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Longitudinal association between television watching and computer use and risk markers in diabetes in the SEARCH for Diabetes in Youth Study

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Abstract

Background—The study provides evidence of the longitudinal association between screen time with hemoglobin A1c and cardiovascular risk markers among youth with type 1 (T1D) and type 2 diabetes (T2D) .

Objective—To examine the longitudinal relationship of screen time with HbA1c and serum lipids among youth with diabetes.

Subjects—Youth with T1D and T2D.

Methods—We followed up 1049 youth (≥10 yr. old) with recently diagnosed T1D and T2D participating in the SEARCH for Diabetes in Youth Study.

Results—Increased television watching on weekdays and during the week over time was associated with larger increases in HbA1c among youth with T1D and T2D (p-value<0.05). Among youth with T1D, significant longitudinal associations were observed between television watching and TG (p-value<0.05) (week days and whole week), and LDL-c (p-value<0.05) (whole week). For example, for youth who watched 1 hour of television per weekday at the outset and 3 hours per weekday 5 years later, the longitudinal model predicted greater absolute increases in

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HbA1c (2.19% for T1D and 2.16% for T2D); whereas for youth who watched television 3 hours per weekday at the outset and 1 hour per weekday 5 years later, the model predicted lesser absolute increases in HbA1c (2.08% for T1D and 1.06% for T2D).

Conclusions—Youth with T2D who increased their television watching over time vs those that decreased it had larger increases in HbA1c over 5 years. Youth with T1D who increased their television watching over time had increases in LDL-c, TG and to a lesser extent HbA1c .

Keywords

Diabetes; youth; hemoglobin A1c; serum lipids; screen time

Background

Excessive time spent watching television, playing video games, and using computers is an emerging public health issue(1). The American Academy of Pediatrics recommends that television watching among children should be limited to less than 2 hours per day(2). This is based on cross-sectional and longitudinal studies conducted among children and adults without diabetes that link increased television watching to adverse health outcomes (3-6). US children spend more time watching television than any other activity besides sleep, and time spent watching television may even exceed time spent in school(2, 7-9). Television watching is the most usual screen time which has been studied comprehensively in the non-diabetic population (7, 9-14).Recent estimates indicate that children 2 to 18 years of age watch at least 2.5 hours of television, spend 1.5 hours playing video games and using computers each day, and are exposed to about 6.5 hours of media per day from all sources(15-17).

Children with T1D or T2D are at increased risk of developing cardiovascular complications in later life(18), and more television watching in children with T1D has been associated with poorer glycemic control and more adverse lipid profiles in cross-sectional studies (19-21). However, to the best of our knowledge, the extent to which television watching and computer use influence the cardiovascular risk profile of youth with T1D and T2D has not been evaluated in longitudinal analyses. We therefore studied the longitudinal relationship between changes in television watching and computer use over time and changes in HbA1c and serum lipids over 5 years in youth with diabetes using the SEARCH for diabetes in youth data. These analyses will quantify the extent to which television watching and computer use, potentially modifiable factors, impact the evolution of HbA1c and cardiovascular risk markers in youth with diabetes.

Methods

Study design and population

The SEARCH study is an on-going multicenter, population-based, observational investigation of non-gestational diabetes among youth < 20 years old. The SEARCH study clinical centers that contributed data for this analysis are Ohio, Colorado, Washington, South Carolina, California and Hawaii. The SEARCH study has been previously described in detail (22) .

This analysis included 1049 multi-ethnic US youth (≥ 10 years old at the initial visit) with T1D and T2D who participated in the SEARCH for Diabetes in Youth Study and provided baseline data from 2002 to 2005. These participants were followed-up prospectively at 1, 2 and 5 years after the initial visit (61% participants had 3 or more visits). All participants included in these analyses had physician diagnosed diabetes, documented year of diagnosis, were less than 20 years old on December 31 of the year of diagnosis, and attended at least one follow-up visit.

Data collection and measurement

Before implementation of data collection, this study was reviewed and approved by each local institutional review board that had jurisdiction over the local study population. Also, written informed consent and child assent were obtained at the start of each study visit. For both initial and follow-up visits, data collection procedures were performed by trained and certified staff following standardized protocols(22). Data collection approaches included questionnaires, physical examination and laboratory tests.

Exposure—Television watching and computer use questions were adapted from the Youth Risk Behavioral Survey (YRBS) questionnaires(23) and were asked at the initial visit and each follow-up visit. In this questionnaire, there were two items asking about television watching behavior. They were: "On each week day, about how much time do you usually spend watching television?" and "On each weekend day, about how much time do you usually spend watching television?" The two questions about computer use were: "On each week day, about how much time do you usually spend on the computer for fun, including playing video or computer games?" and "On each weekend day, about how much time do you usually spend on the computer for fun, including playing video or computer games?" The responses to these four questions were categorized as follows: "None", "Less than 1 hour", "1 hour", "2 hours", "3 hours", "4 hours", and "5 or more hours". Weighted television watching and computer use per week were calculated as follows: weighted television watching per week= (5*weekday television watching/7) + (2*weekend television watching/7) and weighted computer use per week= (5*weekday computer use/7) + (2*weekend computer use/7).

Outcomes from laboratory tests—Blood samples were drawn at each visit under the condition of metabolic stability defined by 8 hours of fasting and no episode of diabetic ketoacidosis in the previous month. Within 24 hours, these blood samples were shipped with dry ice to the central laboratory in Seattle, WA for the measurement of HbA1c, LDL-c, HDL and TG.

Other covariates—Demographic information including gender, race/ethnicity, age, highest parental education, household income, type of insurance and family composition were obtained by an initial survey at baseline(24).

Physical activity was assessed using a question adapted from the Youth Risk Behavioral Survey (YRBS) questionnaires(23) and was asked at the initial and each follow-up visit.

Standardized physical examinations were conducted for all participants at each visit that included height, weight, waist circumference, and blood pressure.

Statistical methods

There were 1049 participants in this analysis with at least 2 visits; 61% had 3 or more visits. Demographic information is shown as means and standard deviation for continuous variables and frequencies and percents for categorical variables.

Television watching and computer use were evaluated separately for weekdays, weekends, and the whole week. One category increase in television watching and computer use corresponded to one hour increase in the longitudinal analyses. Longitudinal mixed models were fit separately for individuals with T1D and T2D to characterize the relation between changes in television watching and computer use (initial and time-varying values) and time-varying HbA1c and serum lipids among youth with diabetes that were included as random effects. Multivariate mixed models tested the effects of television watching and computer use at the initial visit, and the time-varying effects of television watching and computer use measured at the 1 year, 2 year and or 5 year follow-up visits. In addition, an interaction term (initial television watching/computer use* time-varying television watching/computer use) was added into the model to determine whether changes in HbA1c and serum lipids (HDL, LDL-c and log TG) over time varied with changes in television watching and computer use habits over time as a function of initial television watching and computer use. Duration of diabetes (number of months since diabetes diagnosis) was included in these models as an indicator of time for each participant. All models were expanded to include fixed/non-time varying effects, including gender, age at the initial visit, race/ethnicity, highest parental education, type of insurance and household income, and time-varying covariates including BMI-z score, waist circumference, physical activity and treatment for diabetes and dyslipidemia (25, 26). To evaluate the role of dietary intake we further adjusted all models for usual intake of total calories measured at baseline. For all models, we further stratified by intensive use (insulin ≥3 times/day or insulin pump) and non-intensive (insulin < 3 times/day) regimens for youth with T1D, and by insulin treatment and non-insulin treatment for youth with T2D.

Statistical analyses were conducted using SAS (version 9.1, 2003, SAS Institute Inc, Cary, NC). Mixed models were used to fit statistical models. We used $p < 0.05$ as standard of significance.

Results

Characteristics of Study Population

Participants with T1D consisted of 384 (46.8%) females and 437 (53.2%) males with a mean age of 13.6±2.4 years at the initial visit, and included 617 (75.1%) Non-Hispanic Whites, 81(9.9%) African Americans, 90 (11.0%) Hispanics, and 33 (4.0%) individuals belonging to other race/ethnic groups. Participants with T2D consisted of 139 (61.0%) females and 89 (39.0%) males with a mean age of 15.1±2.5 years at the initial visit, and included 49

(21.5%) Non-Hispanic Whites, 82 (36.0%) African Americans, 52 (22.8%) Hispanics, and 45 (19.7%) individuals belonging to other race/ethnic groups (Table 1).

Youth with both T1D and T2D (2002-2005) tended to watch more television during weekends than weekdays (T1D: 29% vs.15% watched more than 4 hours of television per day; T2D: 42% vs. 30% watched more than 4 hours of television per day). Computer use during weekends and weekdays was low among youth with T1D and T2D during the study period (Figures 1 and 2).

Longitudinal Mixed Models

Increased television watching on weekdays, and during the entire week (weighted whole week as described in methods), was positively associated with changes in HbA1c among youth with T1D and T2D after adjusting for age at the initial visit, gender, race, physical activity, computer use on weekdays, parental education, household income, insurance type, BMI z-score, family composition, and treatment for diabetes and dyslipidemia. Similar significant longitudinal associations were observed between weekday television watching and changes in log TG levels, weighted whole week television watching and changes in LDL-c levels among youth with T1D, and weekend television watching and changes in HbA1c levels among youth with T2D (p-values for interaction between the initial and time-varying visits <0.01)(Tables 2 and 3). The relationship between television watching and HbA1c was similar among youth with T1D when stratifying by intensive versus non-intensive treatment, and among youth with T2D stratified by insulin versus no insulin treatment. We did not find significant associations between changes in television watching and changes in HDL-c among youth with T1D or T2D, or log TG and LDL-c among youth with T2D. Computer use was not associated with any of the outcomes in this analysis. Further adjustment for total usual caloric intake did not materially alter the results.

Predicted Models

The data presented in Table 4 are statistically significant results from multivariable mixed models described in Tables 2 and 3. Table 4 illustrates the predicted time varying changes at selected time points in HbA1c among youth with T1D and T2D, LDL-c and TG among youth with T1D from the initial visit (n=1049) to 5 years (n=575) of follow-up. Predicted mean values of outcomes were estimated for 1 hour/day and 3 hours/day of television watching at the initial and 5 year follow-up visits respectively.

HbA1c increased on average from the initial visit to the 5 year follow-up visit among youth with both T1D and T2D (Table 4). However, the magnitude of HbA1c increase was smaller in those who decreased television watching over time and larger in those who increased it. For example, the HbA1c value for youth who watched television on weekdays for 3 hours/d at the initial visit and 1 hour/d at the 5 year follow-up visit rose less than for those who watched television on weekdays for 1 hour/d at the initial visit and 3 hour/d the 5 years follow-up visit were (T1D: 2.08% vs. 2.19%; T2D: 1.06% vs. 2.16%) (Table 4).

LDL-c and TG levels also increased on average from the initial visit to the 5 year follow-up visit among youth with T1D (Table 4). LDL-c and TG increased less in who decreased television watching over time and more in those who increased it. For example, LDL-c and

TG increased less among youth who watched television for 3 hours/d at the initial visit and 1 hour/d at the 5 year follow-up visit and more among those who watched television for 1 hour/d at the initial visit and 3 hour/d the 5 years follow-up visit (LDL-c-weighted whole week television watching: 6.27 mg/dl vs. 9.32 mg/dl; TG-weekdays television watching: 8.43 mg/dl vs. 13.47 mg/dl) (Table 4).

Discussion

In this study HbA1c, LDL-c and TG levels increased over time in all youth with T1D and T2D. However, the magnitude of increase was significantly greater among those who watched more television and increased their television watching behavior over time, compared to those who watched less TV, after adjusting for several important confounders. Computer use was not associated with HbA1c and serum lipids in this analysis.

Our results are consistent with previous cross-sectional studies evaluating the relationship between television watching and HbA1c in youth with T1D (19-21). Margeirsdottir et al. (19) reported in a cross-sectional study in Norway that among 538 children and adolescents with T1D aged approximately 13 years on average, HbA1c was 9.4% for those who watched television for ≥4 hours/d versus 8.2% for those who watched television for <1 hour/d. Michaliszyn and Faulkner reported that US youth with T1D aged 14.5 years on average (21) spent about 10 hours per day in sedentary activities and more sedentary time was correlated with increased total cholesterol, LDL-c and TG($p<0.05$). In another study among 2093 youth with T1D with mean age of 14.5 years from 19 countries, Aman et al.,(20) indicated that HbA1c was not correlated with total hours of television watching in a week ($r=0.04$, $P>0.1$). However, these were descriptive cross-sectional studies and were unable to demonstrate the long-term impact of television watching on glycemic control and cardiovascular markers among youth with T1D.

The influence of sedentary behavior on health is a public health concern (27). Youth on average watch at least 2.5 hours of television, 1.5 hours of video games playing and computer use each day and are exposed to about 6.5 hours of media per day from all sources (15-17). Research studies commonly use screen-based media use, including television watching, video game playing, and computer use, to measure the sedentary behavior, although we know these behaviors are not completely representative.

Several mechanisms might explain the positive longitudinal association between television watching and changes in HbA1c, LDL-c and TG. First, television watching may replace time that would be used for physical activity that can improve insulin sensitivity(2) and increase energy expenditure leading to lower HbA1c and improved lipid profile. However, some other studies report poor correlation between television watching and physical activity(12, 14, 28). Second, television watching is associated with snacking and sweetened beverage consumption causing increased total calorie intake (29-31). Television contents, including advertisements for fast food and sweetened beverages, can negatively influence youth’s food choices causing unhealthy dietary behavior(32-36). Third, a recent study evaluating 2003/2004 and 2005/2006 NHANES data found a positive association between time spent in sedentary behavior and insulin resistance among youth with diabetes(37, 38).

In addition, television watching is a lower energy expenditure behavior compared with other sedentary activities like writing and driving (12).Thus, it has been hypothesized that increased television watching may lead to less physical activity, reduced energy expenditure, increased food and energy intake, and increased insulin resistance. However, in our study, adjustment for physical activity and total calories did not attenuate the associations in this study, possibly due to measurement error in assessing these variables.

A minimum of 2 hours per week of physical activity on average can significantly increase HDL-c levels among individuals without diabetes (39). However, change in sedentary time measured by accelerometer was not associated with HDL-c in a longitudinal analysis of adults with T2D (37), similar to what we observed. The reasons for this are not clear. Moreover, in our analyses, sedentary time was measured using a questionnaire which would lead to attenuation of any associations due to measurement error. There were no reports, to the best of our knowledge, of a longitudinal relationship between sedentary behavior and T1D.

This study had several potential limitations. First, the exposure variable, television watching, was assessed through self-report questionnaire. However, because participants did not know their HbA1c or serum lipid values when television watching was assessed, it is unlikely that the outcome contributed to error related to assessment of television watching. Therefore, measurement error associated with assessment of television watching in this study would bias the result towards the null. Second, the estimated changes in HbA1c (particularly for T1D), LDL-c and TG over time attributed to television watching were small. Television watching was collected in 7 categories to make it easier for respondents to estimate, but this strategy resulted in the television watching categories to be more homogeneous. Moreover, more than half the youth watched 2 or more hours of television on weekdays and more than two thirds did so on weekends. The lower estimated changes in HbA1c, LDL-c and TG attributed to change in television watching in our study may be due to the smaller contrast between the comparison groups (1 and 3 hours of television watching) resulting from the homogeneous estimates of television watching categories and the large proportion of individuals watching more television. However, the results were statistically significant and therefore provide evidence supporting the hypothesis that reducing television watching favorably impacts changes in metabolic markers over several years in youth with T1D and T2D. The magnitude of change in HbA1c was small for T1D, but relatively stronger for lipids in youth with T1D vs those with T2D and for HbA1c in youth with T2D vs those with T1D. Moreover, as small reductions in HbA1c contribute to large declines in diabetes related complications(40), including the recommendation to reduce television watching on top of other advice on self-care may provide additive benefits to youth with diabetes. Our data suggest that most youth with diabetes do not make large changes in their television watching practices. In our study, only approximately 10% of the youth who completed the 5-year follow-up visit reported reducing their televisions watching practices by 2 hours. Third, baseline data were collected between 2002 and 2005 and then followed up for 5 years when television watching was the main contributor to screen time and sedentary behavior (2, 7-9). Even though computer time was not related to the outcomes in our analyses, time spent using smart phones, tablets and other such devices may increasingly contribute to sedentary behavior today, data not captured herein. Another limitation was the potential for residual confounding because of the observational study design. However, we adjusted for many potential confounders including age, gender, race, physical activity, computer use on weekdays parental education, household income, insurance type, BMI z-score, family composition, and treatment for diabetes, and dyslipidemia. The associations reported in this paper were independent of these potential confounders.

This study had several strengths. The sample for this analysis was drawn from the SEARCH for Diabetes in Youth study population, which is the largest prospective investigation among youth with T1D and T2D, and includes all major US ethnic groups. The longitudinal study design, including 5 years of follow-up, and the ability to adjust for many important potential confounders were also important strengths of this study. Also, we can evaluate the comprehensive longitudinal effect of television watching and computer use on HbA1c and serum lipids since we had the chance to measure television watching and computer use on both weekdays and weekends.

In conclusion, HbA1c, LDL-c and TG increased in all youth with T1D and T2D over 5 years. Youth with T2D who increased their television watching time had larger increases in HbA1c over 5 years. Youth with T1D who increased their television watching time had larger increases in LDL-c, TG and to a lesser extent HbA1c. Television watching may contribute to poor glycemic control and dyslipidemia in youth with diabetes and can be a potentially modifiable behavior to improve health outcomes in youth with diabetes.

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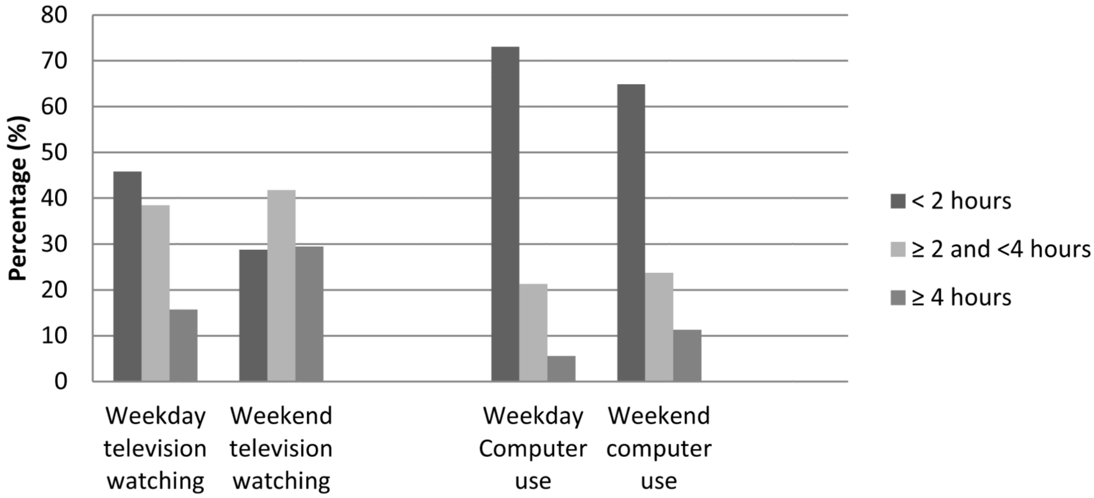

Figure 1.

Frequency of television watching and computer use among youth with T1D at the initial visit: SEARCH for Diabetes in Youth 2002-2005

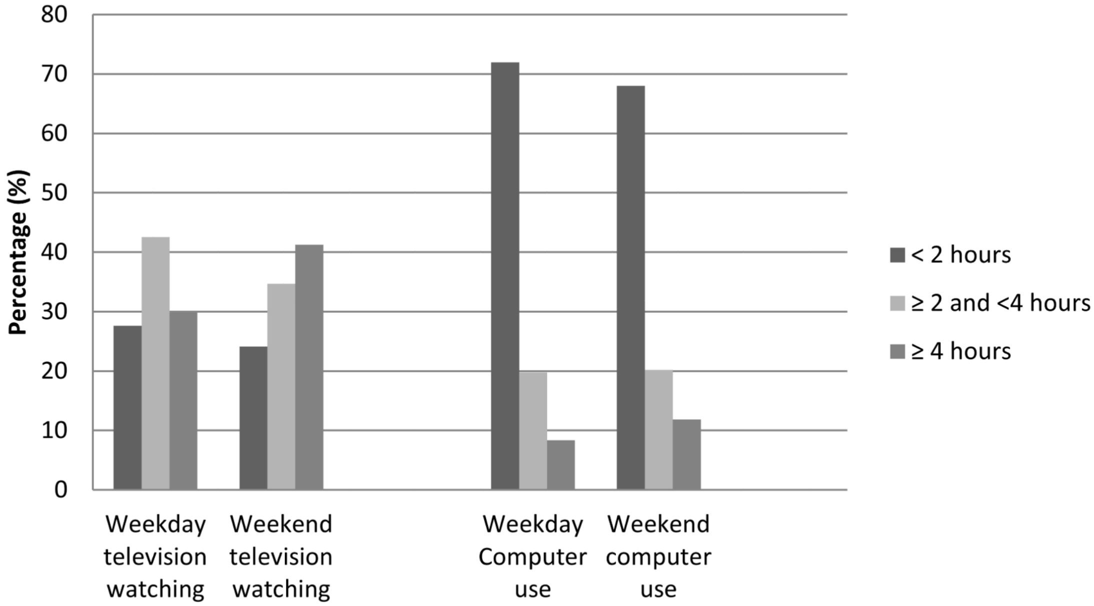

Figure 2.

Frequency of television watching and computer use among youth with T2D at the initial visit: SEARCH for Diabetes in Youth 2002-2005

Table 1

Demographic and clinical characteristics of participants at the initial visit: SEARCH for Diabetes in Youth, 2002-2005

		T1D(n=821)	T2D(n=228)
Demographics			
Gender: n(%)	Female	384(46.8)	139(61.0)
	Male	437(53.2)	89(39.0)
Race: n(%)	Non-Hispanic White	617(75.1)	49(21.5)
	African American	81(9.9)	82(36.0)
	Hispanic	90(11.0)	52(22.8)
	Others [a]	33(4.0)	45(19.7)
Age: mean± SD		13.6±2.4	15.1±2.5
Parental highest education: n(%)	Bachelor degree or more	383(46.9)	36(16.0)
	Some college with associate degree	279(34.2)	80(35.4)
	High school	122(14.9)	76(33.6)
	Less than high school	33(4.0)	34(15.0)
Annual household income: n (%)	<$25,000	106(13.0)	95(41.6)
	$25,000-49,000	160(19.6)	58(25.4)
	$50,000-74,000	172(21.1)	25(11.0)
	≥75,000	327(40.0)	20(8.8)
	DK/Ref	51(6.3)	30(13.2)
Insurance: n(%)	Medicaid/Medicare	128(15.7)	90(39.7)
	Private	660(81.1)	119(52.4)
	Other	9(1.1)	10(4.4)
	None	17(2.1)	8(3.5)
Television watching, computer use and physical activity			
Physical activity (days/week)		2.9±2.3	2.9±2.4
Weekday television watching: hours		2.0±1.3	2.6±1.5
Weekend television watching: hours		2.6±1.5	3.0±1.7
Weighted television watching: hours		2.2±1.3	2.7±1.4
Weekday computer use: hours		1.3±1.1	1.2±1.3
Weekend computer use: hours		1.5±1.4	1.3±1.5
Weighted computer use: hours		1.3±1.1	1.2±1.3
Clinical characteristics			
HbA1c : n (%)	<8%	505(63.5)	171(77.7)
	8-9.5%	208(26.1)	22(10.0)
	≥9.5%	83(10.4)	27(12.3)
BMI z-score: mean ± SD		0.6±0.9	2.1±0.6
Caloric intake (cal): mean ±SD		1869.8±842.1	1761.5±850.5
Diabetes treatment: n(%)	Insulin pump	71(8.7)	0(0.0)
	Insulin 3+ times per day	428(52.4)	25(11.0)
	Insulin <3 times per day	305(37.3)	50(22.0)

		T1D(n=821)	T2D(n=228)
	No treatment or Oral meds only	13(1.6)	152(67.0)
HDL: n(%)	Normal HDL (> 40 mg/dl)	648(78.9)	100(43.9)
	Low HDL (≤ 40 mg/dl)	173(21.1)	128(56.1)
LDL-c: n(%)	Normal LDL-c (<100 mg/dl)	546(66.5)	125(54.8)
	High LDL-c (≥ 100 mg/dl)	275(33.5)	103(45.2)
TG: n(%)	Normal TG(< 110 mg/dl)	735(89.5)	123(53.9)
	High TG(≥ 110 mg/dl)	86(10.5)	105(46.1)

[a]Other races: Asian Indian, American Indian or Alaska Native, Native Hawaiian, Asian etc.

Table 2

Adjusted[c] longitudinal associations[b] of changes in means of A1c and serum lipids among youth with T1D: SEARCH for Diabetes in Youth

		A1C(%)	HDL(mg/dl)	LDL(mg/dl)	Log TG[d] (mg/dl)
	Diabetes duration(β_1)	0.034 [a]	0.13 [a]	0.11 [a]	0.003 [a]
Weekday television watching	Baseline(β_2)	0.20[a]	0.11	1.73	0.023
	Time-varying(β_3)	0.15[a]	−0.36	1.31	0.046[a]
	Baseline*time-varying(β_4)	−0.06[a]	0.05	−0.49	−0.013[a]
	Diabetes duration(β_1)	0.034 [a]	0.13 [a]	0.11 [a]	0.003 [a]
Weekend television watching	Baseline(β_2)	0.12	−0.11	1.01	−0.013
	Time-varying(β_3)	0.02	−0.16	1.18	−0.0071
	Baseline*time-varying(β_4)	−0.03	0.1	−0.33	0.001
	Diabetes duration(β_1)	0.034 [a]	0.13 [a]	0.11 [a]	0.003 [a]
Weighted television watching per week	Baseline(β_2)	0.23[a]	0.13	2.21[a]	0.014
	Time-varying(β_3)	0.16[a]	−0.17	2.09[a]	0.040 [a]
	Baseline*time-varying(β_4)	−0.07[a]	0.03	−0.66[a]	−0.01
	Diabetes duration(β_1)	0.035 [a]	0.13 [a]	0.12 [a]	0.003 [a]
Weekday computer use	Baseline(β_2)	0.11	−0.01	1.09	0.017
	Time-varying(β_3)	0.13	−0.5	0.09	0.022
	Baseline*time-varying(β_4)	−0.03	0.13	−0.31	−0.008
	Diabetes duration(β_1)	0.035 [a]	0.13 [a]	0.12 [a]	0.003 [a]
Weekend computer use	Baseline(β_2)	0.04	0.07	0.97	0.0011
	Time-varying(β_3)	−0.02	−0.46	−0.46	0.0012
	Baseline*time-varying(β_4)	0.01	0.08	−0.16	−0.0044
	Diabetes duration(β_1)	0.035 [a]	0.13 [a]	0.12 [a]	0.003 [a]
Weighted computer use per week	Baseline(β_2)	0.07	−0.04	1.5	0.011
	Time-varying(β_3)	0.05	−0.42	−0.24	0.016
	Baseline*time-varying(β_4)	−0.01	0.11	−0.29	−0.005

[a] $p<0.05$

[b] Outcome = $\beta_0 + \beta_1$(duration) + β_2(initial exposure) + β_3(time-varying exposure) + β_4(initial exposure × time-varying exposure) + β_5(other covariates) + ε

[c] Adjusted variables: Age at the initial visit, gender, race, parental education, household income, family composition, insurance type, physical activity, and treatment for diabetes and dyslipidemia

[d] Coefficients are unchanged since log-transformation means that unit conversion is captured in the intercept term.

Table 3

Adjusted[c] longitudinal associations[b] of changes in means of A1c and serum lipids among youth with T2D: SEARCH for Diabetes in Youth

		AlC(%)	HDL(mg/dl)	LDL(mg/dl)	Log TG[d] (mg/dl)
Weekday television watching	Diabetes duration(βl)	0.0l9[a]	0.078[a]	0.056	−0.00l
	Baseline(β_2)	0.43[a]	−0.43	0.99	0.075[a]
	Time-varying(β_3)	0.53[a]	−l.0l	2.35	0.064[a]
	Baseline*time-varying(β_4)	−0.l3[a]	0.29	−0.l8	−0.0l6
Weekend television watching	Diabetes duration(βl)	0.02l[a]	0.066[a]	0.038	−0.00l
	Baseline(β_2)	0.44[a]	−0.0l	0.09	0.056
	Time-varying(β_3)	0.38[a]	−0.l9	2.9l	0.0l5
	Baseline*time-varying(β_4)	−0.1l[a]	−0.0l	−0.43	−0.005
Weighted television watching per week	Diabetes duration(βl)	0.0l9[a]	0.074[a]	0.065	−0.00l
	Baseline(β_2)	0.52[a]	−0.32	−0.42	0.078[a]
	Time-varying(β_3)	0.62[a]	−l.38	l.37	0.046
	Baseline*time-varying(β_4)	−0.15[a]	0.3	0.l8	−0.0l3
Weekday computer use	Diabetes duration(βl)	0.025[a]	0.067[a]	0.038	−0.00l
	Baseline(β_2)	0.45	0.73	2.88	0.033
	Time-varying(β_3)	0.08	−0.l3	0.87	0.045
	Baseline*time-varying(β_4)	−0.08	−0.07	−0.4	−0.022
Weekend computer use	Diabetes duration(βl)	0.027[a]	0.064[a]	0.042	−0.0003
	Baseline(β_2)	0.l7	0.l7	l.49	0.008
	Time-varying(β_3)	0.0l	0.l4	l.07	−0.005
	Baseline*time-varying(β_4)	0.02	0.0l	−0.08	0.0003
Weighted computer use per week	Diabetes duration(βl)	0.026[a]	0.065[a]	0.037	−0.00l
	Baseline(β_2)	0.4	0.l3	2.24	0.052
	Time-varying(β_3)	0.03	0.03	0.96	0.03l
	Baseline*time-varying(β_4)	−0.04	0.0l	−0.l6	−0.0l9

[a] $p<0.05$

[b] Outcome = $\beta_0 + \beta_1$(duration) + β_2(initial exposure) + β_3(time-varying exposure) + β_4(initial exposure × time-varying exposure) + β_5(other covariates) + ε

[c] Adjusted variables: Age at the initial visit, gender, race, parental education, household income, family composition, insurance type, physical activity, and treatment for diabetes and dyslipidemia

[d]Coefficients are unchanged since log-transformation means that unit conversion is captured in the intercept term..

Table 4

Estimated[a,b] HbAlc , LDL-c and TG resulting from change in television watching and computer use after a 5 year interval: SEARCH for Diabetes in Youth,2002-2005

			1 hour to 3 hours	3 hours to 1 hour
		HbAlc (%)-Initial visit	8.23	8.45
		HbAlc (%)-5 year follow-up visit	10.42	10.53
		Change	2.19	2.08
	Weekday television watching			
		TG(mg/dl)-Initial visit	53.30	55.33
		TG(mg/dl)-5 year follow-up visit	66.77	63.76
		Change	13.47	8.43
T1D				
		HbAlc (%)-Initial visit	8.15	8.41
		HbAlc (%)-5 year follow-up visit	10.35	10.5
	Weighted television watching per week	Change	2.20	2.09
	Weighted television watching per week			
		LDL-c (mg/dl)-Initial visit	89.54	92.84
		LDL-c (mg/dl)-5 year follow-up visit	98.86	99.11
		Change	9.32	6.27
		HbAlc (%)-Initial visit	7.55	8.45
	Weekday television watching	HbAlc (%)-5 year follow-up visit	9.71	9.51
		Change	2.16	1.06
		HbAlc (%)-Initial visit	7.57	8.33
T2D	Weekend television watching	HbAlc (%)-5 year follow-up visit	9.38	9.5
		Change	1.81	1.17
		HbAlc (%)-Initial visit	7.25	8.36
	Weighted television watching per week	HbAlc (%)-5 year follow-up visit	9.55	9.36
		Change	2.30	1.00

[a] Estimates were generated from the followed mixed model: Outcome = $\beta_0 + \beta_1$(duration) + β_2(initial exposure) + β_3(time-varying exposure) + β_4(initial exposure × time-varying exposure) + β_5(other covariates) + ε

[b] Reference of adjusted covariates in mixed models: age at initial visit=10 years old, gender=male, race=Non-Hispanic White, physical activity=0 day, higher parental education=less than high school, income= less than $25k per year, insurance=none, family composition= both parents, BMI z-score=0, diabetes treatment=insulin pump, and lipids treatment=none

[c] only presented significant results from mixed models in table 2 and table 3.