past 14 days have you done at least 20 minutes of exercise <u>hard</u> enough to make you breathe heavily and make your heart beat faster? (Hard exercise includes, for example, playing basketball, jogging, or fast bicycling. Please include time in physical education class)". These responses were considered vigorous intensity based on the examples provided. A second question asked about <u>light</u> activity including walking or slow bicycling; considered moderate intensity based on the examples provided. The response categories were 1) None; 2) 1 to 2 days; 3) 3 to 5 days; 4) 6 to 8 days; 5) 9 or more days. The response categories were recoded to the mid-range of the responses to 'None'; '1.5 days'; '4 days'; '7 days'; and '9 days'. The number of days for vigorous and moderate exercise questions was summed and divided by 14 to get the average number of days in the past14 engaged in MVPA for 20 minutes or more per day. Additional MAQ questions regarding past-year PA were not included due to the long-term recall that was inconsistent with the rest of the measurement battery and concerns about excessive subject burden within the context of the broader TREC-IDEA and ECHO studies.

The 3-Day Physical Activity Recall (3DPAR) was a self-administered survey completed during the clinic visit. The 3DPAR self-report instrument[20] was used to assess the PA behavior during the previous three days, recalling the most proximal day first by trained data collectors. Instrument details can be found in Pate, 2003.[20] The number of 3DPAR time blocks corresponding to vigorous PA (VPA; "hard" and "very hard" classifications from the 3DPAR; ≥ 6 METS) and moderate-to-vigorous PA (MVPA; "moderate""hard" and "very hard" classifications from the 3DPAR; ≥ 3 METS) were averaged across all three days.[21]

The ActiGraph activity monitor, model 7164 (ActiGraph, LLC, Pensacola, FL) was used to collect seven days of PA data using 30-second epochs (data collection intervals). The monitor is an objective measure of PA and has been previously validated for use with children in laboratory and field settings.[22–24] At monitor distribution, trained research staff fit the monitor to each student and provided the students with written and verbal instructions.

A custom developed software program was created by JRS using Visual Basic (version 6.0, Microsoft, Corp) [25, 26] and modified for the current study design. Daily inclusion criteria were established to determine days and times with acceptable accelerometer data. Blocks of time incorporating at least 30 continuous minutes of "0" output were considered to be times when the subject was not wearing the monitor and were eliminated. Missing data within an adolescents 7-day record were replaced via imputation based on the Expectation Maximization (EM) algorithm.[27] On average, approximately 22 hours of data (about 13%) for the IDEA sample and 11 hours of data (about 18.5%) for the ECHO sample per adolescent were imputed over the 7 days of data collection. Summary PA variables were calculated using the Freedson age-specific count cutoffs[28] distinguishing moderate and vigorous intensity based on age-adjusted MET values.[29, 30]

Demographic information and pubertal status were assessed using survey-based instruments during the clinic visit. Pubertal status was assessed by the self-report Pubertal Development Scale (PDS). [31] The PDS is a five question summed score with good internal consistency (alpha = 0.77) and high correlation between the PDS and physician rating (0.61–0.67).[31]

Analysis

The final sample size was 700 participants as 23 adolescents were missing accelerometer data. There were 363 adolescents who had accelerometer data and who also participated in the blood draw component of the study. There were no differences in SBP, BMI percentile, percent body fat, accelerometer mean MVPA, age or pubertal status between those who participated in the blood draw and remained in the sample versus those who did not.

Sample characteristics were calculated for analytic variables and differences were tested by gender using a t-test. All three measures of PA were standardized for correlation and regression modeling for comparability with a mean of zero and standard deviation of one by subtracting the mean from the participant value and dividing by the standard deviation. LDL-C, total cholesterol and triglycerides were assessed as part of the overall lipid profile and is presented as part of the descriptive analysis. However, we only use HDL-C in the subsequent analysis due to its association with exercise and PA [8] and the lack of association of LDL-C and total cholesterol with any measure of PA.

Normality of variables and residuals was assessed using the SAS skewness factor, the Kolmorogov-Smirnov test and assessing normality of the residual between PA and biologic measures. Pearson's correlation coefficient was used to assess bivariate relationships between the three measures of PA and the five biological markers. Generalized estimating equations, accounting for clustering at the school level, were used to assess independent unadjusted and adjusted associations between each PA measure and biomarker using PROC GENMOD in SAS v.9.1 of the SAS System for Windows.[13] Final adjusted models included age, puberty, study and gender. Finally, PA level by instrument was dichotomized using the national recommendations of 60 minutes of MVPA daily[8] for the 3DPAR and accelerometer data. Dichotomizing based on meeting recommendations provides a more interpretable analysis although power may be lost due to dichotomizing rather than using the continuous variables. The MAQ was dichotomized at students reporting 20 minutes of PA daily (MAQ≥1) as an estimate of meeting recommendations due to the structure of the question. Proportion of participants meeting recommendations was reported as well as the difference in mean level of each of five biomarkers between adolescents who met or did not meet the MVPA recommendations.

Results

The mean age was 14.6 years (SD=1.8) with 340 males (48.6%). Girls were more advanced in the pubertal scale, as was expected. On the MAQ, participants reported an average of 0.8±0.4 (or less than one) day in which they engaged in 20 minutes or more of MVPA. Participants reported an average of 3.5±2.8 30-minute blocks of time on the 3DPAR during which the majority of the time was spent in MVPA, or a range of minutes per day approximately 58.4–109.5 minutes. Participants achieved an average of 30.7±16.7 minutes of MVPA per day based on accelerometer data. Males had significantly higher SBP than females, but females had higher total cholesterol, HDL-C and %BF as compared to males. See Table 1.

Neither the individual distribution of the variables of interest nor the residuals of the crude associations were substantially skewed according to the SAS PROC UNIVARIATE skewness factor and plots, although the Kolmorogov-Smirnov test was significant.

Therefore, variables were not transformed. The standardized MAQ, 3DPAR, accelerometer measures and %BF were significantly correlated with each other ($p<0.001$) ranging from $r= -0.22–0.24$ (Table 2). SBP and HDL were not significantly correlated with PA, regardless of instrument, but DBP was negatively associated with the MAQ ($r= -0.08$, $p=0.04$). BMI percentile was negatively and significantly correlated with the MAQ, but not the 3DPAR or accelerometers. Using multivariate analysis, controlling for puberty, age, study and gender, all three measures of PA had a strong, negative association with %BF (MAQ; $\beta=-1.93$, $p<0.001$; 3DPAR $\beta=-1.64$, $p<0.001$; accelerometer $\beta=-1.06$, $p<0.001$) (Table 3). In addition, the MAQ ($\beta=-2.92$, $p=0.003$) and accelerometer ($\beta=-1.83$, $p=0.05$) data were negatively associated with BMI percentile. There were no other significant associations or significant interactions by gender.

The 3DPAR and accelerometer values were dichotomized to reflect the proportion of participants meeting the national recommendations of 60 minutes of MVPA daily. The MAQ only has a 20 minute per day option, so the results in Table 4 are approximations and likely an overestimate of the prevalence meeting the recommendations. Sixty-nine percent met the recommendations using the 3DPAR, 6% based on the accelerometer and as a crude approximation, 36% based on the MAQ. The 3DPAR overestimated those meeting recommendations by more than ten times as compared to estimates using accelerometer data. No instrument showed differences in HDL-C levels or mean DBP by those meeting recommendations and those that did not. For each instrument, participants in the 'meeting recommendations' category had lower %BF than those in the 'not meeting recommendations' category. BMI percentile differences were observed between groups for the 3DPAR and the accelerometer data.

Discussion

The purpose of this analysis was to compare the strength of associations between three measures of PA in adolescents and biological markers, including blood pressure, HDL-C, %BF and BMI percentile, all of which are physiological markers associated with a variety of chronic diseases. In this study, the choice of PA measurement instrument did not appear to substantially impact the observed relationship between PA and several biological variables regardless of statistical approach. The three measures of PA have relatively low correlations with each other, although statistically significant and in the hypothesized direction with each other and biological markers. Consistently, higher PA was associated with lower %BF. The relationship with BMI percentile is less consistent and may be at least partly attributable to over reporting of PA (3DPAR) and cut-points in dichotomous comparisons (MAQ). No association was found between blood pressure, HDL and PA in this sample. This is an important finding for researchers deciding which instrument to use to measure biological associations with PA.

These findings of the association between PA and biological measures are consistent with previous research.[5, 32] Evidence suggests that high levels of PA compared to low levels of PA are associated with less adiposity among adolescents.[33, 34] While Rowlands et al. found a similar association, the authors also reported that the relationship differed by measurement instrument, specifically direct observation versus survey-based instruments,[5] but no difference was found between the effect of PA on %BF between survey-based instruments and accelerometers. Intervention research suggests that increasing PA will decrease %BF among the treatment group,[35] consistent with the negative association we observed. To our knowledge, there is no evidence that PA reduces resting blood pressure in normotensive adolescents.[36, 37] Lipids were another potential biomarker associated with PA, although there was no consistent effect of PA on total cholesterol and LDL-C.[8] PA does however appear to have a positive effect on HDL-C levels, but the results are somewhat mixed.[8, 35, 38]

The average number of daily minutes engaged in MVPA in our sample (accelerometer mean=30.7, SD=16.7) are lower than those found by Troiano (accelerometer mean 12–15 years=45.3, sd=3.4) in a national study, although the variation in our sample is substantially larger and the accelerometer data reduction differed somewhat between studies.[9] Treating accelerometer data as the criterion measure of PA,[39] we found that participants over-reported PA on the 3DPAR. When comparing prevalence estimates, ten times as many adolescents were classified as having met recommendations when using the 3DPAR compared to the accelerometer data. Therefore, when estimating the prevalence of PA, the choice of PA instrument is vitally important as all instruments are not equivalent.

The fact that we were able to demonstrate this association regardless of the instrument is useful information for researchers planning studies where the focus is on PA and biological markers. While accelerometers require the most expensive initial financial outlay and ongoing technical and data processing expertise, they can be re-used many times by multiple subjects across numerous studies. On the other hand, the 3DPAR requires only paper and pencils but there is additional cost associated with administering, entering and cleaning the data that also requires personnel and financial resources. The 3DPAR has the added benefit of being able to determine *what* the participant was doing, which may be important information for interventions focused on increasing PA and decreasing sedentary behavior. Lastly, the two PA questions from the MAQ are the least expensive option since they too require only paper and pencils. Since there are only two questions, data entry and processing requirements are minimal. However, data from these selected MAQ questions are difficult to translate into public health recommendations about meeting PA recommendations of at least 60 minutes of MVPA per day. Yet, despite these limitations, the results indicate that compared to the 3DPAR, the MAQ was closer to the accelerometer for the percentage of adolescents meeting the MVPA recommendations.

The strengths of this analysis included the large sample size, the three measures of PA collected during the same time period for each participant, and the ability to combine two sets of data for a more diverse sample. This study does have limitations. This study is a cross-sectional observational study which prevents causal inference. There are inherent challenges in accelerometer data as well, including the use of different criteria for coding, cut points for hours and days of data required for valid measures, and the conversion to appropriate activity levels. And, accelerometry only captures some types of physical activity. Additionally, we did not measure other aspects of cardiorespiratory fitness, abdominal circumference and other plasma variables. Data currently available through the IDEA and ECHO studies limits our research to cross-sectional analysis; the study designs will allow us to examine the relationships longitudinally once the data is available.

In conclusion, the findings from this analysis suggest that researchers who aim to compare biological markers, specifically %BF, with levels of PA have a range of measurement options as the association remained consistent regardless of instrument. This is useful as the participant burden and cost vary substantially by instrument. However, prevalence estimates of those adolescents meeting the daily recommended levels of PA varied substantially between instruments. Current national prevalence estimates collected via survey may represent an overestimation of PA among adolescents, indicating an even more pressing public health concern. Ongoing research is needed to understand declines in PA among adolescents, strategies to increase PA and further testing of measurement approaches.

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Table 1

Descriptive Statistics for the Study Sample of Adolescents by Demographics, BMI, Three Measures of moderate-to-vigorous physical activity (MVPA) and Biological Markers, TREC IDEA and ECHO, Minneapolis, Minnesota 2006–2008.

Variable	Total (n=700)		Boys (n=340)		Girls (n=360)		T-statistic	p-value[4]
Percent Male	**48.6%**							
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**		
Age (yrs)	14.6	1.8	14.6	1.8	14.6	1.8	0.1	0.8912
Puberty	2.9	0.7	2.6	0.7	3.2	0.7	−11.9	<0.001
Modified Activity Questionnaire (MAQ): Ave # days of MVPA[1]	0.8	0.4	0.9	0.3	0.8	0.4	3.1	0.002
3-Day Physical Activity Recall (3DPAR): Ave # blocks of MVPA[2]	3.5	2.8	3.8	3.0	3.2	2.6	2.4	0.02
Accelerometer: Ave daily min. MVPA[3]	30.7	16.7	35.0	18.3	26.7	13.9	6.8	<0.001
Systolic Blood Pressure (mm Hg)	115.2	9.9	117.3	10.4	113.3	9.0	5.5	<0.001
Diastolic Blood Pressure (mmHg)	54.9	7.4	54.6	7.1	54.6	7.1	−1.1	0.10
Total Cholesterol (mg/dL) (n= 363)	151.2	29.7	146.6	29.6	156.0	29.0	−3.1	0.002
Low-density lipoprotein (LDL-C) (mg/dL) (n= 363)	85.4	25.0	83.9	24.2	87.1	25.8	−1.2	0.22
High-density lipoprotein (HDL-C) (mg/dL)(n= 363)	49.7	11.4	46.7	45.1	52.8	51.2	−5.3	<0.001
Triglycerides (n= 363)	80.7	6.3	80.1	47.9	80.9	37.8	−0.2	0.87
Percent Body Fat (%)	80.5	43.2	16.4	9.8	26.3	8.7	−14.1	<0.001
BMI percentile	21.5	10.4	61.4	29.3	60.2	27.0	0.6	0.58

[1]The survey question asked the number of days engage in 20 minutes of activity per 14 days.

Number of days of vigorous physical activity (VPA) and moderate physical activity (MPA) was summed and divided by 14 to get average number of days engaging in moderate-to-vigorous physical activity (MVPA) for 20 minutes or more.

[2]Number of 30 minute periods of MVPA daily (3-day average).

[3]Average daily number of minutes of MVPA (47-day average)

[4]t-statistic and p-value of difference between boys and girls.

Table 2

Pearson Correlation Coefficients for Standardized Measures[1] Of Moderate-to-Vigorous Physical Activity in Adolescents Using a Student Survey, Accelerometers and 3-Day Physical Activity Recall Data And Percent Body Fat, Minneapolis, Minnesota, 2006–2007.

R (p-value)	Modified Activity Questionnaire	3-Day Physical Activity Recall	Accelerometer	Systolic Blood Pressure	Diastolic Blood Pressure	High-density lipoprotein	Percent Body Fat	BMI percentile
Modified Activity Questionnaire	1.0							
3-Day Physical Activity Recall	0.36 (<0.001)	1.0						
Accelerometer	0.22 (<0.001)	0.23 (<0.001)	1.0					
Systolic Blood Pressure	−0.02 (0.68)	−0.02 (0.63)	0.03 (0.39)	1.0				
Diastolic Blood Pressure	−0.08 (0.04)	0.00 (1.00)	−0.04 (0.25)	0.50 (<0.001)	1.0			
High-density lipoprotein	0.05 (0.39)	−0.05 (0.33)	0.02 (0.76)	−0.10 (0.05)	0.04 (0.40)	1.0		
Percent Body Fat	−0.24 (<0.001)	−0.21 (<0.001)	−0.22 (<0.001)	0.11 (<0.01)	0.03 (0.41)	−0.04 (0.46)	1.0	
BMI percentile	−0.10 (0.01)	−0.06 (0.11)	−0.06 (0.10)	0.18 (<0.001)	−0.12 (<0.01)	−0.36 (<0.001)	0.65 (<0.001)	1.0

[1] Standardized scores were calculated taking the value, subtracting the mean and dividing by the standard deviation for a mean score of '0' and a standard deviation of '±1'.

Table 3

Independent Adjusted Multivariate Mixed Model Linear Regression Between Moderate-to-Vigorous Physical Activity (Collected Using Three Different Methods) and Four Biological Measures, TREC-IDEA And ECHO, 2006–2008

	Modified Activity Questionnaire			3-Day Physical Activity Recall			Accelerometer		
	Coeff.	**SE**	**P**	**Coeff.**	**SE**	**P**	**Coeff.**	**SE**	**P**
Systolic Blood Pressure	−0.34	0.43	0.43	−0.53	0.37	0.15	−0.32	0.30	0.28
Diastolic Blood Pressure	−0.53	0.35	0.13	−0.01	0.31	0.97	−0.31	0.29	0.28
High-density Lipoprotein	0.64	0.46	0.17	−0.18	0.45	0.69	0.82	0.48	0.09
Percent Body Fat	**−1.93**	**0.35**	**<0.001**	**−1.64**	**0.34**	**<0.001**	**−1.06**	**0.32**	**0.001**
Body Mass Index percentile	**−2.92**	**0.97**	**0.003**	−1.33	0.90	0.14	**−1.83**	**0.92**	**0.05**

Adjusted for study, puberty, age and gender.

Table 4

Testing the Difference in Mean Values of Four Biological Measures by Meeting the Recommendations For Sixty Minutes Per Day Of Physical Activity Measured With Three Different Instruments.

	Modified Activity Questionnaire[1]		3-Day Physical Activity Recall		Accelerometer	
	Met rec'd	Less than rec'd	Met rec'd	Less than rec'd	Met rec'd	Less than rec'd
N (%)	252 (36%)	447 (64%)	485 (69%)	215 (31%)	43 (6%)	657 (94%)
Systolic Blood Pressure	114.7	115.5	115.0	115.7	114.8	115.3
Diastolic Blood Pressure	54.3	55.3	54.9	55.0	53.6	55.0
High-density Lipoprotein	49.3	49.9	50.2	48.4	52.2	49.5
Percent Body Fat	18.9*	23.0	20.1*	24.5	16.3*	21.8
Body Mass Index percentile	58.3	62.3	59.3*	64.2	51.8*	61.4

[1] MAQ has data in 20 minute segments, as the recommendation is for 20 minutes per day; this is can only be used only as a crude estimate.

* Indicates significant difference at $p<0.05$