Grøntved, A., Ried-Larsen, M., Møller, N. C., Kristensen, P. L., Wedderkopp, N., Froberg, K., Hu, F., Ekelund, U., Andersen, L. B. (2012). Youth screen-time behaviour is associated with cardiovascular risk in young adulthood: the European Youth Heart Study. *European Journal of Preventive Cardiology*, under utgivelse. Hentet 4.oktober 2013. doi: 10.1177/2047487312454760

Title

Youth screen time behaviour is associated with cardiovascular risk in young adulthood (The European Youth Heart Study)

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Abstract

Aims

We prospectively examined the association of television (TV) viewing, computer use, and total screen time use in adolescence, and change in these behaviors, with CVD risk factors in young adulthood.

Methods and results

This was a prospective cohort study among Danish men and women (n=435) followed for up to 12 years. Adiposity, blood pressure (BP), triglycerides, high-density lipoprotein (HDL), glucose, insulin, self-reported TV and computer use were obtained in adolescence and in young adulthood. A continuous metabolic syndrome z-score was calculated as the sum of standardized values of each risk factor (inverse of HDL). In multivariable adjusted analyses, TV- and total screen time in adolescence were positively associated with adiposity, triglycerides, and metabolic syndrome z-score in young adulthood ($p<0.05$). Individuals who increased their TV, computer, or total viewing time with more than 2 hours/day from adolescence to young adulthood had 0.90 (95%CI 0.12-1.69), 0.95 (95%CI 0.01-1.88), 1.40 (95%CI 0.28-2.51) higher BMI respectively in young adulthood compared with individuals who remained stable or decreased their viewing time. Insulin and metabolic syndrome z-scores were also higher among individuals who increased their TV, computer, or total viewing time respectively with more than 2 hours/day compared with individuals who remained stable or decreased their viewing time ($p<0.05$).

Conclusions

Prolonged TV- and total screen time viewing during leisure time in adolescence, and increases in these behaviors, are associated with unfavorable levels of several cardiovascular risk factors in young adulthood.

Keywords: television; screen time; computer; cardiovascular risk; obesity

Introduction

TV viewing and computer use are common daily activities during leisure time among children, adolescents, and adults in Western countries.[1, 2] Among adults prolonged TV viewing and unspecified screen time viewing have been consistently associated with greater risk of chronic diseases, premature death, and raised levels of cardiovascular risk factors independent of moderate and vigorous physical activity level (MVPA).[3-6] More recently, organizational and national recommendations for sedentary behaviors including screen time for children and adolescents have emerged.[7-9] Some of these recommendations state that children and adolescents should limit their recreational screen time to no more than 2 hours/day to minimize health risks.[7, 8, 10] The evidence from prospective studies to support these specific time limits is weak, and it is unknown if time spent on TV viewing and computer use each are independently associated with cardiovascular outcomes. Furthermore, the evidence that childhood or youth screen time viewing are associated with adult cardiovascular health is scarce.[10-12] To extend the evidence that screen time viewing during youth have health effects later in life, we aimed to examine the association of TV viewing, computer use, and total leisure screen time viewing in adolescence with cardiovascular risk factors in young adulthood among Danish men and women participating in the European Youth Heart Study (EYHS) with up to 12 years of follow-up. We also examined the influence of changes in viewing time on cardiovascular risk in young adulthood.

Methods

Design

EYHS is an international population-based multicenter study that addresses cardiovascular disease (CVD) risk factors in children and adolescents.[13] The current study is based on the Danish cohort. In this study a random sample of 658 15-year old adolescents were invited to participate in 1997-98, of whom 429 (65%) agreed to take part in the study. In 2003-04 another random sample of 771 15-year old adolescents was invited of whom 444 (58%) agreed to take part. In 2009-10 a 6- or 12 year follow-up was conducted where all originally invited participants from 1997-98 and 2003-04 were invited again. The eligible cohort for the current analyses was n=435 individuals who had complete data on exposures and outcomes (244 individuals with 6-year follow-up and 191 individuals with 12-year follow-up). The study was approved by the local scientific ethics committee and all participants gave informed consent to participate.

Television, computer use, and total screen time viewing

At baseline and follow-up, TV and computer use time during leisure was obtained by self-report. In both instances this was done using a computer-based questionnaire.[13] At baseline, two questions were asked about the amount of time viewing TV (before and after school).[14] From these two questions a summary variable of daily TV viewing time variable in adolescence was constructed (hours/day). Frequency of eating while viewing TV (five-point scale) was also asked. Daily time spent using computer in adolescence was asked in one question. At follow-up the participants were asked to report their TV viewing time (hours and minutes) in the morning, afternoon, and evening. Again, a summary variable for daily TV viewing (hours/day) in young adulthood was constructed. Participants were asked about their time spent using a computer during leisure time (hours/day and min/day) separately for surfing the internet, playing games, and other tasks (i.e. word processing).

From response to these questions a summary variable for daily computer usage was constructed (hours/day). A total screen time variable (hours/day) was created by summarizing TV and computer use in adolescence and young adulthood, respectively.

Other covariates

Monthly frequency soft drinks, fruit, and vegetable intake were obtained by self-report in adolescence. Family history of CVD (paternal or maternal, yes/no) and parental educational level were obtained by parental self report. Parental educational status was defined according to the International Standard Classification of Education (ISCED) (UNESCO 1997). However, as the details obtained of the description of education was insufficient, the ISCED seven point scale was combined into 3 new groups (1=level 1-2; 2=level 3-4; and 3=level 5-7). Current smoking status (yes/no) was obtained in young adulthood. MVPA and sedentary time in adolescence was assessed using accelerometry with data reduction as described previously.[15] An output >2000 counts/min (equivalent to walking about 4 km/h) was defined as MVPA and an output <100 count/min was defined as sedentary. MVPA and sedentary time were expressed as continuous variables as percentage of total registered time.

Cardiovascular risk factors

Height, weight, and waist circumference (WC) were measured using standard anthropometric procedures. Fasting blood samples (overnight) were taken in the morning from the antecubital vein. Samples were aliquoted and separated within 30 min, and then stored at −80 °C until they were transported to a WHO–certified laboratory in Bristol and Cambridge (UK), for analysis at baseline and in Cambridge at follow-up. Samples were analyzed for serum glucose, insulin, HDL cholesterol, and triglyceride. Triglyceride was analyzed using the lipase/glycerol kinase/glycerol

phosphate oxidase enzymatic method. HDL was analyzed using the homogeneous polyanion/cholesterol esterase/oxidase enzymatic method. Glucose was analyzed using the hexokinase method. Blood lipids and glucose were measured on an Olympus AU600 autoanalyzer (Olympus Diagnostica, Germany) at baseline and on a Dade Behring Dimension RxL autonalyzer (Siemens Healthcare, UK) at follow-up. Insulin was analyzed using enzyme immunoassay (micro-titer plate format, Dako Diagnostics, http://www.dako.co.uk at baseline and 1235 AutoDELFIA automatic immunoassay, Wallac Oy, Finland at follow-up). Between-laboratory correlations in lipids, glucose, and insulin for 30 randomly selected samples analyzed at both laboratories were 0.94–0.98 at baseline.[14]

Resting BP was measured with a Dinamap paediatric and adult neonatal vital signs monitor (model XL, Critikron, Inc, Tampa, FL, USA) using an appropriate cuff size. Five measurements were taken at 2-min intervals with the mean of the final three measurements used in all analyses. Prior to measurements individuals were resting for five minutes while seated.

We calculated a continuous metabolic syndrome z-score to preserve statistical power and because the number of incident cases of metabolic syndrome according to the American Heart Association (AHA) and the National Heart, Lung, and Blood Institute (NHLBI) definition[16] in young adulthood was low (n=17). The z-score was based on the AHA/NHLBI definition with additional inclusion of fasting insulin. Thus, WC, the mean of diastolic and systolic BP, triglycerides, HDL (inverted), fasting glucose, and fasting insulin were standardized and subsequently summed to create a continuous metabolic syndrome z-score. Standardization in young adulthood (follow up) was done according to the baseline distribution (mean and SD) of each risk factor.

Statistics

Associations of screen time use in adolescence with cardiovascular risk factors in young adulthood were analyzed using multiple linear regression with baseline levels of respective risk factors included as a covariate. In multivariable analyses we adjusted for parental educational level, current smoking, family history of CVD, frequency of intake of soft drinks, intake of fruit and vegetables, and MVPA. Because we observed no gender- or cohort dependent associations for any outcomes we present all analysis for men, women and follow-up time (cohort) combined. Standard linear regression diagnostics were performed, including examining linearity and normality of residuals. Since we and others previously have shown that the association of prolonged TV viewing with metabolic risk may be mediated by adiposity,[14, 17] we also analyzed the association of screen time viewing with metabolic syndrome z-score without adiposity included but with adjustment for WC in adolescence. Furthermore, we included both computer use and TV viewing in the same model to examine the independent role of each type of behavior. The association of adolescence TV viewing with each outcome was also analyzed with additional adjustment for eating while viewing TV and with adjustment for percent time spent on sedentary behavior. Because adiposity also have been shown to predict sedentary time,[18] we also analyzed if BMI and WC in adolescence was associated with screen time viewing in young adulthood.

We then examined the association of change in viewing time with each respective cardiovascular risk factor in young adulthood. We used the difference in young adult- and adolescence viewing time as a continuous variable adjusting for adolescence viewing time, and we also analyzed change in TV viewing and total screen time viewing as categorical variables using the following categories: stable or decrease (≤0 hours/day), modest increase (>0-2 hours/day), large increase (>2 hours/day). A test for linear trend across groups of change in the categorical analysis was done by treating the 'change variable' as ordinal in the models.

As information on accelerometry measured MVPA and sedentary behavior at baseline

was missing among 161 individuals (37%), we imputed missing values using a multiple univariate linear regression imputation approach ("mi impute" in STATA) including all covariates. Beta coefficients and SE's were obtained based on 20 imputed datasets while the variability between imputations is adjusted for.[19] We did not observe appreciable differences in magnitude of effect estimates from complete case analyses compared with analyses on imputed dataset, although the CI's were wider in complete case analyses.

All statistical analyses were performed in STATA 11.2 with alpha=0.05 (two-sided). As the study is observational and the nature of the present analysis is exploratory rather than a confirmatory analysis of a clinical trial, no adjustments for multiple testing were carried out.

Results

Characteristics of individuals with baseline measurements that were lost to follow-up (n=351) are shown in supplementary Table. TV viewing time, SBP, glucose, intake of soft drinks was higher and a larger proportion was from parents with only a basic education among individuals lost to follow-up or with missing data. Table 1 shows the baseline characteristics of the study population by levels of TV viewing in adolescence. TV viewing at baseline was correlated with glucose, insulin, metabolic syndrome z-score, intake of soft drinks, and intake of fruit and vegetables ($p<0.05$). There was also a tendency that prolonged TV viewing was correlated with higher WC and lower HDL and to be higher among boys compared to girls ($p<0.10$) at baseline. TV, computer, and total screen time viewing increased noticeably from 1.6 hours/day of TV viewing, 0.6 hours/day of computer use, and 2.2 hours/day of screen time viewing in adolescence to 3.2 hours/day of TV viewing, 2.9 hours/day of computer use, and 6.1 hours/day of total screen time viewing in young adulthood (Figure 1). Changes were fairly similar in men and women and between cohorts ($p>0.1$ for interaction). TV viewing, computer use, and total screen time viewing tracked with stability coefficients (partial correlation coefficients) of 0.36 (95%CI 0.27-0.45), 0.15 (95%CI 0.05-0.25), and 0.30 (95%CI 0.20-0.39) from adolescence to young adulthood (age, gender, and cohort adjusted) indicating moderate tracking of TV- and total screen time viewing and low tracking of computer use.

Table 2 shows the association of TV viewing, computer use, and screen time viewing in adolescence with cardiovascular risk factors in young adulthood. In multivariable adjusted models each 1 hour increment in TV viewing time in adolescence the levels of respective outcomes in young adulthood increased by 0.24 (95%CI 0.00–0.49) kg/m^2 BMI points, 0.83 (95%CI 0.13–1.53) cm WC, 0.05 (95%CI 0.01–1.10) mmol/l triglycerides, 2.00 (95%CI -0.19–4.17) pmol/l insulin, and 0.45 (95%CI 0.14–0.76) SD metabolic syndrome z-score. Slightly weaker associations

were observed for total screen time viewing with the outcomes. In multivariable adjusted analyses total screen time viewing were significantly associated with BMI, WC, triglycerides, and metabolic syndrome z-score. Additional adjustment for TV viewing or total screen time viewing in adulthood attenuated the associations of adolescence viewing time with all risk factors, except for triglyceride which remained significant for both exposures. However, associations with WC and metabolic syndrome z-score were marginally significant for both adolescence TV- and screen time viewing after adjustment for adult viewing time ($p<0.1$). Additional adjustment for eating while viewing TV or objectively measured sedentary time did not materially change the results. Excluding adiposity from the metabolic syndrome z-score and adjusting for WC in adolescence slightly attenuated the associations with TV or screen time viewing, notwithstanding they were still significantly associated with metabolic syndrome z-score ($p<0.05$). No associations with any outcomes were observed for computer use in adolescence ($p>0.05$). Including both TV and computer use separately in the same model, TV viewing in adolescence was independently associated with BMI, WC, triglycerides, and metabolic syndrome z-score in young adulthood in multivariable adjusted analyses. We also explored the possibility of reverse causality (i.e. that adiposity predicts viewing time). Neither BMI nor WC in adolescence predicted any type of screen time viewing in young adulthood.

In multivariable adjusted analyses, changes in any type of viewing time from adolescence to young adulthood were consistently positively associated with BMI, insulin, and metabolic syndrome z-score in young adulthood (Table 3). Individuals who increased their TV, computer, or total viewing time with more than 2 hours/day had 0.90 (95%CI 0.12-1.69), 0.95 (95%CI 0.01-1.88), 1.40 (95%CI 0.28–2.51) higher BMI respectively in young adulthood compared with individuals who remained stable or decreased their viewing time. Insulin levels were 7.62 (95%CI 0.59-14.67), 10.67 (95%CI 2.34-19.00), and 8.14 (95%CI -1.80-18.08) pmol/l higher

among individuals who increased their TV, computer, or total viewing time respectively with more than 2 hours/day compared with individuals who remained stable or decreased their viewing time. Including change in TV and computer use in the same model, changes in both types of viewing were independently associated with BMI and insulin in continuous multivariable adjusted analyses.

Discussion

In this population based prospective study, prolonged TV viewing- and total screen time use in adolescence, and increases in screen time through young adulthood, were consistently associated with greater adiposity and clustered CVD risk in young adulthood. The associations were independent of various confounding factors including objectively measured MVPA and showed evidence of dose response relationships. Associations were generally attenuated after adjustment for viewing time in young adulthood, which suggest that prolonged viewers in adolescence are likely to be prolonged viewers in young adulthood as indicated by the moderate stability coefficients of TV- and total screen time viewing. Whereas adolescent computer use was not associated with any of the cardiovascular outcomes in young adulthood, increases in computer use during leisure time from adolescence to young adulthood was associated with higher levels of BMI and insulin in young adulthood independent of changes in TV viewing. Collectively, these findings provide support for recommending limiting prolonged screen time viewing among youth.

Our findings on TV viewing are consistent with a previous study among New Zealanders followed from childhood to young adulthood.[11] In this study prolonged TV viewing in childhood and adolescence was associated with greater BMI, lower cardio-respiratory fitness, and raised cholesterol in young adulthood independent of physical activity level. Another study from US among 13-year olds followed over five years found that TV viewing was positivity associated with the risk of high systolic BP.[20] We extend these findings by showing that both TV- and total screen time in adolescence, and change in TV viewing and computer use, are independently associated with unfavorable levels of several cardiovascular risk factors in young adulthood.

Because previous studies among children, adolescents, and adults on the associations of objectively measured sedentary behavior with cardiovascular risk factors have been equivocal[18, 21, 22] it is unclear if sedentariness *per se* is the principle cause of the harmful cardiovascular effect of

prolonged screen time viewing. It is possible that especially TV viewing are accompanied by other unhealthy lifestyle, such as eating more unhealthy food, increasing or initiating alcohol drinking and smoking during and beyond TV viewing time,[23-25] may exert effects on cardiovascular risk factors beyond what origins from sedentariness. When we adjusted for eating while viewing TV no change in the estimates was observed, nevertheless, because we observed weaker associations of computer use with cardiovascular risk, it is likely that the influence of prolonged TV viewing at least partly is mediated by these exposures and not only by sedentariness. Possible explanations to why computer use in youth was unrelated to CVD risk factors in young adulthood could be that youth in the present study on average spent little time using a computer, because computer use are less sedentary compared with TV viewing, or that exposure to factors such as food advertisements are more intense for TV viewing compared with computer use. We also found that the association of TV viewing with clustered cardiovascular risk was only partly mediated by adiposity. This is in accordance with studies among adults having incident CVD or type 2 diabetes as outcomes,[3, 6] but in opposite to our previous cross-sectional analysis among children and adolescents[14] and a previous study among adults.[26]

Limited amount of evidence from randomized trials on restricting TV- or screen time viewing exists. However, the few studies that have been carried out provide some support of the associations we observe. Two randomized trials among children have shown that reducing TV viewing time can lead to favorable changes in adiposity status.[27, 28] Another small scale randomized trial among overweight or obese adults did not find a statistically significant change in adiposity status from restricting TV viewing time during a period of three weeks, but did see an increase in energy expenditure.[29]

There are a number of limitations to this study. All screen time measures were self-reported, and measurement errors are therefore inevitable. Loss to follow-up and missing data can

lead to bias if the associations are different in these individuals. We found differences in some baseline characteristics among individuals lost to follow-up or with missing data compared with the individuals with complete data. However, associations between TV viewing and outcomes were fairly similar by parental educational level (data not shown), which gives us some confidence that the associations are unaffected by selection bias. In addition, our study was not adequately powered to consistently do stratified analyses by cohort which could provide valuable information about the timing of interventions to prevent the large increase in viewing time. Other limitations of this study include the possibility of unknown and residual confounding, although we adjusted for important confounding factors including objectively measured MVPA. Because the magnitudes of the multivariable adjusted estimates were substantial for many of the outcomes it is unlikely that residual or unknown confounding fully accounts for these associations. Finally, some of the statistically significant findings may arise from multiple testing since we tested several CVD risk factors.

In conclusion, our findings suggest that prolonged TV- and total screen time viewing during leisure time in adolescence, and increases in these behaviors, are associated with unfavorable levels of several cardiovascular risk factors in young adulthood. These findings indicate that efforts to reduce these viewing behaviors in youth would be important to prevent adverse cardiovascular effects in adulthood, and provide support for recommending limiting prolonged TV- and total screen time viewing among youth.

Funding

This work was supported by the Danish Council for Strategic Research [grant number 2101-08-0058]; The Danish Heart Foundation; the Danish Health Fund (Sygekassernes Helsefond); and the Trygfoundation (Trygfonden).

Acknowledgement

The authors are grateful to the participants and their families who gave their time to the study.

Conflicts of interest

None declared

References

1. Currie C, Roberts C, Morgan A, Smith R, Settertobulte W, Samdal O, Rasmussen VB. Young People's Health in Context. Health Behaviour in School-Aged Children (HBSC) Study: International Report from the 2001/2002 Survey. *World Health Organization. Health Policy for Children and Adolescents,* No. 4, WHO: Geneva; 2004.

2. Office for Official Publications of the European C. Time use at different stages of life. Results from 13 European countries. Luxembourg 2003.

3. Grøntved A, Hu FB. Television Viewing and Risk of Type 2 Diabetes, Cardiovascular Disease, and All-Cause Mortality. *JAMA: The Journal of the American Medical Association* 2011;**305**(23):2448-2455.

4. Stamatakis E, Hamer M, Dunstan DW. Screen-Based Entertainment Time, All-Cause Mortality, and Cardiovascular Events: Population-Based Study With Ongoing Mortality and Hospital Events Follow-Up. *Journal of the American College of Cardiology* 2011;**57**(3):292-299.

5. Fung TT, Hu FB, Yu J, Chu NF, Spiegelman D, Tofler GH, Willett WC, Rimm EB. Leisure-Time Physical Activity, Television Watching, and Plasma Biomarkers of Obesity and Cardiovascular Disease Risk. *American Journal of Epidemiology* 2000;**152**(12):1171-1178.

6. Wijndaele K, Brage S, Besson H, Khaw KT, Sharp SJ, Luben R, Wareham NJ, Ekelund U. Television viewing time independently predicts all-cause and cardiovascular mortality: the EPIC Norfolk Study. *International Journal of Epidemiology* 2011;**40**(1):150-159.

7. Committee on Public Education. Children, Adolescents, and Television. *Pediatrics* 2001;**107**(2):423-426.

8. Tremblay MS, LeBlanc AG, Janssen I, Kho ME, Hicks A, Murumets K, Colley RC, Duggan M. Canadian Sedentary Behaviour Guidelines for Children and Youth. *Applied Physiology, Nutrition, and Metabolism* 2011;**36**(1):59-64.

9. Australian Government, Department of Health and Ageing. Australia's Physical Activity Recommendations. In. *Canberra, Australia: Department of Health and Ageing*; 2004.

10. Tremblay M, LeBlanc A, Kho M, Saunders T, Larouche R, Colley R, Goldfield G, Gorber S. Systematic review of sedentary behaviour and health indicators in school-aged children and youth. *International Journal of Behavioral Nutrition and Physical Activity* 2011;**8**(1):98.

11. Hancox RJ, Milne BJ, Poulton R. Association between child and adolescent television viewing and adult health: a longitudinal birth cohort study. *The Lancet* 2004;**364**(9430):257-262.

12. Chinapaw MJM, Proper KI, Brug J, van Mechelen W, Singh AS. Relationship between young peoples' sedentary behaviour and biomedical health indicators: a systematic review of prospective studies. *Obesity Reviews* 2011;**12**(7):e621-e632.

13. Riddoch C, Edwards D, Page A, Froberg K, Anderssen SA, Wedderkopp N, Brage S, Cooper AR, Sardinha LB, Harro M, Heggebo LK, Mechelen WV, Boreham C, Ekelund U, Andersen LB. The European Youth Heart Study - cardiovascular disease risk factors in children: rationale, aims, design and validation of methods. *J Physical Activity Health* 2005;**2**:115-129.

14. Ekelund U, Brage S, Froberg K, Harro M, Anderssen SA, Sardinha LB, Riddoch C, Andersen LB. TV viewing and physical activity are independently associated with metabolic risk in children: the European Youth Heart Study. *PLoS.Med.* 2006;**3**(12):e488.

15. Kristensen P, Moeller N, Korsholm L, Kolle E, Wedderkopp N, Froberg K, Andersen L. The association between aerobic fitness and physical activity in children and adolescents: the European youth heart study. *European Journal of Applied Physiology* 2010;**110**(2):267-275.

16. Grundy SM, Cleeman JI, Daniels SR, Donato KA, Eckel RH, Franklin BA, Gordon DJ, Krauss RM, Savage PJ, Smith SC, Spertus JA, Costa F. Diagnosis and Management of the Metabolic Syndrome. *Circulation* 2005;**112**(17):2735-2752.

17. Stamatakis E, Hamer M. The Extent to Which Adiposity Markers Explain the Association Between Sedentary Behavior and Cardiometabolic Risk Factors. *Obesity* 2012;**20**(1):229-232.

18. Ekelund U, Luan Ja, Sherar LB, Esliger DW, Griew P, Cooper A. Moderate to Vigorous Physical Activity and Sedentary Time and Cardiometabolic Risk Factors in Children and Adolescents. *JAMA: The Journal of the American Medical Association* 2012;**307**(7):704-712.

19. Rubin DB. Multiple Imputation After 18+ Years. *Journal of the American Statistical Association* 1996;**91**(434):473-489.

20. Dasgupta K, O'Loughlin J, Chen S, Karp I, Paradis G, Tremblay J, Hamet P, Pilote L. Emergence of Sex Differences in Prevalence of High Systolic Blood Pressure. *Circulation* 2006;**114**(24):2663-2670.

21. Healy GN, Matthews CE, Dunstan DW, Winkler EAH, Owen N. Sedentary time and cardio-metabolic biomarkers in US adults: NHANES 2003–06. *European Heart Journal* 2011;**32**(5):590-597.

22. Carson V, Janssen I. Volume, patterns, and types of sedentary behavior and cardio-metabolic health in children and adolescents: a cross-sectional study. *BMC Public Health* 2011;**11**(1):274.

23. Wellman RJ, Sugarman DB, DiFranza JR, Winickoff JP. The Extent to Which Tobacco Marketing and Tobacco Use in Films Contribute to Children's Use of Tobacco: A Meta-analysis. *Arch Pediatr Adolesc Med* 2006;**160**(12):1285-1296.

24. Anderson P, de Bruijn A, Angus K, Gordon R, Hastings G. Impact of Alcohol Advertising and Media Exposure on Adolescent Alcohol Use: A Systematic Review of Longitudinal Studies. *Alcohol and Alcoholism* 2009;**44**(3):229-243.

25. Wiecha JL, Peterson KE, Ludwig DS, Kim J, Sobol A, Gortmaker SL. When Children Eat What They Watch: Impact of Television Viewing on Dietary Intake in Youth. *Archives of Pediatrics Adolescent Medicine* 2006;**160**(4):436-442.

26. Stamatakis E, Hamer M, Mishra G. Early adulthood television viewing and cardiometabolic risk profiles in early middle age: results from a population, prospective cohort study. *Diabetologia* 2012;**55**(2):311-320.

27. Robinson TN. Reducing Children's Television Viewing to Prevent Obesity. *JAMA: The Journal of the American Medical Association* 1999;**282**(16):1561-1567.

28. Epstein LH, Roemmich JN, Robinson JL, Paluch RA, Winiewicz DD, Fuerch JH, Robinson TN. A Randomized Trial of the Effects of Reducing Television Viewing and Computer Use on Body Mass Index in Young Children. *Archives of Pediatrics Adolescent Medicine* 2008;**162**(3):239-245.

29. Otten JJ, Jones KE, Littenberg B, Harvey-Berino J. Effects of Television Viewing Reduction on Energy Intake and Expenditure in Overweight and Obese Adults: A Randomized Controlled Trial. *Archives of Internal Medicine* 2009;**169**(22):2109-2115.

Figure legends

Figure 1

Age, gender, and cohort adjusted estimates with 95%CI of television, computer, and total screen time viewing during leisure from adolescence to young adulthood (n=435).

Table 1. Baseline characteristics by television viewing time in adolescence.

	Television viewing time in adolescence			
	0 – 1 hours/day (n=163)	>1 – 3 hours/day (n=224)	>3 hours/day (n=48)	P
Age (years)	15.6 (0.4)	15.6 (0.4)	15.6 (0.4)	0.64
Gender (% boys)	41.7	45.1	60.4	0.07
BMI (kg/m^2)	21.0 (2.4)	20.8 (2.4)	21.4 (3.5)	0.25
Waist circumference (cm)	71.7 (6.1)	71.3 (6.4)	73.6 (8.8)	0.08
Systolic BP (mmHg)	109.2 (9.8)	110.4 (10.1)	111.5 (9.6)	0.28
Diastolic BP (mmHg)	61.8 (6.2)	61.9 (6.5)	61.1 (6.9)	0.71
Triglyceride (mmol/l)	0.9 (0.4)	0.9 (0.4)	1.0 (0.7)	0.42
HDL-C (mmol/l)	1.4 (0.3)	1.4 (0.3)	1.3 (0.3)	0.09
Glucose (mmol/l)	5.0 (0.4)	5.1 (0.4)	5.2 (0.4)	<0.01
Insulin (pmol/l)	64.3 (29.1)	69.9 (35.4)	79.0 (42.5)	0.03
Metabolic syndrome z-score (SD)	-0.2 (2.6)	-0.1 (2.5)	1.2 (3.5)	<0.01
Computer use (hours/day)	0.7 (0.8)	0.6 (0.7)	0.8 (0.9)	0.21
Soft drinks (servings/month)	7.9 (7.9)	9.7 (9.0)	11.9 (9.9)	0.01
Fruits and vegetables (servings/month)	41.0 (16.4)	37.0 (17.9)	31.4 (15.3)	<0.01
MVPA (% of total time)	5.9 (3.0)	5.6 (3.0)	6.1 (4.6)	0.72
Sedentary (% of total time)	58.3 (8.8)	57.9 (8.2)	55.5 (12.0)	0.38
Parental education level (% 1 / 2 / 3)	9.8 / 23.3 / 66.9	10.3 / 30.8 / 58.9	10.4 / 31.3 / 58.3	0.53
Family history of CVD (%)	26.4	30.8	31.3	0.60

Data are means (SD) or numbers (%).

Table 2. Television viewing, computer use, and total screen time viewing in adolescence and cardiovascular risk factors in young adulthood.

	Viewing time in adolescence	
	Beta (95% CI)	P
Television		
BMI	0.24 (0.00–0.49)	0.049
Waist circumference	0.83 (0.13–1.53)	0.02
Triglycerides	0.05 (0.01–0.10)	0.02
HDL-C	-0.02 (-0.04–0.004)	0.12
Systolic BP	0.38 (-0.39–1.13)	0.33
Diastolic BP	0.62 (-0.01–1.25)	0.06
Glucose	0.02 (-0.01–0.06)	0.21
Insulin	2.00 (-0.19–4.17)	0.07
Metabolic syndrome z-score	0.45 (0.14–0.76)	0.005
Computer		
BMI	0.20 (-0.21–0.61)	0.33
Waist circumference	0.30 (-0.88–1.46)	0.63
Triglycerides	0.02 (-0.05–0.10)	0.55
HDL-C	0.01 (-0.03–0.05)	0.56
Systolic BP	-0.18 (-1.44–1.08)	0.78
Diastolic BP	-0.06 (-1.12–1.00)	0.91
Glucose	-0.02 (-0.08–0.03)	0.43
Insulin	0.65 (-2.99–4.30)	0.73
Metabolic syndrome z-score	0.03 (-0.48–0.55)	0.90
Total screen time		
BMI	0.24 (0.03–0.46)	0.03
Waist circumference	0.71 (0.10–1.32)	0.02
Triglycerides	0.05 (0.009–0.09)	0.02
HDL-C	-0.01 (-0.03–0.009)	0.29
Systolic BP	0.24 (-0.42–0.90)	0.47
Diastolic BP	0.45 (-0.10–1.01)	0.11
Glucose	0.01 (-0.02–0.04)	0.50
Insulin	1.70 (-0.20–3.60)	0.08
Metabolic syndrome z-score	0.35 (0.08–0.62)	0.01

Beta coefficient (95% CI) represents change in risk factor in young adulthood per each 1 hour/day change in viewing time in adolescence.

Models were adjusted for baseline of risk factor, age, gender, cohort, parental education level, current smoking status, moderate and vigorous physical activity, intake of soft drinks, fruit- and vegetable intake, and family history of CVD.

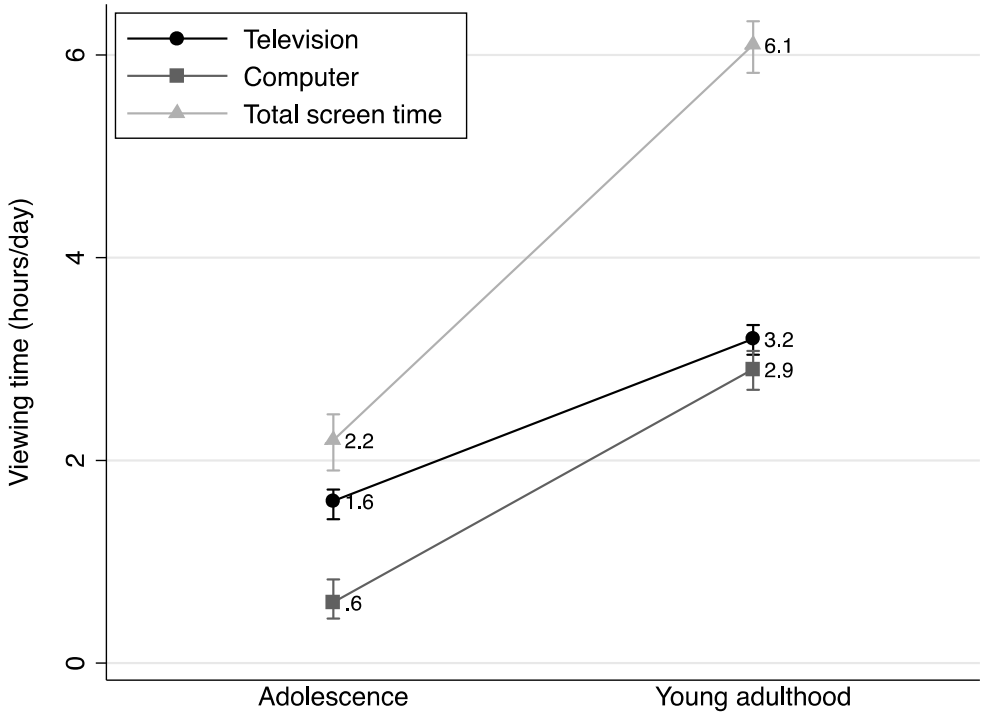
Table 3. Change in TV viewing, computer use, and total screen time from adolescence to young adulthood and cardiovascular risk factor in young adulthood.

	Change in viewing time from adolescence to young adulthood					
	Stable or decrease (≤0 hours/day)	Modest increase (>0-2 hours/day)	Large increase (>2 hours/day)	P trend	Continuous (per 1 hour/day of change)	P
Television	(n=86)	(n=197)	(n=152)			
BMI	Reference	0.24 (-0.50–0.98)	0.90 (0.12–1.69)	0.01	0.28 (0.13–0.43)	<0.001
Waist circumference	Reference	-0.72 (-2.83–1.38)	1.25 (-1.01–3.50)	0.14	0.58 (0.15–1.02)	0.009
Triglycerides	Reference	-0.02 (-0.15–0.20)	0.09 (-0.06–0.23)	0.15	0.01 (-0.02–0.04)	0.37
HDL-C	Reference	0.004 (-0.06–0.07)	-0.05 (-0.12–0.02)	0.10	-0.01 (-0.03–0.002)	0.09
Systolic BP	Reference	1.26 (-1.03–3.54)	1.80 (-0.64–4.23)	0.16	0.37 (-0.11–0.84)	0.13
Diastolic BP	Reference	0.27 (-1.65–2.18)	1.21 (-0.85–3.26)	0.20	0.25 (-0.15–0.65)	0.22
Glucose	Reference	0.05 (-0.05–0.15)	0.04 (-0.07–0.15)	0.61	0.01 (-0.01–0.03)	0.49
Insulin	Reference	2.41 (-4.17–8.99)	7.62 (0.59–14.67)	0.02	2.19 (0.82–3.55)	0.002
Metabolic syndrome z-score	Reference	0.07 (-0.85–1.00)	1.02 (0.03–2.01)	0.02	0.27 (0.08–0.46)	0.006
Computer	(n=50)	(n=234)	(n=151)			
BMI	Reference	0.53 (-0.38–1.44)	0.95 (0.01–1.88)	0.03	0.10 (0.01–0.20)	0.03
Waist circumference	Reference	2.55 (-0.08–5.17)	2.87 (0.19–5.55)	0.09	0.08 (-0.20–0.35)	0.58
Triglycerides	Reference	0.09 (-0.08–0.26)	0.10 (-0.08–0.27)	0.39	0.005 (-0.01–0.02)	0.54
HDL-C	Reference	0.04 (-0.05–0.12)	-0.02 (-0.10–0.07)	0.23	-0.005 (-0.01–0.003)	0.23
Systolic BP	Reference	-0.60 (-3.43–2.22)	0.03 (-2.87–2.92)	0.73	0.25 (-0.05–0.56)	0.10
Diastolic BP	Reference	-0.23 (-2.61–2.15)	0.52 (-1.92–2.95)	0.46	0.30 (0.05–0.55)	0.02
Glucose	Reference	-0.07 (-0.19–0.06)	-0.04 (-0.17–0.09)	0.94	0.001 (-0.01–0.01)	0.92
Insulin	Reference	7.72 (-0.42–15.87)	10.67 (2.34–19.00)	0.02	1.07 (0.22–1.92)	0.01
Metabolic syndrome z-score	Reference	0.61 (-0.55–1.77)	1.09 (-0.10–2.28)	0.06	0.12 (-0.002–0.24)	0.05
Total screen time	(n=29)	(n=114)	(n=292)			
BMI	Reference	0.96 (-0.22–2.15)	1.40 (0.28–2.51)	0.01	0.14 (0.06–0.21)	0.001
Waist circumference	Reference	3.04 (-0.35–6.43)	3.75 (0.56–6.94)	0.04	0.18 (-0.04–0.41)	0.10
Triglycerides	Reference	0.09 (-0.13–0.30)	0.20 (-0.007–0.40)	0.01	0.006 (-0.008–0.02)	0.41

HDL-C	Reference	-0.007 (-0.11–0.10)	-0.03 (-0.13–0.07)	0.32	-0.006 (-0.01–0.007)	0.08
Systolic BP	Reference	4.61 (0.95–8.27)	4.66 (1.21–8.10)	0.06	0.26 (0.02–0.50)	0.04
Diastolic BP	Reference	2.43 (-0.64–5.51)	3.60 (0.79–6.49)	0.01	0.25 (0.05–0.45)	0.01
Glucose	Reference	-0.03 (-0.20–0.13)	0.03 (0.13–0.18)	0.30	0.002 (-0.009–0.01)	0.68
Insulin	Reference	0.78 (-9.79–11.34)	8.14 (-1.80–18.08)	0.006	1.23 (0.54–0.92)	<0.001
Metabolic syndrome z-score	Reference	1.05 (-0.44–2.54)	1.92 (0.52–3.33)	0.001	0.14 (0.04–0.24)	0.005

All models were adjusted for baseline levels of risk factor and viewing time, age, gender, cohort, parental education level, current smoking status, moderate and vigorous physical activity, current smoking status, intake of soft drinks, fruit- and vegetable intake, and family history of CVD.

Figure 1.


Television
Computer
Total screen time
Viewing time (hours/day)
0
2
4
6
6.1
3.2
2.9
2.2
1.6
.6
Adolescence
Young adulthood