# Sedentary time, physical activity, and adiposity in a longitudinal cohort of nonobese young adults

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## ABSTRACT

**Background:** Young adulthood is a critical period for excessive weight gain. The extent to which young adults' sedentary time (ST) and moderate-to-vigorous physical activity (MVPA) relate to adiposity and weight gain remains unclear.

**Objective:** The purpose of this study was to examine the relation of ST and MVPA with adiposity and change in adiposity in healthy, nonobese young adults over a 2-y period.

**Design:** Participants were 71 adults aged 20–35 y. Measurements included ST and MVPA by accelerometry and reported energy intake at baseline, and anthropometry (%FM) and fat mass (FM) by dual-energy X-ray absorptiometry at baseline, year 1, and year 2. Associations of baseline ST and MVPA with adiposity were examined with the use of repeated-measures linear regression models, controlling for age, sex, and reported energy intake. The Benjamini-Hochberg procedure was used to adjust for multiple comparisons.

**Results:** Participants [mean ± SD body mass index (BMI; kg/m$^2$): 22.6 ± 2.4] engaged in 8.5 ± 1.5 h ST/d and 0.4 ± 0.3 h MVPA/d. At baseline, adults who engaged in ST for ≥8 h/d had higher FM, %FM, and lower MVPA, whereas those who engaged in MVPA for ≥30 min/d had lower FM and %FM. In fully adjusted models, ST was significantly associated with baseline body weight, hip circumference, BMI, FM, and %FM and with year-1 body weight, waist and hip circumference, FM, and %FM, but not with any year-2 adiposity indicators. MVPA was not significantly associated with any adiposity indicators at baseline, year 1, or year 2 in fully adjusted models. Over 2 y, participants significantly increased waist circumference, BMI, FM, and %FM (all *P*-values <0.05), but there were no associations among baseline ST and MVPA with change in adiposity.

**Conclusions:** Among nonobese young adults, high ST and low MVPA were related to elevated adiposity but did not predict change in adiposity over time. This trial was registered at clinicaltrials.gov as NCT00945633. *Am J Clin Nutr* 2018;108:946–952.

**Keywords:** obesity prevention, primary prevention, exercise, actigraphy

## INTRODUCTION

Early adulthood is a neglected target for studying the development of obesity (1, 2). Substantial weight gain has been observed in prospective cohort studies of young adults (2–4), contributing to a higher incidence of type 2 diabetes and cardiovascular disease (5). Because most people do not develop obesity until adulthood (6), primary prevention efforts are needed to prevent excessive weight gain among healthy weight young adults (7). Young adults may be particularly vulnerable to adverse energy balance behaviors, with newfound independence contributing to decreased physical activity and increased sedentary behaviors (2, 8). Nonetheless, there are limited published data on the role of physical activity and sedentary behavior on health during this transitional period, resulting in few effective strategies to prevent weight gain in early adulthood (9, 10).

Moderate-to-vigorous physical activity (MVPA) has been promoted as a strategy to prevent weight gain (11). Although

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Supplemental Figure 1 is available from the "Supplementary data" link in the online posting of the article and from the same link in the online table of contents at https://academic.oup.com/ajcn/.

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Abbreviations used: DXA, dual-energy X-ray absorptiometry; FFM, fat-free mass; FM, fat mass; MVPA, moderate-to-vigorous physical activity; ST, sedentary time; %FM, percentage of fat mass.

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MVPA is inversely related to adiposity in the general adult population (12–15), there are few data in young adults. In a cohort of 421 young adults [BMI (kg/m$^2$) range 20–35], fat mass (FM) was higher among the most physically active quintile (MVPA determined by accelerometry), and the least active quintile was significantly more likely to gain FM over 1 y (16), but analyses did not specifically examine nonobese adults. For young adults in the Coronary Artery Risk Development in Young Adults (CARDIA) study, maintaining high levels of MVPA was associated with lower gains in BMI over 20 y, but this study used self-reported MVPA data and did not examine associations by weight status (17). There may be different correlates of energy balance by weight status, with normal-weight adults engaging in less sedentary behavior and more MVPA than their overweight or obese peers (18).

Excessive sedentary time (ST) is a risk factor for adiposity independent from MVPA (19–21). Increasing quartiles of ST were associated with higher waist circumference in a nationally representative cohort of US adults aged ≥20 y (21). Although a systematic review indicated a significant association among ST, body weight, and weight gain (19), most studies relied on self-reported ST. Differential associations have been detected based on whether ST is collected by self-report or measured by a device that detects movement; for instance, in a cross-sectional study of 5948 adults, self-reported ST was associated with BMI and waist circumference, whereas accelerometer-assessed ST was not (22). Although self-report can provide contextual information, sensors provide more accurate assessment of ST and MVPA that is free from recall bias (22) and may better clarify the ambiguous relation between ST and weight gain (19).

The objective of the present study was to examine the associations among objectively measured ST and MVPA with directly measured adiposity in healthy, nonobese young adults over a 2-y period.

## METHODS

### Participants

The analytic sample was drawn from a sample of 90 healthy, nonobese adults enrolled in the prospective InSight study, which investigated the dietary, physiologic, genetic, and behavioral predictors of weight gain [the methodology used has been published previously (23)]. See **Supplemental Figure 1**. Participants were recruited through media advertising and email listservs. Inclusion criteria were 20–35 y of age, BMI <27.5, fasting blood glucose <126 mg/dL, and intention to live in the Baton Rouge metropolitan area during the study timeframe. Exclusion criteria were a history of diabetes; a history of obesity (BMI ≥30); a history of known inherited medical conditions; current or planned medication usage, or prior serious injuries/surgeries that might influence future health status; women who were pregnant or breastfeeding; women who were <6 mo postpartum or who had discontinued breastfeeding <3 mo prior to screening; a history of cancer within the previous 5 y; organ transplant, or previous diagnosis with HIV, hepatitis B or C, or tuberculosis; abuse of alcohol or illegal drugs; abnormal electrocardiogram; presence of pacemaker, defibrillator, or implanted metal; or history of eating disorders and abnormal psychological scores for screening measures. Study procedures were approved by the institutional review board, and participants provided written informed consent. Eighteen participants were excluded from the present analysis because of incomplete accelerometry data, and 1 participant was excluded as an outlier for change in FM (>8 kg FM loss between baseline and year 2). In sensitivity analyses, the results did not appreciably change with the outlier included. The final sample for the present analysis included 71 participants.

### Procedures

Participants underwent 3 screening visits, which included anthropometry, vital signs, medical history and physical examination, lab work, and questionnaires. Within 2 wk of the screening visits, participants underwent a series of baseline clinic visits that occurred over a 30-d period. The series of baseline clinic visits included a whole-body dual-energy X-ray absorptiometry (DXA) scan, maximal exercise test, 24-h metabolic chamber stay, a hyperinsulinemic euglycemic clamp, and doubly labeled water dosing for the measurement of energy expenditure. These screening and baseline visits are collectively referred to as baseline. Participants also attended a brief clinic visit approximately every 12 mo thereafter (years 1 and 2), which included anthropometry, vital signs, electrocardiogram, blood work, DXA scan, medical history, health/psychological questionnaires, and dietary assessments. Retention measures included a biannual newsletter mailed out with a reminder to update contact information; visits made to home or workplaces when the participant could not report for a follow-up clinic visit; and the provision of good medical practice recommendations based on current guidelines (vaccinations, PAP testing for women, feedback on age-specific cholesterol and blood pressure). Data were collected between the years 2008 and 2011 and analyzed in 2017.

### Sedentary time and physical activity

At baseline, free-living physical activity and ST were assessed with an ActiGraph GT1M accelerometer (Ft. Walton Beach, FL) that was worn on a belt on the hip during waking hours for ≤7 consecutive days (24). Standard data decision rules regarding non-wear time (sequences of ≥60 min of 0 counts) and the definition for a valid day (≥10 h of wear time in a 24-h period) were used (24). Participants' data were included in the present analysis if they had ≥3 valid days of accelerometry data. Participants wore the devices for 823 ± 76 min/d over 5 ± 1 d/wk. Standard intensity thresholds were applied, categorizing 1-min epochs as sedentary if <100 counts/min and MVPA if ≥2020 counts/min (24–27).

### Anthropometry and adiposity

Anthropometry and adiposity were measured at each visit. Height and body weight were measured with a wall-mounted stadiometer and a digital scale, respectively, by trained clinic staff according to standardized procedures. Height was measured twice to the nearest 0.5 cm, and body weight was measured twice to the nearest 0.1 kg. Waist and hip circumferences were measured with an inelastic tape on a horizontal plane without compressing the tissue and with the participant standing straight with feet together. The waist circumference was measured to the nearest 0.1 cm at the midway point between the inferior border of the rib cage and superior aspect of the iliac crest, and the hip circumference was measured to the nearest 0.1 cm at the level of the trochanters, which is usually the maximal extension of the buttocks. All anthropometric measurements were taken twice, and a third was taken if the first 2 differed by >0.5 units. Averages were used in the analysis. BMI and waist-to-hip ratio were calculated.

Total FM, fat-free mass (FFM), and percentage of fat (%FM) were measured by whole-body DXA (QDR 4500A, Hologic, Inc., Waltham, MA). The participants were supine on a table wearing a hospital gown while the scanner emitted low-energy X-rays and a detector passed over the body for 4–6 min. Scans were automatically analyzed with QDR for Windows version 11.1 (28). FM was calculated as %FM × measured body weight. FFM was calculated as body weight – FM.

### 24-h dietary recall

At each yearly visit, an interviewer-administered 24-h dietary recall was used with a 5-step multiple-pass approach to enhance complete and accurate food recall and reduce participant burden. Total caloric intake was calculated with the use of the database from the CSFII 1994–96, 1998 (29). Self-reported intake is subject to recall bias including systematic underreporting (30); however, dietary recalls are recommended as a feasible approach to estimate energy intake in nutrition research (31).

### Sociodemographic characteristics

At baseline, participants self-reported their date of birth, sex, race, and household income.

### Statistical analysis

Statistical analyses were performed with SAS version 9.4 (SAS Institute Inc., Cary, NC). Descriptive characteristics were examined for the overall sample, by ST category [≥8 compared with <8 h/d selected based on mean hours per day from a nationally representative sample (25)], and by MVPA category [≥30 compared with <30 min/d selected to approximate physical activity guidelines (32)]. Independent-sample $t$ tests and chi-square tests were used to examine differences between groups.

Paired-sample $t$ tests were used to examine changes between baseline and year 2 in each dependent variable. Repeated-measures linear regression models were used to examine the associations between ST or MVPA and each anthropometric and body composition measure at baseline, year 1, and year 2, making use of all the available data. Linear regression models were also used to examine the associations between ST or MVPA and change over the 2-y period. Model 1 tested ST as the independent variable; Model 2 tested MVPA; and Model 3 included both ST and MVPA and controlled for reported energy intake. By including both ST and MVPA simultaneously in the same model (Model 3), the "independent" associations of each could be examined, i.e., the associations of ST controlling for MVPA and vice versa. All models included age and sex as covariates. An interaction term of ST by MVPA was not significant in the models and was not included in the reported results. The Benjamini-Hochberg procedure for false discovery rates (33) was used, resulting in a false discovery rate of $P < 0.019$.

## RESULTS

Participants were 26.9 ± 4.5 y of age with a BMI of 22.6 ± 2.4 (all values are mean ± SD). See **Table 1** for baseline characteristics. The sample was 83% white, 11% black, and 6% other, and included 56% women. Household annual income was diverse: 25% earned <$20,000; 20% earned

**TABLE 1**
Baseline descriptive characteristics of young adults in the InSight cohort[1]

| | Sedentary time, h/d | | MVPA, min/d | | |
|---|---|---|---|---|---|
| | <8 ($n$ = 29) | ≥8 ($n$ = 42) | <30 ($n$ = 30) | ≥30 ($n$ = 41) | Overall ($n$ = 71) |
| Age, y | 27.2 ± 4.4 | 26.7 ± 4.7 | 27.8 ± 5.4 | 26.3 ± 3.7 | 26.9 ± 4.5 |
| Women, % | 45 | 65 | 70 | 46 | 56 |
| Nonwhite, % | 28 | 10* | 17 | 17 | 12 |
| Body weight, kg | 66.0 ± 10.1 | 67.0 ± 10.5 | 64.9 ± 10.3 | 67.9 ± 10.2 | 66.6 ± 10.3 |
| BMI, kg/m$^2$ | 22.2 ± 2.4 | 23.0 ± 2.3 | 22.7 ± 2.4 | 22.6 ± 2.4 | 22.6 ± 2.4 |
| Waist circumference, cm | 75.8 ± 6.4 | 76.4 ± 7.5 | 75.6 ± 6.2 | 76.6 ± 7.7 | 76.2 ± 7.1 |
| Hip circumference, cm | 93.8 ± 4.8 | 96.4 ± 5.4* | 95.2 ± 5.6 | 95.4 ± 5.1 | 95.3 ± 5.3 |
| Waist-to-hip ratio | 0.8 ± 0.0 | 0.8 ± 0.1 | 0.8 ± 0.0 | 0.8 ± 0.1 | 0.8 ± 0.1 |
| Fat mass, kg | 12.6 ± 4.1 | 16.9 ± 5.4*** | 16.6 ± 5.5 | 14.0 ± 5.0* | 15.1 ± 5.3 |
| Fat mass, % | 19.4 ± 6.9 | 25.6 ± 8.0** | 26.0 ± 8.1 | 21.0 ± 7.5** | 23.1 ± 8.1 |
| Fat-free mass, kg | 53.4 ± 10.8 | 50.2 ± 11.3 | 48.3 ± 11.0 | 53.8 ± 10.7* | 51.5 ± 11.1 |
| Sedentary time, h/d | 6.9 ± 0.8 | 9.5 ± 0.8 | 8.7 ± 1.5 | 8.3 ± 1.5 | 8.5 ± 1.5 |
| MVPA, h/d | 0.5 ± 0.3 | 0.4 ± 0.3* | 0.1 ± 0.1 | 0.6 ± 0.2 | 0.4 ± 0.3 |
| Reported energy intake,[2] kcal/d | 1892.8 ± 1071.0 | 1574.9 ± 882.7 | 1345.6 ± 732.4 | 1969.7 ± 1043.4** | 1704.9 ± 969.1 |

[1] Values are means ± SDs unless otherwise noted. ***,**,*Significant results indicated from independent-sample $t$ tests for continuous variables and chi-square tests for categoric variables across the sedentary time groups and MVPA groups: ***$P < 0.001$, **$P < 0.01$, *$P < 0.05$. MVPA, moderate-to-vigorous physical activity.

[2] $n = 66$ due to missing energy intake data.

\$20,000 to <\$40,000; 17% earned \$40,000 to <\$60,000; 13% earned ≥\$60,000; and 25% did not report income information. Compared to baseline, the 60 participants who returned for the year-2 visit significantly increased body weight (mean change ± SD: 1.5 ± 4.0 kg, $P = 0.006$), waist circumference (1.4 ± 4.9 cm, $P = 0.027$), BMI (0.5 ± 1.4, $P = 0.01$), FM (1.4 ± 2.6 kg, $P < 0.0001$), and %FM (1.6 ± 2.7, $P < 0.0001$).

The median ST was 8.8 h/d (IQR: 7.3, 9.4 h/d) and the median MVPA was 0.4 h/d (IQR: 0.2, 0.7 h/d). ST was not significantly correlated with MVPA (Pearson's $r = -0.17$, $P = 0.14$). Those who engaged in ≥8 h of ST/d were more likely to be white and to have higher hip circumference, FM, and %FM, and engage in less MVPA at baseline. Those who engaged in ≥30 min of MVPA/d had lower FM and %FM, higher FFM, and higher reported energy intake.

See **Table 2** for $\beta$ coefficients from the repeated-measures linear regression models. In Model 1, controlling for age and sex, ST was significantly associated with body weight at baseline ($P = 0.001$) and year 1 ($P = 0.004$); waist circumference at baseline ($P = 0.014$) and year 1 ($P = 0.013$); hip circumference at baseline ($P = 0.001$), year 1 ($P = 0.007$), and year 2 ($P = 0.017$); BMI at baseline ($P = 0.010$); %FM at baseline ($P = 0.004$) and year 1 ($P = 0.004$); and FM at baseline ($P = 0.001$) and year 1 ($P = 0.002$). In Model 2, controlling for age and sex, MVPA was significantly inversely associated with %FM at baseline ($P = 0.002$), year 1 ($P = 0.005$), and year 2 ($P = 0.009$); and with FM at baseline ($P = 0.009$).

In the fully adjusted model (Model 3), ST remained significantly associated with body weight at baseline ($P = 0.003$) and year 1 ($P = 0.007$); waist circumference at year 1 ($P = 0.016$); hip circumference at baseline ($P = 0.001$) and year 1 ($P = 0.005$); BMI at baseline ($P = 0.017$); %FM at baseline ($P = 0.002$) and year 1 ($P = 0.002$); and FM at baseline ($P = 0.001$) and year 1 ($P = 0.002$). However, the associations for MVPA were no longer significant.

There were no associations among baseline ST or MVPA with change in any anthropometric or adiposity indicators across the 2-y period.

## DISCUSSION

The present study examined the relations among ST, MVPA, and adiposity in nonobese young adults. The study design employed objective measurements of ST and MVPA, a direct assessment of FM, and a focus on nonobese young adults to overcome limitations of prior studies that used self-reported surveys (34–37), used anthropometry as a proxy for adiposity (34, 35, 38, 39), and included a broad age and weight range (15,

**TABLE 2**
Associations between baseline ST and MVPA with cross-sectional and longitudinal measures of adiposity in young adults in the InSight cohort[1]

| | Model 1[2] | | | | Model 2[3] | | | | Model 3[3] | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Baseline ST, h/d | | | | Baseline MVPA, h/d | | | | Baseline ST, h/d | | | | Baseline MVPA, h/d | | | |
| | $\beta$ | SE | $P$ | $R^2$ | $\beta$ | SE | $P$ | $R^2$ | $\beta$ | SE | $P$ | $R^2$ | $\beta$ | SE | $P$ | $R^2$ |
| Body weight, kg | | | | | | | | | | | | | | | | |
| Baseline | 2.1* | 0.6* | 0.001* | 0.10 | − 2.6 | 3.4 | 0.45 | 0.01 | 2.1* | 0.7* | 0.003* | 0.10 | − 0.0 | 3.5 | 0.99 | 0.00 |
| Year 1 | 2.2* | 0.7* | 0.004* | 0.00 | − 2.1 | 3.8 | 0.59 | 0.00 | 2.2* | 0.8* | 0.007* | 0.09 | 0.9 | 4.0 | 0.83 | 0.00 |
| Year 2 | 1.8 | 0.8 | 0.021 | 0.06 | − 3.3 | 3.9 | 0.39 | 0.01 | 1.7 | 0.8 | 0.042 | 0.05 | − 1.3 | 4.2 | 0.77 | 0.00 |
| Waist, cm | | | | | | | | | | | | | | | | |
| Baseline | 1.3* | 0.5* | 0.014* | 0.08 | − 3.1 | 2.7 | 0.26 | 0.02 | 1.3 | 0.6 | 0.022 | 0.07 | − 1.5 | 2.9 | 0.61 | 0.00 |
| Year 1 | 1.5* | 0.6* | 0.013* | 0.09 | − 2.8 | 3.0 | 0.36 | 0.01 | 1.6* | 0.6* | 0.016* | 0.09 | − 0.8 | 3.2 | 0.80 | 0.00 |
| Year 2 | 0.9 | 0.6 | 0.113 | 0.03 | − 4.3 | 2.7 | 0.11 | 0.03 | 0.8 | 0.6 | 0.174 | 0.03 | − 3.6 | 2.9 | 0.23 | 0.02 |
| Hip, cm | | | | | | | | | | | | | | | | |
| Baseline | 1.6* | 0.4* | 0.001* | 0.18 | − 2.1 | 2.4 | 0.37 | 0.01 | 1.7* | 0.5* | 0.001* | 0.19 | 0.9 | 2.3 | 0.71 | 0.00 |
| Year 1 | 1.4* | 0.5* | 0.007* | 0.12 | − 1.3 | 2.6 | 0.62 | 0.00 | 1.6* | 0.5* | 0.005* | 0.13 | 1.4 | 2.7 | 0.62 | 0.00 |
| Year 2 | 1.4* | 0.5* | 0.017* | 0.10 | − 2.8 | 2.8 | 0.33 | 0.02 | 1.4 | 0.6 | 0.026 | 0.09 | − 0.8 | 3.0 | 0.80 | 0.00 |
| BMI, kg/m$^2$ | | | | | | | | | | | | | | | | |
| Baseline | 0.5* | 0.2* | 0.010* | 0.11 | − 1.3 | 1.0 | 0.21 | 0.03 | 0.5* | 0.2* | 0.017* | 0.10 | − 0.7 | 1.1 | 0.52 | 0.01 |
| Year 1 | 0.5 | 0.2 | 0.019 | 0.09 | − 1.1 | 1.1 | 0.35 | 0.02 | 0.6 | 0.3 | 0.024 | 0.09 | − 0.3 | 1.2 | 0.78 | 0.00 |
| Year 2 | 0.4 | 0.2 | 0.049 | 0.07 | − 1.6 | 1.1 | 0.16 | 0.03 | 0.4 | 0.2 | 0.089 | 0.05 | − 1.1 | 1.2 | 0.36 | 0.02 |
| Fat mass, % | | | | | | | | | | | | | | | | |
| Baseline | 1.3* | 0.4* | 0.004* | 0.05 | − 6.8* | 2.1* | 0.002* | 0.06 | 1.3* | 0.4* | 0.002* | 0.05 | − 4.8 | 2.0 | 0.020 | 0.03 |
| Year 1 | 1.4* | 0.4* | 0.004* | 0.05 | − 6.5* | 2.2* | 0.005* | 0.05 | 1.4* | 0.4* | 0.002* | 0.05 | − 4.5 | 2.2 | 0.044 | 0.02 |
| Year 2 | 0.9 | 0.5 | 0.044 | 0.03 | − 5.9* | 2.2* | 0.009* | 0.05 | 0.9 | 0.4 | 0.039 | 0.03 | − 5.0 | 2.3 | 0.033 | 0.03 |
| Fat mass, kg | | | | | | | | | | | | | | | | |
| Baseline | 1.3* | 0.4* | 0.001* | 0.12 | − 5.0* | 1.9* | 0.012* | 0.07 | 1.3* | 0.4* | 0.001* | 0.12 | − 3.0 | 1.9 | 0.119 | 0.02 |
| Year 1 | 1.4* | 0.4* | 0.002* | 0.11 | − 4.6 | 2.3 | 0.045 | 0.05 | 1.5* | 0.4* | 0.002* | 0.12 | − 2.4 | 2.3 | 0.290 | 0.01 |
| Year 2 | 1.0 | 0.4 | 0.024 | 0.06 | − 4.6 | 2.2 | 0.040 | 0.05 | 1.0 | 0.5 | 0.028 | 0.06 | − 3.3 | 2.3 | 0.162 | 0.03 |

[1]*Statistical significance in repeated-measures linear regression models after applying the Benjamini-Hochberg adjustment for false discovery rate, $P < 0.019$ threshold. $P$-values >0.20 not reported. $R^2$ is the partial variance explained by the independent variable conditional on the other covariates in the model. MVPA, moderate-to-vigorous physical activity; ST, sedentary time.

[2]Model included age and sex as covariates.

[3]Model included age, sex, and reported energy intake as covariates.

39, 40). In these nonobese young adults, ST was associated with adiposity indicators including body weight, waist circumference, hip circumference, BMI, %FM, and FM, even when controlling for MVPA; those who engaged in higher ST had higher adiposity. Interestingly, ST was more consistently related to adiposity indicators than MVPA and explained more of the variance in adiposity. Further, MVPA was no longer significantly related to %FM or FM when ST and reported energy intake were included in the models. These findings build on prior studies that detected associations of adiposity with lower ST (19, 20, 41) and higher MVPA (12–15), but are among the first to show these cross-sectional and prospective associations specifically in nonobese young adults and controlling for reported energy intake.

The magnitude of increase in body weight over 2 y in these young adults (on average 1.5 kg, of which 1.4 kg was FM) is similar to prior studies of young adults (3, 35, 42, 43) and indicates a gradual weight gain that may contribute to the eventual onset of obesity. A recent study of 197 young adults observed that nonoverweight young adults increased FM and body weight twice as much over 1 y compared with overweight/obese adults (43). In the same cohort, minutes of moderate physical activity decreased only in the nonoverweight but not overweight/obese group (43). These and the current data indicate that nonobese young adults may be particularly at risk for short-term increases in adiposity and worsening of energy balance behaviors.

There was evidence that ST and MVPA were related to adiposity 2 y later, but these associations were no longer significant when energy intake was taken into account. Further, neither ST nor MVPA predicted change in adiposity. It may be that 2 y is an insufficient duration to detect prospective associations with adiposity change, particularly among nonobese young adults. For example, there was a significant association between baseline (self-reported) physical activity and weight gain in an 11-y study of 21,685 men with normal weight at baseline (44). By contrast, similar nonsignificant findings between ST and adiposity change have been observed in other prospective cohorts, including a study of 8233 middle-aged women surveyed across 6 y in which self-reported sitting time was not associated with change in weight (34). Similarly, ST measured by heart-rate monitoring did not predict change in BMI or waist circumference over a 5-y follow-up in middle-aged adults despite significant associations at baseline (45). Whereas most prior studies used anthropometry, the present study is among the first to examine changes in DXA-measured adiposity as the outcome variable while controlling for energy intake.

Characteristics of time spent sedentary or physically active beyond total daily duration may be important to consider. For example, the accelerometer used in the present study cannot distinguish between sitting and standing, and these behaviors may differentially influence adiposity (46). Further, the frequency of breaks in ST was inversely related to waist circumference in a nationally representative sample of adults (21). An examination of the CARDIA cohort of young adults indicated no association between total ST and increase in BMI or waist circumference over 5 y; however, prolonged bouts of ST (≥10 min/bout) were significantly associated with both BMI and waist circumference particularly among adults who were less physically active (38). Similarly, breaks in ST and MVPA were each inversely associated with adiposity in a British sample of 878 adults representing a range of ages (40). The adverse consequences of ST may occur specifically due to a prolonged deprivation of muscular contraction that disrupts metabolic signalling (47).

Although the young adults who engaged in high levels of ST (≥8 h/d) also engaged in significantly less MVPA, there was no difference in ST among those who attained ≥30 min MVPA/d compared with those who did not. Weak to moderate inverse associations between sedentary behavior and physical activity have been previously reported, but these are predominantly based on self-reported data (48). The evidence remains mixed for the extent to which MVPA is (49) or is not (50) protective against potential deleterious effects of ST. In the present study there were no significant interactions between ST and MVPA with the adiposity indicators, and each was independently associated with adiposity at baseline.

ST explained more of the variance in adiposity than MVPA and was related to more adiposity indicators. There are other factors that predict adiposity in young adults that were not accounted for in the present analyses, including cardiorespiratory fitness (43), socioeconomic status (42), and consumption of specific dietary components (42). Furthermore, the relation of MVPA and ST with adiposity may be influenced by other concurrent behaviors such as consumption of energy-dense foods and viewing food advertisements when the ST is in front of a screen (51).

Strengths of the study include the use of objective measurements of ST and MVPA and direct assessment of FM. A unique feature of this cohort is the ability to examine changes in body weight in a cohort that is free of obesity at baseline. Although the sample size was relatively small, analyses met standards to adequately estimate regression coefficients and standard errors in linear regression models (52). However, a larger sample size would allow for greater diversity and generalizability and for comparisons by sex, age, race/ethnicity, and other individual characteristics.

A limitation is that ST and MVPA were only measured at baseline, so it was not possible to examine changes in these behaviors over time as potential predictors for change in adiposity, or to investigate the directionality of the association among ST, MVPA, and adiposity as previously examined (45, 53). One study of young adults that did directly assess change in FM by DXA observed mixed evidence for an association between 1-y change in MVPA and adiposity, and detected no association between change in ST and adiposity (43). In a cohort of young Australian women that measured both weight and sitting time across 6 y, weight gain was higher among women who increased their sitting time, but only among overweight and obese women and not in the normal-weight women (35). Future studies should collect ST and MVPA at multiple time points concurrently with adiposity to examine if there is reverse causation such that body weight contributes to a decrease in MVPA over time (54), or if the reallocation of ST to MVPA may attenuate weight gain over time (55). Further, clinical trials are required to establish causal relations among ST, MVPA, and adiposity and other health outcomes.

In summary, higher ST and lower MVPA were related to higher amounts of FM in these nonobese young adults, and ST was more consistently related to adiposity indicators than MVPA, but there was no association between baseline ST or MVPA and change in adiposity over a 2-y period. Identifying modifiable behavioral targets that predict excessive weight gain in young adulthood should be a public health priority.

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