# Television Viewing and Low Leisure-Time Physical Activity in Adolescence Independently Predict the Metabolic Syndrome in Mid-Adulthood

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**OBJECTIVE**—We investigated whether television (TV) viewing and low leisure-time physical activity in adolescence predict the metabolic syndrome in mid-adulthood.

**RESEARCH DESIGN AND METHODS**—TV viewing habits and participation in leisure-time physical activity at age 16 years were assessed by self-administered questionnaires in a population-based cohort in Northern Sweden. The presence of the metabolic syndrome at age 43 years was ascertained in 888 participants (82% of the baseline sample) using the International Diabetes Federation criteria. Odds ratios (ORs) and CIs were calculated using logistic regression.

**RESULTS**—The overall prevalence of the metabolic syndrome at age 43 years was 26.9%. Adjusted OR for the metabolic syndrome at age 43 years was 2.14 (95% CI 1.24–3.71) for those who reported "watching several shows a day" versus "one show/week" or less and 2.31 (1.13–4.69) for leisure-time physical activity "several times/month" or less compared with "daily" leisure-time physical activity at age 16 years. TV viewing at age 16 years was associated with central obesity, low HDL cholesterol, and hypertension at age 43 years, whereas low leisure-time physical activity at age 16 years was associated with central obesity and triglycerides at age 43 years.

**CONCLUSIONS**—Both TV viewing and low leisure-time physical activity in adolescence independently predicted the metabolic syndrome and several of the metabolic syndrome components in mid-adulthood. These findings suggest that reduced TV viewing in adolescence, in addition to regular physical activity, may contribute to cardiometabolic health later in life.

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Current public health guidelines recommend moderate-intensity aerobic physical activity for a minimum of 30 min on 5 days each week or vigorous-intensity aerobic physical activity for a minimum of 20 min on 3 days each week to promote and maintain health (1). Aside from this, sedentary behavior such as prolonged sitting during commuting and in the workplace and the domestic environment has recently emerged as a distinct contributor to adverse health effects, particularly for cardiometabolic outcomes (2). On the physical activity continuum, sedentary behaviors do not simply exist at one end but, rather, are a class of behaviors that can coexist and compete with physical activity (3). Changes in television (TV)-viewing levels (a common leisure-time sedentary behavior) have been associated with concurrent changes in cardiometabolic biomarkers that are independent of the protective effects of regular moderate- to vigorous-intensity physical activity (4). Generally, evidence for a physical activity–independent link between TV viewing and cardiometabolic outcomes has been generated from cross-sectional analyses. Few longitudinal studies have been conducted, and a recently published review concluded that there is insufficient evidence to conclude that a definitive longitudinal relationship exists between sedentary behavior, markers of cardiometabolic health, and metabolic conditions (2). Moreover, there is a lack of prospective studies that have examined the relationship between sedentary behaviors during childhood or adolescence and adult cardiometabolic risk. One of the few longitudinal studies with a life course perspective showed that TV viewing in childhood was associated with raised cholesterol and overweight in adulthood (5). However, the individuals were not followed longer than up to age 26 years. Thus, although interventions to reduce TV viewing in children have shown promising short-term results (6), uncertainty remains as to whether preventive actions during childhood and adolescence may have an impact on cardiometabolic risk in adulthood.

The aim of this study was to investigate whether TV viewing and low leisure-time physical activity in adolescence predict the metabolic syndrome in mid-adulthood. We also aimed to examine the extent to which leisure-time physical activity in mid-adulthood mediates the relationships of TV viewing and low leisure-time physical activity in adolescence with the metabolic syndrome in mid-adulthood.

## RESEARCH DESIGN AND METHODS

Participants were drawn from the Northern Swedish Cohort, a 27-year prospective cohort study previously described in detail (7). The sample is defined as all school leavers of the 9th (final) grade of the Swedish compulsory school in 1981 in the municipality of Luleå at participant age 16 years ($n$ = 1,083). Ethics approval was granted by the regional ethics review board in Umeå, Sweden. The cohort has been found to be representative of the corresponding age cohort of Sweden in various demographic comparisons (7). Follow-up data collections

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were conducted in 1983 (age 18 years), 1986 (age 21 years), 1995 (age 30 years), and 2008 (age 43 years). At the 2008 follow-up, $n$ = 1,010 were still active in the cohort (94% of those of the baseline sample who were still alive [$n$ = 1,071]).

The present report is based on data from the age 16 and 43 years data collections. As a result of internal dropout, the analyses were conducted in 888 participants (464 men and 424 women): 82% of the baseline sample and 88% of those participating at the 2008 data collection. (See the statistical analysis, below, for details and analysis of the missing data.)

At ages 16 and 43 years, participants completed comprehensive self-administered questionnaires. The questionnaires covered health, behaviors, leisure activities, and work, family, school, and other social circumstances (7) and were used in the present report to operationalize lifestyle factors, socioeconomic status, and family history of diabetes. Information on weight and height at age 16 years was retrieved from school health records, as measured by school nurses as a part of a compulsory school health examination, and was used to calculate BMI. For the operationalization of the metabolic syndrome at age 43 years, the participants took part in a more comprehensive health examination performed by trained medical personnel at the participants' respective health care center (8). Blood pressure (two consecutive readings) was measured according to the World Health Organization Multinational MONItoring of trends and determinants in CArdiovascular disease (MONICA) manual (9). Waist circumference was measured to the nearest 0.5 cm in indoor clothing. Blood samples were drawn after an overnight fast and analyzed with respect to HDL cholesterol (HDL-C), triglycerides, and glucose. Coefficient of variance at high and low concentrations was 1.7 and 1.5% for triglycerides, 2.8 and 2.8% for HDL-C, and 1.5 and 1.2% for glucose, respectively.

### TV-viewing habits and participation in leisure-time physical activity at age 16 years

TV-viewing habits were operationalized through the question, "How often do you watch television?" with the following five response options: *1*) several shows a day, *2*) one show per day, *3*) one show every other day, *4*) one show per week, and *5*) less than one show per week. Because of the low number in several categories (e.g., 14 participants in the fifth category), we collapsed category 2 with category 3 and category 4 with category 5. Consequently, analyses were performed using three levels of TV viewing. Participants reported leisure-time physical activity (sport activities or exercise) during the last 12 months, with six response options: daily, several times per week, once a week, several times per month, once a month, and seldom. The last three categories were collapsed based on the low number in each of these categories. Additionally, the same question regarding leisure-time physical activity (coded in the same way) was used at age 43 years.

### Metabolic syndrome and its components at age 43 years

The metabolic syndrome and its components were operationalized in a manner similar to that in our previous reports (8,10,11), according to the guidelines by the International Diabetes Federation (12): waist circumference ≥80 cm for women and ≥94 cm for men and two or more of the following criteria: *1*) increased triglycerides (≥1.7 mmol/L) or specific treatment for that lipid abnormality, *2*) reduced HDL-C (<1.29 mmol/L for women and <1.03 mmol/L for men) or specific treatment for that lipid abnormality, *3*) increased blood pressure (systolic blood pressure ≥130 mmHg or diastolic blood pressure ≥85 mmHg) or treatment of hypertension, and *4*) increased fasting glucose (≥5.6 mmol/L) or diagnosed type 2 diabetes. Information on medication was based on self-report. Current type 2 diabetes was based on self-reported presence of diabetes at age 43 years, excluding those who also reported diabetes at age 30 years, who were regarded as having type 1 diabetes. Both the metabolic syndrome and its components were used as binary outcomes in the subsequent analyses.

### Covariates

Socioeconomic status in adolescence was operationalized in the same manner as in our previous reports (8,10,11). Parental occupation, as reported by participants at age 16 years, was coded into three social groups, corresponding to the manual workers (blue-collar) (III), lower white-collar employees (II), and upper white-collar employees and self-employed (I) classification scheme of Statistics Sweden (13). As only 8.5% of the fathers and 2.5% of the mothers belonged to group I, groups I and II were collapsed into a favorable socioeconomic category, whereas the manual group was retained as a disadvantaged socioeconomic category. Socioeconomic disadvantage was defined as both parents belonging to manual occupation versus one or both parents belonging to a nonmanual or self-employed occupation. For a participant who only lived with one parent or who had one unknown or deceased parent, only the occupation of the parent with whom they were currently living was considered. For parents who were not currently employed, the last held occupation was used. Annual consumption of alcohol was estimated from self-reported typical frequency and quantity of alcoholic beverage consumption and categorized into sex-specific quintiles. Due to the high percentage of abstainers, quintiles 1 and 2 were collapsed, and the final alcohol consumption variable thus comprised four levels of alcohol consumption (10). Family history of diabetes and smoking habits were self-reported in the questionnaire and dichotomized. Dietary intake was assessed in a short simplified food-frequency questionnaire, and a calculation of nutrient intake was not possible. However, we included a single question on intake of sweets and pastries, which was dichotomized. BMI was calculated from measured height and weight as weight in kilograms divided by the square of height in meters.

Overweight was defined as BMI 25.0–29.9 kg/m$^2$ and obesity as BMI ≥30 kg/m$^2$. Incident overweight or obesity was defined as BMI ≥25 kg/m$^2$ at follow-up (age 43 years) among participants with a sex-specific BMI <90th percentile at baseline (age 16 years).

### Statistical analysis

Statistical analyses were conducted using SPSS statistics, version 19 (SPSS, Chicago, IL). $\chi^2$ test was used for testing differences in proportions. Kruskal-Wallis test was used for testing group differences in ordinal continuous variables. Correlation between TV viewing and leisure-time physical activity was calculated using Spearman rank correlation. Logistic regression was used to estimate odds ratios (ORs) and 95% CIs. Multivariate models included TV viewing and leisure-time physical activity in the same model and a model with additional adjustment for sex, socioeconomic disadvantage, family history of diabetes, BMI, intake of sweets/pastries, alcohol consumption, and smoking at age 16 years. In order to test whether the associations between TV viewing and low leisure-time physical activity with metabolic syndrome were mediated by leisure-time physical activity in adulthood, we also included leisure-time physical activity at age 43 years in the last multivariate model (model 3). We performed a test for interactions of TV viewing and leisure-time physical activity by including an interaction term in the multivariate-adjusted model (model 2). The same multivariate model was used in analyses of the metabolic syndrome components. A $P$ value $<0.05$ was considered significant. In the study, 107 individuals (10.7%) were excluded because data on the metabolic syndrome were missing and 6 individuals (0.6%) were excluded because data on TV viewing or leisure-time physical activity were missing. For examination of potential selection bias, those with incomplete measures were compared with those with complete measures. There were no differences in TV viewing, leisure-time physical activity, or any of the included covariates in this study. A total of 888 individuals remained after exclusions. The multivariate analyses were conducted as a complete case analysis in which 19 additional cases were lost as a result of missing data on covariates.

**RESULTS**—The overall prevalence of the metabolic syndrome at age 43 years among the 888 participants was 26.9%, and the incident overweight or obesity was 54.5%. Selected characteristics according to TV-viewing habits and participation in leisure-time physical activity at age 16 years are presented in Table 1. A higher frequency of TV viewing at age 16 years was related to male sex, socioeconomic disadvantage, lower alcohol consumption, and lower proportion of daily smoking at age 16 years and to prevalence of the metabolic syndrome and all metabolic syndrome components except for central obesity at age 43 years. Boys' and girls' participation in leisure-time physical activity at age 16 years was unevenly distributed with a higher proportion of girls compared with boys in one category: once per week. A lower frequency of leisure-time physical activity at age 16 years was related to socioeconomic disadvantage, higher alcohol consumption, and a higher proportion of daily smokers at age 16 years and to prevalence of the metabolic syndrome, central obesity, and raised triglycerides at age 43 years. TV viewing and leisure-time physical activity at age 16 years were not closely related (Spearman correlation coefficient −0.032, $P$ = 0.343).

Table 2 shows the ORs for the presence of the metabolic syndrome at age 43 years according to TV viewing and leisure-time physical activity at age 16 years. We found no significant interaction between TV viewing or low leisure-time physical activity and sex on presence of the metabolic syndrome at age 43 years ($P$ = 0.704 and $P$ = 0.745, respectively). Thus, the analyses were not stratified by sex. TV viewing and low leisure-time physical activity were associated with the metabolic syndrome in crude analyses. These associations with the metabolic syndrome were only modestly attenuated when TV viewing and low leisure-time physical activity were included in the same model (model 1) and when analyses were further adjusted for the other covariates (model 2). To test whether the association between TV viewing and low leisure-time physical activity in adolescence with the metabolic syndrome was dependent on leisure-time physical activity in adulthood, we also added leisure-time physical activity at age 43 years to the multivariate-adjusted model (model 3). This adjustment attenuated the association for TV viewing somewhat, but the $P$ for trend ($P$ = 0.008) across the TV-viewing categories as well as the OR for several shows per day versus one show per week or less remained significant (OR 1.96 [95% CI 1.13–3.42]), whereas the association for low leisure-time physical activity was more markedly attenuated and no longer significant.

Fig. 1 shows the relationship between TV viewing at age 16 years and the metabolic syndrome at age 43 years across two categories of physical activity. The interaction term between TV viewing and leisure-time physical activity on risk for the metabolic syndrome was not significant ($P$ = 0.21). Compared with those who watched one TV show per day or less and were physically active once a week or more, those who watched several TV shows per day had an increased risk for the metabolic syndrome irrespective of their level of leisure-time physical activity.

In crude analyses of the metabolic syndrome components, TV viewing at age 16 years was associated with all metabolic syndrome components except for central obesity at age 43 years, whereas low leisure-time physical activity at age 16 years was associated only with central obesity and raised triglycerides (Table 3). After multivariate adjustments, TV viewing at age 16 years was associated with central obesity, low HDL-C, and raised blood pressure, but the associations with raised triglycerides and fasting glucose were attenuated and no longer significant. After similar adjustments, low leisure-time physical activity at age 16 years remained associated with central obesity and raised triglycerides at age 43 years.

**CONCLUSIONS**—To our knowledge, this is the first prospective study examining the relationship between TV viewing and participation in leisure-time physical activity in adolescence with the metabolic syndrome and its components in mid-adulthood. We found that both TV viewing and low leisure-time physical activity in adolescence independently predicted the metabolic syndrome and several of the metabolic syndrome components in mid-adulthood. Our results suggested a dose-response relationship for both TV viewing and leisure-time physical activity with subsequent cardiometabolic risk. Furthermore, our analyses indicate that low leisure-time physical activity in adolescence is mediated by leisure-time physical activity in mid-adulthood to a considerable degree, whereas TV viewing in adolescence is not.

The finding of an association between TV viewing and cardiometabolic risk is consistent with the results from several previous cross-sectional studies on adults (14–17). Our results also expand previous longitudinal findings (4,5,18,19) by showing that the link between TV viewing and cardiometabolic risk stretches over a 27-year period from adolescence and into midlife. Consistent with previous studies (15,20), TV viewing and leisure-time physical activity were not closely related at age 16 years. Moreover, the relationship between TV viewing and the metabolic syndrome was not dependent on leisure-time physical activity in mid-adulthood, which may provide further support for the hypothesis that the association between sedentary behavior, such as TV viewing, and cardiometabolic risk is not mediated by physical activity habits (2). The association between low adolescent leisure-time physical activity and the metabolic syndrome, on the other hand, appeared to be mediated to a large extent by leisure-time physical activity in mid-adulthood. Sedentary behavior and

**Table 1**—*Selected characteristics according to TV-viewing habits and participation in leisure-time physical activity at age 16 years for the 888 participants from the Northern Swedish Cohort*

| | *n* | TV viewing at age 16 years | | | |
|---|---|---|---|---|---|
| | | One show/week or less (*n* = 137) | One show/day or every other day (*n* = 492) | Several shows/day (*n* = 257) | *P* for difference |
| Assessed at age 16 years | | | | | |
| Sex (male) | 888 | 28.8 | 48.6 | 71.2 | <0.001 |
| Socioeconomic disadvantage | 883 | 38.7 | 34.3 | 46.1 | 0.007 |
| Family history of diabetes | 881 | 6.6 | 3.3 | 4.3 | 0.219 |
| BMI (kg/m$^2$) | 888 | 20.1 (2.60) | 19.9 (2.59) | 19.9 (2.87) | 0.388 |
| Daily intake of sweets/pastries | 886 | 16.1 | 15.6 | 17.6 | 0.787 |
| Highest quintile of alcohol consumption | 882 | 27.9 | 19.8 | 16.1 | 0.020 |
| Daily smoking | 888 | 35.0 | 25.7 | 21.0 | 0.010 |
| Assessed at age 43 years | | | | | |
| Metabolic syndrome | 888 | 19.7 | 24.1 | 36.2 | <0.001 |
| Metabolic syndrome components | | | | | |
| Central obesity | 884 | 56.6 | 57.8 | 64.6 | 0.150 |
| Raised triglycerides | 883 | 16.1 | 22.7 | 32.0 | 0.001 |
| Low HDL-C | 883 | 20.4 | 29.0 | 32.8 | 0.035 |
| Raised blood pressure | 888 | 31.4 | 38.9 | 50.2 | 0.001 |
| Raised fasting glucose | 883 | 15.3 | 14.7 | 24.6 | 0.003 |

| | *n* | Leisure-time physical activity at age 16 years | | | | |
|---|---|---|---|---|---|---|
| | | Daily (*n* = 80) | Several times/week (*n* = 348) | Once a week (*n* = 251) | Several times/month or less (*n* = 209) | *P* for difference |
| Assessed at age 16 years | | | | | | |
| Sex (male) | 888 | 61.3 | 55.7 | 40.2 | 57.4 | <0.001 |
| Socioeconomic disadvantage | 883 | 32.5 | 37.8 | 32.8 | 48.5 | 0.004 |
| Family history of diabetes | 881 | 1.3 | 3.8 | 2.8 | 7.2 | 0.051 |
| BMI (kg/m$^2$) | 888 | 19.7 (2.18) | 20.0 (2.56) | 19.9 (2.80) | 19.8 (2.87) | 0.622 |
| Daily intake of sweets/pastries | 886 | 11.3 | 14.7 | 19.2 | 17.3 | 0.274 |
| Highest quintile of alcohol consumption | 882 | 10.0 | 11.6 | 20.1 | 37.7 | <0.001 |
| Daily smoking | 888 | 8.8 | 14.1 | 28.3 | 48.8 | <0.001 |
| Assessed at age 43 years | | | | | | |
| Metabolic syndrome | 888 | 16.3 | 24.1 | 26.3 | 36.4 | 0.001 |
| Metabolic syndrome components | | | | | | |
| Central obesity | 884 | 53.8 | 55.2 | 57.0 | 72.2 | <0.001 |
| Raised triglycerides | 883 | 15.0 | 23.7 | 23.2 | 30.4 | 0.042 |
| Low HDL-C | 883 | 23.8 | 26.6 | 30.4 | 32.4 | 0.332 |
| Raised blood pressure | 888 | 38.8 | 38.5 | 43.4 | 43.1 | 0.564 |
| Raised fasting glucose | 883 | 16.3 | 15.7 | 16.9 | 22.5 | 0.210 |

Data are % or means (SD) unless otherwise indicated.

physical activity have also been suggested to have different environmental determinants (21), which makes it likely that different strategies may need to be adopted within interventions targeting sedentary behavior compared with physical activity behavior.

We found that TV viewing in adolescence, in contrast to leisure-time physical activity, was associated with raised blood pressure and low HDL-C in mid-adulthood. These differences indicate that the associations between sedentary behavior and low leisure-time physical activity with subsequent metabolic risk may be mediated by different cardiometabolic pathways. A longitudinal association between sedentary behavior and hypertension has previously been shown in adults (18,22), but we have found no previous study reporting a significant association between sedentary behavior in adolescence and hypertension in adulthood. Sedentary behavior has been reported to predict lipid levels in several previous studies on different age-groups. Ki et al. (23) reported that TV viewing during early adulthood (at age 23 years) was inversely associated with HDL-C in mid-adulthood (at age 45 years). Hancox, Milne, and Poulton (5) found that TV viewing during childhood and adolescence was associated with total cholesterol in early adulthood (at age 26 years). The likely mechanisms by which sedentary behavior may affect lipid

**Table 2**—*ORs for presence of the metabolic syndrome at age 43 years according to TV viewing and leisure-time physical activity at age 16 years in 869 participants*

| | *n* | Crude | Model 1[a] | Model 2[b] | Model 3[c] |
|---|---|---|---|---|---|
| TV viewing | | | | | |
| One show/week or less | 136 | 1.00 | 1.00 | 1.00 | 1.00 |
| One show/day or every other day | 483 | 1.31 (0.81–2.10) | 1.39 (0.86–2.24) | 1.39 (0.83–2.31) | 1.30 (0.78–2.18) |
| Several shows/day | 250 | 2.46 (1.50–4.06) | 2.47 (1.50–4.09) | 2.14 (1.24–3.71) | 1.96 (1.13–3.42) |
| *P* for trend | | <0.001 | <0.001 | 0.003 | 0.008 |
| Leisure-time physical activity | | | | | |
| Daily | 78 | 1.00 | 1.00 | 1.00 | 1.00 |
| Several times/week | 342 | 1.58 (0.83–3.01) | 1.51 (0.79–2.89) | 1.44 (0.74–2.81) | 1.32 (0.67–1.59) |
| Once a week | 246 | 1.76 (0.91–3.40) | 1.69 (0.87–3.28) | 1.76 (0.88–3.52) | 1.55 (0.77–3.12) |
| Several times/month or less | 203 | 2.81 (1.45–5.44) | 2.64 (1.35–5.15) | 2.31 (1.13–4.69) | 1.82 (0.88–3.77) |
| *P* for trend | | <0.001 | 0.001 | 0.007 | 0.064 |

Data are OR (95% CI) unless otherwise indicated. [a]TV viewing and leisure-time physical activity in the same model. [b]Adjusted for model 1 variables plus sex, socioeconomic disadvantage, family history of diabetes, BMI, intake of sweets/pastries, alcohol consumption, smoking, and TV viewing/leisure-time physical activity at age 16 years. [c]Adjusted for model 2 variables plus physical activity at age 43 years.

metabolism are not clear, but animal studies have suggested that sedentary behavior suppresses the activity of the enzyme lipoprotein lipase in skeletal muscles (24). Lipoprotein lipase is the rate-limiting enzyme for hydrolysis of triglyceride-rich lipoproteins, which contributes to the formation of HDL-C. Whether a similar relationship exists in humans awaits the findings from experimental research currently underway.

Aside from the possible physiological mechanisms, it has been suggested that sedentary behavior may influence cardiometabolic risk via other behavioral mechanisms that are linked to sedentary behavior. This hypothesis is supported by results from previous research showing that students reporting medium or high TV viewership snacked more frequently while watching TV (25). In our study, we adjusted for general intake of sweets/pastries but could unfortunately not control for snacking related to TV viewing. It has also been suggested that sedentary behavior increases cardiometabolic risk via a psychosocial pathway. For example, in a prospective study of university graduates by Sanchez-Villegas et al. (26), sedentary behavior was reported to be associated with increased risk for mental disorders (diagnosed depression, anxiety, or stress) at follow-up. This and other components of a psychosocial pathway need to be further investigated, and we have an excellent opportunity to continue such work within the Northern Swedish Cohort.

The finding of an association between low leisure-time physical activity at age 16 years and the metabolic syndrome at age 43 years is consistent with several previous reports (27–29). Furthermore, low leisure-time physical activity in adolescence was associated with central obesity and raised triglycerides in mid-adulthood. Interestingly, these prospective associations between TV viewing and low leisure-time physical activity with the metabolic syndrome were not dependent on BMI at age 16 years. This indicates that both sedentary behavior and physically inactive behavior may precede overweight in a potential causal chain from adolescent behavior to adult cardiometabolic risk. However, this will need to be further explored within well-controlled intervention studies.

The strengths of this study include the prospective design and the high proportion of the original cohort that was assessed for the metabolic syndrome according to standardized criteria. The low attrition to follow-up also enabled us to

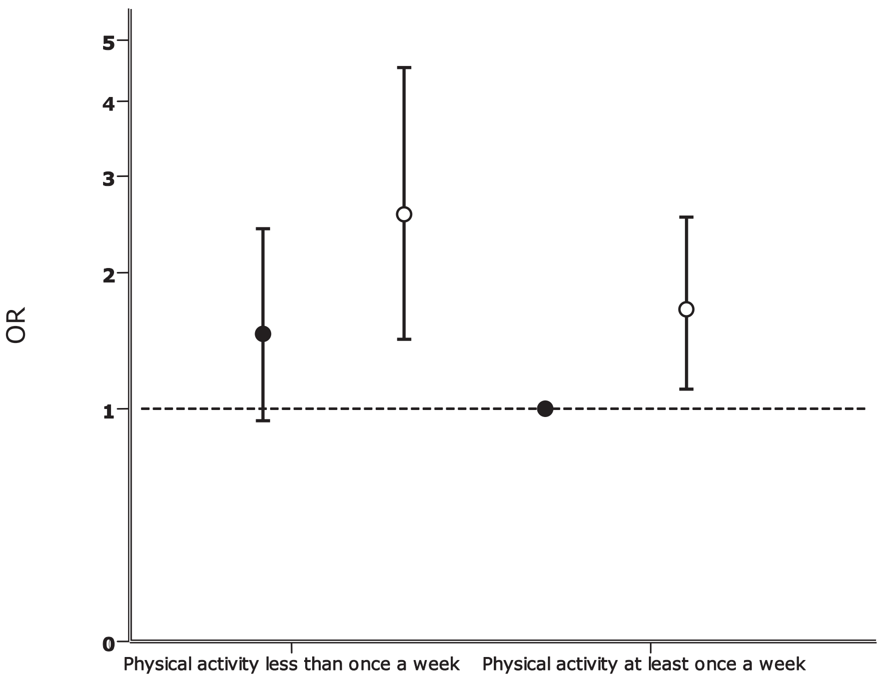


**Figure 1**—*ORs for presence of the metabolic syndrome (95% CI) at age 43 years according to leisure-time physical activity and TV viewing (adjusted for sex, socioeconomic disadvantage, family history of diabetes, BMI, intake of sweets/pastries, alcohol consumption, and smoking). TV viewing one show per day or less, ●; TV viewing several shows a day, ○.*

examine the internal dropout, which did not indicate that the dropout was systematic with respect to key measures. The study was limited by the crude assessment of TV-viewing habits and participation in leisure-time physical activity. At 16 years of age, BMI and several lifestyle factors were collected, but the metabolic syndrome components were not assessed. If individuals watching a lot of TV in adolescence were on the projection to the metabolic syndrome, this could bias the results, since adjustment for BMI and several lifestyle factors may not fully compensate for missing information on metabolic syndrome components at baseline. Information was also missing for TV viewing at age 43 years. TV viewing at different ages has been shown to be moderately correlated (18,19,30), which indicates that viewing habits established in adolescence may persist into adulthood. However, several studies have found that TV viewing in childhood and adolescence is a stronger predictor of adverse health outcomes in adulthood than TV viewing in adulthood (5,31). It is therefore likely that the association between TV viewing and the metabolic syndrome in adulthood is modified rather than mediated by TV viewing in adulthood. Moreover, although TV viewing was the most important indicator of sedentary behavior during leisure-time in the early 1980s, before computers were commonly available (32), several other sedentary behaviors at school or the workplace and during commuting and leisure time may be linked to TV viewing and of relevance for cardiometabolic health. Leisure-time physical activity was also crudely assessed, and therefore we cannot rule out residual confounding from sedentary behaviors and leisure-time physical activity that were not assessed in this study.

In conclusion, this study supports previous findings that prolonged TV viewing is independently associated with subsequent metabolic risk and provides some new evidence that this association may stretch over a considerable proportion of the lifespan: from adolescence to mid-adulthood. Low leisure-time physical activity in adolescence was also independently associated with metabolic risk in mid-adulthood, and this study indicates that the associations between sedentary behavior and low leisure-time physical activity with subsequent metabolic risk may be mediated by different cardiometabolic pathways. These findings suggest that reduced TV viewing in

**Table 3—*ORs for the presence of the metabolic syndrome components at age 43 years according to TV viewing and leisure-time physical activity at age 16 years in 869 participants***

| | Central obesity | | Raised triglycerides | | Low HDL-C | | Raised blood pressure | | Raised fasting glucose | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Crude OR (95% CI) | Multivariate OR (95% CI)[a] | Crude OR (95% CI) | Multivariate OR (95% CI)[a] | Crude OR (95% CI) | Multivariate OR (95% CI)[a] | Crude OR (95% CI) | Multivariate OR (95% CI)[a] | Crude OR (95% CI) | Multivariate OR (95% CI)[a] |
| TV viewing | | | | | | | | | | |
| One show/week or less | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| One show/day or every other day | 1.04 (0.78–1.53) | 1.25 (0.83–1.90) | 1.61 (0.97–2.69) | 1.41 (0.81–2.45) | 1.63 (1.03–2.60) | 1.90 (1.17–3.06) | 1.39 (0.92–2.09) | 1.36 (0.88–2.10) | 0.92 (0.54–1.57) | 0.84 (0.48–1.48) |
| Several shows/day | 1.43 (0.93–2.19) | 1.72 (1.07–2.77) | 2.64 (1.55–4.51) | 1.73 (0.96–3.12) | 1.98 (1.20–3.26) | 2.23 (1.32–3.78) | 2.20 (1.42–3.42) | 1.78 (1.10–2.87) | 1.86 (1.07–3.20) | 1.34 (0.74–2.44) |
| *P* for trend | 0.060 | 0.020 | 0.001 | 0.064 | 0.009 | 0.005 | <0.001 | 0.016 | 0.003 | 0.124 |
| Leisure-time physical activity | | | | | | | | | | |
| Daily | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Several times/week | 1.06 (0.65–1.74) | 0.95 (0.57–1.59) | 1.72 (1.89–3.34) | 1.77 (0.89–3.52) | 1.12 (0.63–1.98) | 1.03 (0.58–1.83) | 1.05 (0.63–1.74) | 1.01 (0.59–1.71) | 0.91 (0.47–1.76) | 0.80 (0.40–1.59) |
| Once a week | 1.12 (0.67–1.86) | 0.99 (0.57–1.71) | 1.67 (0.84–3.30) | 2.14 (1.04–4.40) | 1.37 (0.76–2.46) | 1.28 (0.70–2.34) | 1.26 (0.74–2.13) | 1.38 (0.79–2.42) | 1.04 (0.53–2.06) | 1.01 (0.49–2.08) |
| Several times/month or less | 2.14 (1.25–3.68) | 1.90 (1.05–3.42) | 2.40 (1.21–4.75) | 2.32 (1.11–4.87) | 1.42 (0.78–2.58) | 1.17 (0.62–2.20) | 1.24 (0.73–2.13) | 1.02 (0.57–1.84) | 1.47 (0.74–2.89) | 1.03 (0.49–2.17) |
| *P* for trend | 0.001 | 0.008 | 0.018 | 0.033 | 0.119 | 0.389 | 0.232 | 0.607 | 0.061 | 0.458 |

[a]Adjusted for sex, socioeconomic disadvantage, family history of diabetes, BMI, intake of sweets/pastries, alcohol consumption, smoking, and TV viewing/leisure-time physical activity at age 16 years.

adolescence, in addition to and independently of regular leisure-time physical activity in adolescence and adulthood, may contribute to cardiometabolic health later in life.

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P.W. was responsible for the concept and design of the study, gave final approval of the version to be published, obtained funding, analyzed data, wrote early drafts, and wrote the final manuscript. P.E.G. was responsible for the concept and design of the study, gave final approval of the version to be published, obtained funding, made substantial contributions to analysis and interpretation of data, and revised the manuscript critically for important intellectual content. D.W.D. was responsible for the concept and design of the study, gave final approval of the version to be published, made substantial contributions to analysis and interpretation of data, and revised the manuscript critically for important intellectual content. M.W. was responsible for the concept and design of the study, gave final approval of the version to be published, obtained funding, made substantial contributions to analysis and interpretation of data, and revised the manuscript critically for important intellectual content. A.H. was the principal investigator, conceived the Northern Swedish Cohort, collected data, was responsible for the concept and design of the study, gave final approval of the version to be published, obtained funding, made substantial contributions to analysis and interpretation of data, and revised the manuscript critically for important intellectual content. P.W. is the guarantor of this work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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