Television Viewing Time and Stroke Risk: Australian Diabetes Obesity and Lifestyle Study (1999-2012)

Toby B. Cumming, PhD, BBSc (Hons),[*,†] Elizabeth Holliday, PhD, MStat, BSc (Hons),[‡,§] David Dunstan, PhD, BAppSc (Hons),[¶,‖] and Coralie English, PhD, BAppSc (Hons)[†,§,#]

Introduction: Having a low level of physical activity is an established risk factor for stroke, but little is known about the importance of common sedentary behavior—television viewing—to stroke risk. *Methods:* We conducted a retrospective analysis of data that were collected as part of the longitudinal Australian Diabetes, Obesity, and Lifestyle study. Stroke events reported during the study (between baseline assessment in 1999-2000 and April 2011) were confirmed using adjudication based on medical records. Baseline data on minutes per week spent watching television were used as the exposure variable. Other variables were collected in assessments at wave 2 (2004-05) and wave 3 (2011-2012). Univariable and multivariable logistic regression analyses were performed. *Results:* Among the full Australian Diabetes, Obesity, and Lifestyle study population (n = 11,247), there were 153 participants with confirmed stroke during the study period, and 9207 participants with no stroke in this period. Participants who went on to have their first stroke during the study had significantly higher levels of TV viewing time at baseline than those who did not have a stroke (P = .001). This association was not present (P = .83), however, when age and sex were included in the regression model. *Conclusion:* In the Australian Diabetes, Obesity, and Lifestyle study dataset, there was no evidence that more TV viewing is independently associated with risk of stroke, although analyses may have been underpowered.

Key Words: Cerebrovascular disease—stroke—sedentary behavior—physical activity—exercise

Introduction

Insufficient physical activity is a potent risk factor for stroke.[1] Hu et al[2] reported adjusted hazard ratios for stroke associated with moderate and high leisure-time physical activity—versus low—of 0.86 and 0.74 (P_{trend} < .001). The link between physical inactivity and stroke has serious implications: with a population attributable risk of 16%, $US 2.0 billion of the 10.6 billion total cost of stroke in China in 2007 was attributed to inactivity.[3] In formal stroke prevention guidelines, promotion of increased physical activity and implementation of exercise training are key components of a comprehensive stroke risk reduction

From the *Florey Institute of Neuroscience and Mental Health, University of Melbourne, Australia; †Centre of Research Excellence in Stroke Rehabilitation and Brain Recovery, Australia; ‡School of Medicine and Public Health, University of Newcastle, Newcastle, Australia; §Priority Research Centre for Stroke and Brain Injury, University of Newcastle, Newcastle, Australia; ¶Baker Heart and Diabetes Institute, Melbourne, Australia; ‖Mary MacKillop Institute for Health Research, Australian Catholic University, Melbourne, Australia; and #School of Health Sciences, University of Newcastle, Callaghan, Australia.

Received September 17, 2018; revision received December 5, 2018; accepted December 14, 2018.

Financial Disclosure: English was supported by National Heart Foundation Future Leaders Fellowship (#101177). Dunstan was supported by an NHMRC Senior Research Fellowship (NHMRC #1078360). The Baker Institute acknowledges the Victorian State Government's Operational Infrastructure Support Program. The funding sources played no role in the study design, data collection, analysis or preparation of this paper.

Address correspondence to Coralie English, Priority Research Centre for Stroke and Brain Injury, University of Newcastle, University Drive, Callaghan, NSW 2308, Australia. E-mail: Toby.Cumming@florey.edu.au

1052-3057/$ - see front matter

https://doi.org/10.1016/j.jstrokecerebrovasdis.2018.12.020

strategy.[4] It is now accepted that sedentary behavior and physical activity or exercise are not 2 poles of the same continuum; people can have low levels of both, just as they can have high levels of both. Too much time spent sitting is an important additional risk factor for all-cause mortality[5] and, more specifically, for cardiovascular disease.[6] Yet the relationship between sitting time and stroke risk specifically is less clear with data largely confined to just 3 longitudinal studies.[7-9] In each of these studies, TV viewing was used as a proxy measure of sitting time. While objective, device-based measures of sitting time are clearly preferable, they are not always possible in large epidemiological studies. In a recent comparison of 18 different self-report tools with device-measured sitting time, TV viewing time outperformed all other self-report measures.[10] Therefore, where device-based data are not available, TV viewing time is the most appropriate proxy measure.

McDonnell et al[7] analyzed data from the 22,257 participants in the REGARDS longitudinal study who reported the amount of time per day they spent watching television (TV) at baseline. In this dataset over a mean of 7 years follow-up, 727 stroke events occurred. Those in the ≥4 h/day group were more likely to have a stroke than those in the <2 h/day group, adjusting for demographics such as age, race, sex and region (HR = 1.37, 95% CI 1.10-1.71). Further adjustment for education and income attenuated this effect (HR = 1.21, 95% CI 0.96-1.53), and additional adjustment for physical activity, general health, marital and employment status, and depressive symptoms attenuated it further (HR = 1.14, 95% CI 0.88-1.48). In a Japanese study, 85,899 participants (aged 40-79, without a history of cardiovascular disease or cancer) were monitored for 2 decades, during which time there were 2553 deaths from stroke.[8] Compared to those in the <2 h/day of TV group, those in the ≥6 h/day group were at higher risk of stroke death, adjusting for age and sex (HR = 1.20, 95% CI 1.00-1.43). Further adjustment for body mass index (BMI), smoking, physical activity, sleep, employment, and depressive symptoms attenuated this effect (HR = 1.15, 95% CI 0.96-1.37), and additional adjustment for history of hypertension and diabetes attenuated it further (HR = 1.10, 95% CI 0.92-1.32). Rather than relying on TV viewing time, Chomistek et al[9] ascertained hours per day spent sitting via self-report. They analyzed data from 71,018 women (aged 50-79, without a history of cardiovascular disease) at baseline (1993-1998), following them up to 2010. Those in the ≥10 h/day group were more likely to suffer a stroke than those in the ≤5 h/day group, adjusting for age (HR = 1.28, 95% CI 1.14-1.55). Further adjustment for physical activity, demographics, and lifestyle risk factors attenuated this effect, but it remained significant (HR = 1.21, 95% CI 1.07-1.37).

These studies illustrate the difficulty of disentangling the variables that are related to both TV viewing and stroke risk. Greater amounts of sitting time and prolonged sitting time are independently associated with BMI, waist circumference, high-density-lipoprotein cholesterol, and triglycerides,[11] factors that are also linked to vascular risk. The array of inter-relationships are likely to be culturally specific. Little is known about the association between sitting time and stroke risk in an Australian context. In this study, we aimed to examine the association between TV viewing time and stroke risk in a population of Australian adults.

Methods

Study Design

The Australian Diabetes, Obesity, and Lifestyle Study (AusDiab) featured a national population-based cohort of men and women. All eligible adults were recruited from within 42 randomly selected urban and nonurban areas (6 in each state and 6 in the Northern Territory) that were based on Census Collector Districts. Baseline data collection (termed "wave 1") took place between May 1999 and December 2000. Measurement procedures have been described previously.[12] Follow-up assessments took place between June 2004 and December 2005 (wave 2) and again between August 2011 and June 2012 (wave 3). Ethical approval was granted by the International Diabetes Institute and written informed consent was obtained from all participants. The Australian Institute of Health and Welfare Ethics Committee gave permission to link the AusDiab cohort to the National Death Index. Ethical approval for the analyses contained in this paper was provided by the Alfred Hospital Ethics Committee and University of Newcastle Human Research Ethics Committee.

Population

In total, 28,033 households were approached, and contact was made with 19,215. With 2086 considered ineligible, there were 17,129 eligible households. Of these, 5178 households refused to participate and others could not be included for other reasons (e.g., away from the residence at the time of assessment). From the 11,249 households that participated in the household interview, there were 11,247 adults (≥25 years old) who had a baseline assessment and biomedical examination (after an overnight fast of ≥9 hours). Follow-up assessments were conducted with 6400 participants in wave 2 and 4614 participants in wave 3.

Quantifying TV Viewing Time

Total time spent watching TV or videos in the previous 7 days was reported at each of the 3 waves.[13] This excluded time that the TV was on but other activities (e.g., preparing a meal) were being undertaken concurrently. This self-report measure provides a reliable estimate of TV viewing time in adults (intraclass correlation = 0.82, 95% CI 0.75-0.87).[14]

Stroke Ascertainment

Assessment at each of the 3 waves included the yes or no question: "Have you ever been told that you have had

a stroke?" Stroke events taking place between baseline and April 2011 were confirmed using a rigorous process—medical records were obtained from the relevant hospitals—just prior to the wave 3 assessments. Possible outcomes included: (1) stroke, (2) no stroke, (3) died (but no data on the cause from the National Death Index), (4) unable to adjudicate, or (5) did not complete the yes or no question. This approach to the adjudication of cardiovascular disease events has been validated in an Australian sample.[15] To differentiate between participants with and without a history of stroke prior to the AusDiab study period, we relied on self-report responses to the stroke yes-or-no question at baseline (there was no adjudication of previous stroke events).

Other Outcome Measures

Demographic characteristics were recorded, including age, sex, educational attainment, and employment status. Smoking status and lipid-lowering medication use were established. Total energy intake, and energy intake from alcohol were assessed with a self-administered, validated food frequency questionnaire.[16] Diet quality was evaluated with the Diet Quality Index−Revised dietary assessment tool, modified for Australian dietary recommendations, with a scale of 1-100, where 100 is the highest quality.[17] Exercise time was measured by the Active Australia questionnaire, which asks respondents about their participation in predominantly leisure-time exercise.[18] This tool has been shown to provide a reliable estimate of exercise among adults (intraclass correlation = 0.59, 95% CI 0.52-0.65).[19] Waist circumference, BMI, and triplicate resting blood pressures were measured by trained personnel. Hypertension was defined as blood pressure ≥140/90 mmHg or treatment with blood pressure lowering medication. Oral glucose tolerance tests were performed following World Health Organization specifications.[20] Fasting and 2-hour plasma glucose levels, fasting serum triglycerides, total cholesterol, and high-density-lipoprotein cholesterol levels were obtained by enzymatic methods, measured on an Olympus AU600 analyzer (Olympus Optical, Tokyo, Japan). All specimens were analyzed at a central laboratory.

Statistical Analyses

A univariable logistic regression model was used to assess the crude association between TV viewing time at baseline and stroke outcome during follow-up. Subsequent multivariable logistic regression models also included: (1) age and sex, and (2) age, sex, education, smoking status, alcohol intake, and diet quality. Following these primary analyses, 2 different types of sensitivity analyses were conducted. First, analysis was repeated with all potential strokes included rather than only adjudicated events. Second, analysis was repeated with categorical rather than continuous TV viewing time data. In order to confirm our findings, we matched nonstroke "controls" to the stroke cases on the central variables of age, sex, and systolic blood pressure (as a proxy for general vascular risk). We extracted matched case-control sub-samples from the AusDiab cohort at a 1:1 ratio (126 strokes and 126 nonstrokes), and used Mann-Whitney *U* tests to compare cases to controls on weekly sedentary time (i.e., TV viewing) and exercise time. We attempted to match a higher ratio of controls, but, despite the large cohort, were not able to balance the groups on age with any more than 1:1. Finally, we moved beyond using TV viewing time alone as the independent variable and incorporated information on exercise alongside it. Four groups were derived using median splits on the baseline TV time and exercise time data: (1) low TV, high exercise; (2) low TV, low exercise; (3) high TV, high exercise; (4) high TV, low exercise. Logistic regression analyses were conducted to determine whether the 2 extreme exposure groups (1 and 4) differed on stroke outcome.

Results

Adjudicated data on stroke outcome indicated that there were 153 participants with confirmed stroke during the AusDiab study period, and 9207 participants with no stroke in the study period (see Fig 1). These data were combined with data on previous stroke to derive 4 "stroke status" groups. Of the 153 participants with a stroke during the study period, 23 had prior stroke and 126 did not (4 had missing data). Of the 9207 participants with no stroke during the study period, 164 had prior stroke and 8978 did not (65 had missing data).

Table 1 outlines the characteristics of participants who had first stroke during the study and participants who were stroke-free. The amount of time, in minutes per week, spent watching TV at baseline in each of the different stroke status groups is shown in Figure 2.

The primary analysis of interest was to take those with no prior stroke and compare participants who had a stroke during AusDiab (n = 126) with those who did not (n = 8978). Those who went on to have stroke reported a median of 840 minutes per week (IQR 450-1260) of TV time at baseline, compared with a median of 690 minutes per week (IQR 360-1080) in those who remained stroke-free. Univariable logistic regression indicated that TV minutes per day at baseline was significantly associated with stroke outcome (odds ratio [OR] = 1.003, 95% CI 1.001-1.005; $P = .001$), though this association was extinguished in models that adjusted for (1) age and sex (OR = 1.000, 95% CI 0.998-1.002; $P = .83$), and (2) age, sex, education, smoking status, alcohol intake, and diet quality (OR = 1.000, 95% CI 0.997-1.002; $P = .87$). Full regression results are outlined in Table 2.

Participants who had stroke were older than those who did not (mean 67.4 years versus 50.7), and age was positively correlated with TV viewing time (Spearman's r = 0.19, $P < .001$). Men were more likely to have stroke

Figure 1. *Participant flowchart of stroke outcome.*

during the study [74/4036 (1.8%) men versus 52/5068 (1.0%) women] and watched more TV than women (Mann-Whitney $U = 14\,022\,993$, $Z = -8.1$; $P < .001$). Interestingly, those with stroke during the study drank less alcohol at baseline than those without stroke (Mann-Whitney $U = 369{,}709$, $Z = -4.17$; $P < .001$).

Sensitivity Analyses

In the first sensitivity analysis, we included all participants with stroke during the study, adjudicated or unadjudicated, regardless of stroke history. This meant there were 198 cases (153 with confirmed stroke, plus the 45 with positive responses to the self-report question that were unable to be adjudicated). The comparison group was the 9207 without stroke during the study. Results were similar. Univariable logistic regression revealed a significant association between baseline TV minutes per day and stroke outcome (OR = 1.003, 95% CI 1.002-1.004; $P < .001$). Adjusting for age (OR = 1.096, 95% CI 1.082-1.109; $P < .001$) and sex (OR = 1.577, 95% CI 1.175-2.116; $P = .002$) extinguished the association with TV minutes per day (OR = 1.000, 95% CI 0.999-1.002; $P = .62$). For the second sensitivity analysis, we split TV viewing time data into 4 categories ($\leq$1 h/day, >1 and $\leq$2 h/day, >2 and $\leq$3 h/day, >3 h/day). Using logistic regression adjusted

Table 1. *Baseline characteristics of participants who had first stroke during the study and those with no stroke (means and standard deviations or N and percentage)*

	First stroke in study (n = 126)	No stroke (n = 8978)
Age	67.4 (13.0)	50.7 (13.4)
Sex, male	74 (59%)	3962 (44%)
Education, completed high school	51 (40%)	5215 (58%)
SF36 - Physical component	43.7 (10.6)	49.9 (8.8)
Mental component	49.0 (10.7)	49.0 (9.7)
Smoking - current	19 (15%)	1277 (14%)
Ex-smoker	49 (39%)	2539 (29%)
Exercise group - sufficient	57 (45%)	4744 (53%)
Insufficient	40 (32%)	2744 (31%)
Sedentary	29 (23%)	1471 (16%)
Exercise time, mins	262 (336)	278 (331)
TV viewing time, mins	928 (603)	765 (564)
BMI	27.1 (4.5)	26.9 (4.9)
Diet guideline index	86.1 (13.5)	84.2 (14.3)
Energy, kJ/day (total)	7959 (2988)	8642 (3511)
Energy, kJ/day (alcohol only)	299 (534)	455 (617)
Systolic BP	143.1 (19.6)	128.6 (18.1)
Diastolic BP	73.6 (13.7)	70.1 (11.6)
Fasting glucose	6.00 (1.61)	5.56 (1.13)
Post-load glucose	7.14 (3.10)	6.24 (2.28)
Cholesterol	5.79 (1.08)	5.66 (1.07)
HDL	1.33 (0.39)	1.43 (0.38)
LDL	3.70 (0.95)	3.53 (0.93)
Triglycerides	1.77 (1.12)	1.53 (1.06)

Abbreviations: BMI, Body Mass Index; BP, blood pressure; HDL, high-density lipoprotein; LDL, low-density lipoprotein; SF36, Short-Form Health Survey 36 item.

for age and sex, we found no significant difference between the >3 h/day and the ≤1 h/day groups in stroke outcome (OR = 0.715, 95% CI 0.410-1.247; P = .24).

Case-control Matching

Given the markedly different profile of stroke and non-stroke participants in terms of baseline characteristics, in

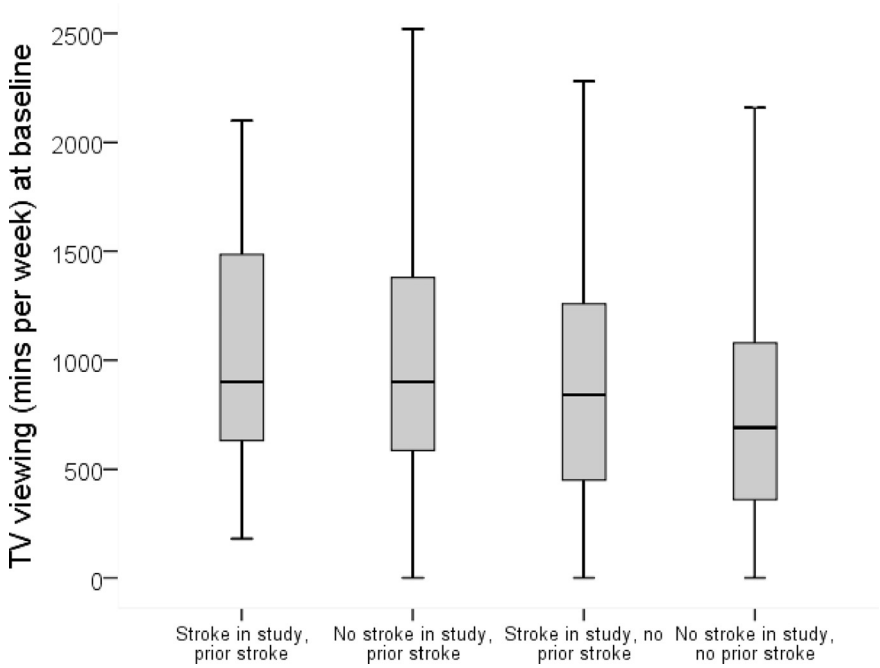

Figure 2. *Boxplots of baseline TV viewing time according to stroke status (outliers not shown).*

Table 2. *Univariable and multivariable logistic regression results for the association between TV minutes per day at baseline and stroke outcome*

	OR	95% CI	*P*
Univariable			
TV time	1.003	1.001-1.005	.001
Model 1			
TV time	1.000	0.998-1.002	.83
Age	1.098	1.081-1.115	<.001
Sex	1.812	1.257-2.612	.001
Model 2			
TV time	1.000	0.997-1.002	.87
Age	1.096	1.078-1.115	<.001
Sex	1.751	1.165-2.632	.007
Education	1.010	0.831-1.229	.92
Smoking status	0.655	0.493-0.871	.004
Alcohol intake	0.999	0.999-1.000	.024
Diet quality	0.999	0.985-1.014	.94

order to further disentangle the effect of TV viewing from other known stroke risk factors, we performed follow-up analyses in stroke cases and matched ''controls.'' With tolerances set at 5 years for age and 10 mmHg for systolic blood pressure (BP), there was successful 1:1 matching of all 126 stroke cases (74 men, mean 67.4 ± 13.0 years old, mean sBP 143.1 ± 19.6 mmHg) to 126 controls (74 men, mean 65.9 ± 12.3 years old, mean sBP 143.8 ± 18.8 mmHg). Within the matched sample, participants with stroke had similar TV viewing time per week at baseline (median 840 mins, IQR 450-1260) to controls (median 840 mins, IQR 420-1260) (Mann-Whitney $U = 7339$, $Z = -0.83$; $P = .41$). Interestingly, those with stroke had significantly less exercise time per week at baseline (median 120 mins, IQR 16-405) than controls (median 240 mins, IQR 65-455) (Mann-Whitney $U = 6429$, $Z = -2.52$; $P = .012$).

TV Viewing Time and Exercise Combined

First, stroke and nonstroke participants were broken down into sub-groups according to a 4-level categorical variable that combined sedentary and exercise information (low TV, high exercise; low TV, low exercise; high TV, high exercise; high TV, and low exercise; Fig 3).

Comparing the low TV-high exercise and the high TV-low exercise groups on stroke outcome in logistic regression revealed a significant association (OR = 0.434, 95% CI 0.256-0.737; $P = .002$). Once again, however, the association was diluted by adjusting for age (OR = 1.098, 95% CI 1.075-1.121; $P < .001$) and sex (OR = 1.533, 95% CI 0.927-2.535; $P = .10$), with TV viewing-exercise status no longer significantly related to stroke (OR = 0.746, 95% CI 0.428-1.299; $P = .30$).

Discussion

Our central finding was that participants in AusDiab who had their first stroke during the study period reported significantly more TV viewing time at baseline

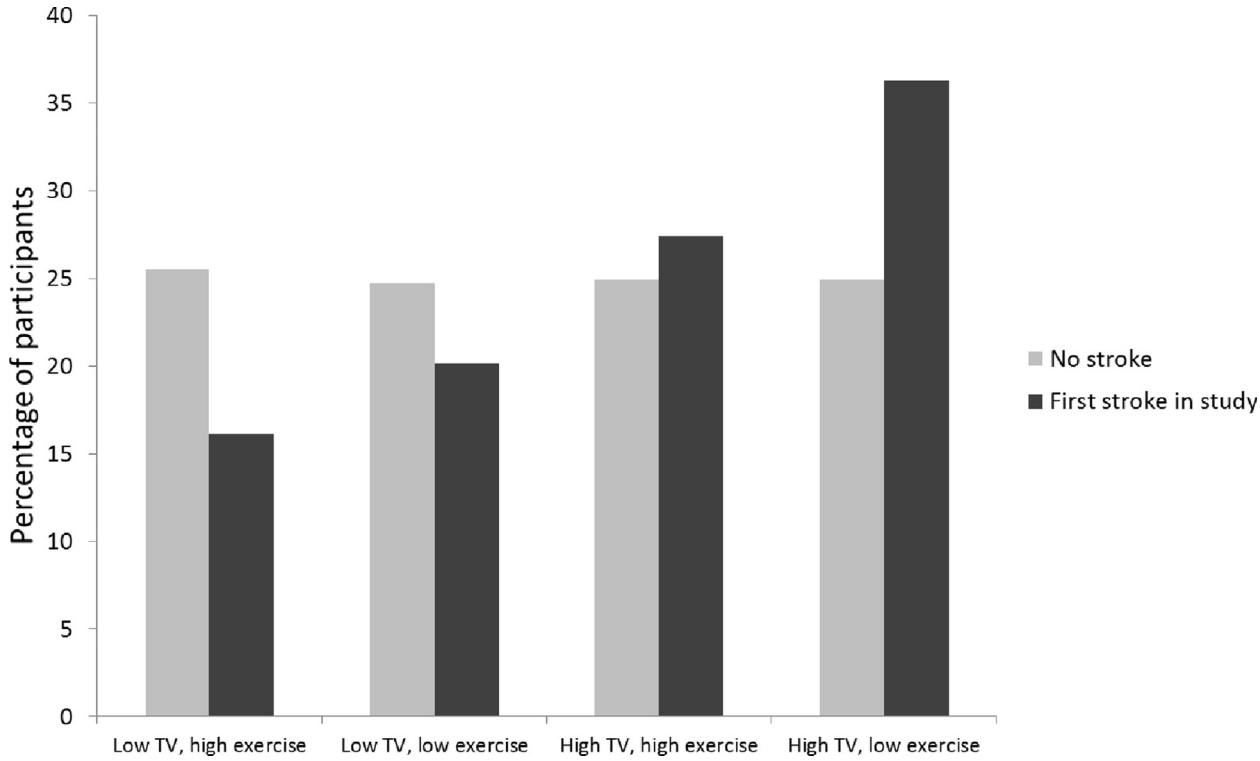

Figure 3. *Percentage of participants by stroke status and TV viewing-exercise status.*

than participants who remained stroke-free. This association between sedentary behavior and higher stroke risk, however, was largely accounted for by older age and, to a lesser extent, male sex. Our findings were largely unchanged in secondary analyses that included all potential stroke events, not only the adjudicated cases. As a follow-up to the regression-based adjustment approach, we derived a matched case-control sample to address the imbalance in key baseline characteristics between the stroke and nonstroke participants. The most notable imbalance was in age—participants with first stroke during the study were much older (mean age 67.4) than those without stroke (mean age 50.7). The case-control analysis indicated that stroke participants had similar levels of TV viewing time at baseline to matched participants without stroke, though it did reveal lower levels of exercise at baseline in stroke participants than their nonstroke controls.

The previous studies to examine the association between sedentary behavior and stroke risk[7-9] yielded a relatively consistent pattern of results. With adjustment for basic demographics like age and sex, the hazard ratio for stroke related to being in the highest versus the lowest sitting time category indicated a significant independent effect, hovering somewhere between 1.2 and 1.4 (i.e., 20%-40% more likely). Further adjustment for general health, lifestyle risk factors, and socioeconomic indicators typically reduced the hazard ratio to between 1.1 and 1.2 (i.e., 10%-20% more likely). In contrast to these studies, we did not detect an association between greater sitting time and stroke that was independent of age and sex. Our analysis of the AusDiab data differed from the previous work in at least 2 important ways. First, we had a smaller number of stroke cases, and thus less power to detect an association. Second, we chose to analyze sitting time as a continuous variable—to maintain the greatest level of detail—rather than break it up into arbitrarily chosen categories. The earlier studies all used a categorical approach, and compared stroke risk between the highest and lowest sitting time categories, thus maximizing any effect. To appreciate the impact this difference can make, consider the findings of Ikehara et al from Japan.[8] Comparing the people who watched ≥6 h/day of TV to those who watched <2 h/day yielded hazard ratios for stroke death of 1.20 (95% CI 1.00-1.43), 1.15 (95% CI 0.96-1.37), and 1.10 (95% CI 0.92-1.32) in the 3 multivariable models. Yet the hazard ratio for each additional 1 h/day increment of TV watching was only 1.02 (95% CI 1.00-1.04), 1.01 (95% CI 0.99-1.04), and 1.01 (95% CI 0.98-1.03) in the same 3 models. Of course, any association may not be linear. A recent meta-analysis of prospective studies of cardiovascular disease indicated a nonlinear relationship, with increased risk spiking at levels of sedentary time >10 h/day.[6]

It is notable that the Japanese study[8] contained a weaker initial estimate of the effect of sedentary behavior on stroke than the American REGARDS study[7] (the other main work to use TV viewing time), but it was not attenuated by adjustment for risk factors to the same degree. This may be partly attributable to its different choice of outcome: stroke mortality rather than stroke incidence. It may also reflect lower levels of vascular risk, and a greater decoupling of risk factors from TV viewing time, in Japan as compared to the United States. For example, average BMI in the Japanese study rose from 22.5 to 23.1 across the 6 TV viewing time groups, with rates of diabetes rising from 4.6% to 8.5%. In REGARDS, average BMI jumped from 28.0 to 30.3 across the 3 TV time groups, with diabetes rising from 15.2% to 25.1%.

It is rare for research datasets to include all the necessary characteristics for a reliable analysis of the link between sedentary behavior and stroke risk. The AusDiab study satisfies all requirements: prospective design, collection of a relevant sedentary behavior outcome, long-term follow-up of a large enough group to capture sufficient stroke events, rigorously adjudicated stroke outcomes. Thus, our findings are an important addition to the literature. There were also shortcomings of this study. TV viewing time is an incomplete indicator of the full range of sedentary behaviors. More specific metrics of sedentary behavior were collected at waves 2 and 3 in AusDiab, but these follow-ups involved fewer participants than wave 1 baseline data collection. We cannot exclude the possibility of residual confounding, particularly given the different age and sex profile of the groups.

In summary, we did not detect a significant independent association between TV viewing time and stroke outcome. It is likely that low levels of exercise have a stronger effect on stroke risk than does high TV viewing time. However, given the association between increasing age and greater sedentary behavior, targeting high sitting time and low exercise levels in older people may be beneficial in reducing morbidity, particularly cardiovascular disease. Furthermore, people who have had a first stroke have both very high levels of sitting time and very low exercise time,[21] putting them at particularly high risk.[5] Targeting sitting time reductions in this group may be more feasible than increasing exercise time, and should be considered as part of a comprehensive secondary stroke risk prevention strategy.

Acknowledgments

We thank Parneet Sethi, for her help with extracting the relevant AusDiab data, and Elizabeth Barr, for her confirmation of stroke adjudication procedures.

Conflict of Interest

The authors have no conflicts of interest to declare.

References

1. Lee CD, Folsom AR, Blair SN. Physical activity and stroke risk: a meta-analysis. Stroke 2003;34:2475-2481.

2. Hu G, Sarti C, Jousilahti P, et al. Leisure time, occupational, and commuting physical activity and the risk of stroke. Stroke 2005;36:1994-1999.
3. Zhang J, Chaaban J. The economic cost of physical inactivity in China. Prev Med 2013;56:75-78.
4. Furie KL, Kasner SE, Adams RJ, et al. Guidelines for the prevention of stroke in patients with stroke or transient ischemic attack: a guideline for healthcare professionals from the American heart association/American stroke association. Stroke 2011;42:227-276.
5. Ekelund U, Steene-Johannessen J, Brown WJ, et al. Does physical activity attenuate, or even eliminate, the detrimental association of sitting time with mortality? A harmonised meta-analysis of data from more than 1 million men and women. Lancet 2016;388:1302-1310.
6. Pandey A, Salahuddin U, Garg S, et al. Continuous dose-response association between sedentary time and risk for cardiovascular disease: a meta-analysis. JAMA Cardiol 2016;1:575-583.
7. McDonnell MN, Hillier SL, Judd SE, et al. Association between television viewing time and risk of incident stroke in a general population: results from the REGARDS study. Prev Med 2016;87:1-5.
8. Ikehara S, Iso H, Wada Y, et al. Television viewing time and mortality from stroke and coronary artery disease among Japanese men and women—the Japan Collaborative Cohort Study. Circ J 2015;79:2389-2395.
9. Chomistek AK, Manson JE, Stefanick ML, et al. Relationship of sedentary behavior and physical activity to incident cardiovascular disease: results from the Women's Health Initiative. J Am Coll Cardiol 2013;61:2346-2354.
10. Chastin SFM, Dontje ML, Skelton DA, et al. Systematic comparative validation of self-report measures of sedentary time against an objective measure of postural sitting (activPAL). Int J Behav Nutr Phys Act 2018;15:21.
11. Bellettiere J, Winkler EAH, Chastin SFM, et al. Associations of sitting accumulation patterns with cardio-metabolic risk biomarkers in Australian adults. PLoS One 2017;12:e0180119.
12. Dunstan DW, Zimmet PZ, Welborn TA, et al. The Australian Diabetes, Obesity and Lifestyle Study (AusDiab)—methods and response rates. Diabetes Res Clin Pract 2002;57:119-129.
13. Dunstan DW, Salmon J, Owen N, et al. Physical activity and television viewing in relation to risk of undiagnosed abnormal glucose metabolism in adults. Diabetes Care 2004;27:2603-2609.
14. Salmon J, Owen N, Crawford D, et al. Physical activity and sedentary behavior: a population-based study of barriers, enjoyment, and preference. Health Psychol 2003;22:178-188.
15. Barr ELM, Tonkin AM, Welborn TA, et al. Validity of self-reported cardiovascular disease events in comparison to medical record adjudication and a statewide hospital morbidity database: the AusDiab study. Internal Med J 2009;39:49-53.
16. Ireland P, Jolley D, Giles G, et al. Development of the Melbourne FFQ: a food frequency questionnaire for use in an Australian prospective study involving an ethnically diverse cohort. Asia Pac J Clin Nutr 1994;3:19-31.
17. Newby PK, Hu FB, Rimm EB, et al. Reproducibility and validity of the Diet Quality Index Revised as assessed by use of a food-frequency questionnaire. Am J Clin Nutr 2003;78:941-949.
18. Australian Institute of Health Welfare. The active Australia survey: a guide and manual for implementation, analysis and reporting/Australian Institute of Health and Welfare. Canberra: Australian Institute of Health and Welfare; 2003.
19. Brown WJ, Trost SG, Bauman A, et al. Test-retest reliability of four physical activity measures used in population surveys. J Sci Med Sport 2004;7:205-215.
20. Alberti KG, Zimmet PZ. Definition, diagnosis and classification of diabetes mellitus and its complications. Part 1: diagnosis and classification of diabetes mellitus provisional report of a WHO consultation. Diabet Med 1998;15:539-553.
21. English C, Manns PJ, Tucak C, et al. Physical activity and sedentary behaviors in people with stroke living in the community: a systematic review. Phys Ther 2014;94:185-196.