Predictors of Back Pain in Middle Aged Women: Data from the Australian Longitudinal Study on Women's Health

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The authors declare that they have no competing interests.

Abstract

Background: Back pain causes greater disability worldwide than any other condition, with women more likely to suffer from back pain than men. Our aim was to identify modifiable risk factors for back pain in middle-aged women.

Methods: Women born between 1946 and 1951 were randomly selected from the national health insurance scheme database to participate in The Australian Longitudinal Study of Women's Health. Self-reported data on back pain in the last 12 months, weight, physical activity and other socio-demographic factors were collected in 1998, 2001, 2004, 2007, 2010 and 2013. In 1998, 12,338 women completed the survey and 10,011 (74%) completed the 2013 survey.

Results: At baseline, median (range) age was 49.5 (44.6 – 53.5) years and 54% reported back pain. In multivariate analysis, baseline weight and depression were positive predictors of back pain over each 3 year survey interval and over the following 15 years, whereas participation in vigorous physical activity was protective. The effects of weight on back pain were most marked in women with a BMI ≥25.

Conclusions: Back pain is common in middle-aged women. Increased weight, weight gain and depression were independent predictors of back pain over 15 years, whereas participation in vigorous physical activity was protective. Targeting these lifestyle factors is an important area for future research on reducing the burden of back pain in middle-aged women.

Significance and Innovation

- Back pain is common among middle-aged women.

- Increased weight, weight gain and depression were independent predictors of back pain over 15 years, whereas participation in vigorous physical activity was protective.

- Strategies to prevent back pain should focus on prevention of weight gain and depression; and promotion of vigorous physical activity.

Introduction

Back pain is a major public health issue, causing greater disability worldwide than any other condition (1). It is associated with a considerable financial burden (2) and substantial disability, as current treatment options have poor efficacy (3). Women are not only more likely to suffer from back pain (4-6), they are also more likely to utilise health care services to a greater extent than men (7, 8). In this context, understanding the predictors of back pain in women is vital to optimize preventive strategies. This is particularly important as past episodes of back pain predict recurrences over time (9, 10), and understanding risk factors associated with back pain will allow us to focus on prevention in women at high risk.

Previous studies of risk factors for back pain have largely been extracted from cross-sectional studies (11-13); they suggest that weight, physical activity and depression are common risk factors for back pain (11, 14). However, there is inconsistency in the literature regarding the role of these risk factors on the prediction of future back pain, (15-17), and because most data are from working populations (18-20), with often lower rates of obesity than are seen in most developed countries (16).

Of the prospective studies that have assessed weight as a risk factor for back pain, only one has assessed back pain at more than one time point (21). That study found that obesity, but not overweight, was a predictor for persistent back pain. Similarly, while some cohort studies have demonstrated an association between physical inactivity and back pain (15, 22),

other studies have yielded inconsistent results (17, 21, 23-26). Moreover, while some systematic reviews have supported the notion that depression and psychological distress are potential predictors of back pain in women (27-29), another showed no relationship between work related psychosocial factors and back pain (30). Also, many of the prospective studies included in these reviews are limited by short duration, high rates of loss to follow up, small sample sizes and assessment of the exposure variables at a single time point (11, 14, 15).

Although it is well-known that both obesity (16) and depression (31) are risk factors for back pain, interactions between these risks have received little research attention. For example, people who are both obese and depressed might be more susceptible to back pain and depression may increase suffering from back pain (32). Physical activity may also impact on both depression and weight, and therefore indirectly on back pain. To date few studies have examined these modifiable predictors of back pain in middle-aged women, with exposure and outcome measures assessed at multiple time points; hence major inconsistency and knowledge gaps persist in this area (6, 8, 11-17).

The aim of this study was to determine whether modifiable factors, such as weight, depression and physical activity, predict back pain in middle-aged women in a large population-based cohort study conducted over a 15 year period. Based on the literature, we hypothesized that higher weight, lack of vigorous physical activity and the presence of depression would be predictors of future back pain in middle-aged women. Additionally, we

hypothesized that the adverse effects of obesity on back pain would be heightened by a lack of participation in vigorous physical activity, or the presence of depression (11, 14, 15).

Patients and Methods

Participants

The Australian Longitudinal Study of Women's Health (ALSWH) first collected mailed survey data from three age cohorts of Australian women in 1996 (young women 1973-1978; middle-aged women 1946-1951; older women 1921-1926). Participants were selected at random from the national health insurance scheme (Medicare) database (which includes most permanent residents of Australia), with intentional oversampling from rural and remote regions (33, 34). Surveys included questions about a wide range of issues such as health behaviours, health service use and physical and mental health, as well as socio-demographic factors. The middle cohort, born 1946-1951, was surveyed in 1996, 1998, 2001, 2004, 2007, 2010 and 2013. The current study analysed data collected predominantly from the second survey in year 1998 (because important variables were available in this survey that were not included in the 1996 survey) through to the seventh survey in year 2013. Figure 1 shows the number of women who participated in the study, including those who answered a specific question on back pain. Further details of the methods used and cohort characteristics have been reported elsewhere (33, 34) and are available on the ALSWH website (www.alswh.org.au). The Human Research Ethics Committees of the University of Newcastle and the University of Queensland approved the study methods. Written informed consent was obtained from all participants.

Back pain

At each survey, women were asked "In the last 12 months have you had back pain?" They were asked to circle one response which related to the frequency of their back pain: 'never', 'rarely', 'sometimes' or 'often'. Those who responded 'rarely' or 'never' having back pain were categorized as 'no back pain,' while those who responded 'sometimes' or 'often' were categorized as 'back pain'. They were also asked "Did you seek help for this problem?" Participants were asked to circle either 'Yes' or 'No'.

Obesity

Body mass index (BMI) was calculated at each survey from self-reported height and weight and classified as underweight or healthy (BMI <25 kg/m^2); overweight (BMI 25.0–29.9 kg/m^2); or obese (BMI ≥30 kg/m^2) using the World Health Organization (WHO) criteria. Self-reported weight and height have previously been shown to be fairly accurate for the estimation of prevalence of overweight and obesity in middle-aged women (35).

Physical activity

Physical activity level was assessed using questions developed for the national surveillance of physical activity in Australia (36). Frequency and duration of brisk walking, moderate-intensity and vigorous activity were used to calculate total physical activity in MET·minutes per week. Participants were instructed only to count activities lasting for at least 10 minutes. Physical activity was categorised based on total MET·minutes per week [none (<40); low (40-<600); moderate (600-<1200); or high (≥1200)] (36). Inadequate physical activity was determined to be less than 600 MET·minutes per week, the equivalent of 150 minutes per week of moderate-intensity physical activity, as per the Australian and US guidelines for

women (37-39). Vigorous physical activity was defined as those who undertook any vigorous leisure physical activity based on the question "If you add up all the times you spent in each activity last week, how much time did you spend altogether doing vigorous physical activity (the ones that make you puff and pant, like vigorous aerobics, competitive sport, vigorous cycling, running, swimming)?" Participants reported time spent doing this type of physical activity and were categorised as either undertaking or not undertaking vigorous physical activity.

Education and work

Data on education status was collected only in the 1996 survey. Low education was classified as having either 'no formal qualifications' or 'School or Intermediate Certificate'. Data on workforce participation was collected at each survey, with questions such as "Which of the following describes your main occupation?" or "In the last week, how much time in total did you spend doing the following things?" Women were classified as either being 'in paid work' (i.e. full time, part time or casual paid work), or 'not in paid work' (i.e. studying, work without pay, looking for work, unpaid voluntary work, home duties, active leisure, passive leisure, socialising). Those in paid work were categorized as 'working one to 34 hours per week in paid work' or 'working 35 hours or greater per week in paid work'.

Depression

The presence or absence of depression in the 1998 survey was identified by the question "Have you ever been told by a doctor that you have depression?" Participants selected from the responses "Yes in the last 2 years", "Yes, more than 2 years ago" or the answer was left

blank if the participant "never had this problem". In subsequent surveys (2001 onwards), the question "In the past three years, have you been diagnosed or treated for depression?" was asked, and participants answered yes if it applied to them.

Smoking and menopausal status

Smoking status was identified by the question "How often do you currently smoke cigarettes or any tobacco products?" Participants selected from the responses "Daily", "At least weekly", "Less often than weekly" or "Not at all". Those reported to be smoking daily, at least weekly or less often than weekly were categorised as smokers. Menopausal status was determined using the answers to several questions which asked women about gynaecological surgeries (oophorectomy, hysterectomy), hormonal replacement therapy, age of menopause and menstrual bleeding.

Statistical analysis

Chi-square tests were used to compare categorical variables in women with and without back pain; independent sample t tests were used to examine differences in continuous variables between these two groups. The predictors of interest in this study were weight, physical activity and depression; the other variables, age, height, employment status, menopause and smoking status, were included as potential confounders. In multivariate analyses we included variables if the relationship between the variable and the outcome was significant at $p \leq 0.1$ in univariate analysis, or had been shown in previous studies to be clinically significant. Generalized estimating equations (GEE) were used with logit link and exchangeable correlation structure to analyse the associations between risk factors such as

weight (per 5kg increments), weight gain (per 1.4kg, as the mean weight gain from survey 1 to 2), depression, age (per 5 years) and physical activity at baseline, with the risk of back pain at any time during the 15 year follow up period. Time lag analyses were also conducted using repeated measurements of the above risk factors at each survey and back pain reported one survey later (40, 41). All analyses, including interaction testing, were performed using two-sided tests and a significance level of less than 5% was considered statistically significant. All analyses were performed using Stata SE version 13.0 (StataCorp).

Results

In 1998, 12,338 women participated in the study. Their median age was 49.5 years (range 44.6 to 53.3 years). After 15 years, 74% of these women completed the 2013 survey (Figure 1). The proportion of women who reported back pain at each of the six surveys is shown in Figure 2. Fifty four percent of women reported back pain at the first survey and 59.6% reported back pain in the final survey (Figure 2). Those with complete follow up at all surveys (n=7606) were of similar age (49.5 vs 49.5 years) and BMI (26.1 vs 26.3 kg/m^2) at baseline, to those who completed only the baseline survey. The proportions who reported back pain (52.3% vs 54.0%), depression (15.8% vs 17.7%) and participation in inadequate levels of physical activity (28.0% vs 28.7%) were similar in these two groups.

Baseline characteristics of the participants in 1998 are shown in Table 1. Those who reported back pain were heavier, more likely to have been diagnosed with depression, more likely to be peri- or post-menopausal, a current smoker, and less likely to participate in vigorous leisure physical activity, than those who did not. However, the proportion doing inadequate levels of physical activity (<600 MET.mins/week) was not significantly different in these two groups. Those with back pain were also more likely to have a low level of education, less likely to be in paid work and less likely to be working more than 35 hours per week. Fifty-two percent of women with back pain reported seeking help for the condition at the first survey.

Predictors of back pain over the following 15 years are presented in Table 2. In univariate models, baseline age, weight, weight gain and depression were associated with an increased risk of reporting back pain at any time over 15 years, whereas vigorous physical activity was associated with a lower risk of back pain. In multivariate models, for every 5kg higher weight at the baseline survey, there was a 7% (95% CI 6%-8%) higher odds of back pain over the following 15 years, after adjustment for age, height, employment status, depression, vigorous physical activity, menopause and smoking status ($p<0.001$). Women gained a mean of 1.4kg (SD 6.0) between the baseline and second survey and a mean of 4.1kg (SD 8.5) across the entire 15 year study period. For every 1.4kg of weight gain from the baseline to the second survey, there was a 1% (95% CI 1%-2%) increased risk of back pain over the following 12 years. Participation in vigorous physical activity at baseline was associated with a 19% reduced risk of back pain, while being diagnosed with depression was associated with a 37% increased risk of back pain over the following 15 years, after adjustment for the above confounders including weight (both $p<0.001$).

In addition, the effect of risk factors were examined using time lag analyses, whereby the measurement of the risk factors at each survey were related to back pain at the subsequent survey (approximately 3 years later) (Table 3). In multivariate analysis, for every 5kg of weight, there was a 2% higher risk of back pain over each 3 year survey interval ($p<0.001$). Participation in vigorous physical activity was associated with a 9% lower risk of back pain and depression was associated with a 23% higher risk of back pain over each survey interval, after adjustment for above confounders (both $p<0.001$).

The effects of weight and weight gain on back pain, stratified by BMI <25 kg/m^2 and ≥25 kg/m^2, are presented in Table 4. There was a consistently significant association between weight and back pain in overweight and obese women, but not in women with a healthy BMI. There was no evidence of an interaction between weight or weight gain and vigorous physical activity, weight or weight gain and depression and weight or weight gain and menopausal status, on the risk of back pain (all p>0.05 for interactions).

Discussion

This large population-based cohort study of middle-aged Australian women demonstrated that self-reported back pain is common, with 54% of women reporting back pain at the baseline survey. In longitudinal analysis, baseline weight and depression were independent predictors of back pain over each 3 year survey interval and over the following 15 year period, whereas vigorous leisure time physical activity was protective. The mean weight gain was 1.4kg from baseline to survey two and gaining 1.4kg was also associated with an increased risk of back pain over the following 12 years. The effects of weight on back pain were not affected by participation in vigorous physical activity, being menopausal or depression status. However, the associations between weight and back pain were more consistent in those who were overweight or obese, than in those with healthy BMI.

The 12 month prevalence is largely consistent with the high rates of back pain reported in large, community and population-based, cross-sectional studies from the UK, Turkey, Denmark and France, where the prevalence ranged from 40.9 – 57.2% for women of similar age (42-45). These data, together with our study, confirm that back pain is relatively common in middle-aged women living in Western countries.

In the current study, we found that weight was an independent predictor of back pain in middle-aged women over each 3 year survey interval and over the entire 15 year period. We

also found that weight gain (which was on average 1.4kg) between baseline and survey two predicted back pain risk over the following 12 years. Most previous data assessing the relationship between weight and back pain have been from cross-sectional studies (11-13) or selected working populations (18-20) and most only assessed back pain at one follow up point. For example in a Norwegian, prospective study of 25,450 community-based adults, baseline BMI in women was positively associated with incident back pain 11 years later (defined as pain persisting for at least 3 months continuously during the past year) (16). However, only 57% completed follow up at 11 years, with lower participation in those who were obese (16). There was also a lower rate of obesity in this cohort (14.5-19.1% of women), than in many developed nations (approximately 30% for women in their 50s) (46). In another Norwegian cohort study of 32,417 adults, using a similar definition of chronic back pain, BMI was associated with chronic back pain in women (15). However, there was no information in these studies about back pain in the intervening years. In another population-based study, persistent back pain (at three time points over 10 years) was predicted by obesity but not overweight (21). Whereas, this current ongoing study of a large sample of Australian community based women over multiple time points provides robust evidence that weight independently predicts future back pain risk in middle-aged women, in both the short and long term.

Our study also found that middle-aged women who participated in any vigorous leisure physical activity (defined as activities that make you 'puff and pant') had a decreased risk of back pain over each 3 year survey interval and over the following 15 years. The few prospective studies that have examined the relationship between physical activity and back

pain in community-based populations have so far yielded inconsistent results (17, 24). In a large Norwegian study, women who did 1-1.9, but not 2 or more, exercise sessions per week had a lower risk of chronic back pain at 11 year follow-up, than those who did less than one exercise session per week (15). In another cohort study of 1836 adults with persistent back pain, the chance of recovery from back pain was greater for women who were physically active (22). In contrast, other cohort studies and systematic reviews have either found no significant association or conflicting evidence for an association between physical activity and back pain (17, 21, 23-26). However, our large, population based study of women shows that any vigorous physical activity in middle-aged women is protective against the onset of back pain over the following 15 year period.

Depression also independently predicted back pain in middle-aged women over each 3 year survey interval and over 15 years. Depression and psychological distress have, in prospective studies, been previously shown to be predictors of back pain (27, 32, 47, 48). However, limitations in these studies have included small sample size, short duration of follow up and non-contemporaneous populations. Also, not all studies have shown consistent results. In a study of 2556 Belgian workers, women who felt depressed were not more likely to develop back pain over a 6 year period (49). However, data on psychological factors were only collected at baseline. Here we address these gaps in a large community based study over multiple time points, by showing that depression is an independent predictor of back pain in middle aged women over the following 15 years.

The current study also demonstrated that the deleterious effects of weight on back pain were not affected by vigorous physical activity, being menopausal or depression status. Few longitudinal studies have sufficiently addressed these interactions and of those that have, exposure and outcome assessments were not performed at multiple time points, and one study evaluated only those with chronic back pain (15, 16). Our results support the importance of weight management in the prevention of back pain in mid-age women, as, most appear to be vulnerable to the adverse effects of weight gain. The predictive effects of weight gain persisted, despite the cohort gaining on average only 4.1 kg over 15 years.

Some limitations of our study were that weight was based on self-reported data at each time point. Although overweight and obese women are more likely to under-report their weight (35, 50), estimates of weight changes are unlikely to be affected, especially if the degree of under-reporting remains constant across surveys. However, under-reporting weight change is unlikely to explain the observed positive association, since it is more likely to bias the results toward the null, particularly in overweight and obese women.

While physical activity levels were also self-reported, the survey questions used have been found to have satisfactory validity when compared with accelerometry, and vigorous physical activity is reported more accurately (36). While there is a possibility that some participants over-estimated their participation in vigorous physical activity, it is most likely to cause non-differential misclassification and attenuate the findings towards the null. Although depression status was self-reported, similar questions have been found to be

reasonably accurate when compared with psychiatric or psychological assessment (50). While back pain was self-reported, the question identified women with back pain that was sufficient to result in a high proportion of help-seeking and was associated with less likelihood of being in paid work. Whilst participants did not have a physician assessment or imaging to investigate the origin of their back pain, it is known that imaging does not correlate well with back pain symptoms and the majority of patients with back pain cannot be given an exact pathoanatomical diagnosis (51). Currently, recommendations are that investigations be generally performed if 'red flag' features are present, such as unexpected weight loss, fever or recent infection (52), but serious pathology among back pain sufferers in primary care is rare (52). Any potential misclassification where participants made an error in their reporting of back pain would be expected to cause non-differential misclassification, and attenuate our results. Although loss-to-follow-up in this 15 year study was low, it is possible that the sample has become less representative over time. However, there were no important differences in general characteristics and pain status between those who completed follow up and those who did not. A major strength of this study was the large, population-based sample, with relatively high participation rates over 15 years.

In summary, back pain was common in this large, longitudinal, community-based, middle-aged female cohort. Weight and depression were independent predictors of back pain over each 3 year survey interval and over the following 15 year period. However, doing any vigorous leisure physical activity (defined as activities that make you 'puff and pant') significantly reduced back pain risk. We also found that weight-related back pain risk was

not affected by participation in vigorous physical activity, being menopausal, or depression status, suggesting that all women appear to be vulnerable to the adverse effects of weight on back pain. Back pain is the leading cause of disability worldwide, thus even though the magnitude of the increased risk of back pain in this study was small, the significant burden of back pain on a population level means that these risk factors could potentially have a large impact. Despite the average weight gain in this cohort being only 4.1 kg over 15 years, there was a significant association between weight and back pain, suggesting that an emphasis on weight management may be important as a future prevention strategy. Although clinical intervention trials are required, strategies that target weight, lack of physical activity and mental health may be important in the prevention of back pain in middle-aged women.

Author contributions

S.R.E.B. was responsible for data analysis, writing the first draft, and editing the manuscript. S.R.E.B. affirms that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned have been explained. S.M.H. assisted in data analysis, editing and review of manuscript. W.J.B. was responsible for data collection and acquisition, contributed to study conception and the analysis plan, provided editing assistance and review of the manuscript. S.H. assisted with statistical analysis and manuscript editing. Y.W. assisted with editing and review of manuscript. H.T. contributed to study conception, provided editing assistance and review of the manuscript. D.M.U. provided editing assistance and review of the manuscript. F.M.C. contributed to study conception, data analysis, editing and review of manuscript. All authors gave final approval of the submitted version of the manuscript.

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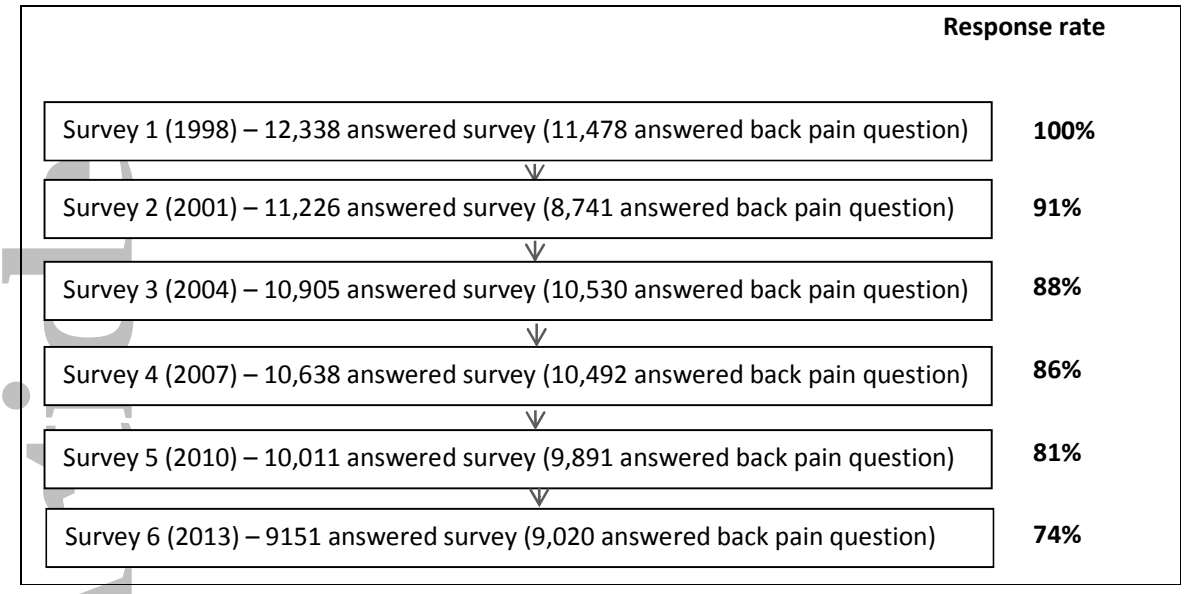
Figure 1: Numbers of women who answered the back pain question at each survey from 1998 to 2013

Figure 2: Proportion of women who reported back pain ('sometimes' or 'often') at each survey



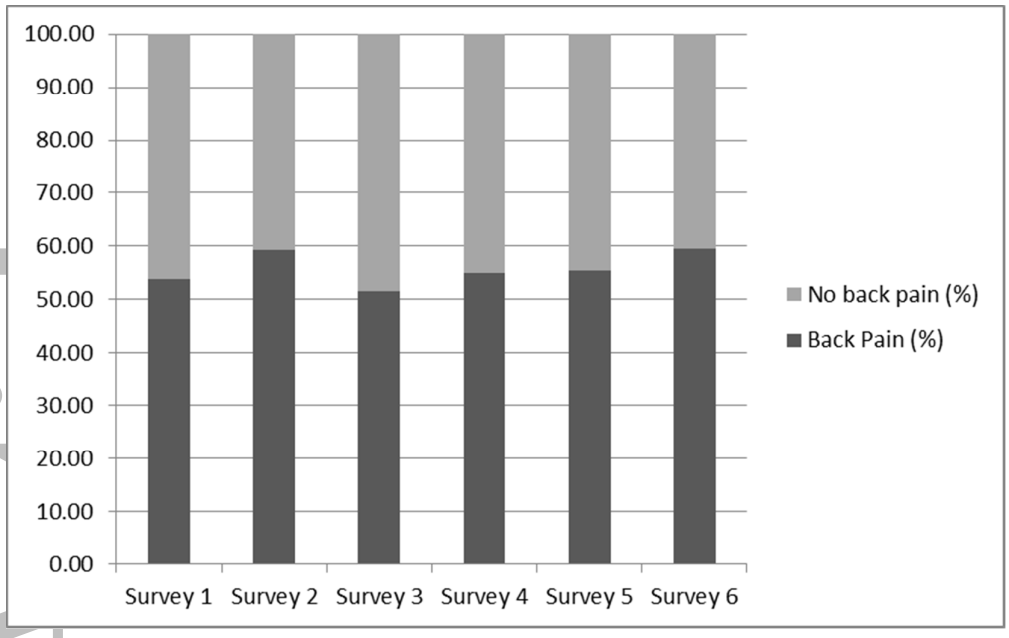


Table 1: Characteristics of the women who did and did not report back pain ('sometimes' or 'often') at baseline in 1998 (n=11,478)

	No back pain	Back pain	P value
Total number of participants, n (%)	5,286 (46.1)	6,192 (54.0)	-
Age (years), mean (SD)	49.48 (1.5)	49.53 (1.5)	0.079
Weight (kg), mean (SD)	68.40 (13.7)	71.11 (15.2)	<0.001
Body mass index (kg/m^2), mean (SD)	25.82 (5.0)	26.73 (5.6)	<0.001
BMI <25 kg/m^2, n (%)	2,564 (51.8)	2,604 (45.6)	<0.001
Overweight (BMI 25 - <30 kg/m^2), n (%)	1,525 (30.8)	1,810 (31.7)	
Obese (BMI ≥30 kg/m^2), n (%)	857 (17.3)	1,302 (22.8)	
Depression ever diagnosed by a doctor, n (%)	688 (13.0)	1,298 (21.0)	<0.001
Peri- or post-menopausal, n (%)	2,779 (52.6)	3,538 (57.2)	<0.001
Smoker, n (%)	816 (15.5)	1,130 (18.4)	<0.001
Physical activity (MET.min/week), n (%)			
None (<40)	495 (9.9)	686 (11.7)	0.003
Low (≥40, <600)	914 (18.3)	1,015 (17.4)	
Moderate (≥600, <1200)	897 (17.9)	950 (16.3)	
High (≥1200)	2,699 (53.9)	3,190 (54.6)	
Inadequate physical activity (<600), n (%)	1,409 (28.2)	1,701 (29.1)	0.266
Participation in vigorous leisure physical activity, n (%)	995 (19.3)	868 (14. 5)	<0.001
Low education status (intermediate certificate or below), n (%)*	2,301 (43.9)	3,232 (52.6)	<0.001
Employment status, n (%)			
Not in paid work	1,171 (22.9)	1,604 (26.9)	<0.001
Working 1-34 hours per week in paid work	1,822 (35.6)	2,195 (36.8)	
Working ≥35 hours per week in paid work	2,125 (41.5)	2,168 (36.3)	
Proportion seeking help for back pain, n (%)	388 (8.3)	2,711 (52.0)	<0.001
*Education status was only available from the 1996 survey			

Table 2: Risk factors for back pain over 15 years - GEE models using risk factors from baseline survey and report of back pain at any survey

	Univariate Odds ratio (95% CI)	P value	Multivariate Odds ratio (95% CI)[a]	P value
Age at baseline (per 5 year increase)	1.06 (1.05 - 1.08)	<0.001	1.01 (0.99 – 1.03)	0.225
Weight (per 5kg) at baseline	1.07 (1.06 - 1.08)	<0.001	1.07 (1.06 – 1.08)	<0.001
Weight gain (per 1.4kg) from baseline to the second survey *	1.01 (1.00 – 1.01)	<0.001	1.01 (1.01 – 1.02)	<0.001
Vigorous leisure physical activity at baseline	0.81 (0.78 - 0.85)	<0.001	0.81 (0.78 – 0.85)	<0.001
Depression at baseline	1.35 (1.28 - 1.41)	<0.001	1.37 (1.29 – 1.45)	<0.001

[a] Multivariate analysis adjusted for age, weight, height, employment status, depression, vigorous physical activity, menopausal and smoking status at baseline.

*Average weight gain in this population

Table 3: Risk factors for back pain - time lagged GEE models using explanatory and outcome variables over each 3 year survey interval

	Univariate Odds ratio (95% CI)	P value	Multivariate Odds ratio (95% CI)[a]	P value
Age (per 5 year increase) one survey prior to back pain	1.02 (1.01 – 1.04)	<0.001	0.98 (0.97 - 1.00)	0.030
Weight (per 5kg increase) one survey prior to back pain	1.03 (1.03 - 1.04)	<0.001	1.02 (1.02 – 1.03)	<0.001
Vigorous leisure physical activity one survey prior to back pain	0.90 (0.86 – 0.93)	<0.001	0.91 (0.87 – 0.95)	<0.001
Depression one survey prior to back pain	1.24 (1.18 -1.31)	<0.001	1.23 (1.17 – 1.31)	<0.001

[a] Multivariate analysis adjusted for age, height, weight, employment status, depression, menopausal status, smoking status and vigorous physical activity from the time of back pain assessment.

Table 4: Associations between weight and back pain, stratified by BMI

	BMI<25 kg/m^2		BMI ≥25 kg/m^2	
	Multivariate OR (95% CI)	**P value**	**Multivariate OR (95% CI)**	**P value**
Weight (per 5kg) at baseline	1.07 (1.03 – 1.10)	<0.001	1.06 (1.05 – 1.08)	<0.001
Weight gain (per 1.4 kg) at baseline*	1.01 (1.00 – 1.01)	0.234	1.01 (1.00 – 1.01)	0.003
Weight (per 5 kg) one survey prior to back pain	1.00 (0.98 – 1.01)	0.574	1.02 (1.01 – 1.03)	<0.001

All multivariate analyses were adjusted for age, height, depression, vigorous physical activity, employment status, smoking and menopause status.

*Average weight gain in this population

STROBE Statement—checklist of items that should be included in reports of observational studies

	Page No(s)	Recommendation
Title and abstract	2-4	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	6-8	Explain the scientific background and rationale for the investigation being reported
Objectives	7-8	State specific objectives, including any prespecified hypotheses
Methods		
Study design	9	Present key elements of study design early in the paper
Setting	9	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	9	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	10-12	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	10-12	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	10-12	Describe any efforts to address potential sources of bias
Study size	9	Explain how the study size was arrived at
Quantitative variables	10-12	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12-13	(*a*) Describe all statistical methods, including those used to control for confounding
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy
		(*e*) Describe any sensitivity analyses

Continued on next page

Results		
Participants	9, 14	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	14	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	14	*Cohort study*—Report numbers of outcome events or summary measures over time
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures
Main results	15-16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	16	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results	17	Summarise key results with reference to study objectives
Limitations	20-21	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	21-22	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	22	Discuss the generalisability (external validity) of the study results
Other information		
Funding	24	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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