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Television viewing time and 13-year mortality in adults with cardiovascular disease:

Data from the Australian Diabetes, Obesity and Lifestyle Study (AusDiab)

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Abstract

Background: In the general population, excessive sedentary behaviour is associated with increased all-cause mortality. Few studies have examined this relationship in people with cardiovascular disease (CVD). Using a sample of people with CVD who were excluded from an analysis of the Australian Diabetes, Obesity and Lifestyle (AusDiab) study, we examined the relationship between sedentary behaviour and 13-year all-cause mortality.

Methods: In the original AusDiab study, television viewing time was used as a marker of sedentary behavior in 609 adults (≥ 45 years of age) with CVD. During 6,291 person-years of follow-up (median follow-up 13 years), there were 294 deaths (48% of sample). Using the time scale of attained age, the Cox proportional hazards model predicting all-cause mortality adjusted for sex, self-rated general health, leisure-time physical activity, smoking status, education, household income, body mass index, lipid levels, blood pressure, and diabetes mellitus was used.

Results: Compared with a TV viewing time of < 2 hours per day, the fully adjusted hazard ratios for all-cause mortality were 1.18 (95% CI, 0.88 to 1.57) for ≥ 2 to < 4 hours per day and 1.52 (95% CI, 1.09 to 2.13) for > 4 hours per day.

Conclusions: Sedentary behaviour was associated with increased risk of all-cause mortality in people with CVD, independent of physical activity and other confounders. In addition to the promotion of regular physical activity, cardiac rehabilitation efforts which also focus on reducing sedentary behaviour may be beneficial.

Keywords: cardiovascular disease, sedentary behaviour, mortality, prevalence, risk factors

Introduction

Adults in the general population spend more than half of their waking hours engaged in sedentary behaviours [1]. Sedentary behaviour refers to any waking behaviour characterised by low energy expenditure while in a sitting or reclining posture [2] and is a distinct behavioural entity from insufficient physical activity (PA) [3]. While more sophisticated measures of sedentary behaviour are now available [4], early studies in this area typically used television (TV) viewing as a marker of sedentary behavior [5, 6]. TV viewing occupies a large amount of adults' leisure time [7] and is particularly prevalent in older adults, who typically watch between 3 and 5 hours of TV per day [8]. High TV viewing is associated with low household income, low education, poor self-rated health [9], and the consumption of energy-dense snack foods [10].

Cardiovascular disease (CVD), including coronary heart disease (CHD) and stroke, is the leading cause of death and disability worldwide [11]. People who survive an acute event are at an increased risk of a subsequent event and premature death [12]. PA is a unique form of treatment and management for CVD because it contributes to lowering physiological risk factors [13, 14], reducing premature all-cause and cardiac-related mortality [15] and morbidity [16], and improving quality of life and psychological wellbeing [17]. Adults with CVD are less likely to engage in sufficient PA than the general population [18, 19]. Emerging evidence suggests that people with CVD engage in more sedentary behaviour than those without CVD [18, 19]. To our knowledge, no studies have investigated the prevalence of sedentary behaviour in Australians with CVD.

Over the past decade, research in the general adult population has consistently shown an association between TV viewing time and poor health outcomes, independent of PA levels. Excessive TV viewing is associated with increased risk of all-cause [5, 20-22] and CVD [5,

21, 22] mortality as well as higher morbidity, including higher rates of CVD [5, 20, 22-24], type 2 diabetes [25] and depression [26], independent of confounding factors such as age [27, 28], lower education levels [29-32], smoking [31], higher waist circumference/body mass index (BMI) [31], serum triglycerides [5], blood pressure [5], total cholesterol [5], high-density-lipoprotein cholesterol (HDL-C) [5] and PA [31]. Even adults who meet the minimum PA recommendations remain at risk of poorer health if they spend excessive amounts of time engaged in TV viewing [22, 27, 33].

To ensure results are not biased by the presence of illness categories, the majority of population-based studies of sedentary behaviour and health have excluded people with established CVD [5, 20-22]. In a large population study of Australian adults, Van der Ploeg and colleagues [34] found consistent associations, independent of PA levels, between self-reported sitting time and all-cause mortality among healthy participants and also among those with pre-existing CVD, diabetes mellitus and overweight/obesity. While these findings highlight the importance of investigating not only healthy but also chronically ill populations, the impact of sedentary behaviour on mortality risk in adults with existing CVD is unknown.

The present study replicates the approach used in the Australian Diabetes, Obesity and Lifestyle (AusDiab) study with the sub-sample of patients with self-reported CVD who were excluded from the original study [5]. The primary aim was to investigate the association between TV viewing time and 13-year all-cause mortality. TV viewing was used in the original AusDiab study as the indicator of sedentary behaviour. The secondary aims were to examine the amount of time spent in TV viewing among people with CVD and to characterize high versus low TV viewers according to sociodemographic and lifestyle factors, medical conditions and cardiometabolic health outcomes.

Methods

Population and procedure

Participants were part of a national population-based cohort of men and women from the AusDiab study which was designed to evaluate the national prevalence of diabetes and related risk factors. The study included three rounds of data collection: baseline (1999-2000); phase 2 (2004-2005); and phase 3 (2011-2012). The methods for the baseline AusDiab study have been described in full elsewhere [35]. In brief, the original study sample was drawn from 42 randomly selected urban and non-urban areas of each state and territory in Australia. A total of 11,247 adults over the age of 25 years completed the household interview and had a biomedical examination. The response rate to the baseline biomedical examination was 55%.

In a previous study, Dunstan and colleagues investigated the relationships between prolonged TV viewing time and 6-year mortality, with a number of exclusions, including CVD patients [5]. The present study included 612 participants who were excluded from the original study on the basis that they had a self-reported history of CHD or stroke (hereafter termed 'CVD'). After excluding 3 participants with missing TV data, the current sample comprised 609 participants (241 females, 368 males) ranging in age from 45 to 91 years (mean age=68.8 years, $SD=10.0$). All participants had answered "yes" to the questions "have you been told you have had a heart attack?" or "have you been told you have had a stroke?" Those who were unsure were not included in the current study.

The AusDiab study was approved by the Ethics Committee of the International Diabetes Institute and the current study, by the University of Melbourne Human Research Ethics Committee. Permission to link the AusDiab cohort to the Australian National Death Index (NDI) was provided by the Australian Institute of Health and Welfare Ethics Committee.

Measures

TV viewing time

Participants self-reported the total time spent watching TV or videos on weekdays and weekends in the previous seven days. This did not include time in which the TV was switched on but other activities, such as preparing a meal or doing other household chores, were performed. This measure has been shown to provide a reliable (intraclass correlation = 0.82; 95% CI 0.75 to 0.87) and valid (assessed against a 3-day behavioural log, Spearman rank order correlation, $r=0.3$) estimate of TV viewing among adults [36]. Similar to the original Dunstan et al. study [5], three categories of TV viewing time were created: low (<2 hrs/d), medium (≥ 2 to <4 hrs/d) and high (≥ 4 hrs/d) based on previously identified associations with biomarkers of cardiometabolic risk [37].

Other measures

PA was assessed using the validated and reliable [38] Active Australia Survey which measures frequency and duration of walking, moderate activity and vigorous activity in the past week. Minutes per week of total PA was calculated for each participant using the recommended algorithm weighting vigorous activity by two [39]. Activity level was dichotomized into sufficient levels of PA (≥ 150 minutes/week) or insufficient PA (<150 minutes/week) based on PA guidelines for health benefits [40]. Demographic information including age, sex, educational attainment (<or \geq 12 years), marital status (partnered or unpartnered), household income (<or \geq \$600 per week), place of residence (capital city or regional centre/rural area), smoking status (current/former or non-smoker). Lipid medication use was obtained via interviewer administered questionnaires. Self-report questionnaires were used to ascertain dietary information, namely energy intake (total and alcohol) and the Dietary Quality Index-Revised score [41]. An index is calculated from 10 separate nutritional elements (range 0 to 100, higher score=better diet). A full description of clinical measures

can be found in Dunstan et al. [35]. Fasting and 2-hour plasma glucose levels, fasting serum triglycerides, total cholesterol and HDL-C levels were obtained using methods described in Dunstan et al. [5]. Waist circumference, height and weight, BMI (kg/m^2) and triplicate resting blood pressures were measured by trained personnel as reported previously [35]. Diabetes was diagnosed on the basis of fasting plasma glucose of ≥ 7.0 mmol/l or 2-h plasma glucose of ≥ 11.1 mmol/l or on current treatment with insulin or oral hypoglycaemic medication. General health was assessed using the General Health sub-scale of the SF-36 version 1 [42]. This is a rating of one's own health, a comparison with others health and proneness to illness.

Collection of all-cause mortality data

All-cause mortality status was collected to the date of death or January 9, 2014, whichever occurred first. On average, thirteen year mortality status was determined by linking the AusDiab cohort to the NDI using methods described previously [43]. The NDI has been found to display 93.7% sensitivity and 100% specificity for the identification of deaths [44]. For this data set, cause of death was available only for deaths occurring prior to 30 November 2011, therefore the study was underpowered to examine the relationship between CVD-specific mortality and TV viewing time.

Statistical Analyses

Baseline participant characteristics were compared by TV viewing time categories (lowest: <2.0 hrs/d, middle: 2.0 - 3.9 hrs/d, highest: ≥ 4.0 hrs/d) using one-way analysis of variance and chi-squared tests, and by mortality status using independent samples t-tests and chi-square tests. Unadjusted mortality rates (95% CI) per 1000 person-years according to increments of television viewing time (0, 1, 2, 3, and ≥ 4 h/d) were plotted. Cox proportional-hazards models were used to estimate the hazard ratios (HRs) and 95% confidence intervals (CIs) of all-cause mortality according to categories of TV viewing time. As recommended

for use with longitudinal studies [45], the attained age scale was used where the primary time variable in the Cox model is defined by CVD participants' age at entry into the study and age at which they experience an event or their follow-up is censored.

The proportional hazards assumption was checked with a log-log plot of the survival function. Potentially confounding variables, in addition to age and sex, were selected in the final multivariate model if they were associated with mortality (at $P < 0.10$) in the univariate analyses, or have been shown in the literature to be associated with mortality. We also used log-likelihood ratio tests to check for the significance of any first order interactions between variables. In the Cox regression analysis, two models were assessed: categories of TV viewing time were initially adjusted for sex and general health; and a fully adjusted multivariate model including smoking (current or ex-smoker), education level ($< \text{or} \geq 12$ years), household weekly income ($< \text{or} \geq \$600$ per week), BMI, systolic blood pressure (mm Hg), high density lipoprotein (mmol/L), triglycerides (mmol/L), general health (SF-36 question 1), minutes of leisure time PA per day and diabetes mellitus status. For all other analyses, the P value was set at ≤ 0.05 . All analyses were carried out using SPSS version 22 [46].

Results

Descriptive characteristics

CVD participants spent an average of 143.5 mins/d ($SD=97.3$) watching TV. Table 1 shows the baseline characteristics of the sample in relation to categories of TV viewing time. Participants who watched more TV were older ($P < 0.05$) and less educated ($P < 0.01$), had lower household incomes ($P < 0.001$), higher systolic blood pressure and BMI, and were more likely to have diabetes mellitus (all $P < 0.05$).

Insert Table 1 about here

Association of TV viewing time and PA with all-cause mortality

During the median follow-up period of 13.0 years, 294 participants (183 men and 111 women; 48% of the total 609 participants) died from any cause. Unadjusted mortality rates per 10,000 person-years increased for every 1-hour increment in TV viewing time. Testing of curves (linear, quadratic, exponential), showed that a linear association between TV time and all-cause mortality was the best fit (Figure 1).

Insert Figure 1 about here

The univariate associations for TV viewing time categories, meeting the recommended PA guidelines and all-cause mortality status are detailed in Table 2. The 13-year all-cause mortality was significantly higher in the >4 hour a day TV category than in the <2 hours a day TV viewing category.

Insert Table 2 about here

Interaction tests showed that age, sex, education, smoking, hypertension, waist circumference, BMI, and leisure-time PA did not significantly modify the associations between TV viewing and all-cause mortality ($P>0.05$ for all factors). Results for the Cox regression (Table 3) showed that TV time (hours/day) was positively associated with all-cause mortality in the model adjusted for sex and general health status. In the fully adjusted model, ≥ 4 hours of TV viewing time per day was associated with a 52% increase in all-cause mortality compared with watching <2 hours of TV per day. Examination of the cumulative survival curves by TV viewing categories (Figure 2) revealed a clear dose-response relationship between TV viewing time and all-cause mortality; lowest TV viewing was associated with best survival, highest TV viewing was associated with worst survival, and moderate TV viewing was associated with intermediate survival rates.

Insert Table 3 about here

Insert Figure 2 about here

Discussion

This is the first study to examine sedentary behavior and all-cause mortality in a CVD population. Excessive TV viewing time, used here as a marker of sedentary behaviour, was associated with an increased risk of 13 year all-cause mortality, independent of leisure-time PA level. Almost half (48%) of the 609 participants died from any cause over the 13-year follow-up period. After controlling for potential confounding variables such as age, education, household income, smoking, BMI and lipid levels, people with CVD who watched high levels of TV (i.e., more than 4 hours per day) were 52% more likely to die from any cause than those who watched less than 2 hours per day. As expected, the relationship between TV viewing time and all-cause mortality was linear: the more TV that people watched, the higher the likelihood of premature mortality. Similar to the general population [5, 6], even those people with CVD who achieve the recommended levels of PA, which is highly promoted during rehabilitation programs, remain at risk of premature death if they watch high levels of TV.

The increased mortality risk of TV viewing observed here for people with CVD is similar to that reported for the original AusDiab cohort of people without CVD. Compared to those who watched TV less than 2 hours per day, watching 4 hours per day conferred a 52% increased risk (OR=1.52) in our study, and 48% increased risk (OR=1.48) in the original cohort [5]. Other studies have reported similar findings in the general population [20, 22].

To our knowledge, this is the first study to identify the characteristics of TV viewing among CVD participants. TV viewing time was highest in those who were older, less educated, with lower household incomes, higher blood pressure, higher BMI and/or diabetes mellitus. Importantly, the patterns are similar to those found in general population studies [27-

32] and similar to the socio-demographic correlates of the full sample of non-CVD AusDiab participants [29]. Lower socio-economic status, indicated here by lower education and income, is often shown to be associated with high TV viewing [29-31], possibly because TV viewing is a relatively inexpensive recreational activity [9].

TV viewing was not associated with the health behaviours investigated, namely PA, dietary intake and smoking. This is somewhat surprising, in light of the positive associations between TV viewing and physiological indicators, including high blood pressure, BMI and diabetes. Given that previous research is limited and equivocal in its findings [29], further research is required to investigate a wider range of behavioural, psychosocial, medical and environmental correlates of TV viewing in people with CVD. Findings could be used to help identify those at risk of excessive TV viewing and other sedentary behaviours, and to assist in informing appropriate intervention development.

The current study was limited in its assessment of sedentary behaviour (a self-report measure of TV viewing time). Although this has been shown to be a reasonable marker of overall sedentary time [7], objective measures, such as inclinometers (e.g. activPAL) are more accurate at measuring overall sitting behavior [47] and detailed self-report measures can provide broader accounts of sedentary behavior. However, with TV viewing a typical indicator in early studies in this area, mortality follow-ups will be restricted to this measure for some time. Another potential limitation was the use of self-reported history of CVD to categorise participants. It is possible that this may have resulted in some measurement error, however, previous studies have found self-reported myocardial infarction [48] and stroke [49] to be moderately to highly accurate in determining disease status. In addition, although we adjusted for several potential confounding variables, there may have been others that were unknown or not measured that contributed to the relationships reported. Of particular note are psychosocial factors which have received limited attention [31] such as depression and

loneliness, both of which have been shown to be associated with prolonged TV viewing [31, 32] and, for depression at least has been repeatedly linked with premature death [50]. Further, reverse causality is a possible explanation for our results (e.g. those who are more physically affected by their CVD may sit more because of physical limitations). It should be noted, however, that measures were taken to limit this possibility, such as adjusting the survival models for self-rated health.

Despite these limitations, the present findings have important implications for health care professionals. They highlight the prevalence of excessive TV viewing in people with CVD, particularly amongst older people from lower socioeconomic status backgrounds, and the increased all-cause mortality risk for people with CVD who engage in high TV viewing. Health care professionals can use this information to identify and assist at-risk patients, either in hospital or during cardiac or stroke rehabilitation. Despite the recent introduction of sedentary behaviour guidelines into the general population PA guidelines [51], there are no current guidelines on screening for sedentary behaviour in cardiac or stroke rehabilitation programs, nor is there any recommended inclusion of sedentary behaviour education into the core components of cardiac rehabilitation [52]. The current findings highlight that, in addition to the recommended incidental PA and moderate-vigorous intensity exercise implemented during cardiac rehabilitation, there should be a focus on reducing TV viewing and other passive sedentary behaviours. People with CVD are already at high risk of recurrent events, co-morbidities and early death, therefore excessive TV viewing may be especially deleterious for health outcomes of this at-risk population.

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Table 1. Baseline characteristics according to categories of television (TV) viewing time:
AusDiab cardiovascular disease participants (n=609)

	TV Viewing Time			<i>p</i>
	<2 hours/day (n=250)	2-4 hours/day (n=264)	>4 hours/day (n=95)	
<i>Sociodemographic variables</i>				
Female, n (%)	90 (36.0)	108 (40.9)	43 (45.3)	0.244
Age, y	66.8 (10.2)	68.3 (10.1)	71.0 (8.0)	0.002
Education <12 y n (%)	119 (48.0)	144 (55.0)	65 (69.9)	0.001
Rural (non-capital city) n (%)	116 (40)	126 (43)	52 (18)	0.373
Household income <\$600/week n (%)	165 (68)	203 (79)	77 (83)	0.003
<i>Lifestyle variables</i>				
Current or former smoker n (%)	132 (54)	154 (61)	54 (57)	0.364
Energy intake KJ/d	7316 (3338)	7311 (3083)	7495 (3461)	0.882
Energy intake (alcohol) KJ/d	264(428)	284 (507)	262 (553)	0.877
Dietary Quality Index Score	87.0(14.3)	86.6 (14.0)	84.3 (13.5)	0.288
Leisure time PA (mins/day)	35.5 (43.2)	36.5 (47.2)	27.0 (33.1)	0.179
Sufficient PA (>150 mins/week) n (%)	121 (49)	130 (49)	36 (38)	0.136
<i>Medical history/conditions</i>				
Cardiovascular disease type				0.145
CHD n (%)	150 (60)	148 (56)	46 (48)	
Stroke n (%)	75 (30)	74 (28)	34 (36)	
CHD & Stroke n (%)	25 (10)	42 (16)	15 (16)	
Lipid medication use n (%)	87 (33)	109 (40)	35 (34)	0.218
Diabetes Mellitus ^a n (%)	49 (20)	73 (47)	33 (35)	0.009
Self-rated General Health (SF-36 GH)	43 (10)	43 (10)	40 (10)	0.027
<i>Cardiometabolic variables</i>				
BMI (kg/m ²)	27.3 (4.5)	28.5 (5.1)	27.5 (4.7)	0.017
Waist circumference (cm)	95.9 (12.8)	98.4 (13.3)	96.4 (14.0)	0.081

Systolic Blood Pressure (mm Hg)	139.7 (20.6)	140.4 (21.5)	145.8 (18.9)	0.042
Diastolic Blood Pressure (mm Hg)	72.7 (11.7)	72.0 (12.7)	72.3 (12.3)	0.808
Total Cholesterol (mmol/L)	5.5 (1.1)	5.5 (1.1)	5.4 (1.0)	0.761
HDL-C (mmol/L)	1.4 (0.4)	1.3 (0.4)	1.3 (0.3)	0.498
Triglycerides (mmol/L)	1.7 (1.2)	1.8 (1.0)	2.0 (1.3)	0.091

Data are mean (SD) when appropriate. ^aknown diabetes mellitus. PA=physical activity.

CHD=coronary heart disease. BMI=body mass index. HDL-C=high-density-lipoprotein

Table 2. Association of television (TV) viewing with 13-year mortality status: AusDiab CVD participants (n=609)

	Alive (n=315)		Dead (n=294)		Sig
	n	(%)	n	(%)	
<i>TV viewing (hours/day)</i>					
<2	154	(61.6)	96	(38.4)	< 0.001
2-4	131	(49.6)	133	(50.4)	
>4	30	(31.6)	65	(68.4)	

Table 3. All-cause mortality (hazard ratios: HR) according to categories of television (TV) viewing time: AusDiab CVD participants

	Person -y	Deaths, n	Sex and general health adjusted HR (95% CI)	Multivariate- adjusted HR (95% CI) ^a
<i>TV viewing time</i>				
<2 hours/day (n=250)	2655	96	1 (reference)	1 (reference)
2-4 hours/day (n=264)	2751	133	1.20 (0.92-1.57)	1.18 (0.88-1.57)
≥ 4 hours/day (n=95)	885	65	1.43 (1.04-1.96)	1.52 (1.09-2.13)

*Multivariate models are adjusted for sex, smoking (current or ex-smoker), education level attained (<year 12 or year 12 and higher), household weekly income (<\$600 AUD/week or ≥\$600 AUD/week), body mass index, diabetes mellitus status, high-density-lipoprotein cholesterol, triglycerides, systolic blood pressure, SF-36 General Health, leisure time physical activity (mins/day).

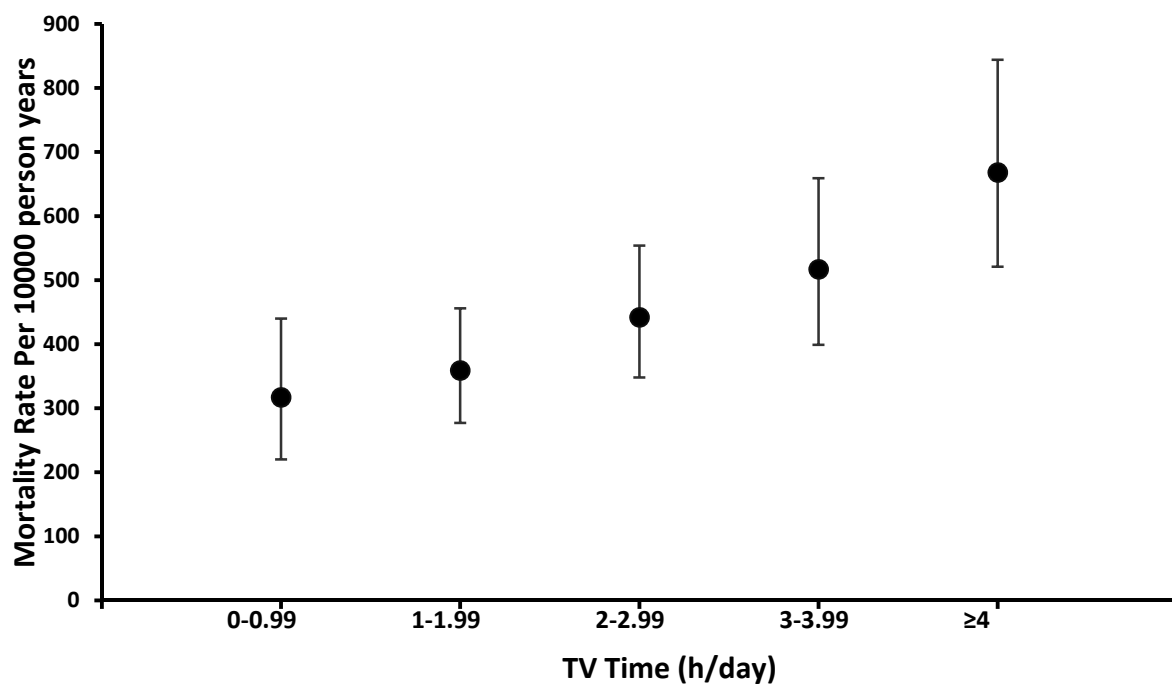


Figure 1.

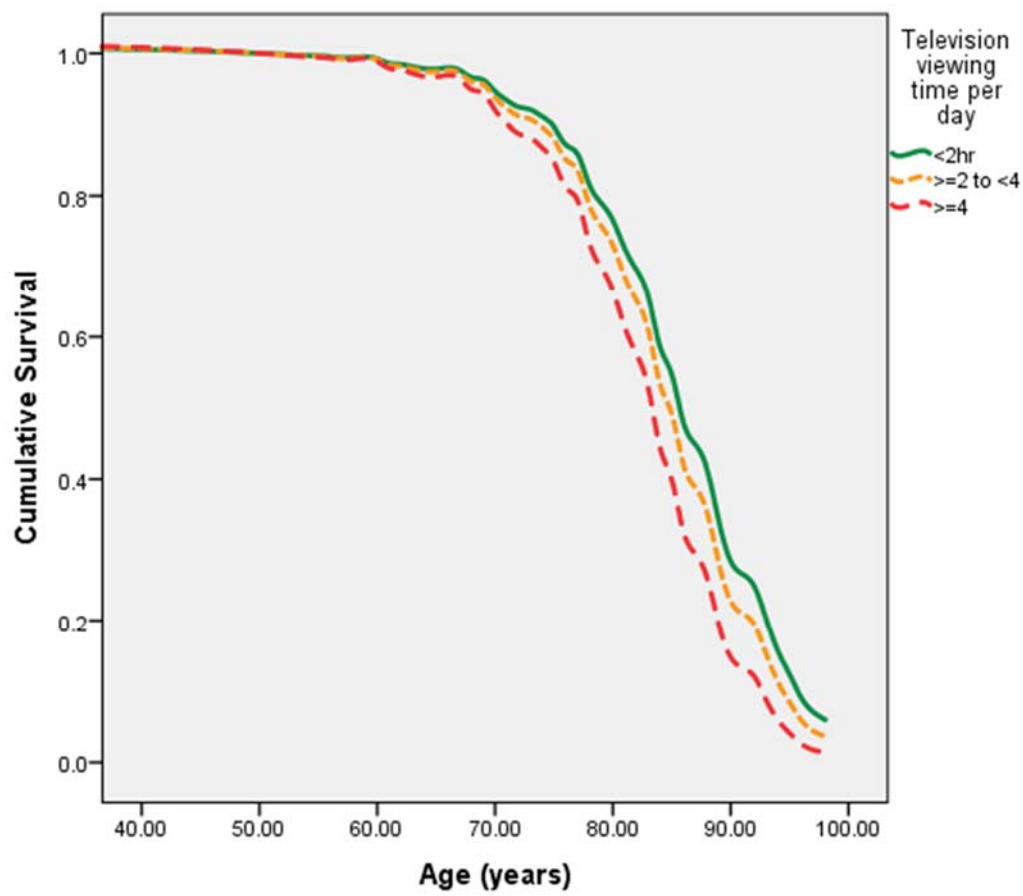


Figure 2.

Figure legends:

Figure 1. Unadjusted all-cause mortality rates (95% CI) per 10 000 person-years by 1-hour increments of TV time (hrs/d) in 609 AusDiab CVD men and women, 1999–2014 (n television categories: 0–0.99: n=90; 1–1.99: n=160; 2–2.99: n=150; 3–3.99: n=114; \geq 4.0 n=95).

Figure 2. Multivariate adjusted survival for all-cause mortality according to TV viewing categories: the AusDiab study CVD participants (n=609).