

# Television Viewing Time and Mortality

## The Australian Diabetes, Obesity and Lifestyle Study (AusDiab)

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**Background**—Television viewing time, the predominant leisure-time sedentary behavior, is associated with biomarkers of cardiometabolic risk, but its relationship with mortality has not been studied. We examined the associations of prolonged television viewing time with all-cause, cardiovascular disease (CVD), cancer, and non-CVD/noncancer mortality in Australian adults.

**Methods and Results**—Television viewing time in relation to subsequent all-cause, CVD, and cancer mortality (median follow-up, 6.6 years) was examined among 8800 adults  $\geq 25$  years of age in the Australian Diabetes, Obesity and Lifestyle Study (AusDiab). During 58 087 person-years of follow-up, there were 284 deaths (87 CVD deaths, 125 cancer deaths). After adjustment for age, sex, waist circumference, and exercise, the hazard ratios for each 1-hour increment in television viewing time per day were 1.11 (95% confidence interval [CI], 1.03 to 1.20) for all-cause mortality, 1.18 (95% CI, 1.03 to 1.35) for CVD mortality, and 1.09 (95% CI, 0.96 to 1.23) for cancer mortality. Compared with a television viewing time of  $< 2$  h/d, the fully adjusted hazard ratios for all-cause mortality were 1.13 (95% CI, 0.87 to 1.36) for  $\geq 2$  to  $< 4$  h/d and 1.46 (95% CI, 1.04 to 2.05) for  $\geq 4$  h/d. For CVD mortality, corresponding hazard ratios were 1.19 (95% CI, 0.72 to 1.99) and 1.80 (95% CI, 1.00 to 3.25). The associations with both cancer mortality and non-CVD/noncancer mortality were not significant.

**Conclusions**—Television viewing time was associated with increased risk of all-cause and CVD mortality. In addition to the promotion of exercise, chronic disease prevention strategies could focus on reducing sitting time, particularly prolonged television viewing. (*Circulation*. 2010;121:384-391.)

**Key Words:** epidemiology ■ exercise ■ lifestyle ■ mortality ■ obesity ■ risk factors

Moderate- to vigorous-intensity exercise has been shown to be consistently associated with reduced risk of premature mortality.<sup>1</sup> However, less is known about the relationships of sedentary behavior (ie, too much sitting, as distinct from too little exercise) with mortality risk. A recent study of Canadian adults found a progressively greater risk of all-cause and cardiovascular, but not cancer, mortality across increasing levels of reported overall sitting time.<sup>2</sup> Another study in Japanese men and women showed all-cause mortality to be elevated in men who reported sitting for  $\geq 8$  h/d relative to those reporting sitting for  $< 3$  h/d; less prolonged sitting durations did not predict mortality risk.<sup>3</sup> High volumes of sitting time ( $\geq 16$  h/d) have also been shown to be positively associated with cardiovascular events (both fatal and nonfatal) in postmenopausal women.<sup>4</sup>

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However, in these studies, sitting time has broadly encompassed the sum of time spent in several sedentary behaviors in

different domains (work, leisure, and transportation). The particular relationship of television viewing time, the predominant leisure-time sedentary behavior in many developed countries,<sup>5-8</sup> with mortality risk has not been examined. Several studies have reported television viewing time to be detrimentally associated with weight gain, type 2 diabetes mellitus, some cancers, abnormal glucose metabolism, the metabolic syndrome, and other cardiovascular risk factors<sup>9-24</sup>; detrimental associations with television viewing have been observed even in those adults who met exercise guidelines.<sup>18</sup> Dose-response relationships have been reported, with moderate associations for at least 2 h/d<sup>9,15,16</sup> and stronger associations for  $\geq 4$  h/d.<sup>9,14</sup> Thus, it is plausible that prolonged television viewing time may be associated with risk of premature mortality. We examined the relationships of prolonged television viewing time with total, cardiovascular disease (CVD), cancer, and non-CVD/noncancer mortality in a national population-based cohort of men and women from the Australian Diabetes, Obesity and Lifestyle Study (AusDiab).

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## Methods

### Study Design and Population

The baseline AusDiab was conducted during 1999 to 2000.<sup>15,25</sup> Briefly, all eligible adults were recruited within 42 randomly selected urban and nonurban areas based on Census Collector Districts, 6 in each of the Australian states and in the Northern Territory of Australia. In total, 28 033 households were approached in the selected clusters. In the 19 215 households where contact was made, 2086 households were considered ineligible. Of the 17 129 eligible households, 5178 households refused to participate in the household survey, and the occupants of an additional 472 households were away from the residence during the survey period; thus, the number of eligible adults living in these 5650 households could not be ascertained. Of the 11 249 households that participated in the household interview, 20 347 adults ( $\geq 25$  years of age) completed the household interview, and 11 247 (55.3%) had a biomedical examination after an overnight fast (minimum, 9 hours), giving an estimated overall response rate of 37%. Measurement procedures have been described previously.<sup>15,25</sup> We excluded those who reported that they had a previous history of CVD (coronary heart disease or stroke;  $n=634$ ). We further excluded those who were pregnant at baseline ( $n=60$ ), did not fast for  $\geq 9$  hours ( $n=25$ ), had missing data on television viewing time ( $n=30$ ), had missing data for exercise time ( $n=73$ ), overreported or underreported total energy intake ( $n=322$ ), had missing data for the variables under consideration ( $n=1296$ ), or could not be matched to the Australian National Death Index (NDI;  $n=7$ ); 8800 remained in the analysis (3846 men, 4954 women). Comparisons of those included with those excluded showed no marked differences in age (50 versus 55 years) or sex (44% versus 49% men). The Ethics Committee of the International Diabetes Institute approved the study, and permission to link the AusDiab cohort to the NDI was provided by the Australian Institute of Health and Welfare Ethics Committee. Written informed consent was obtained from all participants.

### Television Viewing Time

Total time spent watching television or videos in the previous 7 days was reported.<sup>15</sup> This did not include time when the television was switched on but other activities (such as preparing a meal or doing other household chores) were being undertaken concurrently. This measure has been shown to provide a reliable (intraclass correlation=0.82; 95% CI 0.75 to 0.87) and valid (criterion validity=0.3) estimate of television viewing time among adults.<sup>26</sup> Three categories of television viewing time ( $<2$ ,  $\geq 2$  to  $<4$ , and  $\geq 4$  h/d) were created based on previously identified associations with biomarkers of cardiometabolic risk.<sup>14,20,23</sup>

### Other Measures

Demographic attributes, parental history of diabetes mellitus, smoking, highest level of educational attainment, previous history of CVD (self-reported angina, myocardial infarction, or stroke), and lipid medication use were assessed with interviewer-administered questionnaires. Exercise time was measured by the Active Australia questionnaire, which asks respondents about their participation in predominantly leisure-time exercise.<sup>27</sup> This measure has been shown to provide a reliable (intraclass correlation=0.59; 0.52 to 0.65) and valid (criterion validity=0.3) estimate of exercise among adults.<sup>28,29</sup> Dietary intake (usual eating habits over the past 12 months), total energy intake, and energy intake from alcohol were assessed with a self-administered validated food frequency questionnaire.<sup>30</sup> Data were considered valid and included in the analysis if total energy intake was between 500 and 3500 kcal/d for women and 800 and 4000 kcal/d for men.<sup>31</sup> Diet quality was assessed with the Diet Quality Index–Revised dietary assessment tool modified for Australian dietary recommendations.<sup>32,33</sup> Diet quality was reported on a scale of 1 to 100, with 100 being high diet quality.

Oral glucose tolerance tests were performed following World Health Organization specifications.<sup>34</sup> Fasting and 2-hour plasma glucose levels, fasting serum triglycerides, total cholesterol, and high-density-lipoprotein cholesterol (HDL-C) levels were obtained

by enzymatic methods and measured on an Olympus AU600 analyzer (Olympus Optical, Tokyo, Japan). All specimens were analyzed at a central laboratory. Categories of abnormal glucose metabolism were determined according to the 1999 World Health Organization criteria.<sup>35</sup> Waist circumference and triplicate resting blood pressures were measured by trained personnel as reported previously.<sup>25</sup> Hypertension was defined as treatment with blood pressure-lowering medication or blood pressure  $\geq 140/90$  mm Hg.

### Ascertainment of Mortality

Follow-up for mortality was to the date of death or November 16, 2006, whichever occurred first. Mortality status and underlying and contributory causes of death (*International Classification of Diseases*, 10th revision) were determined by linking the AusDiab cohort to the NDI using methods previously described.<sup>36</sup> The accuracy of the NDI has been established.<sup>37</sup> Those who were not matched to the NDI were assumed to be alive. Deaths were attributed to CVD if the underlying cause of death was coded I10-I25, I46.1, I48, I50-I99, or R96 and cancer if coded C00 to D48. In cases when uncomplicated diabetes mellitus (E109, E119, or E149) or unspecified hyperlipidemia (E785) was the underlying cause of death ( $n=6$ ) and the contributory causes of death were coded as I10-I25, I48, or I50-I99 in the first position on the death certificate, CVD was considered the cause of death.

### Statistical Analyses

Analyses were conducted with SPSS version 14.0 (SPSS, Chicago, Ill) and Stata Statistical Software version 10.0 (Stata Corp, College Station, Tex). A bivariate correlation (Spearman  $r$ ) assessed the relationship of leisure-time exercise with television viewing time. For baseline characteristics, age- and sex-adjusted linear and logistic regression models were used to test differences in continuous and dichotomous variables, respectively, according to television viewing time category ( $<2$ ,  $\geq 2$  to  $<4$ , and  $\geq 4$  h/d). Cox proportional-hazards models were used to estimate the hazard ratios (HRs) and 95% confidence intervals (CIs) of all-cause, CVD, cancer, and non-CVD/noncancer mortality according to television viewing time, considered a continuous variable (average hours per day) and as a categorical variable. The assumptions required for proportional hazards were met. They were assessed with graphs of log-log plots of the relative hazards by time and scaled Schoenfeld residuals. For models considering television viewing time as a continuous measure, outliers were identified through the use of plots of the deviance residuals by television viewing time (average hours per day), and the corresponding individuals were excluded ( $n=2$ ). To test whether a linear relationship existed between television viewing time and the mortality outcomes, we used plots of martingale residuals by television viewing time and likelihood ratio tests of a model containing the linear television viewing time term nested within a model also containing the quadratic term for television viewing time that was adjusted for age and sex. Furthermore, unadjusted mortality rates (95% CI) per 1000 person-years according to increments of television viewing time (0, 1, 2, 3, 4, 5, and  $\geq 6$  h/d) were plotted, along with a regression line representing the linear relationship between these increments of television viewing and all-cause, CVD, and non-CVD mortality rates.

Models of the continuous television viewing time measure were initially adjusted for age, sex, leisure-time exercise, and waist circumference, a widely used indirect measure of central adiposity that has previously been shown to be an independent predictor of mortality risk.<sup>38</sup> Thereafter, further adjustment for smoking, education, total energy intake, alcohol intake, Diet Quality Index, hypertension, total cholesterol, HDL-C, serum triglycerides, lipid-lowering medication use, previously reported CVD, and glucose tolerance status was made. Additionally, models of categories of television viewing time were initially adjusted for age and sex, with subsequent models adjusted for all covariates listed above, with and without leisure-time exercise.

We also evaluated whether the effect of television viewing ( $<2$ ,  $\geq 2$  to  $<4$ , and  $\geq 4$  h/d) on all-cause, CVD, cancer, or non-CVD/noncancer mortality was modified by age ( $<65$  or  $\geq 65$  years), sex,

**Table 1. Baseline Characteristics According to Average Hours per Day Spent Watching Television: AusDiab**

|                                    | Television Viewing Time, h/d |                   |               | P for Linear Trend* |
|------------------------------------|------------------------------|-------------------|---------------|---------------------|
|                                    | <2 (n=4970)                  | ≥2 to <4 (n=3158) | ≥4 (n=672)    |                     |
| Men, n (%)                         | 2049 (41)                    | 1478 (47)         | 319 (47)      | <0.001              |
| Age, y                             | 48.5 (12.7)                  | 52.2 (14.4)       | 56.9 (15.3)   | <0.001              |
| Education ≥12 y, n (%)             | 3248 (65)                    | 1612 (51)         | 251 (37)      | <0.001              |
| Lifestyle variables                |                              |                   |               |                     |
| Current or ex-smoker, n (%)        | 2023 (41)                    | 1509 (48)         | 380 (57)      | <0.001              |
| Energy intake (total), kJ/d        | 8245 (2729)                  | 8396 (2833)       | 8311 (2840)   | <0.01               |
| Energy intake (alcohol), kJ/d      | 443 (590)                    | 463 (632)         | 365 (617)     | 0.09                |
| Diet Quality Index, %              | 63.8 (13.2)                  | 62.5 (13.2)       | 60.3 (14.1)   | <0.001              |
| Television viewing time, h/d       | 0.93 (0.5)                   | 2.6 (0.5)         | 5.0 (1.4)     | <0.001              |
| Exercise time, h/d                 | 0.67 (0.8)                   | 0.65 (0.8)        | 0.54 (0.71)   | <0.01               |
| Medical history/conditions, n (%)  |                              |                   |               |                     |
| Hypertension†                      | 1233 (25)                    | 1096 (35)         | 292 (43)      | <0.01               |
| Lipid medication use               | 234 (5)                      | 277 (9)           | 86 (13)       | <0.001              |
| Diagnosed diabetes mellitus‡       | 109 (2)                      | 128 (4)           | 47 (7)        | <0.001              |
| Diagnosed diabetes mellitus >10 y‡ | 28 (1)                       | 26 (1)            | 17 (3)        | 0.02                |
| Cardiometabolic variables          |                              |                   |               |                     |
| Body mass index, kg/m <sup>2</sup> | 26.4 (4.8)                   | 27.2 (4.9)        | 28.3 (5.7)    | <0.001              |
| Waist circumference, cm            | 88.6 (13.6)                  | 92.0 (13.4)       | 95.8 (14.6)   | <0.001              |
| Systolic blood pressure, mm Hg     | 126.4 (17.5)                 | 130.8 (18.7)      | 133.8 (19.7)  | <0.001              |
| Diastolic blood pressure, mm Hg    | 69.5 (11.6)                  | 70.4 (11.7)       | 71.1 (12.0)   | 0.94                |
| Total cholesterol, mmol/L          | 5.6 (1.0)                    | 5.8 (1.1)         | 5.9 (1.1)     | <0.001              |
| HDL-C, mmol/L                      | 1.5 (0.4)                    | 1.4 (0.4)         | 1.4 (0.4)     | <0.001              |
| Triglycerides, mmol/L§             | 1.2 (0.8–1.7)                | 1.3 (0.9–2.0)     | 1.5 (1.1–2.3) | <0.001              |
| Fasting plasma glucose, mmol/L§    | 5.5 (1.0)                    | 5.6 (1.2)         | 5.8 (1.7)     | <0.001              |
| 2-h Plasma glucose, mmol/L§        | 5.6 (4.8–6.8)                | 6.0 (5.0–7.2)     | 6.5 (5.3–8.0) | <0.001              |

Data are mean (SD) when appropriate.

\*Adjusted for age and sex.

†Hypertension defined as blood pressure ≥140/90 mm Hg or taking antihypertensive medication.

‡Diagnosed diabetes mellitus based on self-reported hypoglycemic medication use, a fasting plasma glucose ≥7.0 mmol/L, or a 2-hour plasma glucose level of ≥11.1 mmol/L.

§Data are median (25th to 75th percentiles).

||P for trend based on logarithmic transformation of predicted variables in a regression model.

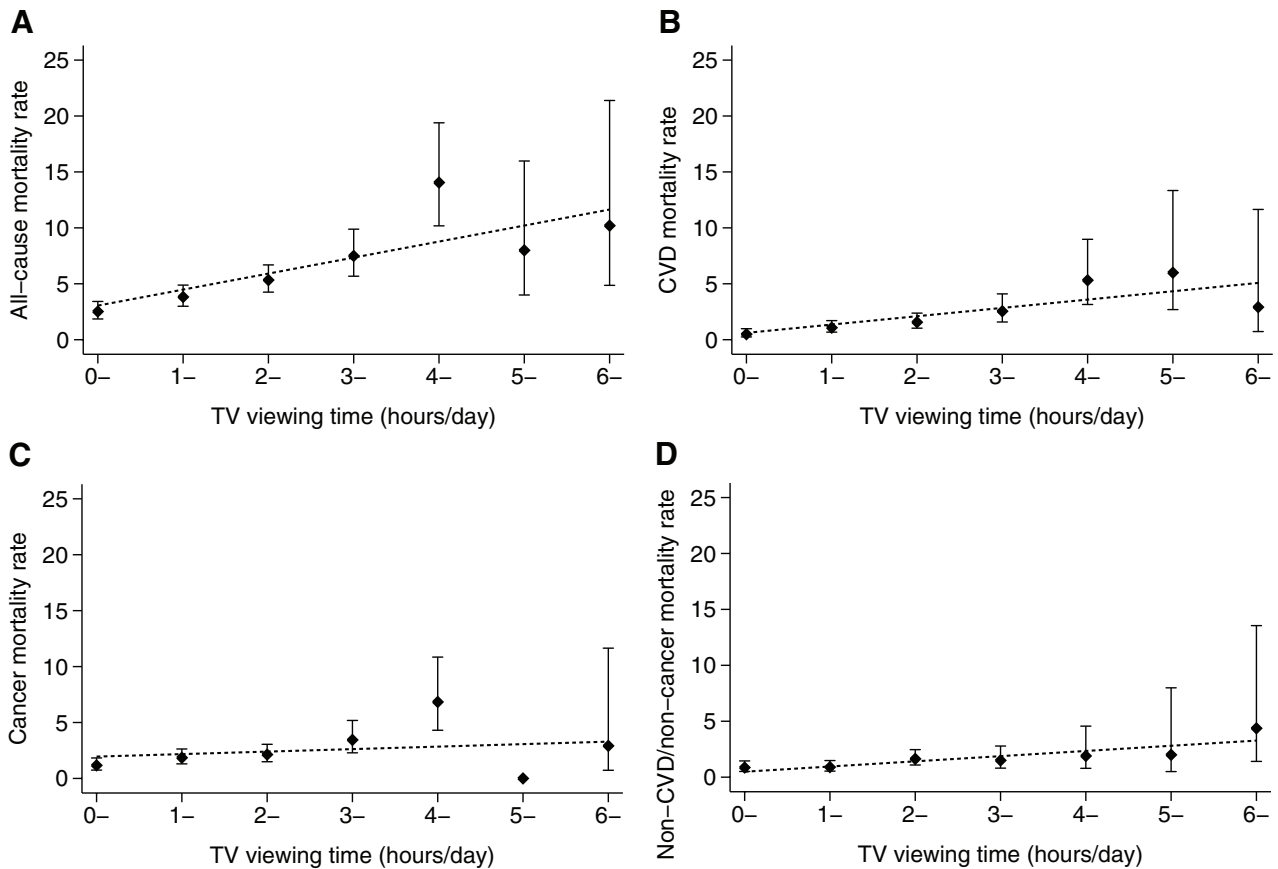
education (<12 or ≥12 years), smoking (current/ex-smoker or nonsmoker), hypertension (blood pressure <140/90 mm Hg or ≥140/90 mm Hg and taking antihypertensive medication), waist circumference (women: <80, 80 to <88, ≥88 cm; men: <94, 94 to <102, ≥102 cm), body mass index (<25, 25 to 29.9 or ≥30 kg/m<sup>2</sup>), glucose tolerance status categories (normal glucose tolerance compared with impaired fasting glucose, impaired glucose tolerance, or diabetes mellitus), or leisure-time exercise (0, >0 to 2.49, ≥2.5 h/wk) by using log-likelihood ratio tests of models containing the variables as single terms nested within models also including the first-order interactions. To account for multiple testing, a stringent significance level of  $P<0.01$  was used to test the addition of the interaction terms to the models.

## Results

Participant characteristics by the 3 television viewing time categories (<2, ≥2 to <4, and ≥4 h/d) are shown in Table 1. Those who spent more time watching television had a more adverse health profile and were less likely to have completed at least 12 years of education. There was a weak but statistically significant correlation between leisure-time exer-

cise and television viewing time (Spearman  $r=-0.03$ ,  $P<0.01$ ).

Over a median follow-up of 6.6 years, 284 deaths occurred. Of these, 87 (31%) were due to CVD, 125 (44%) were due to cancer, and 72 (25%) were non-CVD/noncancer deaths. For all-cause and CVD mortality, there was evidence of a steady progressive rise in the unadjusted mortality rates with each additional hour of television viewing, particularly for television viewing between 0 and 4 h/d. There was a weak relationship between television viewing time and cancer and noncancer/non-CVD mortality (the Figure). Adding a quadratic term for television viewing time to a model with television viewing time, age, and sex did not significantly improve the prediction of all-cause mortality ( $P=0.64$ ), CVD mortality ( $P=0.78$ ), cancer mortality ( $P=0.67$ ), or non-CVD/noncancer mortality ( $P=0.32$ ), thus indicating that the relationship between television viewing time and mortality outcomes was linear. Television viewing time remained significantly associated with both all-cause (HR per 1 h/d,



**Figure.** Unadjusted all-cause (A), CVD (B), cancer (C), and non-CVD/noncancer (D) mortality rates per 1000 person-years according to television (TV) viewing time (h/d). Dashed line presents the linear relationship between increments of television viewing time and all-cause, CVD, cancer, and non-CVD/noncancer mortality rates. Number of people in each television viewing category was as follows: 0 h/d, 2442;  $\geq 1$  h/d, 2528;  $\geq 2$  h/d, 2138;  $\geq 3$  h/d, 1020;  $\geq 4$  h/d, 407;  $\geq 5$  h/d, 155; and  $\geq 6$  h/d, 108.

1.11; 95% CI, 1.03 to 1.20) and CVD mortality (HR per 1 h/d, 1.18; 95% CI, 1.03 to 1.35) after adjustment for age, sex, leisure-time exercise, and waist circumference but not with cancer mortality (HR, 1.09; 95% CI, 0.96 to 1.23) or non-CVD/noncancer mortality (HR, 1.08; 95% CI, 0.92 to 1.27). Further adjustment for all other covariates attenuated the relationship between television viewing time and all-cause mortality (HR, 1.08; 95% CI, 1.00 to 1.17), CVD mortality (HR, 1.14; 95% CI, 0.99 to 1.30), cancer mortality (HR, 1.06; 95% CI, 0.93 to 1.20), and non-CVD/noncancer mortality (HR, 1.04; 95% CI, 0.89 to 1.22); however, the association with all-cause mortality remained, albeit at a borderline level of significance ( $P=0.048$ ).

Compared with 0 to  $<2.0$  h/d of television viewing, the age- and sex-adjusted HRs for  $\geq 2$  to  $<4$  h/d and for  $\geq 4$  h/d were 1.20 and 1.67 for all-cause mortality, 1.24 and 2.12 for CVD mortality, and 1.18 and 1.68 for cancer mortality (Table 2). Except for cancer mortality, these associations remained significant for all-cause mortality ( $P=0.03$ ) and showed borderline significance for CVD mortality ( $P=0.05$ ) for the highest television viewing time category ( $\geq 4$  h/d) after adjustments for other covariates, including exercise and waist circumference. Similar results were found when this model was reanalyzed with body mass index instead of waist circumference (data not shown).

To minimize potential bias caused by the influence of subclinical disease on the television viewing level, we further examined the associations after excluding individuals who died within the first, second, third, and fourth years of follow-up. In general, the strength and direction of the association of television viewing time with all-cause and CVD mortality were comparable to the original associations shown in Table 2. In age- and sex-adjusted models, the HRs for all-cause and CVD mortality for the highest television viewing category ( $\geq 4$  h/d) after exclusion of the 26 people who died during the first year of follow-up were 1.84 (95% CI, 1.30 to 2.61) and 2.09 (95% CI, 1.13 to 3.80), respectively; 1.80 (95% CI, 1.24 to 2.64) and 1.98 (95% CI, 1.00 to 3.95) after exclusion of the 69 who died before the end of the second year of follow-up; 1.49 (95% CI, 0.97 to 2.28) and 1.94 (95% CI, 0.94 to 4.02) after exclusion of the 103 who died before the end of the third year of follow-up; and 1.69 (95% CI, 1.07 to 2.68) and 2.53 (95% CI, 1.13 to 5.67) after exclusion of the 134 people who died before the end of the fourth year of follow-up. Interaction tests showed that age, sex, education, smoking, hypertension, waist circumference, body mass index, glucose tolerance status, and leisure-time exercise did not significantly ( $P>0.01$  for all factors) modify the associations between television viewing and all-cause, CVD, cancer, or non-CVD/noncancer mortality.



**Table 2. Risk of All-Cause, Cardiovascular, Cancer, and Non-Cardiovascular/Noncancer Mortality According to Categories of Television Viewing Time: AusDiab**

|  | Television Viewing Time, h/d |                  |                  |
|--|------------------------------|------------------|------------------|
|  | <2                           | ≥2 to <4         | ≥4               |
| Person-y   | 33 024                       | 20 737           | 4326             |
| Mortality from any cause   |                              |                  |                  |
| Deaths, n  | 105                          | 125              | 54               |
| Age- and sex-adjusted HR (95% CI)  | 1 (Reference)                | 1.20 (0.92–1.56) | 1.67 (1.20–2.33) |
| HR (95% CI) adjusted for age, sex, education, smoking, alcohol, and diet quality | 1 (Reference)                | 1.17 (0.90–1.52) | 1.49 (1.06–2.08) |
| Multivariate-adjusted HR (95% CI)*   | 1 (Reference)                | 1.14 (0.87–1.48) | 1.49 (1.06–2.09) |
| Multivariate- and exercise time-adjusted HR (95% CI)*                            | 1 (Reference)                | 1.13 (0.87–1.36) | 1.46 (1.04–2.05) |
| Mortality from cardiovascular disease  |                              |                  |                  |
| Deaths, n  | 26                           | 39               | 22               |
| Age- and sex-adjusted HR (95% CI)  | 1 (Reference)                | 1.24 (0.75–2.05) | 2.12 (1.20–3.77) |
| HR (95% CI) adjusted for age, sex, education, smoking, alcohol, and diet quality | 1 (Reference)                | 1.22 (0.74–2.03) | 1.78 (1.01–3.22) |
| Multivariate-adjusted HR (95% CI)*   | 1 (Reference)                | 1.20 (0.72–2.00) | 1.85 (1.03–3.33) |
| Multivariate- and exercise time-adjusted HR (95% CI)*                            | 1 (Reference)                | 1.19 (0.72–1.99) | 1.80 (1.00–3.25) |
| Mortality from cancer causes   |                              |                  |                  |
| Deaths, n  | 50                           | 53               | 22               |
| Age- and sex-adjusted HR (95% CI)  | 1 (Reference)                | 1.18 (0.80–1.76) | 1.68 (1.00–2.80) |
| HR (95% CI) adjusted for age, sex, education, smoking, alcohol, and diet quality | 1 (Reference)                | 1.15 (0.77–1.69) | 1.53 (0.91–2.56) |
| Multivariate-adjusted HR (95% CI)*   | 1 (Reference)                | 1.12 (0.75–1.66) | 1.50 (0.89–2.52) |
| Multivariate- and exercise time-adjusted HR (95% CI)*                            | 1 (Reference)                | 1.12 (0.75–1.66) | 1.48 (0.88–2.49) |
| Mortality from noncardiovascular and noncancer causes                            |                              |                  |                  |
| Deaths, n  | 29                           | 33               | 10               |
| Age- and sex-adjusted HR (95% CI)  | 1 (Reference)                | 1.18 (0.71–1.96) | 1.18 (0.57–2.45) |
| HR (95% CI) adjusted for age, sex, education, smoking, alcohol, and diet quality | 1 (Reference)                | 1.15 (0.70–1.91) | 1.04 (0.50–2.17) |
| Multivariate-adjusted HR (95% CI)*   | 1 (Reference)                | 1.13 (0.68–1.88) | 1.03 (0.49–2.16) |
| Multivariate- and exercise time-adjusted HR (95% CI)*                            | 1 (Reference)                | 1.12 (0.67–1.87) | 1.03 (0.49–2.15) |

\*Multivariate models are adjusted for age, sex, smoking (current or ex-smoker), education (≥12 years), total energy intake, alcohol intake, Diet Quality Index, waist circumference, hypertension (blood pressure ≥140/90 mm Hg or antihypertensive medication use), total plasma cholesterol (mmol/L), HDL-C (mmol/L), serum triglycerides (mmol/L, log), lipid-lowering medication use, and glucose tolerance status (impaired fasting glucose, impaired glucose tolerance, undiagnosed diabetes mellitus, known diabetes mellitus according to 1999 World Health Organization criteria<sup>34</sup>).

## Discussion

These novel findings from a large population-based cohort of Australian men and women indicate that prolonged television viewing time is associated with an increased risk of all-cause and CVD mortality. Each 1-hour increment in television viewing time was found to be associated with an 11% and an 18% increased risk of all-cause and CVD mortality, respectively. Furthermore, relative to those watching less television (<2 h/d), there was a 46% increased risk of all-cause and an 80% increased risk of CVD mortality in those watching ≥4 hours of television per day, which were independent of traditional risk factors such as smoking, blood pressure, cholesterol, and diet, as well as leisure-time exercise and waist circumference.

Insufficient moderate- to vigorous-intensity exercise has long been recognized as a predictor of chronic disease and premature death.<sup>1</sup> However, until recently, the relationship between too

much sitting and mortality had not been investigated. The HR observed for all-cause mortality with high television viewing (>4 h/d) in our study (1.46) is similar in magnitude to that reported for the highest category of sitting (“almost all the time”) in a Canadian population (HR, 1.54).<sup>2</sup> Furthermore, the HR observed for high television viewing time in our study for CVD mortality (1.80) is comparable to that reported in Canadian adults (HR, 1.42) and concurs with findings from a cohort study of postmenopausal women in the United States in which a high level of sitting (≥16 h/d) was a predictor of fatal and nonfatal CVD.<sup>4</sup> The nonsignificant association with high television viewing time and cancer mortality in multivariate-adjusted models observed in our cohort is consistent with the findings observed for sitting time in Canadian adults.<sup>2</sup>

Television viewing time is one of several common behaviors that involve prolonged sitting.<sup>26</sup> Recent time-use surveys from Australia, the United States, and the United Kingdom

indicate that, aside from sleeping, watching television is the behavior that occupies the most time in the domestic setting.<sup>5,7,8</sup> Our findings indicate that, regardless of leisure-time exercise levels and adiposity status, there is a progressive rise in mortality risk for each 1-hour increment in television viewing. From a public health perspective, the increased risk of all-cause and CVD mortality associated with watching television  $\geq 4$  h/d observed in this Australian cohort may have important implications in Australia and elsewhere, because recent estimates indicate that the average television viewing time is  $\approx 3$  hours in both Australia and the United Kingdom and is up to 8 hours in the United States.<sup>39</sup> Furthermore, a recent large population-based study of Scottish adults reported that the average television viewing and other screen-based entertainment time was 3.6 h/d in men and 3.2 h/d in women, with a strong social gradient; on average, those in the lowest socioeconomic position spent an additional 1.8 h/d on screen-based entertainment compared with those in the highest socioeconomic position.<sup>40</sup>

For exercise, the physiological mechanisms underlying the risk of premature mortality are suspected to involve biological, structural, and systemic effects on glucose homeostasis and other metabolic pathways of CVD risk.<sup>41</sup> Less is known about the mechanisms that might underlie the cardiometabolic correlates of sedentary behavior that we<sup>12,14–16,23,42</sup> and others<sup>9,13,17,19–22,24</sup> have identified. Observational studies with objective measures of sedentary time have reported significant associations of total sedentary time with blood glucose, blood lipids, and adiposity that are independent of moderate to vigorous exercise.<sup>42,43</sup> Animal studies have found enforced sedentary time to be related to lipoprotein lipase activity.<sup>44,45</sup> Our findings broadly support these hypothesized physiological links; we found that television viewing time was a significant predictor of CVD rather than non-CVD mortality.

Increased caloric intake and reduced energy expenditure are the most commonly proposed mechanisms for explaining the relationship between television viewing time and health outcomes. Increased snacking has been associated with high levels of television viewing time and increased adiposity.<sup>46</sup> Although in this cohort those with high volumes of television viewing time had poorer dietary profiles, the association between television viewing time and mortality was independent of diet quality and energy intake. Television viewing time could displace exercise time and thus contribute to reductions in overall daily energy expenditure. However, we<sup>15,18</sup> and others<sup>20</sup> have previously shown that television viewing time and moderate- to vigorous-intensity leisure-time exercise are only weakly correlated. It is possible, however, that television viewing time significantly displaces light-intensity physical activity, which has been shown to be beneficially associated with cardiometabolic risk markers, including 2-hour postchallenge blood glucose.<sup>43</sup>

Strengths of our study include the recruitment of a national sample of participants, the large size and wide age range of the cohort, and the objective measurement of key CVD risk factors. Limitations include the assessment of a single sedentary behavior (television viewing time), although this has been shown to be a reasonable proxy measure of an overall sedentary behavior pattern.<sup>47</sup> The television viewing measure

was based on self-report; this may have led to some misclassification and regression dilution bias. However, any imprecision in the measurement is likely to have resulted in an underestimation of the strength of associations. Additionally, having only a baseline assessment of television viewing time and exercise time precluded the assessment of any changes in these behaviors during the follow-up period that could have influenced the relationships with mortality. Although we adjusted for several potential confounding variables, it is possible that other unmeasured or unknown confounding factors may have accounted for the associations that we have reported. Reverse causality, whereby diagnosed or undiagnosed illness at study induction may have been responsible for elevated television viewing time, cannot be ruled out. However, we excluded individuals who reported a previous history of CVD and adjusted for baseline health status in our models. Moreover, the findings were comparable after the exclusion of deaths occurring within the first, second, third, and fourth years of follow-up.

## Conclusions

These findings indicate that television viewing time is associated with an increased risk of all-cause and CVD mortality. Although continued emphasis on current public health guidelines on the importance of moderate- to vigorous-intensity exercise should remain, our findings suggest that reducing time spent watching television (and possibly other prolonged sedentary behaviors) may also be of benefit in preventing CVD and premature death.

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## Disclosures

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### CLINICAL PERSPECTIVE

The findings from this large, national population-based cohort study indicate that 6-year mortality rates from all causes and from cardiovascular disease causes are significantly higher with increased television viewing time in adults. Each 1-hour increment in television viewing time was found to be associated with an 11% and an 18% increased risk of all-cause and cardiovascular disease mortality, respectively. Furthermore, relative to those watching less television (<2 h/d), there was a 46% increased risk of all-cause and an 80% increased risk of cardiovascular disease mortality in those watching  $\geq 4$  hours of television per day, which were independent of traditional risk factors such as smoking, blood pressure, cholesterol, and diet, as well as leisure-time exercise and waist circumference. Although continued emphasis on current public health guidelines on the importance of moderate- to vigorous-intensity exercise should remain, these findings suggest that reducing time spent watching television (and possibly other prolonged sedentary behaviors) may also be of benefit in preventing cardiovascular disease and premature death. Furthermore, these findings suggest that in clinical practice and public health settings, questions about television viewing time (particularly identifying whether individuals watch  $>4$  h/d) may assist in identifying those with elevated mortality risk.



## Television Viewing Time and Mortality: The Australian Diabetes, Obesity and Lifestyle Study (AusDiab)

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