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Television viewing and low participation in vigorous recreation are independently associated with obesity and markers of cardiovascular disease risk: EPIC-Norfolk population-based study

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Objective: This study describes the associations between sedentary behaviour (television viewing) and participation in vigorous recreational activity with obesity and with biomarkers of cardiovascular disease (CVD) risk profile.
Design: Cross-sectional analysis of the EPIC-Norfolk cohort study.
Setting: The study is a population-based study of participants living in Norfolk, UK.
Subjects: A total of 15 515 men and women aged between 45 and 74 y, recruited through General Practice lists, who completed the detailed physical activity questionnaire.
Results: Following exclusion of those with self-reported myocardial infarction, stroke and diabetes, 14 189 participants remained for the analysis. Self-reported television viewing was positively and participation in vigorous activity negatively associated with markers of obesity, blood pressure and plasma lipids. In multiple regression analysis, adjusting for age, alcohol, smoking, treatment for hypertension, vigorous and total physical activity, these associations remained significant. For women who participated in more than 1 h/week of vigorous activity and who watched fewer than 2 h of television each day, the adjusted mean body mass index was 1.92 kg/m^2 less than for women who reported participating in no vigorous activity and who watched more than 4 h of television each day ($P<0.001$). The equivalent figure for men was 1.44 kg/m^2 ($P<0.001$). In a similar analysis, with blood pressure as the outcome, mean diastolic blood pressure difference between the extreme groups of vigorous activity and television viewing was 3.6 mmHg in men ($P<0.001$) and 2.7 mmHg ($P=0.001$) in women.
Conclusions: These data suggest that time spent participating in vigorous recreational physical activity and television viewing, an indicator of a sedentary lifestyle, are associated with obesity and markers of CVD disease risk independent of total reported physical activity. Whether these observations represent the true underlying aetiological relations or are a manifestation of the different precision with which the subdimensions of activity are measured remains uncertain.
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Keywords: physical activity; television; obesity; cardiovascular disease risk; epidemiology

Introduction

Overweight and obesity are important risk factors that have been associated with health problems including type II diabetes, dyslipidaemia, insulin resistance, breathlessness, cardiovascular disease and hypertension (World Health Organization, 1998). The adverse health consequences of obesity are influenced by body weight, the distribution of body fat and the amount of weight gained during adulthood (Bray, 1996).

The prevalence of obesity in the US, defined as a body mass index (BMI) ≥ 30, increased from 10 and 15% to 19.7 and 24.7% in men and women, respectively, between 1960 and 1991. Similar secular trends in the prevalence of obesity in Britain have occurred with an increase from 6 and 8% to 15 and 16.5% in men and women, respectively, between 1980 and 1995 (Bennett *et al*, 1995; Prescott-Clarke & Primatesta, 1997). This epidemic of obesity has occurred despite decreasing average energy intake, highlighting the importance of secular changes in energy expenditure

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(Prentice & Jebb, 1995). Although poorly documented, population energy expenditure is likely to have declined with changes in the nature of work, recreation, transport and domestic life. One rapid social change has been the increase in television viewing, which has risen from an average of 16 h/week in 1970 to 25 h/week in 1996 (Central Statistical Office, 1970; Office for National Statistics, 1998).

There are many studies that demonstrate associations between physical activity and reduced risk of cardiovascular morbidity and mortality. There are also a growing number of studies that show that physical inactivity might adversely affect cardiovascular disease (CVD) risk and its complications (Fung *et al*, 2000, 2001; Kronenberg *et al*, 2000; Hu *et al*, 2001). These effects might be mediated through obesity and distribution of adipose tissue (Crawford *et al*, 1999; Pomerleau *et al*, 1999; Salmon *et al*, 2000; Vioque *et al*, 2000). However, most of these previous studies have been undertaken in occupationally defined cohorts with limited socioeconomic heterogeneity, in which the pattern of variation of physical activity between individuals may be somewhat different from that demonstrable in the population as a whole. Therefore, in this study we aimed to describe the association of television viewing and participation in vigorous recreational activity with markers of obesity and cardiovascular risk in a population-based study in Norfolk (UK) and to investigate the extent to which these two factors were independently predictive of the outcome after adjusting for confounding factors including total physical activity.

Methods

The European Prospective Investigation into Cancer (EPIC) study is a prospective cohort study designed to investigate the aetiology of major chronic diseases. Between 1993 and 1997, EPIC Norfolk (UK) recruited a population-based cohort of 25 000 men and women aged 45–74 y, identified from participating general practice lists. The recruitment and study methods for the EPIC-Norfolk study have been described in detail elsewhere (Day *et al*, 1999). From January 1998, the cohort was invited for a second health check. Following recruitment, trained nurses undertook anthropometric measurements (height, weight, waist and hip) according to standardised protocols. BMI was calculated as weight in kilograms divided by the square of height in metres (kg/m^2). Two measurements of diastolic and systolic blood pressure were taken using an Accutorr Sphygmomanometer (Datascope, UK) after the participant had sat for 3 min. The arm was held horizontal at the level of the midsternum.

Body fat percentage was measured using the Tanita Body Fat Monitor (Tokyo, Japan), a validated impedance technique (Jebb *et al*, 2000). A nonfasting venous blood sample was analysed for total cholesterol, high-density lipoprotein (HDL) cholesterol and triglyceride using RA 1000 (Bayer Diagostics, UK). Low-density lipoprotein (LDL) cholesterol was calculated using the Friedwald formula (Friedewald *et al*, 1972). Glycated haemoglobin (HbA$_{1c}$) was measured using Diamat ion exchange HPLC (Bio-Rad Laboratories, UK). At the second health check, volunteers completed the EPIC Physical Activity Questionnaire (EPAQ2), which is a self-completed questionnaire that collects physical activity behaviours in a disaggregated way such that the information may be reaggregated according to the dimension of physical activity that is of interest (Wareham *et al*, 2002). The questionnaire consists of three sections: activity at home, work and recreation. The occupational activity is derived from the Modified Tecumseh Occupational Activity questionnaire that has been validated elsewhere (Ainsworth *et al*, 1993). The recreational section is derived from the Minnesota Leisure Time Activity questionnaire (Taylor *et al*, 1978), with activities ordered according to the frequency in a UK population (The Sports Council and The Health Education Authority, 1992). The frame of reference for EPAQ2 is the past year. We calculated the amount of television viewing by summing responses to questions about viewing before and after 18.00, separately for weekdays and weekends. Time spent participating in recreational activities was derived from responses to frequency and usual time per episode separately for each of the 36 listed activities. Intensity of recreational activity (MET.hr/wk) was calculated by multiplying published MET values with usual time spent participating (Ainsworth *et al*, 2000). Participation in vigorous recreational activity, defined as requiring a MET score greater than or equal to five, was calculated by summing the product of usual time and frequency in the following activities: lap or leisure swimming, back packing, cycle racing, step aerobics, aerobics, conditioning exercises, competitive running, jogging, tennis, badminton, squash, football, rowing, netball, volleyball, basketball, skating, skiing and boxing. Those who reported no participation formed one category. The remaining participants were grouped into sex-specific tertiles of increasing participation. Overall energy expenditure (EE) was calculated by summing MET.hr/wk derived from the occupation section and the recreation section. The questionnaire was validated against an objective measure of energy expenditure (4-day heart-rate monitoring with individual calibration on four separate occasions over 1 y), and the repeatability of the questionnaire has also been demonstrated (Wareham *et al*, 2002). A total of 15 515 people who attended this second health check by September 2000 and had completed the physical activity questionnaire formed the study group for this analysis.

In order to reduce the degree of measurement error in this analysis, the mean of the two anthropometric or biomarker values from the first and second health check was used. HDL cholesterol and triglyceride were normalised by logarithmic transformation. Results are presented as adjusted mean values, calculated from the regression models, by ordered category of television viewing. The results for men and women are reported separately.

The study received ethical approval from the Norfolk local Research Ethics Committee.

Results

In this analysis, we excluded participants who responded yes to the question "Has your doctor ever told you that you have any of the following?" regarding heart attack ($n = 601$), stroke ($n = 283$) or diabetes (not including gestational diabetes) ($n = 442$). Characteristics of the remaining 14 189 study participants, stratified by sex, are shown in Table 1. Men and women were middle-aged and their mean BMI was similar. Per cent body fat was lower in men (23.9%) compared to women (39.6%). Men reported more participation in recreational activity than women, although both watched the same amount of television on average (21.2 and 21.9 h/week in men and women, respectively). In total, 40% of men and women reported participating in any vigorous recreational activity. There were few current smokers and rates were similar between men and women. Men reported drinking more alcohol than women (median 6.5 and 2.5 units/week, respectively).

Since both the markers of CVD risk and the principal exposure of interest are age dependent, we present all descriptive data following adjustment for age. The age-adjusted mean (s.d.) of the anthropometric measurements and participation rates in vigorous recreational activity are given in Table 2 by category of television viewing. All markers of obesity (BMI, waist to hip ratio and per cent body fat) significantly increase with the amount of viewing time in both men and women. In women, the age-adjusted mean BMI was almost 2 units greater in those who reported watching television more than 4 h/day compared with those who reported watching less than 2 h/day. Participation rates in vigorous activities significantly decreased with the amount of television viewing in both men and women.

Age-adjusted mean values of the CVD risk biomarkers by television viewing category are given in Table 3. Systolic and diastolic blood pressure significantly increased across categories of television viewing with the mean diastolic pressure 2.4 and 2.9 mmHg higher in the top category compared to the bottom category in men and women, respectively. Systolic blood pressure in the top compared to the bottom category of television viewing was 3.4 and 3.1 mmHg higher in men and women, respectively. Mean HDL decreased across categories of television viewing with concentrations 0.08 and 0.12 mmol/l lower in those who report watching more than 4 h/day compared with those who report watching less than 2 h/day in men and women, respectively. HbA_{1c}, a marker of glucose control, was significantly raised by 0.05% (test for trend across categories, $P = 0.02$) in men who reported watching more than 4 h/day compared to those who watched less than 2 h/day. In women, the magnitude of the difference in HbA_{1c} between extreme television viewing categories was less than in men, although the statistical test for trend was significant ($P = 0.03$).

In order to determine the relative contribution of sedentary behaviour and vigorous activity in predicting markers of CVD risk after adjusting for potential confounding factors, gradients of BMI and diastolic blood pressure were studied within categories of television viewing and participation in self-reported vigorous activity. Figures 1a and b show mean BMI by category of television viewing and participation in vigorous activities adjusted for age, alcohol intake, smoking, use of antihypertensive therapy and total physical activity. Men who watched television more than 4 h/day and reported no participation in vigorous activity had an adjusted mean BMI 1.44 kg/m^2 greater than those who watched less than 2 h/day and participated in an hour

Table 1 Characteristics of the EPIC-Norfolk study population who completed the EPIC Physical Activity Questionnaire (EPAQ2) at the second health check[a]

	Men (n=5975) *Mean (s.d.)*	*Women (n=8214)* *Mean (s.d.)*
Age (y)	61.0 (9.0)	59.9 (8.9)
Height (cm)	174.3 (6.6)	161.2 (6.1)
Weight (kg)	80.7 (11.0)	68.0 (11.4)
BMI (kg/m^2)	26.5 (3.2)	26.2 (4.2)
Waist (cm)	95.4 (9.2)	81.4 (10.1)
Hip (cm)	103.0 (6.1)	103.5 (8.8)
Waist to hip ratio	0.93 (0.05)	0.79 (0.06)
Body fat (%)	23.9 (6.9)	39.6 (9.0)
MET.hr/wk in recreational activity (median (IQR))	28 (15–42)	18 (9–33)
MET.hr/wk in work and recreational activity (median (IQR))	67 (30–117)	34 (15–69)
Television viewing (h/week)	21.2 (10.1)	21.9 (10.2)
Percentage of people reporting any participation in vigorous activity (%)	41	43
Current antihypertensive therapy (%)	21	23
Current smokers (%)	10	9
Alcohol intake (units/week) median (IQR)	6.5 (2–14.5)	2.5 (1–7)

[a]Excluding people with a self-reported history of myocardial infarction (n=601), stroke (n=283) and diabetes (n=442).

Table 2 Age-adjusted markers of obesity and proportion of people participating in vigorous recreational activity by frequency of television viewing of the EPIC-Norfolk study population who completed the EPIC Physical Activity Questionnaire (EPAQ2) at the second health check[a]

	Television viewing (h/day)				
	<2 Mean (s.d.)	*2–2.9 Mean (s.d.)*	*3–3.9 Mean (s.d.)*	*>4 Mean (s.d.)*	P-*value*
Men					
BMI (kg/m^2)	26.1 (3.1)	26.4 (3.0)	26.7 (3.2)	27.1 (3.2)	<0.001
Waist (cm)	94.0 (9.1)	94.9 (8.8)	95.7 (9.2)	97.0 (9.3)	<0.001
Hip (cm)	102.3 (5.7)	102.8 (5.7)	103.0 (6.2)	103.7 (6.6)	<0.001
WHR	0.92 (0.06)	0.92 (0.05)	0.93 (0.05)	0.93 (0.05)	<0.001
Body fat (%)	22.5 (6.6)	23.4 (6.2)	24.3 (7.5)	25.3 (7.0)	<0.001
Percentage of people doing any vigorous activity (%)	47	44	38	35	<0.001
Women					
BMI (kg/m^2)	25.3 (3.9)	26.0 (4.1)	26.2 (4.0)	26.9 (4.4)	<0.001
Waist (cm)	79.6 (9.5)	80.7 (10.0)	81.5 (9.9)	82.9 (10.4)	<0.001
Hip (cm)	102.0 (8.1)	103.2 (8.9)	103.5 (8.4)	104.7 (9.3)	<0.001
WHR	0.78 (0.05)	0.78 (0.06)	0.79 (0.06)	0.79 (0.06)	<0.001
Body fat (%)	37.1 (8.6)	38.9 (8.8)	40.0 (8.6)	41.6 (9.3)	<0.001
Percentage of people doing any vigorous activity (%)	51	45	41	35	<0.001

[a]Excluding people with a self-reported history of myocardial infarction (*n*=601), stroke (*n*=283) and diabetes (*n*=442).

Table 3 Age-adjusted biomarkers of cardiovascular risk by frequency of television viewing of the EPIC-Norfolk study population who completed the EPIC Physical Activity Questionnaire (EPAQ2) at the second health check[a]

	Television viewing (h/day)				
	<2 Mean (s.d.)	*2–2.9 Mean (s.d.)*	*3–3.9 Mean (s.d.)*	*>4 Mean (s.d.)*	P-*value*
Men					
Diastolic BP (mmHg)	83.2 (12.6)	83.7 (13.3)	84.9 (13.3)	85.6 (14.3)	<0.001
Systolic BP (mmHg)	135.0 (16.8)	136.4 (17.7)	138.1 (17.7)	138.4 (19.0)	<0.001
Cholesterol (mmol/l)	5.91 (1.26)	5.93 (1.33)	5.96 (1.33)	6.05 (1.43)	<0.001
LDL cholesterol (mmol/l)	3.75 (0.84)	3.77 (0.89)	3.82 (0.89)	3.87 (0.95)	<0.001
HDL cholesterol[b] (mmol/l)	1.28 (0.6–2.7)	1.23 (0.6–2.6)	1.22 (0.6–2.5)	1.20 (0.6–2.6)	<0.001
Triglyceride[b] (mmol/l)	1.70 (0.8–3.6)	1.80 (0.8–3.8)	1.82 (0.9–3.8)	1.92 (0.9–4.1)	<0.001
HbA_{1c} (%)	5.38 (0.42)	5.40 (0.44)	5.40 (0.44)	5.43 (0.48)	0.02
Women					
Diastolic BP (mmHg)	79.2 (7.5)	80.1 (7.7)	80.7 (7.5)	81.1 (7.8)	<0.001
Systolic BP (mmHg)	130.9 (15.1)	132.3 (11.6)	133.4 (11.2)	134.0 (11.7)	<0.001
Cholesterol (mmol/l)	6.17 (1.13)	6.22 (0.77)	6.27 (0.75)	6.28 (0.78)	0.001
LDL cholesterol (mmol/l)	3.82 (0.75)	3.90 (0.77)	3.93 (0.75)	3.97 (0.78)	<0.001
HDL cholesterol[b] (mmol/l)	1.63 (0.7–3.7)	1.58 (0.7–3.8)	1.57 (0.7–3.7)	1.51 (0.6–3.8)	<0.001
Triglyceride[b] (mmol/l)	1.38 (0.6–3.1)	1.40 (0.6–3.3)	1.49 (0.6–3.6)	1.54 (0.6–3.9)	<0.001
HbA_{1c} (%)	5.37 (0.38)	5.38 (0.39)	5.38 (0.37)	5.40 (0.39)	0.03

[a]Excluding people with a self-reported history of myocardial infarction (*n*=601), stroke (*n*=283) and diabetes (*n*=442).
[b]Geometric mean (95% CI).

or more of vigorous activity. The comparison between the same categories of television viewing and participation in vigorous activity in women (Figure 1b) shows a difference of 1.92 kg/m^2.

Using diastolic blood pressure as one example of a CVD risk factor, Figures 2a and b again show means by category of television viewing and participation in vigorous activity, stratified by sex and adjusted for the same confounding factors as in Figure 1. For men, the difference between the extreme categories (least television and most vigorous activity compared to most television and least vigorous activity) was 3.6 mmHg of diastolic blood pressure. For women, the equivalent difference was 2.7 mmHg of diastolic blood pressure. Similar patterns were seen for systolic blood pressure and triglyceride in men and women (data not shown). For HDL cholesterol, the adjusted mean was highest in the least television, most vigorous activity category and lowest in the most television, no vigorous activity category (data not shown). None of the interaction terms for television viewing and vigorous activity in the regression models, for men and women, reached conventional statistical significance.

Table 4 shows mean (s.d.) values of biomarkers adjusted for the same factors as for Figures 1 and 2 (age, alcohol intake, smoking, participation in vigorous activity, use of antihypertensive therapy, total physical activity) and additionally BMI to examine the extent to which the associations with markers of activity were independent of obesity. Significant positive associations between increasing television viewing and systolic and diastolic blood pressure, total cholesterol, LDL cholesterol and triglyceride were found in men and women. A significant inverse association between increasing television viewing and HDL cholesterol was observed in men and women. By comparison with the age-only adjustment results, the adjustment for additional confounders attenuated the results, but measurable differences remained. In men, a difference of 1.5 mmHg diastolic and 2.1 mmHg systolic blood pressure between top and bottom categories of television viewing was observed (test for linear trend, $P<0.001$). For women, after adjustment for the above variables, the difference was 0.8 mmHg diastolic and 1.5 mmHg systolic blood pressure between top and bottom categories of television viewing. The association between television viewing and HbA_{1c} was not detected following adjustment for the additional confounders. However, such an analysis may be over-adjusted as BMI is part of the biological pathway between physical activity or inactivity and CVD.

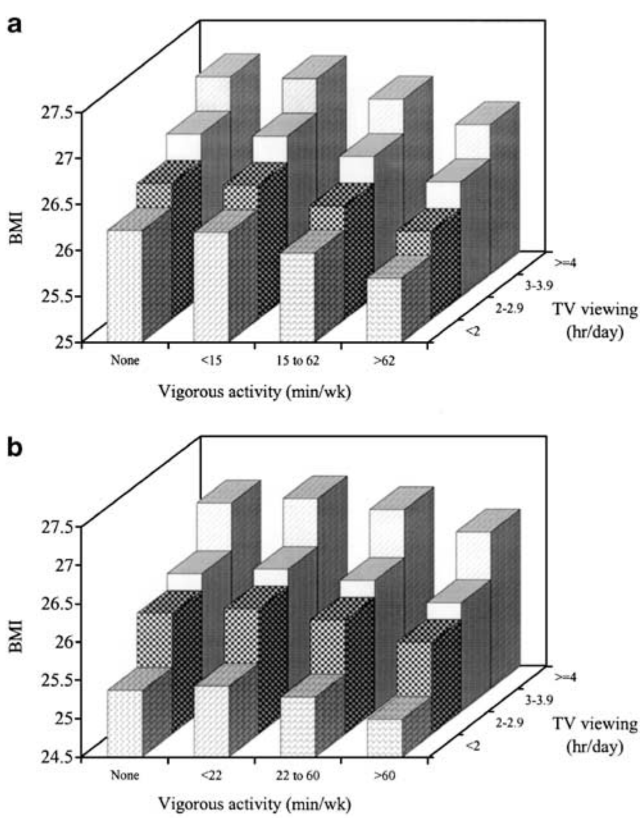

Figure 1 Adjusted mean BMI by category of participation in vigorous activity and TV viewing in (a) men ($n=5975$) and (b) women ($n=8214$).

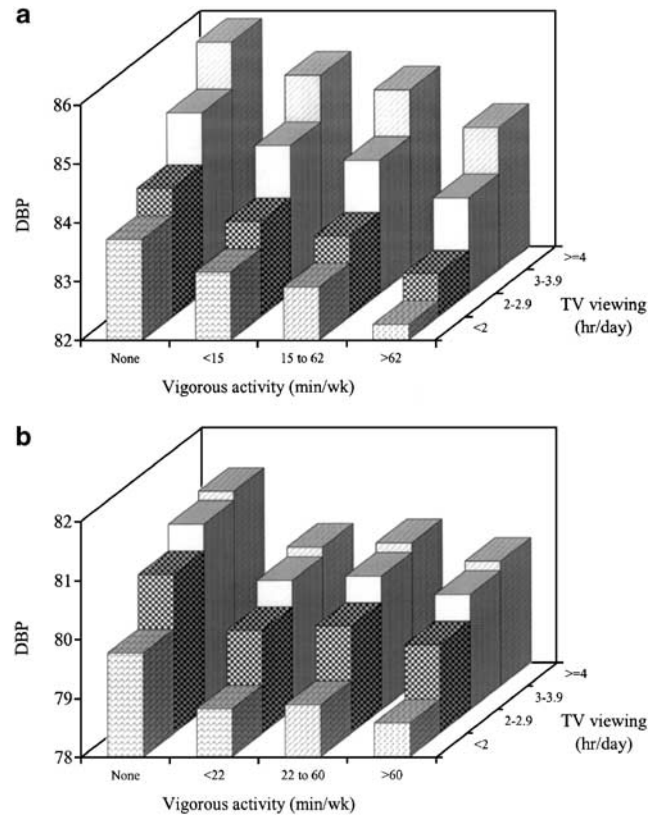

Figure 2 Adjusted mean diastolic blood pressure (mmHg) by category of participation in vigorous activity and TV viewing in (a) men ($n=5975$) and (b) women ($n=8214$).

Discussion

In this study, we observed an independent association between physical inactivity, expressed as hours of television viewing, participation in vigorous activity and CVD risk profile including markers of obesity and biomarkers. The risk profile was worse for those who watched more television and better for those who participated in more vigorous activity. These associations were observed in men and women and were independent of age, alcohol intake, smoking habit, use of antihypertensive therapy and BMI. They were also

Table 4 Adjusted mean[a] bio-markers of cardiovascular risk by frequency of television viewing of the EPIC-Norfolk study population who completed the EPIC Physical Activity Questionnaire (EPAQ2) at the second health check[b]

	Television viewing (h/day)				
	<2 *Mean (s.d.)*	*2–2.9* *Mean (s.d.)*	*3–3.9* *Mean (s.d.)*	*>4* *Mean (s.d.)*	P-*value*
Men					
Diastolic BP (mmHg)	83.6 (11.3)	83.9 (11.6)	84.6 (11.2)	85.1 (11.7)	<0.001
Systolic BP (mmHg)	135.6 (15.1)	136.7 (15.4)	137.7 (14.9)	137.8 (15.6)	<0.001
Cholesterol (mmol/l)	5.92 (1.13)	5.93 (1.16)	5.96 (1.12)	6.04 (1.17)	<0.01
LDL cholesterol (mmol/l)	3.75 (0.75)	3.77 (0.77)	3.82 (0.75)	3.87 (0.78)	<0.01
HDL cholesterol[c] (mmol/l)	1.27 (0.6–2.7)	1.22 (0.6–2.6)	1.22 (0.6–2.5)	1.21 (0.6–2.6)	<0.01
Triglyceride[c] (mmol/l)	1.73 (0.8–3.6)	1.82 (0.9–3.9)	1.80 (0.9–3.7)	1.88 (0.9–4.0)	<0.01
HbA_{1c} (%)	5.41 (0.38)	5.41 (0.39)	5.40 (0.37)	5.41 (0.39)	ns
Women					
Diastolic BP (mmHg)	79.7 (8.4)	80.3 (8.9)	80.7 (8.9)	80.5 (9.5)	<0.01
Systolic BP (mmHg)	131.6 (16.8)	132.6 (13.3)	133.3 (13.3)	133.1 (14.3)	<0.01
Cholesterol (mmol/l)	6.19 (1.26)	6.23 (0.89)	6.27 (0.89)	6.26 (0.95)	<0.01
LDL cholesterol (mmol/l)	3.85 (0.84)	3.91 (0.89)	3.93 (0.89)	3.95 (0.95)	<0.01
HDL cholesterol[c] (mmol/l)	1.60 (0.7–3.6)	1.57 (0.7–3.7)	1.57 (0.7–3.7)	1.54 (0.6–3.9)	<0.001
Triglyceride[c] (mmol/l)	1.42 (0.6–3.2)	1.42 (0.6–3.4)	1.48 (0.6–3.5)	1.49 (0.6–3.8)	<0.001
HbA_{1c} (%)	5.39 (0.42)	5.39 (0.44)	5.38 (0.44)	5.38 (0.48)1	ns

[a]Adjusted for age, alcohol intake, smoking, participation in vigorous activity, use of antihypertensive therapy, total physical activity and BMI.
[b]Excluding people with a self-reported history of myocardial infarction (*n*=601), stroke (*n*=283) and diabetes (*n*=442).
[c]Geometric mean (95% CI).

independent of total reported physical activity assessed as the sum of total recreational and occupational activity.

It is unlikely that the associations observed here are a result of chance because the sample size of 14 189 participants is large. Potential biases in the reporting of physical activity in those most at risk of an adverse CVD risk profile have been reduced by the exclusion of participants who had ever had heart attack, stroke or diabetes at the time the physical activity questionnaire was completed. The results are comparable in direction but vary in magnitude between men and women. Previous studies have tended to focus on single sex cohorts (Pomerleau *et al*, 1999; Fung *et al*, 2000, 2001; Hu *et al*, 2001). In addition, the examination of these associations in a population-based cohort, makes the results more generalisable to the population as a whole when compared to studies that have focused on selected occupationally defined groups.

This paper describes a cross-sectional analysis of a continuing cohort study. The two measures of obesity and cardiovascular risk factors were used as repeated measures rather than to examine change because the interval between the repeats is short (3.7 y) and the between-person variance is much greater than the within-person change. For example, the correlation between repeated measures of BMI was high at 0.92, $P<0.00001$. A study of this design is unable to disentangle the direction of causality between sedentary behaviours and an unfavourable CVD risk profile. However, reverse causality is unlikely, as we have excluded prevalent disease. Examination of change in obesity and markers of CVD risk would require much longer follow-up.

The effect of confounding has been diminished since there was adjustment for age, alcohol intake, smoking habit, participation in total activity, use of antihypertensive therapy and BMI. However, it is possible that residual confounding could explain, in part, the observed associations as a result of measurement error of physical activity and other self-reported behaviours. The critical question is whether assessment of television viewing, participation in vigorous activity and total physical activity are equally well measured. It is likely that the various subdimensions of physical activity are recalled with different degrees of measurement error. More vigorous exercise usually involves a conscious decision to undertake such activity and is therefore easily recalled and less prone to measurement error than total physical activity which is difficult to measure as it is the summation of all activities, many of which are short, intermittent and subconscious (Jacobs *et al*, 1993). The varied degrees of measurement error associated with the assessment of the different subdimensions of physical activity make it difficult to resolve issues concerning dose–response. It may be that the resolution of this problem requires a different approach such as objective measurement of physical activity.

The possibility of confounding by factors that were not considered in this study exists. Television viewing, recorded using EPAQ2, was negatively correlated ($r=-0.21$) with objectively measured cardiorespiratory fitness in a validation study (Wareham *et al*, 2002). Therefore, it might be that the effect of television viewing on the CVD risk profile is associated with the unmeasured confounding effects of cardiorespiratory fitness. It is possible that television viewing is associated with other lifestyles which themselves are associated with obesity. For example, television advertising might influence both the quality and quantity of food consumed. Lank *et al* (1992) reported that 58% of food advertised on television during the afternoon were high in fat. Food cues are also evident during popular viewing times and in advertisements (Story & Faulkner, 1990), and these cues may exert a greater influence in the obese (Falciglia & Gussow, 1980). The television, as a leisure activity, may also serve as an incentive to eat larger amounts of unhealthy foods. Jeffery and French (1998) described the effects of both television viewing and fast food meals in selected groups of men and women. Although they found positive associations, in women, between fast foods and BMI, and between television viewing and BMI, they did not report on whether there was an association between television viewing and eating fast foods. Future analyses on this cohort, in which diet was assessed using 7-day food diaries, will need to consider the extent to which the effects of physical activity and sedentary behaviour are independent of dietary intake.

If the observations represent a genuine relation between markers of inactivity and obesity and cardiovascular risk, then one explanation is that those who watch more television do so at the expense of expending energy in other recreational pursuits. The data presented here show that the percentage of those participating in vigorous recreational activity is reduced as television viewing increases (see Table 2). Further, television viewing is not only a marker of inactivity, but it results in even lower energy expenditure than other types of sedentary behaviours. In a compendium of energy costs of activities, television viewing is nearly comparable to that of activities done while reclining and is lower than that for other sedentary activities such as sewing, playing board games, reading, writing and driving a car (Ainsworth *et al*, 1993). Metabolic rate and observed movements in children have been found to be lower while watching television than when at rest (Klesges *et al*, 1993; Deitz *et al*, 1994). The causal nature of the observed association is strengthened by experimental evidence that suggests that intervening to reduce television viewing reduces weight gain (Robinson, 1999).

The magnitude of the association between television and markers of CVD risk observed in this study is clinically relevant. For example, after adjusting for known confounding variables, women who watched most television and did no vigorous activity had a mean BMI 1.92 kg/m^2 higher than those who watched the least television and did most vigorous activity. The equivalent figure in men was 1.44 kg/m^2. The adjusted difference between similar extreme groups for diastolic blood pressure was 3.6 mmHg in men ($P<0.001$) and 2.7 mmHg ($P=0.001$) in women. A difference of this magnitude would expected to be associated with a 12.6% reduction in the risk of coronary heart disease (CHD) and a 20.4% reduction in stroke risk (MacMahon *et al*, 1990). Although it is unlikely that preventive measures could result in shifts of this magnitude in population physical activity, even small changes on large numbers of individuals would have appreciable effects (Rose, 1985). The data in this study suggest that the effect of watching one less hour of television per day, or approximately 0.7 s.d., is a diastolic blood pressure difference of 0.7 mmHg in men and 0.5 mmHg in women. Such a small change, which is potentially achievable, could result in a risk reduction of CHD and stroke of 2.5 and 4%, respectively (MacMahon *et al*, 1990).

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The physical activity questionnaire (EPAQ2) can be viewed at the following location: http://www.srl.cam.ac.uk/epic/questionnaires/epaq2/

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