

## Associations between sitting time and a range of symptoms in mid-age women

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## **Abstract**

**Objective** To explore longitudinal associations between sitting and physical and psychological symptoms in mid-age women.

**Method** Mid-age (53-58 years) participants in the Australian Longitudinal Study on Women's Health completed mail surveys in 2004 (n=10286), 2007 (n=10128) and 2010 (n=9452) with questions about sitting time (<6, 6-9, and  $\geq$ 9 hours/day) and frequency of 19 symptoms in the preceding 12 months (often vs. never/rarely/sometimes). Associations between sitting and symptoms were examined using two logistic generalized estimating equations models: (a) sequential cross-sectional data from 3 surveys, and (b) prospective model with a 3-year time lag (significance level=0.01).

**Results** Approximately 53%, 30% and 17% of the women were classified as sitting <6, 6-9 and  $\geq$ 9 hours/day in 2004. In adjusted cross-sectional models, women sitting  $\geq$ 9 hours/day had significantly higher odds of breathing difficulties (OR=1.52, 99%CI=1.17-2.00), tiredness (OR=1.21, CI=1.05-1.40), bowel problems (OR=1.26, CI=1.02-1.56), eyesight problems (OR=1.16, CI=1.01-1.34), and depression (OR=1.39, CI=1.15-1.68) than women sitting <6 hours/day. Adjusted prospective models showed higher odds of breathing difficulties (OR=1.94, CI=1.40-2.69), chest pain (OR=2.04, CI=1.14-3.70), and tiredness (OR=1.24, CI=1.04-1.48). Associations with breathing difficulties and chest pain remained significant after excluding participants with chronic conditions in 2004.

**Conclusion** Prolonged sitting may a determinant of breathing difficulties and chest pain three years later in mid-age women.

## **Introduction**

Sedentary behaviour is defined as activities done sitting or lying down that do not increase energy expenditure substantially above the resting level, such as watching television and reading a book (Pate et al., 2008). A growing body of evidence suggests that sedentary behaviour increases the risk of obesity, cardiovascular diseases, diabetes and premature death (Gomez-Cabello et al., 2012; Thorp et al., 2011), and that this increased risk may occur even when physical activity is taken into account (Brown et al., 2009; Tremblay et al., 2010). Sedentary behaviour is measured either objectively (accelerometers) or subjectively (questionnaires) and although neither measure fully captures the definition given above, associations have been found with both (e.g. (Koster et al., 2012; Matthews et al., 2012)). To date, sedentary behaviour epidemiology has mainly focused on outcomes related to cardiovascular and metabolic health. Measures of sedentary behaviour have however, also been related to gallbladder disease (Leitzmann et al., 1998; Leitzmann et al., 1999), cancer (Friberg et al., 2006; Gierach et al., 2009; Patel et al., 2008; Patel et al., 2006), and mental disorders (Sanchez-Villegas et al., 2008). These relationships with conditions that involve various body systems, suggest a wide-ranging impact of sedentary behaviour on health.

Symptoms, such as pain, fatigue, respiratory problems, vasomotor symptoms, and mood disturbances can be associated with high levels of distress and disability (Patterson et al., 2012; van der Windt et al., 2008), and as such are often the main reason for visiting a physician. They can be important indicators of health problems, even before a definitive diagnosis is made. Exploring relationships between sedentary behaviour and symptoms may provide insight in the variety of body systems affected by sedentary behaviour. Mid aged women are a priority target group for such research, as transmenopausal changes can initiate an increase in incidence of chronic disease (Atsma et al., 2006; Meema and Meema, 1976).

The aim of this paper was to explore longitudinal relationships between time spent sitting and a range of physical and psychological symptoms over a period of six years in mid-age Australian women. The analyses included a broad range of symptoms to cover the full range of body systems.

## **Methods**

### *Study sample*

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Data were from the mid-age cohort (born 1946-1951) of the Australian Longitudinal Study on Women's Health (ALSWH); a prospective study of the health and well-being of three generations of women.(Lee et al., 2005) As reported elsewhere, samples were randomly drawn from the national Medicare health insurance database, which includes all Australian citizens and permanent residents, with intentional over-representation of women from rural and remote areas. More details about the study can be found at [www.alswh.org.au](http://www.alswh.org.au). The study was approved by the University of Newcastle Ethics Committee, and informed consent was received from all participants (Brown et al., 1998; Lee et al., 2005). Baseline **surveys were** mailed in 1996, with the first follow-up in 1998, then at three yearly intervals to 2010. Comparison of the baseline sample (n=13,715, response rate 54%) with Australian census data indicated that the sample was representative of Australian women in this age group, but with a somewhat higher representation of partnered women and of women with post-school education (Brown et al., 1998). As questions about sitting time were first included in survey 4, we used data from surveys 4, 5 and 6 (2004, 2007, and 2010, response rates 79.5%, 77.6% and 73%, respectively) for this paper. A flow chart of participants included in the analyses and reasons for non-response at each stage are shown in Figure 1. Participants with missing values for both items assessing sitting or all 19 items assessing symptoms were excluded from the analyses for that survey. Data were included from 10,286 women at survey 4; 10,128 women at survey 5; and 9,529 women at survey 6. A total of 8,056 women provided sitting and symptoms data at all three surveys.

### *Sitting time*

Sitting time was measured using the question “How many hours each day do you typically spend sitting down while doing things like visiting friends, driving, reading, watching television or working at a desk or computer?”. A similar question in the International Physical Activity Questionnaire (IPAQ) has been shown to have good test-retest reliability ( $r>0.75$ ) and acceptable correlation with accelerometry (Rosenberg et al., 2008). Responses were provided both for a typical week-day and a typical weekend-day. Data were cleaned following protocols described by van Uffelen et al (2010) (van Uffelen et al., 2010). Hours spent sitting on a week-day and a weekend-day were then averaged ( $[\text{week-day} * 5 + \text{weekend-day} * 2] / 7$ ) to estimate mean sitting time in hours/day, and categorized as <6, 6-9, or >9 hours/day. These categories were based on approximate tertiles, taking into account that a

threshold in adverse health outcomes has been reported at around 8 or 9 hours/day (Matthews et al., 2012; van der Ploeg et al., 2012).

### *Symptoms*

Participants were asked to indicate the frequency of experiencing each of 19 symptoms in the last 12 months. These symptoms included allergies/hay fever/sinusitis, breathing difficulty, indigestion/heartburn, chest pain, headaches/migraines, severe tiredness, stiff or painful joints, back pain, urine that burns or stings, haemorrhoids, other bowel problems, vaginal discharge or irritation, hot flushes, night sweats, eyesight problems, hearing problems, depression, episodes of intense anxiety, and palpitations. Response options were never, rarely, sometimes, and often. To create maximum contrast while including all participants, the categories were collapsed into often vs. never/rarely/sometimes (reference category).

### *Other variables*

Correlates of both sitting time and symptoms include sociodemographic, health and lifestyle variables (Gold et al., 2000; Rhodes et al., 2012). The following variables were found in preliminary analyses to be significantly associated with both sitting and symptoms ( $p < 0.01$ ) and were included as confounders: age, area of residence, education, body mass index (BMI), cigarette smoking, alcohol consumption, and physical activity. The confounders were measured using the same methods at each survey, unless stated otherwise. Area of residence was categorized based on address as urban, rural, or remote. Level of education was assessed in survey 1 (1996) as the highest qualification completed, ranging from “no formal qualification” to “university degree or higher”. BMI was calculated using self-reported weight and height ( $\text{kg}/\text{m}^2$ ). Based on responses to the smoking and alcohol questions, participants were classified as never, ex-, or current smokers, and as none, low risk, rarely, or risky drinker (National Health and Medical Research Council, 2001). Responses to questions about weekly frequency and duration of walking, moderate and vigorous activities were converted to a physical activity score in MET.min/week (using metabolic equivalent scores of 3.0, 4.0 and 7.5 for walking, moderate and vigorous activities, respectively) (Ainsworth et al., 2011; Brown et al., 2008; Kanis et al., 2004). Although not a confounder, menopausal status was included as a sample characteristic; participants were classified as surgical, HRT/OCP user, pre-, peri- or post-menopausal, based on questions about hysterectomy, oophorectomy, hormone replacement therapy, oral contraceptive use, and menstrual bleeding.

Copies of the surveys and details of composite variables can be obtained from [www.alsw.org.au/surveys.html](http://www.alsw.org.au/surveys.html).

### *Statistical analyses*

Sociodemographic characteristics of the women who were included and those excluded from the main analyses were compared using t-tests for near normally distributed variables, Mann-Whitney U tests for variables not normally distributed, and chi-squared tests for categorical variables.

Longitudinal associations between sitting time and symptoms were tested using Generalized Estimating Equations (GEE) for dichotomous outcomes. Two models were tested: (a) sequential cross-sectional model including data from 3 surveys, and (b) prospective model with a 3-year time lag between sitting and symptoms (Figure 2). Although the first GEE technique is described here as ‘sequential cross-sectional’, it does have a longitudinal element, as it takes into account the fact that repeated observations from the same participants are not independent of each other, and the overall estimates take into account within-subject correlations. The second technique, described here as ‘prospective’, extends this concept by introducing a time-lag into the models. Following comparison of various correlation structures, the default option of exchangeable correlation structure was used (Zeger and Liang, 1986), as this seemed robust against wrong choice of correlation structure. Analyses were done using the Stata `xtgee` command and unadjusted as well as adjusted for age, area of residence, education, BMI, smoking, alcohol consumption, and physical activity. To examine potential reverse causality, the prospective model was repeated after excluding participants reporting any doctor diagnosed heart disease, diabetes, lung disease, cancer (all types excluding skin cancer), or depression/anxiety at study baseline (survey 4, 2004). To reduce the risk of type I error given the multiple comparisons, the significance level was set at 0.01. Both 99% confidence intervals (CI) and p-values are presented. All analyses were done using Stata version 11.1 (StataCorp LP, US).

### **Results**

At baseline in 2004, the mean age of the participants was 55.5 (standard deviation 1.5, range 53-58) years (Table 1). The proportions of women sitting <6, 6-9 and  $\geq$ 9 hours/day were 53%, 30% and 17% at survey 4, 49%, 33% and 19% at survey 5 and 50%, 33% and 17% at

survey 6, respectively. Compared with participants who were included in the analyses, those who were excluded because of missing values on sitting or symptoms had lower levels of education and were more likely to be low risk drinkers across the three surveys. Excluded participants also tended to be slightly older and more likely to live in rural or remote areas, but actual differences were small. In 2004, nearly half the women were peri-menopausal. Three years later the majority of these women had progressed to being post-menopausal.

In the sequential cross-sectional model, unadjusted dose-response relationships were found between sitting and breathing difficulties, indigestion/heartburn, severe tiredness, stiff/painful joints, and depression (Table 2). After adjustment for confounders, none of the associations between sitting 6-9 hours/day and sitting <6 hours/day remained statistically significant. However, compared with sitting <6 hours/day, sitting >9 hours/day was significantly associated with increased odds of breathing difficulties, (OR=1.52, CI=1.17-2.00), severe tiredness (OR=1.21, CI=1.05-1.40), other bowel problems (OR=1.26, CI=1.02-1.56), eyesight problems (OR=1.16, CI=1.01-1.34), and depression (OR=1.39, CI=1.15-1.68). In addition, sitting >9 hours/day was associated with decreased odds of palpitations (OR=0.73, CI=0.51-0.99).

In the unadjusted prospective model, sitting >9 hours/day was associated with breathing difficulties, chest pain, severe tiredness, and depression three years later. After adjustment for confounders, associations remained statistically significant for all these symptoms except depression. Sitting >9 hours/day was associated with increased odds of having breathing difficulties (OR=1.94, CI=1.40-2.69), chest pain (OR=2.05, CI=1.14-3.70), and severe tiredness (OR=1.24, CI=1.04-1.48) three years later. When participants who reported having heart disease (n=331), lung disease (n=1423), diabetes (n=624), cancer (n=336) or depression (n=1776) at the 2004 baseline (total excluded n=3583) were excluded, adjusted odds ratios for sitting >9 hours/day compared with sitting <6 hours/day were even higher for breathing difficulties (OR=3.04, CI=1.56-5.93) and chest pain (OR=2.99, CI=1.14-7.83) (Table 4 - online only). However, the association between sitting and severe tiredness was no longer significant (>9 hours/day: OR=1.06, CI=0.81-1.40).

## **Discussion**

The aim of this study was to explore associations between sitting time and a range of physical and psychological symptoms in mid-age women. The sequential cross sectional model showed that prolonged sitting (>9 hours/day) was significantly associated with increased odds of breathing difficulties, severe tiredness, bowel problems, eyesight problems, and depression, after adjustment for confounders, including physical activity and BMI. Although the results were consistent across the three surveys over six years, the direction of the relationships cannot be confirmed from these data. It seems plausible however, to consider that having problems with breathing, tiredness, eyesight or depression, may predispose women to sit for long periods of time. However, the associations between sitting and breathing difficulties, severe tiredness, and chest pain, were also significant in the prospective model with a 3-year time lag. These three symptoms are all related to cardiovascular health and further research in this area is needed to examine whether a causal relationship between sitting and symptoms related to cardiovascular conditions exists.

The association between sitting time and breathing difficulties is interesting because previous analyses from the ALSWH indicate markedly increased risk of weight gain for mid-age women who sit >8 hours/day (Brown et al., 2005). Increases in body weight have been associated with worsening pulmonary function, caused by the mechanical effects of truncal obesity and metabolic effects of adipose tissue (McClellan et al., 2008). Overweight has been identified as a risk factor for various respiratory conditions, including chronic obstructive pulmonary disease (COPD) and asthma (McClellan et al., 2008).

The current analyses used prevalence, rather than incidence, of symptoms as the outcome. The rationale for this was that the phrasing of the question and design of the study constrained the estimation of incidence. The questionnaire asked about frequency of symptoms perceived in the past 12 months, while there was a 3-year interval between surveys. Hence a 2-year gap in information exists. Moreover, unlike chronic health conditions such as diabetes or heart disease, physical and psychological symptoms not associated with a specific diagnosis may come and go over time, and having a symptom at one time does not mean the participant will still have it three years later. To test whether the associations found in the prospective models were explained by reverse causation, the analyses were repeated after exclusion of participants reporting chronic conditions at the 2004 baseline (survey 4). The prospective associations between sitting >9 hours/day and



breathing difficulties and chest pain remained significant, providing a first hint towards a causal relationship between sitting and symptoms of cardiovascular and respiratory conditions. However, confirmation of the current findings in different samples and evidence supporting a biological mechanism are needed to strengthen the case for a potential causal relationship. The association between sitting and tiredness, however, disappeared, suggesting that the association between sitting and tiredness in the original analyses were explained by pre-existing chronic conditions.

As we are unaware of any previous work on the relationships between sitting and general somatic symptoms, we can only hypothesise about potential underlying mechanisms. It is feasible that there could be a cycle of events whereby women who are tired, for whatever reason, sit more. Over time, a lack of contractile stimulation of skeletal muscles results in significant metabolic changes, the most notable of which is a decrease in lipoprotein lipase activity (LPL), an enzyme involved in skeletal muscle uptake of triglycerides and free fatty acids. This could lead to increases in plasma triglycerides and decreases in HDL-cholesterol, which are risk factors for coronary and cardiovascular disease (Hamburg et al., 2007; Hamilton et al., 2007; Yanagibori et al., 1998), which may then begin to manifest as chest pain and/or breathing difficulties. Although biologically plausible, evidence supporting this pathway is still minimal and much more research is needed.

The major strengths of this study are the use of a large population-based sample that is representative of the mid-age women in Australia; this supports the generalizability of the findings. It is unclear however, if the findings can be generalised to men. In addition, the consistency of the results from the sequential cross-sectional models and prospective models add to the confidence in the associations that were found. The wide range of included symptoms allowed interpretation of the results in a broad context, but also raises the issue of multiple testing. To minimize the risk of type I error, a lower significance level was used ( $\alpha=0.01$ ) and exact p-values were presented, in addition to 99% confidence intervals, to facilitate interpretation of the results. A limitation of the current study is that measurement was based on self-report, which could have resulted in some measurement error and attenuation of the estimated odds ratios. The sitting question was rather simplistic, however, previous studies using this item have shown associations with weight and mortality (Pavey et al., 2012; van Uffelen et al., 2010). Although analyses were adjusted for age, area of

residence, education, physical activity, BMI, smoking status, and alcohol consumption, unmeasured confounding may have occurred. Replication of the current findings in a study with objective measurement of sitting would be ideal, but challenging, given the large sample size and long term follow-up needed.

## **Conclusion**

These analyses indicate that prolonged sitting is associated with an increased risk of somatic symptoms in mid-age women. Prolonged sitting was associated with increased odds of often experiencing breathing difficulties and chest pain three years later, suggesting that sitting may be a determinant of these symptoms. Over time, such symptoms may be indicative of developing cardiovascular or respiratory conditions.

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## **Conflict of interest**

The authors declare there is no conflict of interest.

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Figure 1. Flow chart of participants in the Australian Longitudinal Study on Women's Health (2004-2010)

Figure 2. Study design

This diagram shows the data from the Australian Longitudinal Study on Women's health (2004-2010) included in the two statistical models:

- (a) Sequential cross-sectional model: solid arrows indicate exposure and outcome were measured at the same survey, but data from three consecutive surveys were included.
- (b) Prospective model: dashed arrows indicate the 3-year time lag between the exposure and outcome variables.

Table 1. Characteristics of participants included and excluded from the analyses at each survey

	Survey 4 (2004)			Survey 5 (2007)			Survey 6 (2010)		
	Included	Excluded	p	Included	Excluded	p	Included	Excluded	p
N	10286	619		10128	510		9529	482	
Age <sup>a</sup>	55.5 (1.5)	55.6 (1.5)	0.08	58.5 (1.5)	58.6 (1.5)	0.04	61.5 (1.5)	61.7 (1.5)	0.02
Area of residence			0.002			0.03			0.89
urban	38.4	32.3		39.1	34.7		39.3	38.3	
rural	56.9	61.1		56.2	58.6		56.7	57.9	
remote	4.7	6.6		4.7	6.7		3.9	3.9	
Education			<0.001			<0.001			<0.001
no formal qualifications	16.0	25.7		16.0	23.3		15.0	26.3	
school certificate	31.6	35.1		31.5	33.9		31.7	32.6	
higher school certificate	16.7	15.9		16.8	15		16.9	13.2	
trade/apprenticeship	20.4	14.9		20.4	16.8		20.7	17.8	
university degree	15.4	8.5		15.3	11.1		15.7	10.2	
Physical activity <sup>b,c</sup>	720 [190-1440]	585 [180-1260]	0.03	720 [240-1620]	840 [203-1500]	0.97	720 [225-1560]	720 [90-1650]	0.44
Body mass index <sup>a</sup>	27.1 (5.5)	27.4 (5.7)	0.25	27.3 (5.6)	27.4 (5.5)	0.85	27.6 (5.6)	27.6 (5.5)	0.25
Alcohol consumption			<0.001			0.03			0.006
none drinker	54.5	49.3		60.8	58.0		55.5	52.4	
rarely drinks	23.8	23.9		24.4	26.6		23.4	22.8	
low risk drinker	15.0	22.1		8.0	11.1		14.3	20.0	
risky drinker	6.7	4.7		6.8	4.4		6.8	4.9	
Smoking status			0.08			0.56			0.68
non smoker	59.2	62.5		60.5	62.9		61.1	62.6	
ex smoker	27.4	23.3		28.5	26.6		30.0	29.5	
current smoker	13.4	14.2		11	10.5		9.0	7.9	
Menopausal status			0.09			<0.001			0.99
HRT/OCT use	12.1	12.4		6.3	8.9		3.8	4.0	
surgical menopause	31.1	35.5		33.3	30.3		34.3	34.6	

This is a postprint version of the following article: Peeters, GMEE (Geeske), Burton, Nicola W. and Brown, Wendy J. (2013) Associations between sitting time and a range of symptoms in mid-age women. *Preventive Medicine*, 56 2: 135-141.

pre-menopause	9.6	9.1	0.1	0.8	0	0
peri-menopause	46.8	42.3	2.0	1.6	0.2	0.2
Post-menopause	0.3	0.7	58.3	58.4	61.7	61.2

Data were from participants in the 2004, 2007 and 2010 surveys of the Australian Longitudinal Study on Women's health (ALSWH). Continuous variables are presented as <sup>a</sup> means and standard deviations and p-values are based on t-tests for near normally distributed variables, or <sup>b</sup> medians and interquartile ranges and p-values are based on the Mann-Whitney U test for not normally distributed variables. Categorical variables are presented as proportions and p-values are based on chi-squared tests. <sup>c</sup> Physical activity is presented in MET.minutes/week.



Table 2. Sequential cross-sectional associations between sitting time and symptoms

	Sitting (h/day)	Survey4	Survey 5	Survey 6	Unadjusted			Adjusted <sup>a</sup>		
		(2004) n (% often)	(2007) n (% often)	(2010) n (% often)	OR	99%CI	p	OR	99%CI	p
Allergies	<6	5341 (12.6)	4859 (12.3)	4682 (11.8)	1.00			1.00		
	6-9	3053 (13.5)	3253 (11.7)	3112 (12.4)	1.01	0.92-1.11	0.85	1.01	0.91-1.12	0.84
	≥9	1608 (13.4)	1870 (13.1)	1601 (12.2)	1.07	0.95-1.21	0.14	1.07	0.93-1.22	0.20
Breathing difficulty	<6	5224 (2.4)	4809 (2.4)	4621 (2.3)	1.00			1.00		
	6-9	2967 (3.3)	3219 (2.6)	3089 (3.3)	1.26	1.03-1.54	0.003	1.20	0.95-1.52	0.05
	≥9	1649 (3.5)	1849 (4.6)	1598 (4.9)	1.56	1.24-1.97	<0.001	1.52	1.17-2.00	<0.001
Indigestion/ heartburn	<6	5269 (7.3)	4832 (7.8)	4662 (8.1)	1.00			1.00		
	6-9	2989 (8.4)	3254 (7.9)	3112 (9.4)	1.14	1.01-1.28	0.007	1.09	0.95-1.24	0.11
	≥9	1674 (9.7)	1852 (9.5)	1604 (9.8)	1.27	1.09-1.47	<0.001	1.17	0.99-1.38	0.02
Chest pain	<6	5125 (0.9)	4771 (1.1)	4588 (0.7)	1.00			1.00		
	6-9	2913 (1.0)	3190 (0.9)	3063 (0.8)	1.03	0.71-1.48	0.85	0.95	0.63-1.43	0.74
	≥9	1630 (1.2)	1834 (1.7)	1578 (1.0)	1.38	0.92-2.07	0.04	1.22	0.76-1.95	0.28
Headaches	<6	5317 (9.1)	4868 (8.2)	4695 (7.0)	1.00			1.00		
	6-9	3039 (10.3)	3255 (8.3)	3131 (6.3)	1.04	0.92-1.16	0.43	1.06	0.93-1.20	0.28
	≥9	1691 (9.2)	1868 (8.1)	1602 (8.1)	1.00	0.86-1.16	0.98	1.05	0.89-1.24	0.46
Severe tiredness	<6	5269 (11.3)	4840 (11.0)	4648 (10.4)	1.00			1.00		
	6-9	3010 (12.9)	3229 (12.3)	3118 (11.6)	1.11	1.00-1.23	0.009	1.05	0.94-1.19	0.24
	≥9	1678 (14.5)	1855 (15.0)	1598 (14.8)	1.30	1.15-1.47	<0.001	1.21	1.05-1.40	0.001
Stiff/painful joints	<6	5329 (23.0)	4863 (24.6)	4688 (25.0)	1.00			1.00		
	6-9	3027 (23.9)	3262 (26.1)	3120 (27.0)	1.09	1.01-1.17	0.003	1.07	0.98-1.17	0.04
	≥9	1697 (25.8)	1877 (27.4)	1609 (30.9)	1.16	1.06-1.28	<0.001	1.09	0.98-1.21	0.04
Back pain	<6	5323 (17.3)	4881 (18.9)	4698 (18.3)	1.00			1.00		
	6-9	3024 (17.3)	3263 (18.7)	3126 (19.6)	1.05	0.97-1.14	0.14	1.04	0.95-1.15	0.24
	≥9	1698 (19.6)	1877 (21.9)	1615 (20.8)	1.10	0.99-1.22	0.02	1.07	0.95-1.20	0.14
Urine burns/stings	<6	5267 (0.9)	4865 (1.3)	4672 (0.8)	1.00			1.00		
	6-9	2981 (0.9)	3262 (1.0)	3120 (1.2)	1.00	0.71-1.42	0.97	0.96	0.64-1.43	0.78
	≥9	1670 (1.0)	1859 (0.8)	1605 (1.6)	1.10	0.72-1.66	0.57	0.93	0.56-1.54	0.70
Haemorrhoids	<6	5268 (3.1)	4860 (3.2)	4666 (3.8)	1.00			1.00		
	6-9	2991 (3.5)	3245 (3.5)	3126 (3.6)	1.03	0.86-1.23	0.69	1.02	0.83-1.24	0.84
	≥9	1674 (3.2)	1856 (4.8)	1603 (4.6)	1.18	0.95-1.48	0.05	1.18	0.92-1.50	0.08
Other bowel problems	<6	5235 (4.7)	4827 (4.1)	4672 (4.8)	1.00			1.00		
	6-9	2973 (4.3)	3246 (4.4)	3111 (5.1)	1.05	0.89-1.23	0.45	1.03	0.87-1.24	0.62
	≥9	1672 (6.2)	1853 (5.8)	1592 (5.9)	1.27	1.05-1.54	0.001	1.26	1.02-1.56	0.005
Vaginal discharge /irritation	<6	5246 (1.3)	4843 (1.2)	4675 (1.1)	1.00			1.00		
	6-9	2979 (1.5)	3246 (1.1)	3121 (1.2)	1.10	0.81-1.50	0.43	0.96	0.67-1.36	0.76
	≥9	1671 (1.8)	1850 (1.4)	1597 (1.3)	1.25	0.87-1.81	0.11	1.04	0.69-1.59	0.80
Hot flushes	<6	5350 (22.1)	4887 (17.9)	4692 (12.4)	1.00			1.00		
	6-9	3049 (22.0)	3278 (18.0)	3137 (13.6)	1.05	0.96-1.15	0.13	1.05	0.96-1.16	0.17
	≥9	1711 (19.6)	1871 (18.0)	1606 (12.6)	0.99	0.88-1.11	0.83	0.97	0.86-1.10	0.60

Table 2 (continued).

	Sitting (h/day)	Survey4	Survey 5	Survey 6	Unadjusted			Adjusted <sup>a</sup>		
		(2004) n (% often)	(2007) n (% often)	(2010) n (% often)	OR	99%CI	p	OR	99%CI	p
Night sweats	<6	5311 (15.5)	4863 (13.2)	4680 (9.3)	1.00			1.00		
	6-9	3016 (15.4)	3254 (12.3)	3125 (9.5)	0.99	0.90-1.10	0.86	1.01	0.91-1.13	0.76
	≥9	1689 (15.1)	1858 (12.7)	1592 (9.9)	1.00	0.88-1.14	0.98	1.01	0.87-1.16	0.90
Eyesight problems	<6	5307 (12.4)	4850 (11.2)	4641 (10.6)	1.00			1.00		
	6-9	1691 (13.4)	1860 (14.6)	3112 (9.9)	0.99	0.89-1.10	0.77	0.97	0.87-1.09	0.55
	≥9	1009 (13.9)	1206 (14.8)	1596 (13.3)	1.19	1.04-1.35	0.001	1.16	1.01-1.34	0.007
Hearing problems	<6	5261 (4.8)	4888 (5.5)	4690 (6.1)	1.00			1.00		
	6-9	3004 (4.6)	3266 (5.6)	3133 (5.6)	0.97	0.84-1.11	0.52	0.94	0.80-1.10	0.29
	≥9	1681 (5.4)	1868 (4.9)	1608 (6.3)	1.01	0.85-1.21	0.84	0.93	0.76-1.14	0.38
Depression	<6	5308 (5.5)	4881 (5.5)	4709 (4.6)	1.00			1.00		
	6-9	3018 (7.3)	3276 (6.0)	3137 (5.2)	1.17	1.02-1.34	0.003	1.14	0.97-1.34	0.03
	≥9	1700 (9.1)	1873 (7.8)	1612 (7.9)	1.42	1.21-1.68	<0.001	1.39	1.15-1.68	<0.001
Episodes of intense anxiety	<6	5317 (2.4)	4871 (1.6)	4667 (1.3)	1.00			1.00		
	6-9	3027 (2.4)	3264 (1.8)	3122 (1.4)	1.07	0.84-1.38	0.45	0.96	0.72-1.28	0.70
	≥9	1705 (2.8)	1867 (1.4)	1604 (1.9)	1.05	0.77-1.43	0.70	0.92	0.64-1.32	0.55
Palpitations	<6	5354 (4.1)	4884 (3.3)	4699 (2.5)	1.00			1.00		
	6-9	3030 (3.2)	3270 (3.0)	3137 (2.5)	0.90	0.74-1.10	0.17	0.92	0.74-1.14	0.32
	≥9	1706 (3.5)	1870 (2.6)	1603 (1.9)	0.81	0.62-1.04	0.03	0.73	0.54-0.99	0.008

Data were from participants in the 2004, 2007 and 2010 surveys of the Australian Longitudinal Study on Women's health (ALSWH). OR=odds ratio, 99%CI=99% confidence interval, <sup>a</sup> adjustment was made for age, area of residence, education, physical activity, BMI, smoking status, and alcohol consumption.

Table 3. Prospective associations between sitting time (2004-2007) and prevalence of symptoms 3 years later (2007-2010)

	Sitting (h/day)	Survey 5 2007 n (% often)	Survey 6 2010 n (% often)	Unadjusted			Adjusted <sup>a</sup>		
				OR	99%CI	p	OR	99%CI	p
Allergies	<6	4944 (12.0)	4381 (12.1)	1.00			1.00		
	6-9	2840 (12.6)	2958 (11.3)	1.01	0.89-1.14	0.90	1.02	0.89-1.17	0.68
	≥9	1555 (12.6)	1649 (12.5)	1.08	0.93-1.26	0.19	1.06	0.89-1.25	0.39
Breathing difficulty	<6	4908 (2.3)	4328 (2.4)	1.00			1.00		
	6-9	2806 (2.9)	2930 (2.6)	1.16	0.89-1.52	0.15	1.27	0.94-1.73	0.04
	≥9	1542 (4.2)	1640 (4.9)	1.83	1.37-2.44	<0.001	1.94	1.40-2.69	<0.001
Indigestion/ heartburn	<6	4940 (7.8)	4367 (8.7)	1.00			1.00		
	6-9	2817 (8.1)	2960 (8.6)	1.02	0.88-1.19	0.68	1.02	0.86-1.20	0.78
	≥9	1543 (9.3)	1640 (8.8)	1.07	0.89-1.30	0.34	1.03	0.83-1.27	0.74
Chest pain	<6	4874 (0.8)	4311 (0.7)	1.00			1.00		
	6-9	2772 (0.9)	2902 (0.6)	1.08	0.65-1.79	0.69	1.22	0.70-2.14	0.36
	≥9	1532 (1.8)	1622 (1.0)	1.90	1.13-3.19	0.001	2.05	1.14-3.70	0.002
Headaches	<6	4971 (8.0)	4405 (7.0)	1.00			1.00		
	6-9	2819 (7.6)	2961 (6.8)	0.97	0.83-1.14	0.66	1.01	0.85-1.20	0.89
	≥9	1560 (8.7)	1653 (6.8)	1.09	0.90-1.32	0.25	1.19	0.96-1.46	0.04
Severe tiredness	<6	4936 (11.0)	4364 (10.5)	1.00			1.00		
	6-9	2819 (12.2)	2954 (11.4)	1.10	0.96-1.25	0.07	1.10	0.95-1.28	0.09
	≥9	1541 (14.0)	1641 (13.8)	1.25	1.06-1.47	<0.001	1.24	1.04-1.48	0.002
Stiff/painful joints	<6	4964 (25.2)	4390 (25.9)	1.00			1.00		
	6-9	2840 (24.9)	2963 (26.4)	0.99	0.90-1.09	0.78	0.96	0.87-1.07	0.38
	≥9	1562 (27.0)	1657 (29.2)	1.11	0.99-1.25	0.02	1.03	0.90-1.18	0.56
Back pain	<6	4985 (18.5)	4400 (19.1)	1.00			1.00		
	6-9	2839 (18.9)	2973 (17.4)	1.23	0.80-1.90	0.21	1.26	0.78-2.04	0.21
	≥9	1559 (20.9)	1654 (21.2)	1.32	0.79-2.20	0.17	1.11	0.61-2.03	0.66
Urine burns/ stings	<6	4966 (1.0)	4375 (0.8)	1.00			1.00		
	6-9	2822 (1.1)	2964 (1.1)	0.99	0.79-1.24	0.91	1.03	0.80-1.31	0.78
	≥9	1555 (0.9)	1651 (1.45)	1.06	0.80-1.39	0.60	1.09	0.81-1.47	0.46
Haemorrhoids	<6	4961 (3.3)	4384 (3.7)	1.00			1.00		
	6-9	2807 (3.6)	2962 (3.7)	1.03	0.86-1.23	0.69	1.02	0.83-1.24	0.84
	≥9	1552 (4.3)	1648 (4.3)	1.18	0.95-1.48	0.05	1.18	0.92-1.50	0.08
Other bowel problems	<6	4935 (4.2)	4375 (4.9)	1.00			1.00		
	6-9	2800 (4.1)	2951 (4.8)	0.97	0.79-1.19	0.73	0.97	0.77-1.21	0.70
	≥9	1552 (6.4)	1637 (5.3)	1.24	0.97-1.57	0.02	1.26	0.97-1.63	0.03
Vaginal discharge/ irritation	<6	4944 (1.0)	4381 (1.2)	1.00			1.00		
	6-9	2812 (1.3)	2960 (1.0)	1.06	0.70-1.62	0.70	1.07	0.67-1.70	0.72
	≥9	1545 (1.8)	1645 (1.1)	1.37	0.85-2.19	0.09	1.31	0.78-2.21	0.19

Table 3 (continued).

	Sitting (h/day)	Survey 5	Survey 6	Unadjusted			Adjusted <sup>a</sup>		
		2007 n (% often)	2010 n (% often)	OR	99%CI	p	OR	99%CI	p
Hot flushes	<6	4986 (17.9)	4402 (12.9)	1.00			1.00		
	6-9	2845 (18.0)	2974 (12.9)	1.02	0.91-1.15	0.60	1.06	0.94-1.21	0.20
	≥9	1563 (17.3)	1649 (12.4)	0.96	0.83-1.12	0.52	0.99	0.84-1.16	0.87
Night sweats	<6	4961 (13.0)	4389 (9.6)	1.00			1.00		
	6-9	2821 (12.3)	2963 (8.8)	0.95	0.83-1.09	0.38	0.96	0.83-1.11	0.50
	≥9	1553 (12.4)	1641 (10.2)	0.99	0.83-1.17	0.83	0.99	0.83-1.19	0.94
Eyesight problems	<6	4938 (10.8)	4346 (10.6)	1.00			1.00		
	6-9	2816 (11.8)	2950 (9.9)	1.01	0.88-1.16	0.84	0.97	0.83-1.12	0.56
	≥9	1551 (13.3)	1644 (12.5)	1.18	1.00-1.39	0.01	1.09	0.91-1.30	0.24
Hearing problems	<6	4981 (5.3)	4399 (6.0)	1.00			1.00		
	6-9	2839 (5.1)	2975 (6.2)	1.07	0.90-1.27	0.32	1.08	0.89-1.30	0.30
	≥9	1557 (5.1)	1653 (5.2)	0.93	0.74-1.17	0.40	0.89	0.70-1.15	0.25
Depression	<6	4987 (5.3)	4419 (4.7)	1.00			1.00		
	6-9	2844 (5.8)	2974 (4.9)	1.07	0.89-1.29	0.36	0.98	0.79-1.20	0.76
	≥9	1558 (7.7)	1653 (6.0)	1.26	1.01-1.58	0.007	1.11	0.87-1.42	0.28
Episodes of intense anxiety	<6	4974 (1.5)	4381 (1.5)	1.00			1.00		
	6-9	2832 (1.3)	2960 (1.2)	0.85	0.59-1.24	0.27	0.74	0.49-1.13	0.07
	≥9	1553 (2.3)	1646 (1.2)	1.20	0.79-1.83	0.25	1.12	0.71-1.77	0.51
Palpitations	<6	4983 (3.4)	4410 (2.3)	1.00			1.00		
	6-9	2837 (2.6)	2974 (2.4)	0.94	0.72-1.23	0.58	0.94	0.70-1.26	0.58
	≥9	1561 (2.8)	1647 (1.9)	0.89	0.63-1.26	0.40	0.82	0.56-1.21	0.19

Data were from participants in the 2004, 2007 and 2010 surveys of the Australian Longitudinal Study on Women's health (ALSWH). OR=odds ratio, 99%CI=99% confidence interval, <sup>a</sup> adjustment was made for age, area of residence, education, physical activity, BMI, smoking status, and alcohol consumption.

<Supplementary material> Table 4. Prospective associations between sitting time (2004-2007) and prevalence of symptoms 3 years later (2007-2010) after exclusion of participants (n=3583) reporting heart disease,<sup>a</sup> lung disease,<sup>b</sup> cancer, diabetes or depression in 2004

	Sitting (h/day)	2007 n (% often)	2010 n (% often)	Unadjusted			Adjusted <sup>c</sup>		
				OR	99%CI	p	OR	99%CI	p
Allergies	<6	3303 (9.7)	2789 (9.9)	1.00			1.00		
	6-9	1826 (10.2)	1853 (9.7)	1.04	0.88-1.23	0.51	1.06	0.88-1.27	0.42
	≥9	947 (10.4)	984 (10.5)	1.07	0.87-1.33	0.39	1.06	0.84-1.34	0.53
Breathing difficulty	<6	3281 (0.7)	2752 (0.6)	1.00			1.00		
	6-9	1804 (1.1)	1836 (1.3)	1.80	1.01-3.18	0.008	1.95	1.04-3.63	0.006
	≥9	937 (1.6)	978 (2.5)	3.00	1.65-5.46	<0.001	3.04	1.56-5.93	<0.001
Indigestion/ heartburn	<6	3300 (6.3)	2777 (7.3)	1.00			1.00		
	6-9	1822 (6.5)	1854 (7.0)	1.06	0.86-1.31	0.47	1.08	0.86-1.35	0.38
	≥9	946 (7.7)	982 (7.1)	1.09	0.84-1.43	0.39	1.07	0.80-1.42	0.57
Chest pain	<6	3266 (0.4)	2750 (0.4)	1.00			1.00		
	6-9	1793 (0.5)	1827 (0.4)	1.07	0.47-2.45	0.83	1.55	0.61-3.93	0.22
	≥9	943 (1.2)	971 (0.6)	2.18	0.95-4.99	0.02	2.99	1.14-7.83	0.003
Headaches	<6	3321 (6.4)	2805 (5.8)	1.00			1.00		
	6-9	1816 (5.8)	1860 (5.1)	0.93	0.74-1.15	0.36	0.93	0.73-1.19	0.46
	≥9	952 (6.3)	990 (5.1)	1.00	0.76-1.33	0.98	1.06	0.78-1.44	0.65
Severe tiredness	<6	3295 (8.2)	2781 (6.9)	1.00			1.00		
	6-9	1815 (8.2)	1850 (8.4)	1.07	0.88-1.30	0.38	1.06	0.86-1.32	0.45
	≥9	942 (7.6)	980 (9.2)	1.05	0.81-1.35	0.63	1.06	0.81-1.40	0.57
Stiff/painful joints	<6	3311 (21.9)	2791 (25.9)	1.00			1.00		
	6-9	1827 (19.5)	1856 (26.4)	0.85	0.73-0.98	0.005	0.84	0.72-0.99	0.006
	≥9	954 (20.1)	988 (29.2)	1.09	0.91-1.31	0.21	1.02	0.84-1.25	0.76
Back pain	<6	3327 (15.8)	2795 (15.7)	1.00			1.00		
	6-9	1826 (13.6)	1861 (13.4)	0.95	0.85-1.06	0.24	0.94	0.83-1.07	0.22
	≥9	950 (16.3)	986 (17.1)	1.12	0.98-1.29	0.03	1.06	0.91-1.23	0.32
Urine burns/ stings	<6	3318 (0.6)	2790 (0.4)	1.00			1.00		
	6-9	1820 (0.7)	1859 (0.8)	1.46	0.74-2.88	0.15	1.34	0.64-2.79	0.30
	≥9	950 (0.7)	986 (1.2)	1.86	0.86-4.04	0.04	1.63	0.69-3.84	0.14
Haemorrhoids	<6	3317 (2.9)	2793 (3.4)	1.00			1.00		
	6-9	1812 (3.3)	1859 (3.3)	0.93	0.69-1.25	0.52	1.00	0.73-1.37	0.99
	≥9	947 (3.5)	989 (3.7)	1.00	0.69-1.45	0.99	1.03	0.69-1.55	0.83
Other bowel problems	<6	3300 (3.5)	2784 (4.1)	1.00			1.00		
	6-9	1802 (3.3)	1848 (3.2)	0.89	0.66-1.18	0.28	0.88	0.64-1.21	0.31
	≥9	950 (4.0)	986 (4.3)	1.03	0.72-1.47	0.82	1.10	0.75-1.60	0.54

Table 4 (continued).

	Sitting (h/day)	Survey 5	Survey 6	Unadjusted			Adjusted <sup>c</sup>		
		2007 n (% often)	2010 n (% often)	OR	99%CI	p	OR	99%CI	p
Vaginal discharge/ irritation	<6	3309 (0.5)	2789 (1.1)	1.00			1.00		
	6-9	1807 (0.8)	1858 (0.8)	1.02	0.56-1.88	0.92	0.95	0.48-1.86	0.84
	≥9	946 (1.0)	986 (0.7)	0.99	0.46-2.14	0.98	0.92	0.40-2.13	0.80
Hot flushes	<6	3328 (17.3)	2796 (11.8)	1.00			1.00		
	6-9	1827 (16.0)	1866 (11.9)	0.98	0.84-1.14	0.71	1.01	0.86-1.19	0.82
	≥9	951 (16.5)	987 (10.9)	0.93	0.77-1.14	0.37	0.96	0.78-1.19	0.61
Night sweats	<6	3318 (12.2)	2790 (8.9)	1.00			1.00		
	6-9	1817 (11.0)	1859 (7.9)	0.94	0.79-1.12	0.37	0.96	0.79-1.16	0.56
	≥9	949 (11.3)	986 (9.1)	0.95	0.76-1.20	0.59	1.00	0.78-1.27	0.99
Eyesight problems	<6	3301 (10.1)	2769 (9.5)	1.00			1.00		
	6-9	1815 (9.6)	1844 (8.2)	0.89	0.74-1.07	0.11	0.87	0.72-1.06	0.08
	≥9	945 (11.5)	983 (10.7)	1.09	0.87-1.37	0.3	1.02	0.80-1.30	0.85
Hearing problems	<6	3330 (4.6)	2797 (5.3)	1.00			1.00		
	6-9	1825 (3.9)	1865 (5.0)	1.07	0.85-1.35	0.43	1.05	0.81-1.35	0.65
	≥9	951 (4.3)	990 (4.1)	1.03	0.75-1.40	0.83	0.93	0.66-1.31	0.57
Depression	<6	3331 (2.2)	28807 (2.0)	1.00			1.00		
	6-9	1824 (2.3)	1859 (1.9)	0.97	0.66-1.41	0.81	0.89	0.59-1.34	0.47
	≥9	950 (2.3)	987 (1.9)	0.99	0.61-1.59	0.95	0.85	0.51-1.44	0.43
Episodes of intense anxiety	<6	3324 (0.6)	2789 (1.5)	1.00			1.00		
	6-9	1822 (0.4)	1855 (1.2)	0.64	0.29-1.41	0.14	0.56	0.24-1.32	0.08
	≥9	948 (0.8)	985 (1.2)	0.95	0.39-2.30	0.88	0.79	0.29-2.11	0.53
Palpitations	<6	3329 (1.9)	2803 (1.4)	1.00			1.00		
	6-9	1823 (1.6)	1867 (1.6)	1.08	0.71-1.66	0.62	1.08	0.68-1.71	0.66
	≥9	952 (1.5)	987 (1.1)	0.87	0.59-1.14	0.54	0.89	0.47-1.69	0.64

Data were from participants in the 2004, 2007 and 2010 surveys of the Australian Longitudinal Study on Women's health (ALSWH). <sup>a</sup> Heart disease included heart attack and angina; <sup>b</sup> Lung disease included asthma and bronchitis/emphysema; <sup>c</sup> Adjustment was made for age, area of residence, education, physical activity, BMI, smoking status, and alcohol consumption. OR=odds ratio, 99%CI=99% confidence interval.