SEDENTARY BEHAVIOR AND METABOLIC RISK FACTORS IN ADOLESCENTS

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Abstract

Background: This cross-sectional study was aimed at testing if self-reported sedentary behavior was associated with objectively measured bio-markers for metabolic risk factors in the participants of *"Fit Futures – a part of the Tromsø Study"*.

Methods: All first year students in upper secondary school in the Tromsø region were invited to participate in the *Fit Futures* study in 2010-2011. 508 girls and 530 boys attended, giving an attendance rate of > 90 %. The present analysis included all participants aged 15-17 years with self-reported recreational physical activity and screen time (N=945). A Quest-Back based questionnaire on lifestyle, health and illness was filled out by the participants. Multivariate linear regression models were used to examine the associations of sedentary behavior and screen time with measured metabolic risk factors, including body mass index, waist circumference, waist-to-hip ratio (WHR), systolic and diastolic blood pressure, serum lipids, and glycated hemoglobin (HbA_{1c}).

Results: Sedentary adolescents had significantly higher average screen time than active students (34 versus 30 hours per week), and more smokers and snuff users (all $P<0.01$). Boys (20%) reported to be more sedentary than girls (11%). Sedentary behavior was associated with higher WHR and lower HDL(High-density lipoprotein)-cholesterol (both $P<0.01$) in the total population, and with higher WHR and lower HbA_{1c} in girls ($P<0.05$). Screen time showed positive association with WHR and negative association with HDL-cholesterol in the total population and in girls alone, independent of physical activity (all $P<0.05$). Sedentary behavior was associated with higher WHR in the total population, and in addition, a negative association with HbA_{1c} in girls (all $P<0.05$). There were no associations in boys.

Conclusion: Sedentary behavior and screen time seem to be associated with abdominal obesity and lower levels of HDL-cholesterol among adolescents, and girls in particular. More detailed analysis of these cross-sectional data and prospective studies are needed.

Introduction

Childhood and adolescence is where we lay our foundations for adult life, both physically and mentally. The transition from child to adolescent is an especially vulnerable life phase with diverse bodily changes and also with the development of habits of living. These potentially bad habits could be set for life and contribute to non-communicable diseases in adulthood(1). There is increasing concern about the health consequences of sedentary behaviors in modern societies, in particular in relation to the risk factors of the metabolic syndrome, including obesity, hypertension, dyslipidemia and insulin resistance(2-5).

The young population in Norway have dramatically increased sedentary activities such as TV-watching in their spare time over the last 30 years(6). There is also a drop in the percentage of physically active boys and girls in the transition from child to adolescent(7). It is believed that non-active pass-times like watching Television and using a computer are the main substitutes for physical activity. In a national Norwegian survey, 42% of all 15-year olds and 17% of all 9-year olds spent more than 2 hours a day watching television after school, and a corresponding 38% of 15-year olds and 12% of 9-year olds spent more than 2 hours a day on computer and video games(7).

Sedentary behavior refers to any waking activity characterized by low energy expenditure ($\leq$ 1.5 metabolic equivalents) and a sitting or reclining posture(8). Common sedentary behaviors include TV viewing, video game playing, computer use (collectively termed "screen time"), driving a car and reading.

Being sedentary for long periods of time and lack of strenuous exercise are thought to be two distinct predictors of health (9-11). In a study including 201 healthy adolescents aged 13-17 years in Madrid in 2007-08, objectively measured time spent in sedentary behavior was associated with higher levels of systolic blood pressure, triglycerides and blood glucose(12). Sedentary behavior in combination with obesity was associated with a higher cardiovascular risk score. The larger cross-sectional population study The European Youth Heart Study (EYHS) 1997-2000 among girls and boys aged 9-10 (n=1092) and 15-16 years (n=829), found a positive association between self-reported TV-viewing and adiposity(13), while objectively measured physical activity was associated with individual metabolic risk factors apart from adiposity. TV-viewing was not related to physical activity in the EYHS data. Among 1803

adolescents (12-19 years) from the 1999–04 US National Health and Nutrition Examination Surveys, the average of daily self-reported screen time was associated with the likelihood of metabolic syndrome in a dose-dependent manner independent of physical activity (14). On the contrary, in the 2003-04 and 2005-06 NHANES, volume of sedentary behavior was not an independent predictor of metabolic factors(15). More than 2 hours of television per day has been associated with higher systolic blood pressure and total cholesterol in some prospective studies(16;17). However, a review based on 29 youth cohorts concluded that there was insufficient evidence for a longitudinal relationship between sedentary time and blood pressure or blood lipids (18). Thus, there it is not clear from observational studies whether sedentary behavior in a general population of health adolescents is associated with metabolic risk factors and more studies are needed(19). Although there are findings that indicate increased metabolic risk factors in sedentary adolescents (12), many studies focus on already obese adolescents (20;21), and we believe more research on the total population is needed.

Therefore, we aimed to examine the cross-sectional associations between sedentary behaviors, assessed by self-reported physical inactivity and screen time in leisure time, and measured metabolic risk factors in adolescents participating in the Fit Futures – part of the Tromsø Study.

Methods and Material

Ethics

Informed consent was obtained from all participants in the study. For individuals below 16 years, parental consent was also obtained. Participants were paid 200 Norwegian kroner on completion of the study. All procedures were approved by the Regional Committees for Medical and Health Research Ethics North Norway and the National Data Protection Authority.

Study population

Fit Futures(22) is the largest somatic health survey on adolescents in the north of Norway ever. It is part of the larger *Tromsø Study*. Students in the first year of secondary school in Tromsø and Balsfjord were invited to take part in the survey carried out at UNN-Tromsø (University hospital of North Norway) from September 2010 to April 2011.

Data from Fit Futures 1 were used for this study. All students in the first year of upper secondary schools in the municipality of Tromsø (mostly urban area) and Balsfjord (mostly rural) in 2010-2011 were invited to participate. In Norway, upper secondary school (akin to high school) is 3 years of optional schooling, but due to recent changes to society and law all adolescents are expected to attend. A total of 1301 students were registered in upper secondary school. Of these, 1117 were invited and 1038 students (508 girls and 530 boys) participated, giving an attendance rate among invited of 93%. The survey was carried out during school hours at the Clinical Research Unit, UNN, Tromsø. All participants filled out an electronic questionnaire in *Questback(23)* using laptops at the screening. The questionnaire included information on family, childhood, school, lifestyle, health and illness. All the clinical tests, blood tests and subject interviews were done by a team of experienced research nurses. Serum analysis was done by The Medical Biology department at UNN-Tromsø.

In our study, only adolescents between 15 and 17 years old (year of birth: 1992-94) were included. A second inclusion criteria was having answered the Questback form, including answering the specific questions on levels of physical exertion in leisure time and the questions about screen time (weekdays and weekends) (N=945).

Assessment of metabolic risk factors

Body height given in centimetres (cm) and weight in kilograms (kg) were measured to the nearest 0.1 unit wearing light clothing and no shoes on an automatic electronic scale, the Jenix DS 102 stadiometer (Dong Sahn Jenix, Seoul, Korea). BMI was calculated as weight divided by height squared (kg/m^2). Hip and waist circumference were measured to the nearest cm without outerwear by using a measuring tape. Hip circumference was measured around the widest part of the thigh while waist circumference was measured at the umbilical line. Waist-to-hip ratio (WHR), the ratio of the circumference of the waist to that of the hip, was calculated.

Systolic and diastolic blood pressure were measured three times, with one minute intervals, by the use of an automatic blood pressure measurement device (Dinamap Pro care 300 Monitor, GE Healthcare, Norway), and a mean of the two last measurements was used. All participants sat down for 2 minutes prior to testing.

Non-fasting blood samples were collected from an antecubital vein and analysed consecutively at the Department of Laboratory Medicine, UNN, Tromsø. Serum lipids were analysed by

enzymatic colorimetric methods, and high sensitivity CRP (C-reactive protein) was determined by a latex particle enhanced immunoturbidimetric assay. The analysis were performed on a Modal PPE auto-analyser with reagents from Roche Diagnostics Norway AS. HbA_{1c} was drawn from EDTA-blood samples and determined by high performance liquid chromatography using an automated analyser (Variant II, Bio-Rad Laboratories INC., Hercules, CA, USA). About 90% of the participants had blood samples taken, and serum assays were obtained from the first blood specimen. There are more missing observations for HbA_{1c} measured in EDTA-blood due to non-successful sampling of all the consecutive specimens.

Assessment of sedentary behavior and screen time

Information about sedentary behavior was assessed by questions on self-reported physical activity in the Questback form filled in electronically at the survey. The adolescents had to, among other questions, answer yes or no to a question on whether they were actively doing sports or physical activity outside school. Also they answered an overall question about physical activity in leisure time, 4 levels; mostly sedentary, walking/cycling etc. < 4 hours/week, walking/cycling etc. ≥ 4 hours/week, and hard training and sports. This question was validated among men and women aged 40-42 years in the sixth Tromsø Study 2007-2008; the participants were able to rate their leisure time activity level in correspondence with their objectively measured physical activity(24).

To define sedentary behavior, we focused on two questions. The question regarding actively doing sports outside school would have to be answered “no”, and the students physical activity in leisure time had to be “Mostly reading, watching TV or other sedentary activity”, the lowest of four categories.

To determine screen time, the participants were required to answer how many hours per day they spent by the PC, watching TV, DVD etc. outside school during weekdays, and the same for weekends. Answer options were “ca. 0.5, “ca. 1-1.5”, ca. 2-3”, “ca. 4-6”, “ca. 7-9”,”10 or more” hours per day. The mean value within each category was used in calculation of total screen time per week from 5 weekdays and 2 weekend days.

Assessment of covariates

Information on covariates was collected from questionnaire data. All but one girl had started menstruating. Puberty stage in boys was not estimated the current analysis due to a large number of missing cases. Current use of tobacco was assessed by the questions "Do you smoke?" and "Do you use snuff?"; the answers were "No, never", "Sometimes" and "Daily", and both variables were dichotomised in the analysis as daily smoking and snuff use, yes/no. Alcohol intake per week was calculated from frequency of alcohol intake and units per drinking session, and was used as a continuous variable.

Statistical analysis

Differences in demographical variables, lifestyle and metabolic risk factors between sedentary or active adolescents were evaluated by Student's t-test for continuous variables and chi-square test for categorical variables.

Multivariable linear regression analysis was used to study the association between sedentary behavior, screen time and metabolic risk factors, and beta-estimates with 95% confidence intervals were generated. All models included age and also gender where applicable. In the analysis of 'total screen time', physical activity in leisure time (4 categories) was added to the model.

'Sedentary behavior' was used as a dichotomous variable in the models with the beta-estimate representing the mean difference in metabolic risk factor between the groups. 'Total screen time' was used as a continuous variable in the models with the beta-estimate representing the mean change in metabolic risk factor per hour increase in screen time per week. All analysis were also stratified by gender. Two-sided P-values <.05 were considered statistically significant.

All data were analysed using IBM SPSS 21.0 for Windows 7 64bit (© Copyright IBM Corporation and other(s) 1989, 2012).

Results

Characteristics

Table Ia shows the characteristics of the total study population (N=945). According to our criteria there were 148 sedentary (16%) and 797 active (84%) students. There were significantly more smokers and snuff users in the sedentary category compared to the active category (all P<0.01). There was also a borderline significance for higher alcohol consumption in sedentary adolescents (P=0.08). The results for boys only (N=484) are shown in table Ib, with 97 sedentary (20%) and 387 active (80%) students. Sedentary behavior was associated with younger age and higher levels of smoking and snuff use in boys (both P<0.05). On average, boys reported to be more sedentary than girls. For girls only in Table Ic (N=461), 51 (11%) sedentary and 410 (89%) active students, we found that being sedentary was positively associated with chronic disease, snuff use, and alcohol units per week (all P<0.05). There was also an association between educational programme and sedentary behavior (P<0.001). Mean self-reported screen-time per week was 30.8 hours in the total population (31.9 hours in boys and 29.5 hours in girls, P <0.001). Sedentary behavior was associated with higher screen time in the total population and in both genders separately (all P<0.05).

Table IIa shows the difference in metabolic risk factors for the total population. Sedentary behavior was associated with higher WHR and lower HDL(High-density lipoprotein)-cholesterol (all P<0.01). We also noted a borderline significance for higher waist circumference (P=0.06). In boys, there was no differences in metabolic risk factors between the groups (table IIb). In girls, sedentary behavior was associated with higher WHR and lower HbA_{1c} (all P<0.05) (Table IIc).

Multivariate analysis

The results of the multivariate analysis linear regression models are presented in tables for total population and girls and boys separately. Screen time (adjusted for age, sex and physical activity in leisure time) and sedentary behavior (adjusted for age and sex) were analysed separately. For screen time there was a positive association with WHR and a negative association with HDL-cholesterol in the total population independent of physical activity; for each one hour increase in screen time per week, WHR increased by 0.08 and HDL-cholesterol decreased by 0.07 (both P<0.05; Table IIIa). In boys there were no associations between screen

time and metabolic risk factors in multivariable analysis (Table IIIb). In girls more screen time was associated with higher WHR, and lower HDL-cholesterol, independent of physical activity (both $P<0.05$; Table IIIc), while there was a borderline significance in higher waist circumference ($P=0.05$) and a borderline negative association in total cholesterol ($P=0.06$).

Sedentary behavior was associated with higher WHR in the total population (Table IVa). For boys (Table IVb) we found no association, and for girls (Table IVc) we found a positive association with WHR and a negative association with HbA_{1c} (both $P<0.05$).

Discussion

In this population-based study among adolescents aged 15-17 years, sedentary behavior was associated with higher WHR and lower HDL-cholesterol, both established metabolic risk factors that may predispose for multiple adult chronic diseases, including type II diabetes. The associations of screen time with WHR and HDL-cholesterol were independent of physical activity, and were seen particularly in girls. There was also an association between longer screen time and unhealthy life choices like smoking, snuff use, and increased alcohol consumption. We found that screen time varies between educational programmes.

Due to limited research on this subject that include measured biomarkers in adolescents, there are few comparable studies. One study has somewhat similar associations between sedentary behavior and metabolic risk factors (12), but finds mostly associations in obese adolescents as do others(20). In the European Youth Heart Study self-reported TV-viewing was positively associated with adiposity assessed by four skin folds(13). Some prospective data have shown associations between TV-viewing and total cholesterol(17). In a US study, higher self-reported screen time was associated with higher likelihood of metabolic syndrome(14).

There is evidence for a slightly higher level of sedentary behavior in older children. Also non-white children, children from lower socioeconomic status background and children from households with more access to televisions/computers have higher levels of sedentary behavior. Children with parents who have rules/limitations on screen time have lower levels of sedentary behavior(25). Screen time is known to displace more active pursuits(26), and lowering sedentary time leads to a reduction in BMI(27).

The strengths of this study include measuring the metabolic risk factors in blood samples, and having had a large number of male and female participants (N=945). We had a high participation rate (93%) and we recruited from a diverse population from both rural and urban areas and across different study programmes. The sedentary part of the study population was defined using two questions from a self-reported questionnaire. The validity of the questions have been validated for adults(24), but not for adolescents.

The sensitivity for BMI is highest for relatively fat children, and the differences in BMI in relatively thin children can be largely due to fat-free mass(28). Skinfold measurements do not seem to provide additional information about excess body fat beyond BMI-for-age alone if the BMI-for-age is >95th percentile(29). Waist circumference is thought to be an even better predictor of abdominal fat than BMI in adult men(30). This was a study performed on adolescents potentially still in their growth phase, and waist circumference alone may not take into account the abdominal fat in adolescents with a smaller frame, not fully grown. Thus, we believe WHR could be a good indicator of abdominal fat in this population.

The main limitation of this study is the cross-sectional design which makes it difficult to infer a causal relationship. Even after having adjusted for several possible confounders, there will always be possible unmeasured confounders, such as total energy intake and expenditure, socio-cultural factors and genetic differences. Sitting time has been identified as an independent risk factor for disease(9-11), but being sedentary could also lead to unhealthy eating which in its own is a risk factor(31). We had no data for eating habits available for this study, and the possible role of the participants' eating habits in increasing abdominal fat must not be overlooked. We did not have data for birth weight available for this study, which could possibly influence metabolic risk factors. One study suggest that a slow intrauterine growth trajectory and/or a fast post-natal growth trajectory is associated with greater insulin resistance in childhood(32). Moreover, the present analysis did not include other potential confounders; i.e. puberty score in boys, smoking and snuff use, alcohol, chronic disease, parents' educational level and socioeconomic status. Some of these covariates were left out of the analysis due to large number of missing observations. Future analysis of the data should consider different approaches and methods to better address the possible confounding of these covariates.

Using self-report questionnaires alone could underestimate the strength of some relationships with risk factors(33). Accelerometer data for this study population was not available for this

study, but it will be available for future research. Unfortunately, we could not differentiate between time spent watching television, playing video games and other computer activities, thereby limiting a detailed comparison of our findings with others(13).

In further research one may need to divide the subgroups further, and select the already obese. The results may be different there. We observed interesting behavioral patterns in the different education programmes, something that may be related to socioeconomic status. This is a find that would be interesting for further research.

The results from the present study suggest that sedentary behavior and screen time in adolescence might play a role in development of metabolic disturbances, particularly in girls. However, more detailed and prospective studies are needed to assess whether sedentary behavior is a modifiable determinant for metabolic risk factors in this age group.

Tables

Characteristics

Table Ia. Characteristics of the total study population. Fit Futures – a part of the Tromsø Study 2010-2011. Values are means (standard deviation) and numbers (proportions).

Characteristics	TOTAL N=945**	Sedentary N = 148**	Active N = 797**	P-value*
Age, years	16.1(0.43)	16.0(0.45)	16.1(0.43)	0.12
Height, cm	171.1(8.84)	171.9(8.69)	170.9(8.87)	0.23
Weight, kg	65.7(13.84)	66.2(15.56)	65.6(13.51)	0.61
Educational programme				<0.001
General studies	385(40.7%)	45(30.4%)	340(42.7%)	
Sports and phys.ed	104(11.0%)	1(0.7%)	103(12.9%)	
Vocational programme	456(48.3%)	102(68.9%)	354(44.4%)	
Chronic disease	277(29.3%)	46(31.5%)	231(29.1%)	0.55
Smoking				0.006
Never	737(78%)	102(68.9%)	635(79.9%)	
Sometimes	176(18.6%)	37(25%)	139(17.5%)	
Daily	30 (3.2%)	9(6.1%)	21(2.6%)	
Snuff				<0.01
Never	591(62.5%)	78(52.7%)	513(64.5%)	
Sometimes	129(13.7%)	12(8.1%)	117(14.7%)	
Daily	223(23.6%)	58(39.2%)	165(20.8%)	
Alcohol (units/week)	2.8(3.64)	3.4(3.93)	2.74(3.577)	0.08
Screen time(hours/week)	30.8(6.78)	34.3(6.59)	30.09(6.614)	<0.001
Screen time (hours/day)	4.4(0.97)	4.9(0.94)	4.30(0.945)	<0.001

*Student's T-test for continuous variables; assumed equal variance. Chi-square test for categorical variables.

**Numbers may vary due to missing

Table Ib Characteristics of the boys in the study population. Fit Futures – a part of the Tromsø Study 2010-2011. Values are means (standard deviation) and numbers (proportions).

Characteristics	TOTAL BOYS N=484**	Sedentary N = 97**	Active N = 387**	P-value*
Age, years	16.1(0.5)	16.0(0.5)	16.1(0.5)	0.04
Height, cm	176.9(6.7)	175.9(7.0)	177.1(6.6)	0.12
Weight, kg	70.2(14.5)	69.8(16.2)	70.3(14.0)	0.75
Educational programme				<0,001
General studies		28(28.9%)	117(30.2%)	
Sports and phys.ed		0	65(16.8%)	
Vocational programme		69(71.1%)	205(53.0%)	
Chronic disease	132(27.4%)	24(24.7)	108(28.1%)	0.52
Smoking				0.04
Never	370(76.4%)	66(68%)	304(78.6%)	
Sometimes	99(20.5%)	25(25.8)	74(19.1%)	
Daily	15 (3.1%)	6(6.2)	9(2.3%)	
Snuff				0.02
Never	285(58.9%)	50(51.5%)	235(60.7%)	
Sometimes	63(13.0%)	9(9.3%)	54(14.0%)	
Daily	135(27.9%)	38(39.2%)	97(25.1%)	
Alcohol (units/week)	3.5(4.5)	3.5(3.9)	3.5(4.6)	0.96
Screen time(hours/week)	31.9(6.8)	34.8(6.5)	31.2(6.7)	<0.001
Screen time (hours/day)	4.6(1.0)	5.0(0.9)	4.5(1.0)	<0.001

*Student's T-test for continuous variables; assumed equal variance. Chi-square test for categorical variables.

**Numbers may vary due to missing

Table Ic. Characteristics of the girls in the study population. Fit Futures – a part of the Tromsø Study 2010-2011. Values are means (standard deviation) and numbers (proportions).

Characteristics	TOTAL GIRLS N=461**	Sedentary N = 51**	Active N = 410**	P-value*
Age, years	16.1(0.41)	16.2(0.42)	16.1((0.41)	0.57
Height, cm	165.0(6.36)	164.0(5.86)	165.1(6.41)	0.27
Weight, kg	61.0(11.39)	59.4(11.47)	61.2(11.38)	0.30
Educational programme				<0,001
General studies	240(52.1%)	17(33.3%)	223(54.4)%	
Sports and phys.ed	39(8.5%)	1(2.0%)	38(9.3%)	
Vocational programme	182(39.4%)	33(64.7%)	149(36.3%)	
Chronic disease	145(31.5%)	22(70%)	123(30%)	0.03
Smoking				0.18
Never	367(80.0%)	36(70.6%)	331(81.1%)	
Sometimes	77(16.8%)	12(23.5%)	65(15.9%)	
Daily	15(3.3%)	3(5.9%)	12(2.9%)	
Snuff				<0.001
Never	306(66.5%)	28(54.9%)	306(66.4%)	
Sometimes	66(14.3%)	3(5.9%)	66(14.3%)	
Daily	88(19.1%)	20(39.2%)	88(19.1%)	
Alcohol (units/week)	2.3(2.54)	3.3(4.09)	2.1(2.54)	0.01
Screen time(hours/week)	29.5(6.57)	33.4(6.81)	29.0(6.38)	<0.001
Screen time (hours/day)	4.2(0.94)	4.8(0.97)	4.2(0.91)	<0.001

*Student's T-test for continuous variables; assumed equal variance. Chi-square test for categorical variables.

**Numbers may vary due to missing.

Metabolic risk factors in the study population

Table IIa. Metabolic risk factors in the total study population. Fit Futures – a part of the Tromsø Study 2010-11. Values are means (standard deviation) and proportions.

Metabolic risk factor	Total N = 945**	Sedentary N = 148**	Active N = 797**	P-value*
Waist circumference, cm	79.7(11.01)	81.3(12.80)	79.4(10.63)	0.06
Waist-to-hip ratio	0.81(0.07)	0.8(0.07)	0.8(0.06)	<0.001
Body mass index, kg/m^2	22.4(4.08)	22.3(4.35)	22.4(4.03)	0.81
Triglycerides, mmol/l	1.1(0.50)	1.1(0.59)	1.1(0.49)	0.56
Total cholesterol, mmol/l	4.1(0.77)	4.0(0.85)	4.1(0.75)	0.29
LDL-cholesterol, mmol/l	2.4(0.69)	2.4(0.74)	2.4(0.68)	0.66
HDL-cholesterol, mmol/l	1.3(0.33)	1.3(0.32)	1.4(0.32)	0.01
High sensitive CRP, mg/l	1.4(3.27)	1.6(3.49)	1.4(3.23)	0.64
HbA_{1c}, %	5.3(0.32)	5.3(0.46)	5.3(0.29)	0.12
Systolic blood pressure, mmHg	117.2(12.25)	117.9(12.54)	117.1(12.20)	0.46
Diastolic blood pressure, mmHg	63.1(7.31)	63.6(7.09)	63.0(7.35)	0.37

*Student's T-test. Assumed equal variance.

** Numbers may vary due to missing.

LDL-cholesterol, low-density lipoprotein cholesterol.

HDL-cholesterol, high-density lipoprotein cholesterol.

CRP, C-reactive protein.

HbA_{1c}, Glycated haemoglobin (%) EDTA whole blood.

Table IIb. Metabolic risk factors, boys. Fit Futures – a part of the Tromsø Study 2010-11.

Values are means (standard deviation) and proportions.

Metabolic risk factor	TOTAL BOYS N = 484**	Sedentary N = 97**	Active N = 387**	P-value*
Waist circumference, cm	82.1(11.38)	82.5(13.37)	81.9(10.84)	0.66
Waist-to-hip ratio	0.84(0.06)	0.8(0.07)	0.8(0.05)	0.58
Body mass index, kg/m^2	22.4(4.19)	22.5(4.61)	22.4(4.08)	0.84
Triglycerides, mmol/l	1.1(0.53)	1.1(0.60)	1.1(0.52)	0.94
Total cholesterol, mmol/l	3.9(0.77)	3.8(0.87)	3.9(0.75)	0.33
LDL-cholesterol, mmol/l	2.3(0.70)	2.3(0.74)	2.3(0.69)	0.45
HDL-cholesterol, mmol/l	1.2(0.28)	1.2(0.28)	1.3(0.28)	0.15
High sensitive CRP, mg/l	1.5(3.67)	1.6(2.56)	1.4(3.70)	0.72
HbA_{1c}, %	5.3(0.32)	5.3(0.52)	5.3(0.26)	0.73
Systolic blood pressure, mmHg	122.1(12.34)	120.9(12.16)	122.5(12.38)	0.25
Diastolic blood pressure, mmHg	63.4(7.68)	63.8(7.32)	63.3(7.77)	0.59

*Student's T-test. Assumed equal variance.

** Numbers may vary due to missing.

LDL-cholesterol, low-density lipoprotein cholesterol.

HDL-cholesterol, high-density lipoprotein cholesterol.

CRP, C-reactive protein.

HbA_{1c}, Glycated haemoglobin (%) EDTA whole blood.

Table IIc. Metabolic risk factors, girls. Fit Futures – a part of the Tromsø Study 2010-11.

Values are means (standard deviation) and proportions.

Metabolic risk factor	Total N = 461**	Sedentary N = 51**	Active N =410**	P-value*
Waist circumference, cm	77.2(10.03)	78.9(11.37)	77.0(9.84)	0.21
Waist-to-hip ratio	0.79(0.06)	0.81(0.07)	0.79(0.06)	0.003
Body mass index, kg/m^2	22.4(3.96)	22.0(3.81)	22.4(3.98)	0.48
Triglycerides, mmol/l	1.0(0.47)	1.1(0.58)	1.0(0.46)	0.58
Total cholesterol, mmol/l	4.2(0.72)	4.4(0.68)	4.2(0.73)	0.30
LDL-cholesterol, mmol/l	2.5(0.66)	2.6(0.67)	2.5(0.66)	0.25
HDL-cholesterol, mmol/l	1.5(0.34)	1.4(0.37)	1.5(0.33)	0.41
High sensitive CRP, mg/l	1.4(2.76)	1.5(3.37)	1.4(2.69)	0.82
HbA_{1c}, %	5.3(0.33)	5.2(0.27)	5.3(0.33)	0.02
Systolic blood pressure, mmHg	112.0(9.77)	112.2(11.33)	112.0(9.57)	0.86
Diastolic blood pressure, mmHg	62.8(6.89)	63.2(6.68)	62.7(6.93)	0.63

*Student's T-test. Assumed equal variance.

** Numbers may vary due to missing.

LDL-cholesterol, low-density lipoprotein cholesterol.

HDL-cholesterol, high-density lipoprotein cholesterol.

CRP, C-reactive protein.

HbA_{1c}, Glycated haemoglobin (%) EDTA whole blood.

Screen time

Table IIIa. Estimated change (Beta with 95% confidence interval, CI) in metabolic risk factors by one hour increase in screen time per week, boys and girls. Fit Futures – a part of the Tromsø Study 2010-11.

Metabolic risk factor	N	Beta*	95% CI*	P*
Waist circumference, cm	n=942	0.06	-0.02-0.20	0.01
Waist-to-hip ratio	n=942	0.08	0.00-0.00	0.02
Body mass index, kg/m^2	n= 943	0.03	-0.02-0.06	0.41
Triglycerides, mmol/l	n=836	0.02	-0.00-0.01	0.50
Total cholesterol, mmol/l	n=836	-0.04	-0.01-0.00	0.26
LDL-cholesterol, mmol/l	n=836	-0.02	-0.01-0.01	0.52
HDL-cholesterol, mmol/l	n=836	-0.07	-0.01-0.00	0.05
High sensitive CRP, mg/l	n=836	0.03	-0.02-0.05	0.40
HbA_{1c}, %	n=789	-0.07	-0.01-0.00	0.07
Systolic blood pressure, mmHg	n= 945	0.05	-0.02-0.20	0.11
Diastolic blood pressure, mmHg	n=945	0.06	-0.01-0.14	0.09

*Multivariable linear regression model. Adjusted for age, sex and physical activity in leisure time.

LDL-cholesterol, low-density lipoprotein cholesterol.

HDL-cholesterol, high-density lipoprotein cholesterol.

CRP, C-reactive protein.

HbA_{1c}, Glycated haemoglobin (%) EDTA whole blood.

Table IIIb. Estimated change (Beta with 95% confidence interval, CI) in metabolic risk factors by one hour increase in screen time per week, boys and girls. Fit Futures – a part of the Tromsø Study 2010-11.

Metabolic risk factor	N	Beta*	95% CI*	P*
Waist circumference, cm	n=484	0.03	-0.12-0.20	0.59
Waist-to-hip ratio	n=484	0.03	-0.00-0.00	0.54
Body mass index, kg/m^2	n= 484	0.02	-0.05-0.07	0.64
Triglycerides, mmol/l	n=438	-0.01	-0.01-0.01	0.90
Total cholesterol, mmol/l	n=438	0.01	-0.01-0.01	0.89
LDL-cholesterol, mmol/l	n=438	0.01	-0.01-0.01	0.77
HDL-cholesterol, mmol/l	n=438	-0.04	-0.01-0.00	0.44
High sensitive CRP, mg/l	n=438	0.04	-0.03-0.08	0.44
HbA_{1c}, %	n=430	-0.09	-0.01-0.00	0.09
Systolic blood pressure, mmHg	n= 484	0.05	-0.08-0.26	0.32
Diastolic blood pressure, mmHg	n=484	0.04	-0.07-0.15	0.47

*Multivariable linear regression model. Adjusted for age, sex and physical activity in leisure time.

LDL-cholesterol, low-density lipoprotein cholesterol.

HDL-cholesterol, high-density lipoprotein cholesterol.

CRP, C-reactive protein.

HbA_{1c}, Glycated haemoglobin (%) EDTA whole blood.

Table IIIc. Estimated change (Beta with 95% confidence interval, CI) in metabolic risk factors by one hour increase in screen time per week, boys and girls. Fit Futures – a part of the Tromsø Study 2010-11.

Metabolic risk factor	N	Beta*	95% CI*	P*
Waist circumference, cm	n=458	0.09	-0.00-0.29	0.05
Waist-to-hip ratio	n=458	0.13	0.00-0.00	0.006
Body mass index, kg/m^2	n= 459	0.03	-0.04-0.08	0.48
Triglycerides, mmol/l	n=398	0.06	-0.00-0.01	0.23
Total cholesterol, mmol/l	n=398	-0.10	-0.02-0.00	0.06
LDL-cholesterol, mmol/l	n=398	-0.07	-0.02-0.00	0.18
HDL-cholesterol, mmol/l	n=398	-0.10	-0.01-0.00	0.05
High sensitive CRP, mg/l	n=398	0.02	-0.04-0.05	0.75
HbA_{1c}, %	n=359	-0.05	-0.01-0.00	0.38
Systolic blood pressure, mmHg	n= 461	0.07	-0.05-0.24	0.18
Diastolic blood pressure, mmHg	n=461	0.09	-0.01-0.20	0.08

*Multivariable linear regression model. Adjusted for age, sex and physical activity in leisure time.

LDL-cholesterol, low-density lipoprotein cholesterol.

HDL-cholesterol, high-density lipoprotein cholesterol.

CRP, C-reactive protein.

HbA_{1c}, Glycated haemoglobin (%) EDTA whole blood.

Sedentary behavior

Table IVa. Estimated mean difference (Beta with 95% confidence interval, CI) in metabolic risk factors in sedentary compared with active adolescents, boys and girls. Fit Futures – a part of the Tromsø Study 2010-11.

Metabolic risk factor	N	Beta*	95% CI*	P*
Waist circumference, cm	n=942	-0.03	-0.87-2.95	0.29
Waist-to-hip ratio	n=942	0.07	0.00-0.02	0.02
Body mass index, kg/m^2	n= 943	-0.01	-0.84-0.61	0.76
Triglycerides, mmol/l	n=836	0.01	-0.09-0.11	0.83
Total cholesterol, mmol/l	n=836	-0.01	-0.16-0.13	0.83
LDL-cholesterol, mmol/l	n=836	0.00	-0.13-0.14	0.98
HDL-cholesterol, mmol/l	n=836	-0.05	-0.11-0.02	0.14
High sensitive CRP, mg/l	n=836	0.02	-0.47-0.81	0.60
HbA_{1c}, %	n=789	-0.06	-0.12-0.09	0.09
Systolic blood pressure, mmHg	n= 945	-0.02	-2.78-1.16	0.42
Diastolic blood pressure, mmHg	n=945	0.03	-0.76-1.83	0.42

*Multivariable linear regression model. Adjusted for age, sex and physical activity in leisure time.

LDL-cholesterol, low-density lipoprotein cholesterol.

HDL-cholesterol, high-density lipoprotein cholesterol.

CRP, C-reactive protein.

HbA_{1c}, Glycated haemoglobin (%) EDTA whole blood.

Table IVb. Estimated mean difference (Beta with 95% confidence interval, CI) in metabolic risk factors in sedentary compared with active adolescents, boys.
Fit Futures – a part of the Tromsø Study 2010-11.

Metabolic risk factor	N	Beta*	95% CI*	P*
Waist circumference, cm	n=484	0.02	-2.00 – 3.11	0.67
Waist-to-hip ratio	n=484	0.03	-0.01 – 0.02	0.53
Body mass index, kg/m^2	n=484	0.01	-0.86 – 1.02	0.87
Triglycerides, mmol/l	n=438	-0.00	-0.13 – 0.12	0.93
Total cholesterol, mmol/l	n=438	-0.04	-0.27 – 0.10	0.38
LDL-cholesterol, mmol/l	n=438	-0.03	-0.23 – 0.11	0.50
HDL-cholesterol, mmol/l	n=438	-0.06	-0.11 – 0.02	0.21
High sensitive CRP, mg/l	n=438	0.02	-0.68 – 1.10	0.64
HbA_{1c}, %	n=430	-0.02	-0.10 – 0.06	0.67
Systolic blood pressure, mmHg	n=484	-0.04	-4.03 – 1.47	0.36
Diastolic blood pressure, mmHg	n=484	0.03	-1.07 – 2.36	0.46

*Multivariable linear regression model. Adjusted for age, sex and physical activity in leisure time.

LDL-cholesterol, low-density lipoprotein cholesterol.

HDL-cholesterol, high-density lipoprotein cholesterol.

CRP, C-reactive protein.

HbA_{1c}, Glycated haemoglobin (%) EDTA whole blood.

Table IVc. Estimated mean difference (Beta with 95% confidence interval, CI) in metabolic risk factors in sedentary compared with active adolescents, girls.
Fit Futures – a part of the Tromsø Study 2010-11.

Metabolic risk factor	N	Beta*	95% CI*	P*
Waist circumference, cm	n=458	0.06	-1.05 – 4.85	0.21
Waist-to-hip ratio	n=458	0.14	0.01 – 0.05	0.003
Body mass index, kg/m^2	n=459	-0.03	-1.57 – 0.76	0.49
Triglycerides, mmol/l	n=398	0.03	-0.12 – 0.20	0.59
Total cholesterol, mmol/l	n=398	0.05	-0.12 – 0.37	0.31
LDL-cholesterol, mmol/l	n=398	0.06	-0.10 – 0.36	0.26
HDL-cholesterol, mmol/l	n=398	-0.04	-0.16 – 0.07	0.41
High sensitive CRP, mg/l	n=398	0.01	-0.82 – 1.05	0.81
HbA_{1c}, %	n=359	-0.12	-0.24 - -0.02	0.02
Systolic blood pressure, mmHg	n=461	0.01	-2.63 – 3.08	0.88
Diastolic blood pressure, mmHg	n=461	0.02	-1.52 – 2.51	0.62

*Multivariable linear regression model. Adjusted for age, sex and physical activity in leisure time.

LDL-cholesterol, low-density lipoprotein cholesterol.

HDL-cholesterol, high-density lipoprotein cholesterol.

CRP, C-reactive protein.

HbA_{1c}, Glycated haemoglobin (%) EDTA whole blood.

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