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Healthy lifestyle behaviour improves the prognosis of low back pain in women: A population based cohort study.

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Abstract

Objectives

To study the influence of healthy lifestyle behaviour on the prognosis of occasional low back pain among men and women in a general population.

Design

Cohort study with a four year follow-up.

Settings

General population in Stockholm County, Sweden.

Participants

The study sample comprised 3938 men and 5056 women, aged 18-84, from the Stockholm Public Health cohort reporting occasional low back pain in the baseline questionnaire 2006.

Measures

Lifestyle factors and potential confounders were assessed at baseline. The lifestyle factors smoking habits, alcohol consumption, leisure physical activity and consumption of fruit and vegetables, were dichotomized using recommendations for a health-enhancing lifestyle and combined to form the exposure variable “healthy lifestyle behaviour”. The exposure was categorised into five levels according to the number of healthy lifestyle factors met. The follow-up questionnaire in 2010 gave information about the outcome, long duration troublesome low back pain. Crude and adjusted binomial regression models were applied to estimate the association between the exposure and the outcome analysing men and women separately.

Results

The risk of developing long duration troublesome low back pain among women with occasional low back pain decreased with increasing healthy lifestyle behaviour (test for trend: $p=0.006$). 21% (28/131) among women with no healthy lifestyle factor (reference group) experienced the outcome

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3 compared to nine percent (36/420) among women with all four factors. Compared to the reference
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5 group, the risk was reduced by 35% (RR: 0.65, 95% CI: 0.44 to 0.96) for women with one healthy
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7 lifestyle factor and 52% (RR: 0.48, 95% CI: 0.31 to 0.77) for women with all four healthy lifestyle
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9 factors. There were no clear associations found among men.

10 11 12 **Conclusion**

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14 Healthy lifestyle behaviour decreases the risk of developing long duration troublesome low back pain
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16 among women with occasional low back pain and may be recommended to improve the prognosis.
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19 20 **Article summary**

21 22 **Strengths and limitations of this study**

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 - Strengths of this study are the large sample, the longitudinal design, the long term follow-up, robust analyses and the large number of potential confounding factors assessed.
 - Possible limitations of this study were the potential risk of misclassification of the exposure variable and the relatively large loss to follow-up, although these limitations most probably lead to an underestimation of the associations studied. Further the results may have been affected by questionnaire items not fully validated.

Introduction

Lifestyle factors such as non-smoking, physical activity, healthy diet and moderate alcohol use seem to influence the risk and the prognosis in several diseases (e.g. cancer, type 2 diabetes mellitus, and cardiovascular disease) as well as mortality, especially when the factors are combined.[1-5]

Low back pain (LBP) is one of the most common health problems worldwide and comprises a large burden on individuals as well as on society.[6, 7] When estimating the global prevalence of activity-limiting LBP using 165 studies from 54 countries, Hoy and colleagues found the mean point- and 1 month prevalence to be $11.9 \pm 2.0\%$ and $23.2 \pm 2.9\%$ respectively.[6] Current knowledge of prognostic factors, e.g. lifestyle factors, for LBP is limited and the above mentioned facts support the need for more research on this topic.

In a “review of reviews” from 2009, Hayden and colleagues reported older age, negative cognitive characteristics, poor general health, increased psychological or psychosocial stress, poor relations with colleagues, physically heavy work, functional disability, sciatica, and the presence of worker’s compensation to be associated with poor outcomes of acute and sub-acute LBP.[8] Another 2009 review found recovery expectations to be associated with activity limitations or participation restrictions (e.g. return to work) in persons with non-chronic non-specific LBP.[9] In the review by Hayden and colleagues smoking was the only lifestyle factor included and found, by two studies, to have no association with poor outcomes of acute and sub-acute LBP.[8] Similarly, a recent review studying prognostic factors for recovery from chronic LBP found no association between smoking and the outcome pain and disability.[10] Moreover, reviewing observational studies on LBP patients Hendrick and colleagues found moderate evidence for sports, leisure and occupational physical activity not to be associated with LBP outcomes.[11]

Women seem to have higher prevalence, be more severely affected and have worse prognosis of LBP than men and some studies suggest that men and women should be assessed separately when studying risk and prognostic factors for LBP.[6, 12-14]

To our knowledge, it is not known if healthy lifestyle behavior, defined by a combination of lifestyle factors, is associated with the prognosis of LBP. Healthy lifestyle behaviour seems to have a larger

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3 potential to affect health problems and mortality than separate lifestyle factors alone.[1-5] We
4 hypothesized that healthy lifestyle behaviour would decrease the risk of a poor outcome among men
5 and women with occasional low back pain. If healthy lifestyle behaviour affects the prognosis of LBP
6 implementing this knowledge could potentially prevent transition into disabling LBP and thereby
7 reduce the burden on the individual as well as on the society.
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11 The aim of this study was to explore the influence of healthy lifestyle behaviour on the prognosis of
12 occasional low back pain among men and women in a general population, hypothesizing that healthy
13 lifestyle behaviour can improve the prognosis.
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20 21 **Methods**

22 23 **Study design and source population**

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25 In this study we used data from the Stockholm Public Health Cohort (SPHC).[15] The SPHC was set
26 up by the Stockholm County Council and administered by Statistics Sweden and the Department of
27 Public Health Sciences at Karolinska Institutet, Stockholm. The SPHC is a population based cohort
28 established within the framework of Stockholm County Council public health surveys. In 2006,
29 Stockholm County had an adult population of approximately 1.4 million individuals. From this
30 population a total of 56 634 individuals (18-84 years old) were randomly selected, after stratification
31 for gender and residential area, and received the baseline questionnaire, which 34 707 (61%)
32 answered. The responders received a follow-up questionnaire in 2010, answered by 25 167
33 participants (73%). Compared to consensus data from Stockholm County the SPHC participants were
34 more likely to be of female gender, be born in Sweden, have higher education and income and be more
35 than 45 years old.[15]
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50 51 **Study sample**

52 The study sample (n=8994) consisted of participants reporting occasional LBP at baseline in 2006 who
53 answered the follow-up questionnaire in 2010 and provided complete information on outcome and
54 exposure variables (Figure 1). Occasional LBP at baseline was defined as reporting having had LBP,
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3 on average, up to a couple of days per month during the past 6 months. The information was based on
4
5 a modified version of a question from the Standardized Nordic Questionnaire.[16]
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8 **Data collection and variables**

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10 The baseline and the follow-up questionnaires comprised self-reported information on lifestyle,
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12 demographic- and socioeconomic characteristics, physical and psychological health and work related
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14 factors. The self-reported data were supplemented with information from regional and national
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16 registers.[15] Four reminders were sent after the baseline questionnaire and three reminders after the
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18 follow-up questionnaire.
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20 21 Exposure: healthy lifestyle behaviour (HLB)

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23 Using baseline information we constructed four binary healthy lifestyle factors where cut-offs
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25 (healthy/not healthy) were set in accordance with recommendations for a health-enhancing lifestyle
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27 made by Swedish authorities and WHO.[17-20] The exposure variable “healthy lifestyle behaviour”
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29 (HLB) was a combination of these binary factors and was categorised into five levels according to the
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31 number of healthy lifestyle factors included, i.e. from none to four (HLB0 to HLB4). A healthy
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33 lifestyle behaviour with regard to each of the considered healthy factors was defined by: non-smoking,
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35 no risk consumption of alcohol (≤ 168 g 100% alcohol/week for men and ≤ 108 g 100% alcohol/week
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37 for women, and consuming alcohol corresponding to about half a bottle of spirits (35 cl) on the same
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39 occasion less than once a month), recommended level of leisure physical activity (at least 150 minutes
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41 at moderate intensity or 75 minutes at high intensity per week or a combination of these activities),
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43 and recommended consumption of fruit and vegetables (\geq a total of 4 servings of fruit and
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45 vegetables/day, equal to about 400 g/day) (see the Appendix for a description of the questions and
46
47 how the variables were constructed).
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50 51 Outcome variable: long duration troublesome low back pain (LTLBP)

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53 Information on the outcome LTLBP was collected from the follow-up questionnaire in 2010 and
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55 defined as having had LBP that decreased workability or interfered with other daily activities to some
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57 or to high degree, on average a couple of days per week or more often during the past 6 months. The
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question used to measure LTLBP was modified from the Standardized Nordic Questionnaire and incorporated a dimension of disability suggested to be of importance when defining LBP.[16, 21]

Potential confounding factors

Potential confounders were chosen based on theoretic and empirical relevance, information from literature regarding the prognosis of spinal pain and availability in the questionnaire.[8, 22, 23] The following factors were considered: long-term illness (suffering from long-term illness, health problems following an accident, disability or other persistent health problems), neck pain and pain from hip, thigh or knee during the past 6 months (5 answer alternatives from “no pain” to “daily pain”), suffering from headache or migraine (“no”, “somewhat”, “severe”), rheumatoid arthritis diagnosed by a physician, living alone, living with children (children of all ages included) and hours of sleep a typical night during the workweek (dichotomized into “good sleep”: 6-8 h and “poor sleep”: <6 h or >8 h). The questionnaire also included the 12-item General Health Questionnaire were a sum score of ≥ 3 (using the recommended 0-0-1-1 scoring on the four answer alternatives) was used to assess psychological distress.[24, 25] The frequency of stress was measured by the question “How often do you feel stress?” with 5 answer alternatives from “never” to “most of the week”. Personal support (having persons who can give support in handling personal problems or critical life events) was measured using a question from the Social Support-13 instrument (SS-13).[26] Furthermore, financial stress was assessed by the question “Did it during the previous 12 months happen that you ran out of money and had to borrow from relatives and friends to be able to pay for food or rent?” (“no”, “yes, on one occasion”, “yes, on several occasions”). A Swedish national register supplied information on civil status (married, unmarried, divorced, widow/widower), country of birth (Sweden, Nordic countries and Europe, outside Europe), socio-economic status (SES), annual individual disposable income (grouped in quintiles) and education.[27, 28] The level of education was categorized into, low (only compulsory education and vocational training), intermediate (secondary school) and high (university studies).

Statistical methods

We used generalized linear models with a binomial distribution to estimate the association between the exposure and the outcome analysing men and women separately. To determine the role of a potential confounding factor we included them, one at a time, into the crude model. Only factors that changed the estimated risk ratio (RR) by 10% or more were entered into the final model.[29-33] All final models were adjusted for age categorized into 10 year intervals. Age was categorized as it showed non-linearity with the outcome. We calculated relative risks (RR), using the log function, as well as risk differences (RD), using the identity function, with 95% confidence intervals (95% CI). A likelihood ratio test was used to assess effect measure modification between the exposure and possible confounders as well as between confounders included in the final models.[34] We used Wald test to evaluate potential trends in the associations between the exposure and the outcome, and a Chi-square test to assess if the overall adjusted risk differed between men and women.[34] The effect of attrition was assessed, using Chi-square tests, by comparing the distribution of the four healthy lifestyle factors included in the exposure, healthy lifestyle behaviour, in subjects who were lost to follow-up to the distribution in the study sample.

All p-values were two-sided, and analyses were completed using SAS® version 9.3 and STATA/IC® version 12.1.

Results

Baseline characteristics

The study sample (n=8994) consisted of 56% women. Participants were predominately middle aged, well educated, and born in Sweden. At baseline in 2006, about 15% of the participants were 65 years or older (men 17% and women 14%). Furthermore the majority were cohabitating, and about 35% had children living at home (Table 1). About three percent men and 10% women had an “optimal healthy lifestyle” (HLB4) whereas about five percent men and three percent women had an “unhealthy lifestyle” (HLB0). Healthy lifestyle behaviour improved with increased level of education.

Participants being married or having children living at home had a high proportion of healthy lifestyle behaviour while participants living alone, being psychologically distressed and financially stressed

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2
3 showed low proportions of healthy lifestyle behaviour (Table 1).

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5 The other baseline variables assessed did not differ much between the categories of HLB, neither
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7 among men nor among women.
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Table 1. Baseline characteristics by categories of the exposure healthy lifestyle behaviour (HLB0 - HLB4)* (n = 8994).

Baseline characteristics	Men						Women						Internal drop-out M/W (n)
	All (n=3938)	HLB0 (n=181)	HLB1 (n=958)	HLB2 (n=1747)	HLB3 (n=936)	HLB4 (n=116)	All (n=5056)	HLB0 (n=174)	HLB1 (n=897)	HLB2 (n=2080)	HLB3 (n=1416)	HLB4 (n=489)	
Proportion of study sample (%)	44						56						
Mean age, years (SD)	50(15)	49(14)	48(15)	49(15)	51(15)	50(14)	46(16)	43(17)	47(15)	46(16)	47(15)	46(14)	0/0
Education													234/287
Low	16	30	19	14	14	8	14	22	17	13	12	9	
Intermediate	43	43	46	44	40	35	41	57	46	42	38	34	
High	41	27	35	42	46	57	45	21	37	45	50	57	
Civil status													0/1
Married	54	42	49	56	56	65	47	27	41	46	53	53	
Unmarried	33	38	36	32	31	29	36	49	37	37	33	32	
Divorced/Widow/Widower	13	20	15	12	13	6	17	24	22	17	14	15	
SES^a													292/398
Unskilled/semiskilled worker	14	22	17	13	12	9	16	23	19	16	14	10	
Skilled worker	15	25	16	14	15	8	10	22	12	9	9	11	
Assistant non-manual employees	8	8	10	9	7	5	20	22	21	22	18	15	
Intermediate non-manual	25	14	25	24	27	24	29	23	23	29	31	35	

employees													
Employed/self-employed	25	17	18	28	28	34	19	7	17	18	21	24	
professionals													
Self-employed (other than professionals)	13	14	14	12	11	20	6	3	8	6	7	5	
Poor sleep^b													34/27
<6 or >8 hours/night	9	17	9	10	7	9	10	14	11	11	9	7	
Living alone	17	31	19	16	14	9	19	24	21	19	17	17	10/16
Living with children	34	24	31	35	34	42	38	27	32	39	41	41	10/16
Psychological distress^c	13	18	15	13	11	5	21	33	23	22	19	17	38/37
Financial stress^d	7	15	10	5	4	3	9	23	13	9	7	6	17/24

* HLB0 = no healthy lifestyle factor, HLB1 = 1 of 4 healthy lifestyle factors, HLB2 = 2 of 4 factors, HLB3 = 3 of 4 factors, HLB4 = all 4 healthy lifestyle factors.

^a Socio-economic status. For the economically active population SES was based on current occupation and education. For the non-active population SES was based on previous occupation, current education or the occupation of spouses.

^b Hours of sleep a typical night during the workweek (dichotomized into “good sleep”: 6-8 h and “poor sleep”: <6 h or >8 h).

^c From the 12-item General Health Questionnaire (GHQ-12) were a sum score ≥ 3 was used to assess psychological stress.

^d Financial stress: Had to borrow money from relatives and friends to be able to pay for food or rent on several occasions during the previous 12 months.

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3 The majority of both men and women were non-smokers and did not exceed risk consumption of
4 alcohol. About 40% of both men and women reached recommended levels of leisure physical activity
5 while 26% of the women consumed recommended levels of fruit and vegetables compared to seven
6 percent for men (Figure 2).
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10 11 **Outcome**

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14 At follow-up in 2010, nine percent men and 11% women in the study sample reported LTLBP. Table
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16 2 shows the crude and adjusted binomial regression estimations of the association between healthy
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18 lifestyle behaviour and the outcome.
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Table 2. Association* between healthy lifestyle behaviour and long duration troublesome low back pain (LTLBP) in men and women with occasional LBP at baseline in 2006.

	MEN (n=3646) ^a					WOMEN (n=4658) ^a			
	Healthy lifestyle behaviour ^c	LTLBP/ no LTLBP ^d (n/n)	Crude	Adjusted (Age, SES) ^b		LTLBP/ no LTLBP ^d	Crude	Adjusted (Age, SES) ^b	
			RR (95% CI)	RR (95% CI)	RD (95% CI)		RR (95% CI)	RR (95% CI)	RD (95% CI)
HLB0	14/155	1.0	1.0	0.0	28/131	1.0	1.0	0.0	
HLB1	71/812	0.97 (0.56, 1.68)	1.02 (0.59, 1.76)	-0.01 (-0.06, 0.03)	94/735	0.64 (0.44, 0.95)	0.65 (0.44, 0.96)	-0.05 (-0.12, 0.01)	
HLB2	133/1476	1.00 (0.59, 1.69)	1.05 (0.62, 1.78)	-0.01 (-0.05, 0.04)	181/1721	0.54 (0.38, 0.78)	0.54 (0.38, 0.78)	-0.07 (-0.13, -0.01)	
HLB3	60/818	0.82	0.85	-0.02	125/1187	0.54	0.55	-0.07	

		(0.47, 1.44)	(0.48, 1.48)	(-0.06, 0.02)		(0.37, 0.79)	(0.38, 0.81)	(-0.13, -0.01)
HLB4	6/101	0.68	0.75	-0.03	36/420	0.45	0.48	-0.08
		(0.27, 1.71)	(0.30, 1.89)	(-0.07, 0.01)		(0.28, 0.71)	(0.31, 0.77)	(-0.15, -0.02)

*note: Log- binomial regression estimating the risk ratio (RR) and the risk difference (RD) with 95% confidence interval (95% CI).

^a Reduced number of observations due to missing information about socio-economic status (SES) (men n=292 and women n=398).

^b Adjusted for age in 10 year categories and socio-economic status (SES) in six categories.

^c HLB0 = no healthy lifestyle factor, HLB1 = 1 of 4 healthy lifestyle factors, HLB2 = 2 of 4 factors, HLB3 = 3 of 4 factors, HLB4 = all 4 healthy lifestyle factors.

Healthy lifestyle factors included in HLB: non-smoking, no risk consumption of alcohol (≤ 168 g 100% alcohol/week for men and ≤ 108 g 100% alcohol/week for women, and consuming alcohol corresponding to \approx half a bottle of spirits on the same occasion less than once a month), recommended level of leisure physical activity (at least 150 minutes at moderate intensity or 75 minutes at high intensity per week or a combination of these activities), and recommended consumption of fruit and vegetables (≥ 4 servings of fruit and vegetables/day).

^d Numbers of participants with and without LTLBP at follow-up in 2010.

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3 There was a decreased risk for LTLBP at follow-up for women with a healthy lifestyle behaviour
4 compared to women with unhealthy lifestyle behaviour (test for trend: $p=0.006$). Twenty-one percent
5 of women with no healthy lifestyle factor (HLB0) experienced LTLBP at follow-up compared to nine
6 percent of women with all four factors (HLB4). A five percent lower proportion of women with one
7 healthy lifestyle factor, and an eight percent lower proportion of women with all four factors had
8 LTLBP, in comparison to the reference group (HLB0). Women with one healthy lifestyle factor and
9 women with all four healthy lifestyle factors had a 35% and a 52% lower risk for LTLBP,
10 respectively, compared to women with unhealthy lifestyle behaviour (HLB0). There were no clear
11 associations between healthy lifestyle behaviour and LTLBP found among men.

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13 SES was the only variable found to be a confounder, so the final log-binomial analyses were adjusted
14 by SES and age in 10 year categories. There was no effect measure modifications found.

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16 Figure 3 shows the adjusted risk to develop LTLBP for men and women with occasional LBP by
17 categories of healthy lifestyle behaviour. Women had an overall higher adjusted risk for LTLBP than
18 men ($p=0.001$).

19
20 The subjects lost to follow-up ($n=4552$) had significantly lower proportions of healthy lifestyle factors
21 than the study sample ($p < 0.01$ for all four factors). The differences in proportions were eight percent
22 for non-smoking, 16% for no risk consumption of alcohol, six percent for leisure physical activity and
23 five percent for consumption of fruit and vegetables.

24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 **Discussion**

44
45 In this cohort study we found that healthy lifestyle behaviour had a positive influence on the prognosis
46 of occasional low back pain among women. Healthy lifestyle behaviour comprised four healthy
47 lifestyle factors: non-smoking, no risk consumption of alcohol, recommended level of leisure physical
48 activity and recommended consumption of fruit and vegetables. Compared to women with no healthy
49 lifestyle factor, the risk for development of long duration troublesome low back pain (LTLBP)
50 decreased by 35% among women with one healthy lifestyle factor and by 52% among women with all
51 four healthy lifestyle factors. In absolute terms, the proportion of women with LTLBP at follow-up
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3 was five percent lower if they had one healthy lifestyle factor and eight percent lower if they had four
4 healthy lifestyle factors when compared to women with unhealthy lifestyle behaviour. These
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6 associations were not confirmed among men but the results indicated the same tendency.
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10 Further, compared to women, men had an overall lower adjusted risk for LTLBP, and a low risk even
11 in the unhealthy reference group (Figure 3). Men with unhealthy lifestyle behaviour had about the
12 same risk for LTLBP as women with optimal healthy lifestyle behaviour. These findings were not
13 aimed to be addressed in the present study and needs to be further investigated.
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17 We found no studies concerning the effects of healthy lifestyle behaviour, defined as a combination of
18 healthy lifestyle factors, on the prognosis of LBP or other types of spinal pain. Nevertheless,
19 considering the risk of developing chronic back pain Pronk and colleagues showed results in line with
20 our study.[2] Studying employees, the authors found that an “optimal lifestyle” decreased the 2-year
21 risk of chronic LBP by 66% compared to employees with an unhealthy lifestyle. Having optimal
22 lifestyle was equal to having all four of the healthy lifestyle factors similar to the ones included in our
23 study: non-smoking, adequate physical activity, five servings of fruit and vegetables per day and
24 limited or no alcohol consumption.
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35 **Strengths and limitations**

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37 To our knowledge this is the first study concerning the influence of healthy lifestyle behaviour (HLB)
38 on the prognosis of LBP assessing men and women separately. Measuring the exposure prior to the
39 outcome and the dose-response relationship found supports the validity of the associations between
40 HLB and LTLBP found among women.[32] We believe the use of a complete study sample, the large
41 sample size and the large number of potential confounders assessed strengthens the internal validity,
42 though we cannot rule out residual or unmeasured confounding.[32] The questions used in this study
43 have, since 1975, been used in several Swedish national and local public health surveys. They have on
44 several occasions been tested (e.g. cognitive testing) and improved by Statistics Sweden’s test centre
45 and several questions have shown to have acceptable psychometric properties. Moreover, information
46 on education, disposable income, SES, country of birth and marital status were collected from
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3 Swedish national registers known to have high quality. The questions concerning leisure physical
4 activity and consumption of fruit and vegetables have shown to have acceptable validity and
5 reliability, and the method to measure alcohol consumption has been recommended by Romelsjö and
6 colleagues.[35-38] Despite this the measurements used may not have been optimal in terms of validity
7 and reliability.
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12 Our study also has limitations. Self-reported exposure information may be hampered by low accuracy.
13 For example, some participants may wish to present themselves in a favourable light and overestimate
14 their healthy lifestyle (social desirability) or some may have difficulties understanding the questions
15 and therefore report less well.[32, 39, 40] This could lead to misclassification of the exposure which
16 may result in an under- or overestimation of the association. As this potential misclassification is
17 likely to be non-differential it would probably dilute a true association, at least when comparing
18 extremes.[32] Moreover, if men tend to misclassify their healthy lifestyle factors to a greater extent
19 than women this may partly explain why we did not find any associations among men. For example,
20 Dyrstad and colleagues found that men overestimated their self-reported physical activity when
21 compared to accelerometer-measures to a greater extent than women.[41] As we studied a population
22 between 18-84 years old a large proportion of the participants did not provide work related
23 information why we did not assess potential confounding effects from work related variables,
24 something that may have affected the results. About 34% of participants in the baseline survey were
25 not part of the study sample due to attrition and exclusion (Figure 1). These subjects had significantly
26 lower proportions of healthy lifestyle factors than the study sample. This may have biased our result,
27 most probably leading to an underestimation of the associations.
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32 Considering strengths and limitations in our study we regard our result as a valid contribution to the
33 body of research showing that a healthy lifestyle affects health problems.[1-5] Our study results
34 showing that healthy lifestyle behaviour influences the prognosis of LBP are new and important
35 knowledge with the potential to have an impact on a very common public health problem and have
36 implications both in a public-health and a clinical perspective. Even though the association for healthy
37 lifestyle behaviour to affect LBP among men was not clear, the results showed the same tendency as
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3 for women. Considering this together with the obvious effect of healthy lifestyle on other health
4 problems the work to encourage both men and women to adapt to healthy lifestyle should certainly be
5 continued.
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10 **Conclusion**

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12 Healthy lifestyle behaviour, defined as combinations of non-smoking, no risk consumption of alcohol,
13 recommended level of leisure physical activity and recommended consumption of fruit and vegetables,
14 decreases the risk of developing long duration troublesome low back pain among women with
15 occasional low back pain. There were no clear associations found among men.
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26 the expert group responsible for the design and implementation of the SPHC cohort. TB made the
27 statistical analyses and wrote the first manuscript version. All authors contributed to the interpretation
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55 **Ethical approval:** The regional ethical review board in Stockholm, Sweden, approved the study
56 (Diary nr. 2013/497-32).
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Data sharing: No additional data available.

Transparency: The lead author (TB) 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.

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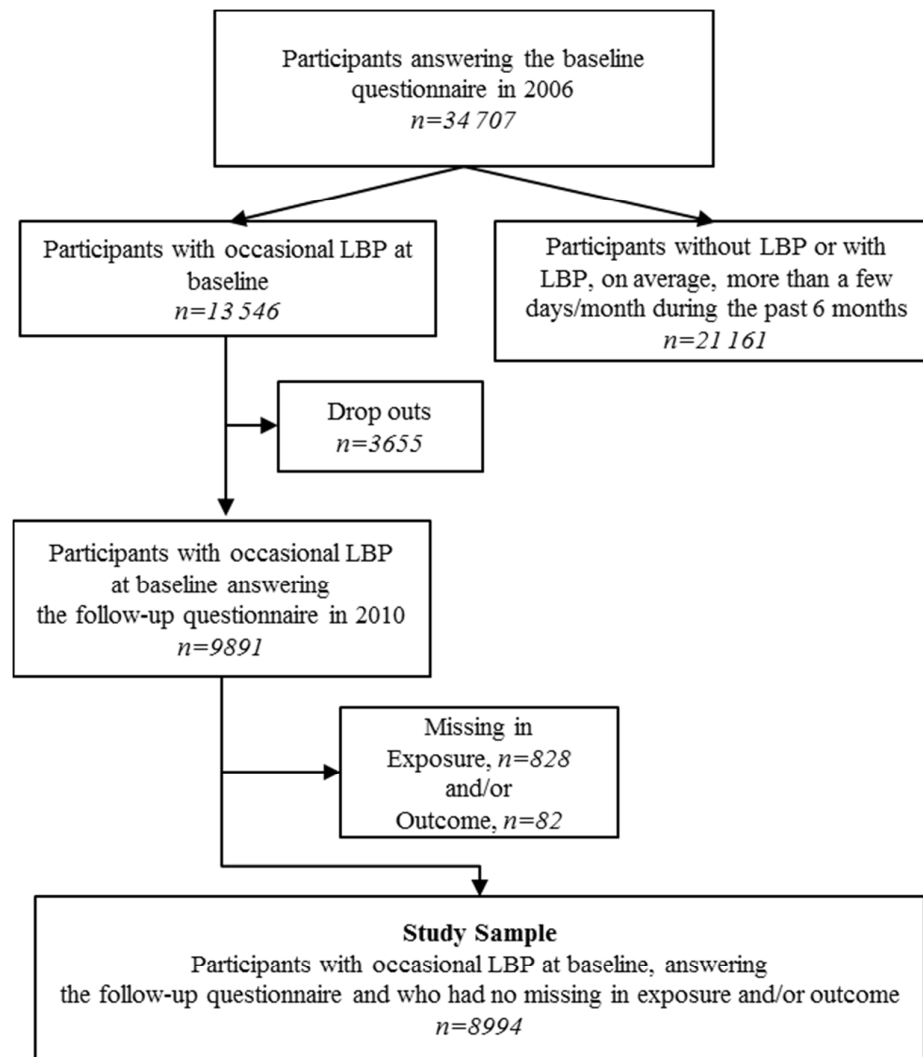
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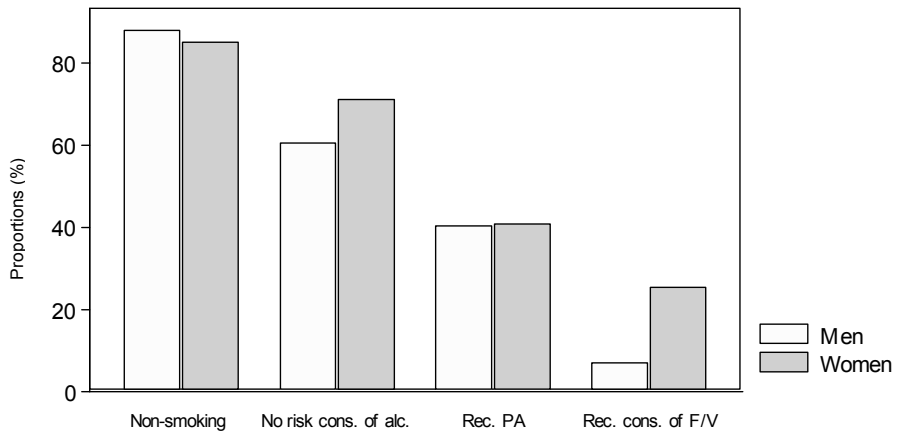
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14 Figure 1. Flowchart of the inclusion process for the study sample. LBP: low back pain.
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17 Figure 2. Distribution of healthy lifestyle factors. PA: Leisure physical activity. F/V: Fruit and
18 vegetables.
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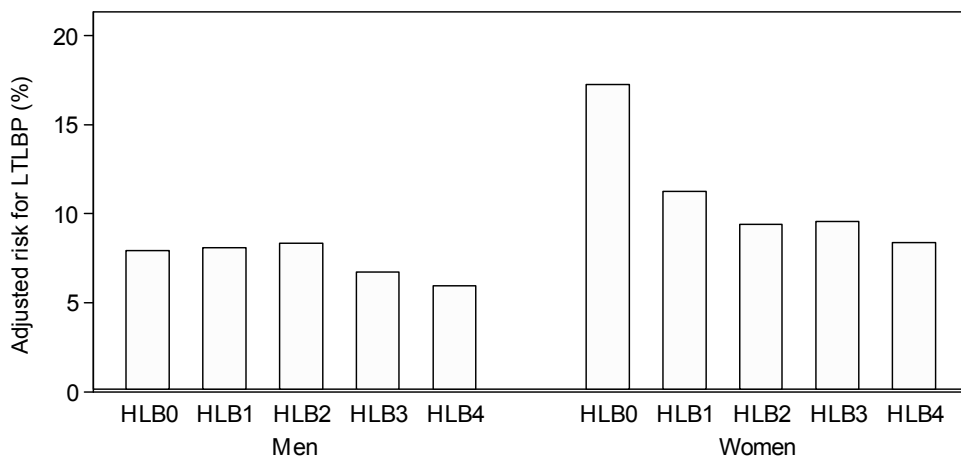
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21 Figure 3. Estimated risk for LTLBP, adjusted for SES and age. Men (n=3646), women (n=4658).
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Appendix

Construction of the binary lifestyle factor variables incorporated in the exposure variable “healthy lifestyle behaviour” (HLB), based on questions from the baseline questionnaire in 2006 (Health Survey 2006, Stockholm County Council).

Non-smoking:

26. Do you smoke daily?

1 No

2 Yes

Recommended level of leisure physical activity:

24. How much have you exercised and exerted yourself physically in *the past 12 months*?

If your activity for example varies between summer and winter, try to state an average. Indicate one alternative.

1 Sedentary leisure time

You spend most of your time reading, watching TV, going to movie theatres or carrying out some other form of sedentary activity. You take walks, cycle or exercise in some other way for less than 2 hours per week.

2 Moderate leisure time exercise

You take walks, cycle or exercise in some other way for at least 2 hours per week, usually without sweating. This also includes walks, ordinary garden chores, fishing, table tennis and bowling.

3 Moderate, regular leisure time exercise

You exercise regularly 1–2 times per week for at least 30 minutes each time by jogging, swimming, playing tennis, badminton or through another activity that makes you sweat.

4 Regular leisure time exercise and training

You, for example, jog, swim, play tennis or badminton or carry out gymnastics or the like and which makes you sweat an average of at least 3 times a week. Each occasion lasts at least 30 minutes..

25. How many days in **an average week** do you devote to at least 30 minutes of physical activity that makes you grow warm?

Count fitness training as well as brisk walks, gardening work, heavy household work, cycling, swimming and the like. This may vary during the year, but try to state an average.

days a week

“Recommended level of leisure physical activity” was theoretically defined as performing leisure physical activity at least 150 minutes at moderate intensity or 75 minutes at high intensity per week or a combination of these activities. This was equal to alternative 4 in question no.24 OR ≥ 5 days a week

in question no.25 OR a combination of alternative 3 in question no.24 and 3 or 4 days a week in question no.25.

No risk consumption of alcohol:

31. What are your alcohol habits during a typical week?

This may vary during the year, but try to state an average. First assess for each day how much you usually drink of the various alcoholic beverages. State in the table what you arrived at in centiliters (cl).

Example:
 If you drink as follows:
 1 bottle of medium-strong beer for lunch Monday-Thursday (33x4 = 132 cl.).
 Tuesday evening, 1 glass of wine (5 cl.).
 Wednesday evening, 2 cans of beer (2x50 = 100 cl.).
 Friday evening, a half bottle of wine (37 cl.).
 Saturday evening, 1 glass of wine (20 cl.) and 1 big cocktail (6 cl. of spirits).
 Sunday lunch, 1 shot (3 cl. of spirits) and 1 can of beer (50 cl.).

Then you would fill in the table as follows:

	Spirit	Strong Wine	Wine	Strong Beer	Beer (Folköl)	Strong cider/Alcopop
Monday-Thursday	<input type="text"/>	<input type="text" value="5"/>	<input type="text"/>	<input type="text" value="100"/>	<input type="text" value="132"/>	<input type="text"/>
Friday	<input type="text"/>	<input type="text"/>	<input type="text" value="37"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Saturday	<input type="text" value="6"/>	<input type="text"/>	<input type="text" value="20"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Sunday	<input type="text" value="3"/>	<input type="text"/>	<input type="text"/>	<input type="text" value="50"/>	<input type="text"/>	<input type="text"/>

1 small shot or cocktail = 3 cl
 1 cocktail = 6 cl
 1 glass of wine = 5 cl
 1 glass of wine = 20 cl
 1 half-bottle of wine = 37 cl

1 bottle of wine = 75 cl
 1 half-bottle of spirits = 35 cl
 1 bottle of spirits = 70 cl
 1 bottle of Alco pop = 27 cl
 1 bottle/can of beer or strong cider - may contain 33 or 50 cl

For the day(s) you drink an alcoholic beverage, you should indicate in cl., how much you drink. The boxes should only be filled in for the days when you drink a certain alcoholic beverage.

	Spirit	Wine	L.a. Wine	Beer	M.s.beer	Strong cider/ alcopop
Monday-Thursday	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Friday	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Saturday	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Sunday	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

Grams of 100% alcohol/week were calculated by summarizing the volume of each of the different alcoholic beverage consumed over the week, multiply this sum with the volume percentage of alcohol

for the specific beverage and finally summarize the volume percentage for all beverages.

As an example from above, the grams of 100% alcohol from strong beer was 150×0.053 (volume % in Swedish strong beer) = 7.95 g of 100% alcohol etc.

32. How often do you, on the same occasion, drink alcoholic beverages equivalent to at least:

- A half bottle of spirits
 - or 2 bottles of wine
 - or 6 cans of beer (8 bottles)
 - or 12 bottles of medium-strong beer
- 1 Virtually every day (at least 5 days per week)
- 2 A few times per week (3–4 times per week)
- 3 Once or twice per week
- 4 2–3 times per month
- 5 Once a month
- 6 1–6 times per year
- 7 Never

Using a combination of question no.31 and no.32, “No risk consumption of alcohol” was theoretically defined as drinking; ≤ 168 g 100% alcohol/week for men and ≤ 108 g 100% alcohol/week for women, AND alternative 6 or 7 on question no.32 (= consuming alcohol corresponding to \approx half a bottle of spirits on the same occasion less than once a month).

Recommended consumption of fruit and vegetables:

21. How often do you eat fruits or berries?

Think of the past 12 months. Count fresh, canned and frozen (for example 1 apple, 1 banana, 1 bunch of grapes, 1 glass of juice, 1 bowl of strawberries or 2 slices of pineapple).

I eat fruits or berries:

- 1 A few times per month or never 0
- 2 Around once a week 0
- 3 A few times per week 0.5
- 4 Virtually every day 1
- 5 2 times per day 2
- 6 3 or more times per day 3

22. How often do you eat a portion of vegetables/root vegetables?

Think of the past 12 months. Count fresh, frozen, canned, stewed in addition to dishes including vegetables (for example ½ bell pepper, 1 tomato, 1–2 dl. shredded carrot, 1–2 dl. mixed vegetables or 1 bowl of lentil soup).

I eat a portion of vegetables/root vegetables:

- | | |
|---|-----|
| <input type="checkbox"/> 1 A few times per month or never | 0 |
| <input type="checkbox"/> 2 Around once a week | 0 |
| <input type="checkbox"/> 3 A few times per week | 0.5 |
| <input type="checkbox"/> 4 Virtually every day | 1 |
| <input type="checkbox"/> 5 2 times per day | 2 |
| <input type="checkbox"/> 6 3 or more times per day | 3 |

The six answer alternatives on question no.21 and no.22 were assigned a score from 0 to 3.

“Recommended consumption of fruit and vegetables” was theoretically defined as having a sum score from the two questions of ≥ 4 . This was equal to eating fruit and vegetables every day and to a minimum of 4 servings per day (≈ 400 g/day).

Tony Bohman

STROBE Statement—Checklist of items that should be included in reports of *cohort studies*

	Item No	Recommendation
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract p.1 (b) Provide in the abstract an informative and balanced summary of what was done and what was found p.2-3
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported p.4-5
Objectives	3	State specific objectives, including any prespecified hypotheses p. 5 paragraph 1 and 2
Methods		
Study design	4	Present key elements of study design early in the paper Method; paragraph 1
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection Methods; paragraph 1-2, fig. 1
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up Methods; paragraph 1-2, fig. 1 (b) For matched studies, give matching criteria and number of exposed and unexposed
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable Methods; p. 6-7
Data sources/ measurement	8*	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 Methods; p. 6-7
Bias	9	Describe any efforts to address potential sources of bias Methods; p.5 – random selection, stratification for gender and residential area
Study size	10	Explain how the study size was arrived at Methods; paragraph 1 and 2, p.5-6, fig.1
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why Methods; p.6-7, Appendix
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding Statistical methods; p.8 (b) Describe any methods used to examine subgroups and interactions Statistical methods; p.8 (c) Explain how missing data were addressed Fig. 1, table 1 and 2 (d) If applicable, explain how loss to follow-up was addressed Methods, Study design and source population and fig. 1 (e) Describe any sensitivity analyses Methods; p.8 last part of Statistical methods.
Results		
Participants	13*	(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 Fig. 1, table 1 and 2 (b) Give reasons for non-participation at each stage – no information on reason (c) Consider use of a flow diagram Fig. 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders Table 1 (b) Indicate number of participants with missing data for each variable of interest

Table 1

(e) Summarise follow-up time (eg, average and total amount)		
Outcome data	15*	Report numbers of outcome events or summary measures over time Table 2
Main results	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 Table 2 and statistical methods (b) Report category boundaries when continuous variables were categorized Statistical methods; p. 8, Age categorised into 10 yr intervals. Results; table 1 and table 2. (c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period Table 2
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses Statistical methods; p.8. Results; p. 15. Trend test, effect modification and loss to follow-up.
Discussion		
Key results	18	Summarise key results with reference to study objectives Discussion; first paragraph
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias p. 17 middle paragraph.
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Other information		
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Primary Subject Heading:	Epidemiology
Secondary Subject Heading:	Public health
Keywords:	Back pain < ORTHOPAEDIC & TRAUMA SURGERY, Public health < INFECTIOUS DISEASES, Epidemiology < TROPICAL MEDICINE

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Manuscripts

Tony Bohman

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5 **Does healthy lifestyle behaviour influence the prognosis of low back pain**
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7 **among men and women in a general population? A population based cohort**
8 **study.**
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48 Tables: 2
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50 References: 41
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52 Supplementary files: 2
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Abstract

Objectives

To study the influence of healthy lifestyle behaviour on the prognosis of occasional low back pain among men and women in a general population.

Design

Cohort study with a four year follow-up.

Settings

General population in Stockholm County, Sweden.

Participants

The study sample comprised 3938 men and 5056 women, aged 18-84, from the Stockholm Public Health cohort reporting occasional low back pain in the baseline questionnaire 2006.

Measures

Lifestyle factors and potential confounders were assessed at baseline. The lifestyle factors smoking habits, alcohol consumption, leisure physical activity and consumption of fruit and vegetables, were dichotomized using recommendations for a health-enhancing lifestyle and combined to form the exposure variable “healthy lifestyle behaviour”. The exposure was categorised into five levels according to the number of healthy lifestyle factors met. The follow-up questionnaire in 2010 gave information about the outcome, long duration troublesome low back pain. Crude and adjusted binomial regression models were applied to estimate the association between the exposure and the outcome analysing men and women separately.

Results

The risk of developing long duration troublesome low back pain among women with occasional low back pain decreased with increasing healthy lifestyle behaviour (trend test: $p=0.006$). 21% (28/131) among women with no healthy lifestyle factor (reference) experienced the outcome compared to nine

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3 percent (36/420) among women with all four factors. Compared to the reference group, the risk was
4
5 reduced by 35% (RR: 0.65, 95% CI: 0.44 to 0.96) for women with one healthy lifestyle factor and
6
7 52% (RR: 0.48, 95% CI: 0.31 to 0.77) for women with all four healthy lifestyle factors. There were no
8
9 clear associations found among men.

11 **Conclusion**

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14 Healthy lifestyle behaviour seems to decrease the risk of developing long duration troublesome low
15
16 back pain among women with occasional low back pain and may be recommended to improve the
17
18 prognosis.
19

22 **Article summary**

25 **Strengths and limitations of this study**

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27
28 ▪ Strengths of this study are the large sample, the longitudinal design, the long term follow-up,
29
30 robust analyses and the large number of potential confounding factors assessed.
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32 ▪ Possible limitations of this study were the potential risk of misclassification of the exposure
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34 variable and the relatively large loss to follow-up, although these limitations most probably
35
36 lead to an underestimation of the associations studied. Further the results may have been
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38 affected by questionnaire items not fully validated.
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Introduction

Lifestyle factors such as non-smoking, physical activity, healthy diet and moderate alcohol use seem to influence the risk and the prognosis in several diseases (e.g. cancer, type 2 diabetes mellitus, and cardiovascular disease) as well as mortality, especially when the factors are combined.[1-5]

Low back pain (LBP) is one of the most common health problems worldwide and comprises a large burden on individuals as well as on society.[6, 7] When estimating the global prevalence of activity-limiting LBP using 165 studies from 54 countries, Hoy and colleagues found the mean point- and 1 month prevalence to be $11.9 \pm 2.0\%$ and $23.2 \pm 2.9\%$ respectively.[6] Current knowledge of prognostic factors, e.g. lifestyle factors, for LBP is limited and the above mentioned facts support the need for more research on this topic.

In a “review of reviews” from 2009, Hayden and colleagues reported older age, negative cognitive characteristics, poor general health, increased psychological or psychosocial stress, poor relations with colleagues, physically heavy work, functional disability, sciatica, and the presence of worker’s compensation to be associated with poor outcomes of acute and sub-acute LBP.[8] Another 2009 review found recovery expectations to be associated with activity limitations or participation restrictions (e.g. return to work) in persons with non-chronic non-specific LBP.[9] In the review by Hayden and colleagues smoking was the only lifestyle factor included and found, by two studies, to have no association with poor outcomes of acute and sub-acute LBP.[8] Similarly, a recent review studying prognostic factors for recovery from chronic LBP found no association between smoking and the outcome pain and disability.[10] Moreover, reviewing observational studies on LBP patients Hendrick and colleagues found moderate evidence for sports, leisure and occupational physical activity not to be associated with LBP outcomes.[11]

Women seem to have higher prevalence, be more severely affected and have worse prognosis of LBP than men and some studies suggest that men and women should be assessed separately when studying risk and prognostic factors for LBP.[6, 12-14]

To our knowledge, it is not known if healthy lifestyle behavior, defined by a combination of lifestyle factors, is associated with the prognosis of LBP. Healthy lifestyle behaviour seems to have a larger

1
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3 potential to affect health problems and mortality than separate lifestyle factors alone.[1-5] We
4
5 hypothesized that healthy lifestyle behaviour would decrease the risk of a poor outcome among men
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7 and women with occasional low back pain. If healthy lifestyle behaviour affects the prognosis of LBP
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9 implementing this knowledge could potentially prevent transition into disabling LBP and thereby
10
11 reduce the burden on the individual as well as on the society.

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13 The aim of this study was to explore the influence of healthy lifestyle behaviour on the prognosis of
14
15 occasional low back pain among men and women in a general population, hypothesizing that healthy
16
17 lifestyle behaviour can improve the prognosis.
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20 21 **Methods**

22 23 **Study design and source population**

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25 In this study we used data from the Stockholm Public Health Cohort (SPHC).[15] The SPHC was set
26
27 up by the Stockholm County Council and administered by Statistics Sweden and the Department of
28
29 Public Health Sciences at Karolinska Institutet, Stockholm. The SPHC is a population based cohort
30
31 established within the framework of Stockholm County Council public health surveys. In 2006,
32
33 Stockholm County had an adult population of approximately 1.4 million individuals. From this
34
35 population a total of 56 634 individuals (18-84 years old) were randomly selected, after stratification
36
37 for gender and residential area, and received the baseline questionnaire, which 34 707 (61%)
38
39 answered. The responders received a follow-up questionnaire in 2010, answered by 25 167
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41 participants (73%). Compared to consensus data from Stockholm County the SPHC participants were
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43 more likely to be of female gender, be born in Sweden, have higher education and income and be more
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45 than 45 years old.[15]
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49 50 **Study sample**

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52 The study sample (n=8994) consisted of participants reporting occasional LBP at baseline in 2006 who
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54 answered the follow-up questionnaire in 2010 and provided complete information on outcome and
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56 exposure variables (Figure 1). Occasional LBP at baseline was defined as reporting having had LBP,
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3 on average, up to a few days per month during the past 6 months (for the item used to define
4 occasional LBP see Appendix 1). The information was based on a modified version of a question from
5 the Standardized Nordic Questionnaire.[16]
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9 10 **Data collection and variables**

11 The baseline and the follow-up questionnaires comprised self-reported information on lifestyle,
12 demographic- and socioeconomic characteristics, physical and psychological health and work related
13 factors. The self-reported data were supplemented with information from regional and national
14 registers.[15] Four reminders were sent after the baseline questionnaire and three reminders after the
15 follow-up questionnaire.
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22 **Exposure: healthy lifestyle behaviour (HLB)**

23 Using baseline information we constructed four binary healthy lifestyle factors where cut-offs
24 (healthy/not healthy) were set in accordance with recommendations for a health-enhancing lifestyle
25 made by Swedish authorities and WHO.[17-20] The exposure variable “healthy lifestyle behaviour”
26 (HLB) was a combination of these binary factors and was categorised into five levels according to the
27 number of healthy lifestyle factors included, i.e. from none to four (HLB0 to HLB4). A healthy
28 lifestyle behaviour with regard to each of the considered healthy factors was defined by: non-smoking,
29 no risk consumption of alcohol (≤ 168 g 100% alcohol/week for men and ≤ 108 g 100% alcohol/week
30 for women, and consuming alcohol corresponding to about half a bottle of spirits (35 cl) on the same
31 occasion less than once a month), recommended level of leisure physical activity (at least 150 minutes
32 at moderate intensity or 75 minutes at high intensity per week or a combination of these activities),
33 and recommended consumption of fruit and vegetables (\geq a total of 4 servings of fruit and
34 vegetables/day, equal to about 400 g/day) (see Appendix 2 for a description of the questions and how
35 the variables were constructed).
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52 **Outcome variable: long duration troublesome low back pain (LTLBP)**

53 Information on the outcome LTLBP was collected from the follow-up questionnaire in 2010 and
54 defined as having had LBP that decreased workability or interfered with other daily activities to some
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3 or to high degree, on average a few days per week or more often during the past 6 months (for the
4 items used to define LTLBP see Appendix 1). The question used to measure LTLBP was modified
5 from the Standardized Nordic Questionnaire and incorporated a dimension of disability suggested to
6 be of importance when defining LBP.[16, 21]
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10 11 Potential confounding factors

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13 Potential confounders were chosen based on theoretic and empirical relevance, information from
14 literature regarding the prognosis of spinal pain and availability in the questionnaire.[8, 22, 23] The
15 following factors were considered: long-term illness (suffering from long-term illness, health problems
16 following an accident, disability or other persistent health problems), neck pain and pain from hip,
17 thigh or knee during the past 6 months (5 answer alternatives from “no pain” to “daily pain”),
18 suffering from headache or migraine (“no”, “somewhat”, “severe”), rheumatoid arthritis diagnosed by
19 a physician, living alone, living with children (children of all ages included) and hours of sleep a
20 typical night during the workweek (dichotomized into “good sleep”: 6-8 h and “poor sleep”: <6 h or
21 >8 h). The questionnaire also included the 12-item General Health Questionnaire were a sum score of
22 ≥ 3 (using the recommended 0-0-1-1 scoring on the four answer alternatives) was used to assess
23 psychological distress.[24, 25] The frequency of stress was measured by the question “How often do
24 you feel stress?” with 5 answer alternatives from “never” to “most of the week”. Personal support
25 (having persons who can give support in handling personal problems or critical life events) was
26 measured using a question from the Social Support-13 instrument (SS-13).[26] Furthermore, financial
27 stress was assessed by the question “Did it during the previous 12 months happen that you ran out of
28 money and had to borrow from relatives and friends to be able to pay for food or rent?” (“no”, “yes, on
29 one occasion”, “yes, on several occasions”). A Swedish national register supplied information on civil
30 status (married, unmarried, divorced, widow/widower), country of birth (Sweden, Nordic countries
31 and Europe, outside Europe), socio-economic status (SES), annual individual disposable income
32 (grouped in quintiles) and education.[27, 28] The level of education was categorized into, low (only
33 compulsory education and vocational training), intermediate (secondary school) and high (university
34 studies).
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Statistical methods

We used generalized linear models with a binomial distribution to estimate the association between the exposure and the outcome analysing men and women separately. To determine the role of a potential confounding factor we included them, one at a time, into the crude model. Only factors that changed the estimated risk ratio (RR) by 10% or more were entered into the final model.[29-33] All final models were adjusted for age categorized into 10 year intervals. Age was categorized as it showed non-linearity with the outcome. We calculated relative risks (RR), using the log function, as well as risk differences (RD), using the identity function, with 95% confidence intervals (95% CI). A likelihood ratio test was used to assess clinically relevant effect measure modification between the exposure and possible confounders (age, education, SES, neck pain, long term illness and psychological distress) as well as between confounders included in the adjusted models (age and SES).[34] An effect measure modification significant at $p \leq 0.05$ was included in further analyses. [34] We used Wald test to evaluate potential trends in the associations between the exposure and the outcome, and a Chi-square test to assess if the overall adjusted risk differed between men and women.[34] The effect of attrition was assessed, using Chi-square tests, by comparing the distribution of the four healthy lifestyle factors included in the exposure, healthy lifestyle behaviour, in subjects who were lost to follow-up to the distribution in the study sample. All p-values were two-sided, and analyses were completed using SAS® version 9.3 and STATA/IC® version 12.1.

Results

Baseline characteristics

The study sample (n=8994) consisted of 56% women. Participants were predominately middle aged, well educated, and born in Sweden. At baseline in 2006, about 15% of the participants were 65 years or older (men 17% and women 14%). Furthermore the majority were cohabitating, and about 35% had children living at home (Table 1). About three percent men and 10% women had an “optimal healthy lifestyle” (HLB4) whereas about five percent men and three percent women had an “unhealthy

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3 lifestyle” (HLB0). Healthy lifestyle behaviour improved with increased level of education.

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5 Participants being married or having children living at home had a high proportion of healthy lifestyle
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7 behaviour while participants living alone, being psychologically distressed and financially stressed
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9 showed low proportions of healthy lifestyle behaviour (Table 1).

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11 The other baseline variables assessed did not differ much between the categories of HLB, neither
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13 among men nor among women.

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Table 1. Baseline characteristics by categories of the exposure healthy lifestyle behaviour (HLB0 - HLB4)* (n = 8994).

Baseline characteristics	Men						Women						Internal drop-out M/W (n)
	All (n=3938)	HLB0 (n=181)	HLB1 (n=958)	HLB2 (n=1747)	HLB3 (n=936)	HLB4 (n=116)	All (n=5056)	HLB0 (n=174)	HLB1 (n=897)	HLB2 (n=2080)	HLB3 (n=1416)	HLB4 (n=489)	
Proportion of study sample (%)	44						56						
Mean age, years (SD)	50(15)	49(14)	48(15)	49(15)	51(15)	50(14)	46(16)	43(17)	47(15)	46(16)	47(15)	46(14)	0/0
Education													234/287
Low	16	30	19	14	14	8	14	22	17	13	12	9	
Intermediate	43	43	46	44	40	35	41	57	46	42	38	34	
High	41	27	35	42	46	57	45	21	37	45	50	57	
Civil status													0/1
Married	54	42	49	56	56	65	47	27	41	46	53	53	
Unmarried	33	38	36	32	31	29	36	49	37	37	33	32	
Divorced/Widow/Widower	13	20	15	12	13	6	17	24	22	17	14	15	
SES^a													292/398
Unskilled/semiskilled worker	14	22	17	13	12	9	16	23	19	16	14	10	
Skilled worker	15	25	16	14	15	8	10	22	12	9	9	11	
Assistant non-manual employees	8	8	10	9	7	5	20	22	21	22	18	15	
Intermediate non-manual	25	14	25	24	27	24	29	23	23	29	31	35	

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employees													
Employed/self-employed	25	17	18	28	28	34	19	7	17	18	21	24	
professionals													
Self-employed (other than professionals)	13	14	14	12	11	20	6	3	8	6	7	5	
Poor sleep^b													34/27
<6 or >8 hours/night	9	17	9	10	7	9	10	14	11	11	9	7	
Living alone	17	31	19	16	14	9	19	24	21	19	17	17	10/16
Living with children	34	24	31	35	34	42	38	27	32	39	41	41	10/16
Psychological distress^c	13	18	15	13	11	5	21	33	23	22	19	17	38/37
Financial stress^d	7	15	10	5	4	3	9	23	13	9	7	6	17/24

* HLB0 = no healthy lifestyle factor, HLB1 = 1 of 4 healthy lifestyle factors, HLB2 = 2 of 4 factors, HLB3 = 3 of 4 factors, HLB4 = all 4 healthy lifestyle factors.

^a Socio-economic status. For the economically active population SES was based on current occupation and education. For the non-active population SES was based on previous occupation, current education or the occupation of spouses.

^b Hours of sleep a typical night during the workweek (dichotomized into “good sleep”: 6-8 h and “poor sleep”: <6 h or >8 h).

^c From the 12-item General Health Questionnaire (GHQ-12) were a sum score ≥ 3 was used to asses psychological stress.

^d Financial stress: Had to borrow money from relatives and friends to be able to pay for food or rent on several occasions during the previous 12 months.

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3 The majority of both men and women were non-smokers and did not exceed risk consumption of
4 alcohol. About 40% of both men and women reached recommended levels of leisure physical activity
5 while 26% of the women consumed recommended levels of fruit and vegetables compared to seven
6 percent for men (Figure 2).
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10 11 **Outcome**

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14 At follow-up in 2010, nine percent men and 11% women in the study sample reported LTLBP. Table
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16 2 shows the crude and adjusted binomial regression estimations of the association between healthy
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18 lifestyle behaviour and the outcome.
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Table 2. Association* between healthy lifestyle behaviour and long duration troublesome low back pain (LTLBP) in men and women with occasional LBP at baseline in 2006.

	MEN (n=3646) ^a					WOMEN (n=4658) ^a			
	Healthy lifestyle behaviour ^c	LTLBP/ no LTLBP ^d (n/n)	Crude	Adjusted (Age, SES) ^b		LTLBP/ no LTLBP ^d	Crude	Adjusted (Age, SES) ^b	
			RR (95% CI)	RR (95% CI)	RD (95% CI)		RR (95% CI)	RR (95% CI)	RD (95% CI)
HLB0	14/155	1.0	1.0	0.0	28/131	1.0	1.0	0.0	
HLB1	71/812	0.97 (0.56, 1.68)	1.02 (0.59, 1.76)	-0.01 (-0.06, 0.03)	94/735	0.64 (0.44, 0.95)	0.65 (0.44, 0.96)	-0.05 (-0.12, 0.01)	
HLB2	133/1476	1.00 (0.59, 1.69)	1.05 (0.62, 1.78)	-0.01 (-0.05, 0.04)	181/1721	0.54 (0.38, 0.78)	0.54 (0.38, 0.78)	-0.07 (-0.13, -0.01)	
HLB3	60/818	0.82	0.85	-0.02	125/1187	0.54	0.55	-0.07	

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		(0.47, 1.44)	(0.48, 1.48)	(-0.06, 0.02)		(0.37, 0.79)	(0.38, 0.81)	(-0.13, -0.01)
HLB4	6/101	0.68	0.75	-0.03	36/420	0.45	0.48	-0.08
		(0.27, 1.71)	(0.30, 1.89)	(-0.07, 0.01)		(0.28, 0.71)	(0.31, 0.77)	(-0.15, -0.02)

*note: Log- binomial regression estimating the risk ratio (RR) and the risk difference (RD) with 95% confidence interval (95% CI).

^a Reduced number of observations due to missing information about socio-economic status (SES) (men n=292 and women n=398).

^b Adjusted for age in 10 year categories and socio-economic status (SES) in six categories.

^c HLB0 = no healthy lifestyle factor, HLB1 = 1 of 4 healthy lifestyle factors, HLB2 = 2 of 4 factors, HLB3 = 3 of 4 factors, HLB4 = all 4 healthy lifestyle factors.

Healthy lifestyle factors included in HLB: non-smoking, no risk consumption of alcohol (≤ 168 g 100% alcohol/week for men and ≤ 108 g 100% alcohol/week for women, and consuming alcohol corresponding to \approx half a bottle of spirits on the same occasion less than once a month), recommended level of leisure physical activity (at least 150 minutes at moderate intensity or 75 minutes at high intensity per week or a combination of these activities), and recommended consumption of fruit and vegetables (≥ 4 servings of fruit and vegetables/day).

^d Numbers of participants with and without LTLBP at follow-up in 2010.

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3 There was a decreased risk for LTLBP at follow-up for women with a healthy lifestyle behaviour
4 compared to women with unhealthy lifestyle behaviour (test for trend: $p=0.006$). Twenty-one percent
5 of women with no healthy lifestyle factor (HLB0) experienced LTLBP at follow-up compared to nine
6 percent of women with all four factors (HLB4). A five percent lower proportion of women with one
7 healthy lifestyle factor, and an eight percent lower proportion of women with all four factors had
8 LTLBP, in comparison to the reference group (HLB0). Women with one healthy lifestyle factor and
9 women with all four healthy lifestyle factors had a 35% and a 52% lower risk for LTLBP,
10 respectively, compared to women with unhealthy lifestyle behaviour (HLB0). There were no clear
11 associations between healthy lifestyle behaviour and LTLBP found among men.

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13 SES was the only variable found to be a confounder, so the final log-binomial analyses were adjusted
14 by SES and age in 10 year categories. There was no clinically relevant effect measure modifications
15 found.
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18 Figure 3 shows the adjusted risk to develop LTLBP for men and women with occasional LBP by
19 categories of healthy lifestyle behaviour. Women had an overall higher adjusted risk for LTLBP than
20 men ($p=0.001$).
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23 The subjects lost to follow-up ($n=4552$) had significantly lower proportions of healthy lifestyle factors
24 than the study sample ($p < 0.01$ for all four factors). The differences in proportions were eight percent
25 for non-smoking, 16% for no risk consumption of alcohol, six percent for leisure physical activity and
26 five percent for consumption of fruit and vegetables.
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28 Discussion

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30 In this cohort study we found that healthy lifestyle behaviour had a positive influence on the prognosis
31 of occasional low back pain among women. Healthy lifestyle behaviour comprised four healthy
32 lifestyle factors: non-smoking, no risk consumption of alcohol, recommended level of leisure physical
33 activity and recommended consumption of fruit and vegetables. Compared to women with no healthy
34 lifestyle factor, the risk for development of long duration troublesome low back pain (LTLBP)
35 decreased by 35% among women with one healthy lifestyle factor and by 52% among women with all
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3 four healthy lifestyle factors. In absolute terms, the proportion of women with LTLBP at follow-up
4 was five percent lower if they had one healthy lifestyle factor and eight percent lower if they had four
5 healthy lifestyle factors when compared to women with unhealthy lifestyle behaviour. These
6 associations were not confirmed among men but the results indicated the same tendency.
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11 Further, compared to women, men had an overall lower adjusted risk for LTLBP, and a low risk even
12 in the unhealthy reference group (Figure 3). Men with unhealthy lifestyle behaviour had about the
13 same risk for LTLBP as women with optimal healthy lifestyle behaviour. These findings were not
14 aimed to be addressed in the present study and needs to be further investigated.
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20 We found no studies concerning the effects of healthy lifestyle behaviour, defined as a combination of
21 healthy lifestyle factors, on the prognosis of LBP or other types of spinal pain. Nevertheless,
22 considering the risk of developing chronic back pain Pronk and colleagues showed results in line with
23 our study.[2] Studying employees, the authors found that an “optimal lifestyle” decreased the 2-year
24 risk of chronic LBP by 66% compared to employees with an unhealthy lifestyle. Having optimal
25 lifestyle was equal to having all four of the healthy lifestyle factors similar to the ones included in our
26 study: non-smoking, adequate physical activity, five servings of fruit and vegetables per day and
27 limited or no alcohol consumption.
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37 **Strengths and limitations**

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39 To our knowledge this is the first study concerning the influence of healthy lifestyle behaviour (HLB)
40 on the prognosis of LBP assessing men and women separately. Measuring the exposure prior to the
41 outcome and the dose-response relationship found supports the validity of the associations between
42 HLB and LTLBP found among women.[32] We believe the use of a complete study sample, the large
43 sample size and the large number of potential confounders assessed strengthens the internal validity,
44 though we cannot rule out residual or unmeasured confounding, for example information on health
45 care services.[32] The questions used in this study have, since 1975, been used in several Swedish
46 national and local public health surveys. They have on several occasions been tested (e.g. cognitive
47 testing) and improved by Statistics Sweden’s test centre and several questions have shown to have
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3 acceptable psychometric properties. Moreover, information on education, disposable income, SES,
4 country of birth and marital status were collected from Swedish national registers known to have high
5 quality. The questions concerning leisure physical activity and consumption of fruit and vegetables
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7 have shown to have acceptable validity and reliability, and the method to measure alcohol
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9 consumption has been recommended by Romelsjö and colleagues.[35-38] Despite this the
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11 measurements used may not have been optimal in terms of validity and reliability.
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15 Our study also has limitations. Self-reported exposure information may be hampered by low accuracy.
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17 For example, some participants may wish to present themselves in a favourable light and overestimate
18 their healthy lifestyle (social desirability) or some may have difficulties understanding the questions
19 and therefore report less well.[32, 39, 40] This could lead to misclassification of the exposure which
20 may result in an under- or overestimation of the association. As this potential misclassification is
21 likely to be non-differential it would probably dilute a true association, at least when comparing
22 extremes.[32] Moreover, if men tend to misclassify their healthy lifestyle factors to a greater extent
23 than women this may partly explain why we did not find any associations among men. For example,
24 Dyrstad and colleagues found that men overestimated their self-reported physical activity when
25 compared to accelerometer-measures to a greater extent than women.[41] As we studied a population
26 between 18-84 years old a large proportion of the participants did not provide work related
27 information why we did not assess potential confounding effects from work related variables,
28 something that may have affected the results. About 34% of participants in the baseline survey were
29 not part of the study sample due to attrition and exclusion (Figure 1). Compared to the study sample
30 the 34% missing had the same proportion of men and women, were younger (mean age for both sexes
31 were 43 years) and both men and women had a slightly lower level of education as well as SES.
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33 Further, they had significantly lower proportions of healthy lifestyle factors than the study sample.
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35 This difference may have introduced selection bias to our results if the attrition and the loss to follow-
36 up are related to the exposure as well as to the outcome. If selection bias is present, we believe that it
37 probably leads to an underestimation of the associations, since these subjects to a higher extent may
38 have developed LTLBP.
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3 Considering strengths and limitations in our study we regard our result as a valid contribution to the
4 body of research showing that a healthy lifestyle affects health problems.[1-5] Our study results
5 showing that healthy lifestyle behaviour influences the prognosis of LBP are new and important
6 knowledge with the potential to have an impact on a very common public health problem and have
7 implications both in a public-health and a clinical perspective. Even though the association for healthy
8 lifestyle behaviour to affect LBP among men was not clear, the results showed the same tendency as
9 for women. Considering this together with the obvious effect of healthy lifestyle on other health
10 problems the work to encourage both men and women to adapt to healthy lifestyle should certainly be
11 continued.
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23 **Conclusion**

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25 Healthy lifestyle behaviour, defined as combinations of non-smoking, no risk consumption of alcohol,
26 recommended level of leisure physical activity and recommended consumption of fruit and vegetables,
27 seems to decrease the risk of developing long duration troublesome low back pain among women with
28 occasional low back pain. There were no clear associations found among men.
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37 **Contributors:** TB, ES, LA, EV and IJ contributed to the design of the study. JH and LA were part of
38 the expert group responsible for the design and implementation of the SPHC cohort. TB made the
39 statistical analyses and wrote the first manuscript version. All authors contributed to the interpretation
40 of the data and critically revised all versions of the manuscript and finally approved the last version.
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10 **Competing interests:** None declared.

11
12 **Ethical approval:** The regional ethical review board in Stockholm, Sweden, approved the study
13 (Diary nr. 2013/497-32).
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16 **Data sharing:** No additional data available.

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19 **Transparency:** The lead author (TB) affirms that the manuscript is an honest, accurate, and
20 transparent account of the study being reported; that no important aspects of the study have been
21 omitted; and that any discrepancies from the study as planned have been explained.
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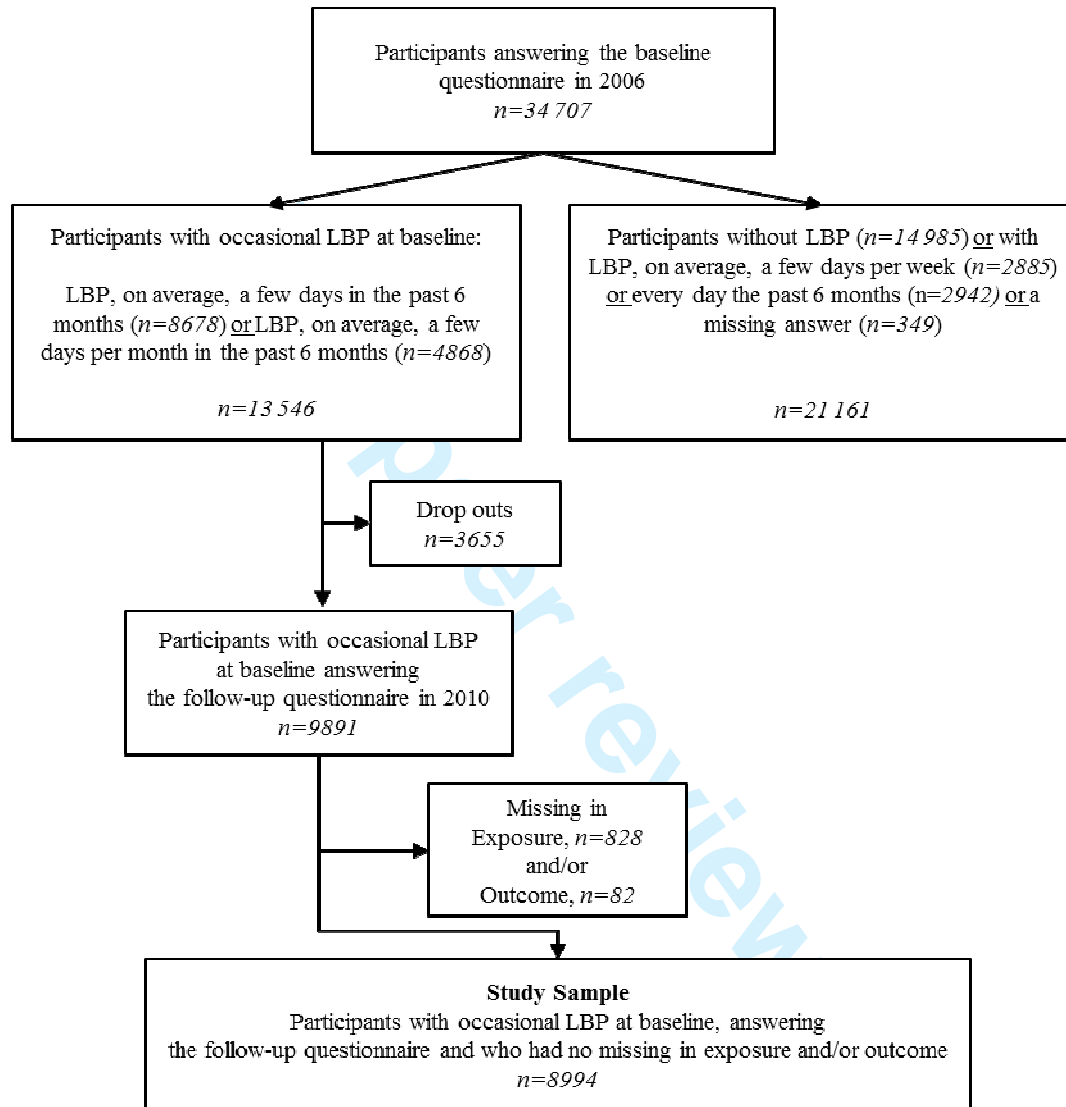
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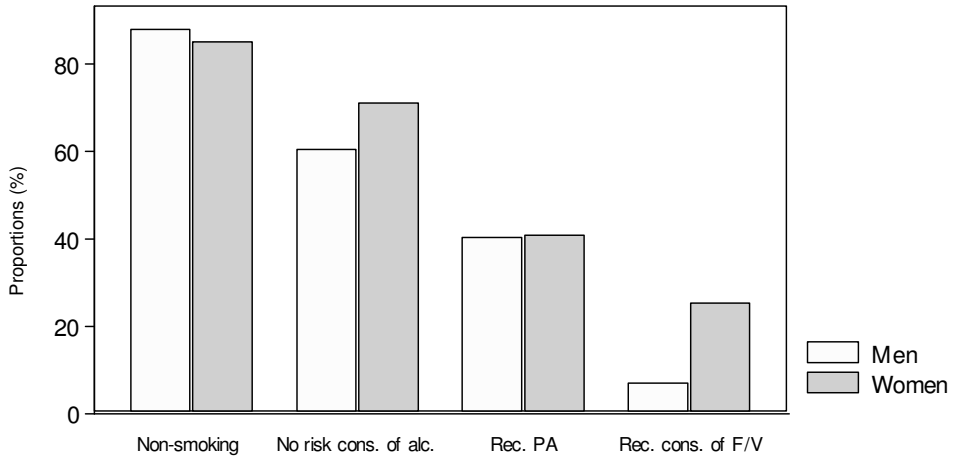
Figure 1. Flowchart of the inclusion process for the study sample. LBP: low back pain.

Figure 2. Distribution of healthy lifestyle factors. PA: Leisure physical activity. F/V: Fruit and vegetables.

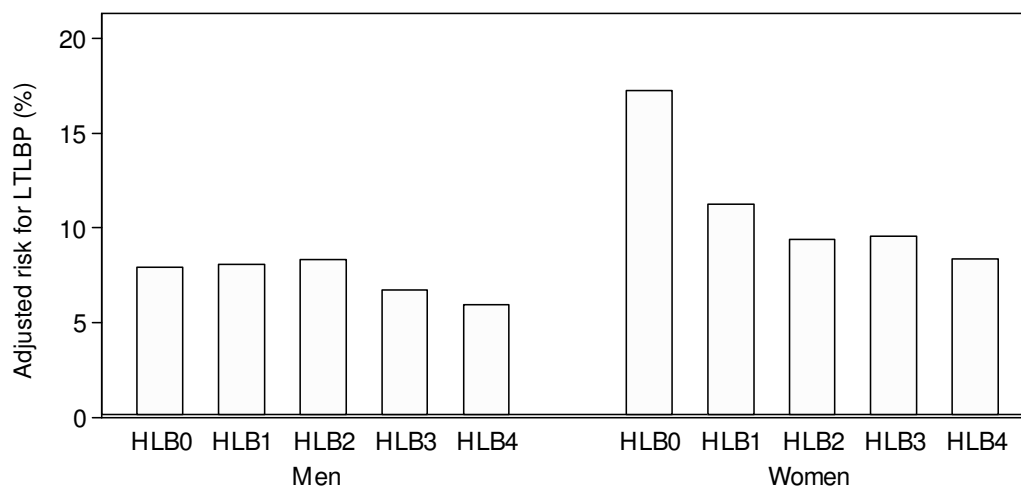
Figure 3. Estimated risk for LTLBP, adjusted for SES and age. Men (n=3646), women (n=4658).



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Appendix 1

Item in the baseline questionnaire in 2006 used to define individuals with occasional low back pain forming the study sample:

Have you had any pain in your lower back in the past 6 months?

If you have experienced pain on several occasions, try to estimate an average and put an X in the most appropriate box.

1. No
2. Yes, a few days in the past six months
3. Yes, a few days per month
4. Yes, a few days per week
5. Yes, every day

Included in the study sample were individuals answering; Yes, a few days in the past six months *OR* Yes, a few days per month.

Items in the follow-up questionnaire in 2010 used to define the outcome long duration troublesome low back pain (LTLBP):

a) Have you had pain in your lower back in the past 6 months?

If you have experienced pain on several occasions, try to estimate an average and put an X in the most appropriate box.

- No
- Yes, a few days per month or more seldom
- Yes, a few days per week or more often

If Yes;

b) Have these problems decreased your workability or interfered with other daily activities?

- Yes, to a high degree
- Yes, to some degree
- No, not at all

LTLBP was defined by answering; Yes, a few days per week or more often in a) AND Yes, to a high degree *OR* Yes, to some degree in b).

Appendix 2

Construction of the binary lifestyle factor variables incorporated in the exposure variable “healthy lifestyle behaviour” (HLB), based on questions from the baseline questionnaire in 2006 (Health Survey 2006, Stockholm County Council).

Non-smoking:

26. Do you smoke daily?

1 No

2 Yes

Recommended level of leisure physical activity:

24. How much have you exercised and exerted yourself physically in *the past 12 months?*

If your activity for example varies between summer and winter, try to state an average. Indicate one alternative.

1 Sedentary leisure time

You spend most of your time reading, watching TV, going to movie theatres or carrying out some other form of sedentary activity. You take walks, cycle or exercise in some other way for less than 2 hours per week.

2 Moderate leisure time exercise

You take walks, cycle or exercise in some other way for at least 2 hours per week, usually without sweating. This also includes walks, ordinary garden chores, fishing, table tennis and bowling.

3 Moderate, regular leisure time exercise

You exercise regularly 1–2 times per week for at least 30 minutes each time by jogging, swimming, playing tennis, badminton or through another activity that makes you sweat.

4 Regular leisure time exercise and training

You, for example, jog, swim, play tennis or badminton or carry out gymnastics or the like and which makes you sweat an average of at least 3 times a week. Each occasion lasts at least 30 minutes..

25. How many days in **an average week** do you devote to at least 30 minutes of physical activity that makes you grow warm?

Count fitness training as well as brisk walks, gardening work, heavy household work, cycling, swimming and the like. This may vary during the year, but try to state an average.

days a week

“Recommended level of leisure physical activity” was theoretically defined as performing leisure physical activity at least 150 minutes at moderate intensity or 75 minutes at high intensity per week or a combination of these activities. This was equal to alternative 4 in question no.24 $OR \geq 5$ days a week

in question no.25 OR a combination of alternative 3 in question no.24 and 3 or 4 days a week in question no.25.

No risk consumption of alcohol:

31. What are your alcohol habits during a typical week?

This may vary during the year, but try to state an average. First assess for each day how much you usually drink of the various alcoholic beverages. State in the table what you arrived at in centiliters (cl).

Example:

If you drink as follows:

1 bottle of medium-strong beer for lunch Monday-Thursday (33x4 = 132 cl.).

Tuesday evening, 1 glass of wine (5 cl.).

Wednesday evening, 2 cans of beer (2x50 = 100 cl.).

Friday evening, a half bottle of wine (37 cl.).

Saturday evening, 1 glass of wine (20 cl.) and 1 big cocktail (6 cl. of spirits).

Sunday lunch, 1 shot (3 cl. of spirits) and 1 can of beer (50 cl.).

Then you would fill in the table as follows:

	Spirit	Strong Wine	Wine	Strong Beer	Beer (Folköl)	Strong cider/ Alcopop
Monday-Thursday	<input type="text"/>	<input type="text"/> 5	<input type="text"/>	<input type="text"/> 100	<input type="text"/> 132	<input type="text"/>
Friday	<input type="text"/>	<input type="text"/>	<input type="text"/> 37	<input type="text"/>	<input type="text"/>	<input type="text"/>
Saturday	<input type="text"/> 6	<input type="text"/>	<input type="text"/> 20	<input type="text"/>	<input type="text"/>	<input type="text"/>
Sunday	<input type="text"/> 3	<input type="text"/>	<input type="text"/>	<input type="text"/> 50	<input type="text"/>	<input type="text"/>

- 1 small shot or cocktail = 3 cl
- 1 cocktail = 6 cl
- 1 glass of wine = 5 cl
- 1 glass of wine = 20 cl
- 1 half-bottle of wine = 37 cl

- 1 bottle of wine = 75 cl
- 1 half-bottle of spirits = 35 cl
- 1 bottle of spirits = 70 cl
- 1 bottle of Alco pop = 27 cl
- 1 bottle/can of beer or strong cider - may contain 33 or 50 cl

For the day(s) you drink an alcoholic beverage, you should indicate in cl., how much you drink. The boxes should only be filled in for the days when you drink a certain alcoholic beverage.

	Spirit	Wine	L.a. Wine	Beer	M.s.beer	Strong cider/ alcopop
Monday-Thursday	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Friday	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Saturday	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Sunday	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

Grams of 100% alcohol/week were calculated by summarizing the volume of each of the different alcoholic beverage consumed over the week, multiply this sum with the volume percentage of alcohol

for the specific beverage and finally summarize the volume percentage for all beverages.

As an example from above, the grams of 100% alcohol from strong beer was 150×0.053 (volume % in Swedish strong beer) = 7.95 g of 100% alcohol etc.

32. How often do you, on the same occasion, drink alcoholic beverages equivalent to at least:

- A half bottle of spirits
 - or 2 bottles of wine
 - or 6 cans of beer (8 bottles)
 - or 12 bottles of medium-strong beer
- 1 Virtually every day (at least 5 days per week)
- 2 A few times per week (3–4 times per week)
- 3 Once or twice per week
- 4 2–3 times per month
- 5 Once a month
- 6 1–6 times per year
- 7 Never

Using a combination of question no.31 and no.32, “No risk consumption of alcohol” was theoretically defined as drinking; ≤ 168 g 100% alcohol/week for men and ≤ 108 g 100% alcohol/week for women, AND alternative 6 or 7 on question no.32 (= consuming alcohol corresponding to \approx half a bottle of spirits on the same occasion less than once a month).

Recommended consumption of fruit and vegetables:

21. How often do you eat fruits or berries?

Think of the past 12 months. Count fresh, canned and frozen (for example 1 apple, 1 banana, 1 bunch of grapes, 1 glass of juice, 1 bowl of strawberries or 2 slices of pineapple).

I eat fruits or berries:

- 1 A few times per month or never 0
- 2 Around once a week 0
- 3 A few times per week 0.5
- 4 Virtually every day 1
- 5 2 times per day 2
- 6 3 or more times per day 3

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3 22. How often do you eat a portion of vegetables/root vegetables?

4 *Think of the past 12 months. Count fresh, frozen, canned, stewed in addition to dishes including*
5 *vegetables (for example ½ bell pepper, 1 tomato, 1–2 dl. shredded carrot, 1–2 dl. mixed vegetables or 1*
6 *bowl of lentil soup).*

7 *I eat a portion of vegetables/root vegetables:*

- 8
9 1 A few times per month or never 0
10 2 Around once a week 0
11 3 A few times per week 0.5
12 4 Virtually every day 1
13 5 2 times per day 2
14 6 3 or more times per day 3
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18 The six answer alternatives on question no.21 and no.22 were assigned a score from 0 to 3.

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20 “Recommended consumption of fruit and vegetables” was theoretically defined as having a sum score
21 from the two questions of ≥ 4 . This was equal to eating fruit and vegetables every day and to a
22 minimum of 4 servings per day (≈ 400 g/day).
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5 **Healthy lifestyle behaviour improves the prognosis of low back pain in**
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7 **women: A population based cohort study.**
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10 **Does healthy lifestyle behaviour influence the prognosis of low back pain**
11 **among men and women in a general population? A population based cohort**
12 **study.**
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Abstract

Objectives

To study the influence of healthy lifestyle behaviour on the prognosis of occasional low back pain among men and women in a general population.

Design

Cohort study with a four year follow-up.

Settings

General population in Stockholm County, Sweden.

Participants

The study sample comprised 3938 men and 5056 women, aged 18-84, from the Stockholm Public Health cohort reporting occasional low back pain in the baseline questionnaire 2006.

Measures

Lifestyle factors and potential confounders were assessed at baseline. The lifestyle factors smoking habits, alcohol consumption, leisure physical activity and consumption of fruit and vegetables, were dichotomized using recommendations for a health-enhancing lifestyle and combined to form the exposure variable “healthy lifestyle behaviour”. The exposure was categorised into five levels according to the number of healthy lifestyle factors met. The follow-up questionnaire in 2010 gave information about the outcome, long duration troublesome low back pain. Crude and adjusted binomial regression models were applied to estimate the association between the exposure and the outcome analysing men and women separately.

Results

The risk of developing long duration troublesome low back pain among women with occasional low back pain decreased with increasing healthy lifestyle behaviour (~~test for trend~~trend test: $p=0.006$).

21% (28/131) among women with no healthy lifestyle factor (reference ~~group~~) experienced the

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3 outcome compared to nine percent (36/420) among women with all four factors. Compared to the
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5 reference group, the risk was reduced by 35% (RR: 0.65, 95% CI: 0.44 to 0.96) for women with one
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7 healthy lifestyle factor and 52% (RR: 0.48, 95% CI: 0.31 to 0.77) for women with all four healthy
8
9 lifestyle factors. There were no clear associations found among men.

11 12 **Conclusion**

14 Healthy lifestyle behaviour seems to decreases the risk of developing long duration troublesome low
15
16 back pain among women with occasional low back pain and may be recommended to improve the
17
18 prognosis.
19

22 23 **Article summary**

25 26 **Strengths and limitations of this study**

- 28 ▪ Strengths of this study are the large sample, the longitudinal design, the long term follow-up,
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30 robust analyses and the large number of potential confounding factors assessed.
- 31
32 ▪ Possible limitations of this study were the potential risk of misclassification of the exposure
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34 variable and the relatively large loss to follow-up, although these limitations most probably
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36 lead to an underestimation of the associations studied. Further the results may have been
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38 affected by questionnaire items not fully validated.
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Introduction

Lifestyle factors such as non-smoking, physical activity, healthy diet and moderate alcohol use seem to influence the risk and the prognosis in several diseases (e.g. cancer, type 2 diabetes mellitus, and cardiovascular disease) as well as mortality, especially when the factors are combined.[1-5]

Low back pain (LBP) is one of the most common health problems worldwide and comprises a large burden on individuals as well as on society.[6, 7] When estimating the global prevalence of activity-limiting LBP using 165 studies from 54 countries, Hoy and colleagues found the mean point- and 1 month prevalence to be $11.9 \pm 2.0\%$ and $23.2 \pm 2.9\%$ respectively.[6] Current knowledge of prognostic factors, e.g. lifestyle factors, for LBP is limited and the above mentioned facts support the need for more research on this topic.

In a “review of reviews” from 2009, Hayden and colleagues reported older age, negative cognitive characteristics, poor general health, increased psychological or psychosocial stress, poor relations with colleagues, physically heavy work, functional disability, sciatica, and the presence of worker’s compensation to be associated with poor outcomes of acute and sub-acute LBP.[8] Another 2009 review found recovery expectations to be associated with activity limitations or participation restrictions (e.g. return to work) in persons with non-chronic non-specific LBP.[9] In the review by Hayden and colleagues smoking was the only lifestyle factor included and found, by two studies, to have no association with poor outcomes of acute and sub-acute LBP.[8] Similarly, a recent review studying prognostic factors for recovery from chronic LBP found no association between smoking and the outcome pain and disability.[10] Moreover, reviewing observational studies on LBP patients Hendrick and colleagues found moderate evidence for sports, leisure and occupational physical activity not to be associated with LBP outcomes.[11]

Women seem to have higher prevalence, be more severely affected and have worse prognosis of LBP than men and some studies suggest that men and women should be assessed separately when studying risk and prognostic factors for LBP.[6, 12-14]

To our knowledge, it is not known if healthy lifestyle behavior, defined by a combination of lifestyle factors, is associated with the prognosis of LBP. Healthy lifestyle behaviour seems to have a larger

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3 potential to affect health problems and mortality than separate lifestyle factors alone.[1-5] We
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5 hypothesized that healthy lifestyle behaviour would decrease the risk of a poor outcome among men
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7 and women with occasional low back pain. If healthy lifestyle behaviour affects the prognosis of LBP
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9 implementing this knowledge could potentially prevent transition into disabling LBP and thereby
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11 reduce the burden on the individual as well as on the society.

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13 The aim of this study was to explore the influence of healthy lifestyle behaviour on the prognosis of
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15 occasional low back pain among men and women in a general population, hypothesizing that healthy
16
17 lifestyle behaviour can improve the prognosis.

21 **Methods**

24 **Study design and source population**

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27 In this study we used data from the Stockholm Public Health Cohort (SPHC).[15] The SPHC was set
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29 up by the Stockholm County Council and administered by Statistics Sweden and the Department of
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31 Public Health Sciences at Karolinska Institutet, Stockholm. The SPHC is a population based cohort
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33 established within the framework of Stockholm County Council public health surveys. In 2006,
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35 Stockholm County had an adult population of approximately 1.4 million individuals. From this
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37 population a total of 56 634 individuals (18-84 years old) were randomly selected, after stratification
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39 for gender and residential area, and received the baseline questionnaire, which 34 707 (61%)
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41 answered. The responders received a follow-up questionnaire in 2010, answered by 25 167
42
43 participants (73%). Compared to consensus data from Stockholm County the SPHC participants were
44
45 more likely to be of female gender, be born in Sweden, have higher education and income and be more
46
47 than 45 years old.[15]

50 **Study sample**

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52 The study sample (n=8994) consisted of participants reporting occasional LBP at baseline in 2006 who
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54 answered the follow-up questionnaire in 2010 and provided complete information on outcome and
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56 exposure variables (Figure 1). Occasional LBP at baseline was defined as reporting having had LBP,
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3 on average, up to a ~~couple of~~ few days per month during the past 6 months ([for the item used to define](#)
4 [occasional LBP see Appendix 1](#)). The information was based on a modified version of a question from
5 the Standardized Nordic Questionnaire.[16]
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7

8 9 10 **Data collection and variables**

11 The baseline and the follow-up questionnaires comprised self-reported information on lifestyle,
12 demographic- and socioeconomic characteristics, physical and psychological health and work related
13 factors. The self-reported data were supplemented with information from regional and national
14 registers.[15] Four reminders were sent after the baseline questionnaire and three reminders after the
15 follow-up questionnaire.
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18 **Exposure: healthy lifestyle behaviour (HLB)**

19 Using baseline information we constructed four binary healthy lifestyle factors where cut-offs
20 (healthy/not healthy) were set in accordance with recommendations for a health-enhancing lifestyle
21 made by Swedish authorities and WHO.[17-20] The exposure variable “healthy lifestyle behaviour”
22 (HLB) was a combination of these binary factors and was categorised into five levels according to the
23 number of healthy lifestyle factors included, i.e. from none to four (HLB0 to HLB4). A healthy
24 lifestyle behaviour with regard to each of the considered healthy factors was defined by: non-smoking,
25 no risk consumption of alcohol (≤ 168 g 100% alcohol/week for men and ≤ 108 g 100% alcohol/week
26 for women, and consuming alcohol corresponding to about half a bottle of spirits (35 cl) on the same
27 occasion less than once a month), recommended level of leisure physical activity (at least 150 minutes
28 at moderate intensity or 75 minutes at high intensity per week or a combination of these activities),
29 and recommended consumption of fruit and vegetables (\geq a total of 4 servings of fruit and
30 vegetables/day, equal to about 400 g/day) (see [the Appendix-Appendix 2](#) for a description of the
31 questions and how the variables were constructed).
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53 **Outcome variable: long duration troublesome low back pain (LTLBP)**

54 Information on the outcome LTLBP was collected from the follow-up questionnaire in 2010 and
55 defined as having had LBP that decreased workability or interfered with other daily activities to some
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3 or to high degree, on average a ~~couple of few~~ days per week or more often during the past 6 months
4 (for the items used to define LTLBP see Appendix 1). The question used to measure LTLBP was
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6 modified from the Standardized Nordic Questionnaire and incorporated a dimension of disability
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8 suggested to be of importance when defining LBP.[16, 21]
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10 11 Potential confounding factors

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14 Potential confounders were chosen based on theoretic and empirical relevance, information from
15 literature regarding the prognosis of spinal pain and availability in the questionnaire.[8, 22, 23] The
16 following factors were considered: long-term illness (suffering from long-term illness, health problems
17 following an accident, disability or other persistent health problems), neck pain and pain from hip,
18 thigh or knee during the past 6 months (5 answer alternatives from “no pain” to “daily pain”),
19 suffering from headache or migraine (“no”, “somewhat”, “severe”), rheumatoid arthritis diagnosed by
20 a physician, living alone, living with children (children of all ages included) and hours of sleep a
21 typical night during the workweek (dichotomized into “good sleep”: 6-8 h and “poor sleep”: <6 h or
22 >8 h). The questionnaire also included the 12-item General Health Questionnaire were a sum score of
23 ≥ 3 (using the recommended 0-0-1-1 scoring on the four answer alternatives) was used to assess
24 psychological distress.[24, 25] The frequency of stress was measured by the question “How often do
25 you feel stress?” with 5 answer alternatives from “never” to “most of the week”. Personal support
26 (having persons who can give support in handling personal problems or critical life events) was
27 measured using a question from the Social Support-13 instrument (SS-13).[26] Furthermore, financial
28 stress was assessed by the question “Did it during the previous 12 months happen that you ran out of
29 money and had to borrow from relatives and friends to be able to pay for food or rent?” (“no”, “yes, on
30 one occasion”, “yes, on several occasions”). A Swedish national register supplied information on civil
31 status (married, unmarried, divorced, widow/widower), country of birth (Sweden, Nordic countries
32 and Europe, outside Europe), socio-economic status (SES), annual individual disposable income
33 (grouped in quintiles) and education.[27, 28] The level of education was categorized into, low (only
34 compulsory education and vocational training), intermediate (secondary school) and high (university
35 studies).
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Statistical methods

We used generalized linear models with a binomial distribution to estimate the association between the exposure and the outcome analysing men and women separately. To determine the role of a potential confounding factor we included them, one at a time, into the crude model. Only factors that changed the estimated risk ratio (RR) by 10% or more were entered into the final model.[29-33] All final models were adjusted for age categorized into 10 year intervals. Age was categorized as it showed non-linearity with the outcome. We calculated relative risks (RR), using the log function, as well as risk differences (RD), using the identity function, with 95% confidence intervals (95% CI). A likelihood ratio test was used to assess clinically relevant effect measure modification between the exposure and possible confounders (age, education, SES, neck pain, long term illness and psychological distress) as well as between confounders included in the final-adjusted models (age and SES).[34] An effect measure modification significant at $p \leq 0.05$ was included in further analyses. [34]

We used Wald test to evaluate potential trends in the associations between the exposure and the outcome, and a Chi-square test to assess if the overall adjusted risk differed between men and women.[34] The effect of attrition was assessed, using Chi-square tests, by comparing the distribution of the four healthy lifestyle factors included in the exposure, healthy lifestyle behaviour, in subjects who were lost to follow-up to the distribution in the study sample.

All p-values were two-sided, and analyses were completed using SAS® version 9.3 and STATA/IC® version 12.1.

Results

Baseline characteristics

The study sample (n=8994) consisted of 56% women. Participants were predominately middle aged, well educated, and born in Sweden. At baseline in 2006, about 15% of the participants were 65 years or older (men 17% and women 14%). Furthermore the majority were cohabitating, and about 35% had children living at home (Table 1). About three percent men and 10% women had an “optimal healthy lifestyle” (HLB4) whereas about five percent men and three percent women had an “unhealthy

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3 lifestyle” (HLB0). Healthy lifestyle behaviour improved with increased level of education.

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5 Participants being married or having children living at home had a high proportion of healthy lifestyle
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7 behaviour while participants living alone, being psychologically distressed and financially stressed
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9 showed low proportions of healthy lifestyle behaviour (Table 1).

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11 The other baseline variables assessed did not differ much between the categories of HLB, neither
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13 among men nor among women.

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For peer review only

Table 1. Baseline characteristics by categories of the exposure healthy lifestyle behaviour (HLB0 - HLB4)* (n = 8994).

Baseline characteristics	Men						Women						Internal drop-out M/W (n)
	All (n=3938)	HLB0 (n=181)	HLB1 (n=958)	HLB2 (n=1747)	HLB3 (n=936)	HLB4 (n=116)	All (n=5056)	HLB0 (n=174)	HLB1 (n=897)	HLB2 (n=2080)	HLB3 (n=1416)	HLB4 (n=489)	
Proportion of study sample (%)	44						56						
Mean age, years (SD)	50(15)	49(14)	48(15)	49(15)	51(15)	50(14)	46(16)	43(17)	47(15)	46(16)	47(15)	46(14)	0/0
Education													234/287
Low	16	30	19	14	14	8	14	22	17	13	12	9	
Intermediate	43	43	46	44	40	35	41	57	46	42	38	34	
High	41	27	35	42	46	57	45	21	37	45	50	57	
Civil status													0/1
Married	54	42	49	56	56	65	47	27	41	46	53	53	
Unmarried	33	38	36	32	31	29	36	49	37	37	33	32	
Divorced/Widow/Widower	13	20	15	12	13	6	17	24	22	17	14	15	
SES^a													292/398
Unskilled/semiskilled worker	14	22	17	13	12	9	16	23	19	16	14	10	
Skilled worker	15	25	16	14	15	8	10	22	12	9	9	11	
Assistant non-manual employees	8	8	10	9	7	5	20	22	21	22	18	15	
Intermediate non-manual	25	14	25	24	27	24	29	23	23	29	31	35	

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employees													
Employed/self-employed	25	17	18	28	28	34	19	7	17	18	21	24	
professionals													
Self-employed (other than professionals)	13	14	14	12	11	20	6	3	8	6	7	5	
Poor sleep^b													34/27
<6 or >8 hours/night	9	17	9	10	7	9	10	14	11	11	9	7	
Living alone	17	31	19	16	14	9	19	24	21	19	17	17	10/16
Living with children	34	24	31	35	34	42	38	27	32	39	41	41	10/16
Psychological distress^c	13	18	15	13	11	5	21	33	23	22	19	17	38/37
Financial stress^d	7	15	10	5	4	3	9	23	13	9	7	6	17/24

* HLB0 = no healthy lifestyle factor, HLB1 = 1 of 4 healthy lifestyle factors, HLB2 = 2 of 4 factors, HLB3 = 3 of 4 factors, HLB4 = all 4 healthy lifestyle factors.

^a Socio-economic status. For the economically active population SES was based on current occupation and education. For the non-active population SES was based on previous occupation, current education or the occupation of spouses.

^b Hours of sleep a typical night during the workweek (dichotomized into “good sleep”: 6-8 h and “poor sleep”: <6 h or >8 h).

^c From the 12-item General Health Questionnaire (GHQ-12) were a sum score ≥ 3 was used to asses psychological stress.

^d Financial stress: Had to borrow money from relatives and friends to be able to pay for food or rent on several occasions during the previous 12 months.

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3 The majority of both men and women were non-smokers and did not exceed risk consumption of
4 alcohol. About 40% of both men and women reached recommended levels of leisure physical activity
5 while 26% of the women consumed recommended levels of fruit and vegetables compared to seven
6 percent for men (Figure 2).
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10 11 **Outcome**

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14 At follow-up in 2010, nine percent men and 11% women in the study sample reported LTLBP. Table
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16 2 shows the crude and adjusted binomial regression estimations of the association between healthy
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18 lifestyle behaviour and the outcome.
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Table 2. Association* between healthy lifestyle behaviour and long duration troublesome low back pain (LTLBP) in men and women with occasional LBP at baseline in 2006.

	MEN (n=3646) ^a					WOMEN (n=4658) ^a			
	Healthy lifestyle behaviour ^c	LTLBP/ no LTLBP ^d (n/n)	Crude	Adjusted (Age, SES) ^b		LTLBP/ no LTLBP ^d	Crude	Adjusted (Age, SES) ^b	
			RR (95% CI)	RR (95% CI)	RD (95% CI)		RR (95% CI)	RR (95% CI)	RD (95% CI)
HLB0	14/155	1.0	1.0	0.0	28/131	1.0	1.0	0.0	
HLB1	71/812	0.97 (0.56, 1.68)	1.02 (0.59, 1.76)	-0.01 (-0.06, 0.03)	94/735	0.64 (0.44, 0.95)	0.65 (0.44, 0.96)	-0.05 (-0.12, 0.01)	
HLB2	133/1476	1.00 (0.59, 1.69)	1.05 (0.62, 1.78)	-0.01 (-0.05, 0.04)	181/1721	0.54 (0.38, 0.78)	0.54 (0.38, 0.78)	-0.07 (-0.13, -0.01)	
HLB3	60/818	0.82	0.85	-0.02	125/1187	0.54	0.55	-0.07	

		(0.47, 1.44)	(0.48, 1.48)	(-0.06, 0.02)		(0.37, 0.79)	(0.38, 0.81)	(-0.13, -0.01)
HLB4	6/101	0.68	0.75	-0.03	36/420	0.45	0.48	-0.08
		(0.27, 1.71)	(0.30, 1.89)	(-0.07, 0.01)		(0.28, 0.71)	(0.31, 0.77)	(-0.15, -0.02)

*note: Log- binomial regression estimating the risk ratio (RR) and the risk difference (RD) with 95% confidence interval (95% CI).

^a Reduced number of observations due to missing information about socio-economic status (SES) (men n=292 and women n=398).

^b Adjusted for age in 10 year categories and socio-economic status (SES) in six categories.

^c HLB0 = no healthy lifestyle factor, HLB1 = 1 of 4 healthy lifestyle factors, HLB2 = 2 of 4 factors, HLB3 = 3 of 4 factors, HLB4 = all 4 healthy lifestyle factors.

Healthy lifestyle factors included in HLB: non-smoking, no risk consumption of alcohol (≤ 168 g 100% alcohol/week for men and ≤ 108 g 100% alcohol/week for women, and consuming alcohol corresponding to \approx half a bottle of spirits on the same occasion less than once a month), recommended level of leisure physical activity (at least 150 minutes at moderate intensity or 75 minutes at high intensity per week or a combination of these activities), and recommended consumption of fruit and vegetables (≥ 4 servings of fruit and vegetables/day).

^d Numbers of participants with and without LTLBP at follow-up in 2010.

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3 There was a decreased risk for LTLBP at follow-up for women with a healthy lifestyle behaviour
4 compared to women with unhealthy lifestyle behaviour (test for trend: $p=0.006$). Twenty-one percent
5 of women with no healthy lifestyle factor (HLB0) experienced LTLBP at follow-up compared to nine
6 percent of women with all four factors (HLB4). A five percent lower proportion of women with one
7 healthy lifestyle factor, and an eight percent lower proportion of women with all four factors had
8 LTLBP, in comparison to the reference group (HLB0). Women with one healthy lifestyle factor and
9 women with all four healthy lifestyle factors had a 35% and a 52% lower risk for LTLBP,
10 respectively, compared to women with unhealthy lifestyle behaviour (HLB0). There were no clear
11 associations between healthy lifestyle behaviour and LTLBP found among men.

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13 SES was the only variable found to be a confounder, so the final log-binomial analyses were adjusted
14 by SES and age in 10 year categories. There was no **clinically relevant** effect measure modifications
15 found.
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19 Figure 3 shows the adjusted risk to develop LTLBP for men and women with occasional LBP by
20 categories of healthy lifestyle behaviour. Women had an overall higher adjusted risk for LTLBP than
21 men ($p=0.001$).
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25 The subjects lost to follow-up ($n=4552$) had significantly lower proportions of healthy lifestyle factors
26 than the study sample ($p < 0.01$ for all four factors). The differences in proportions were eight percent
27 for non-smoking, 16% for no risk consumption of alcohol, six percent for leisure physical activity and
28 five percent for consumption of fruit and vegetables.
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31 Discussion

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33 In this cohort study we found that healthy lifestyle behaviour had a positive influence on the prognosis
34 of occasional low back pain among women. Healthy lifestyle behaviour comprised four healthy
35 lifestyle factors: non-smoking, no risk consumption of alcohol, recommended level of leisure physical
36 activity and recommended consumption of fruit and vegetables. Compared to women with no healthy
37 lifestyle factor, the risk for development of long duration troublesome low back pain (LTLBP)
38 decreased by 35% among women with one healthy lifestyle factor and by 52% among women with all
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3 four healthy lifestyle factors. In absolute terms, the proportion of women with LTLBP at follow-up
4 was five percent lower if they had one healthy lifestyle factor and eight percent lower if they had four
5 healthy lifestyle factors when compared to women with unhealthy lifestyle behaviour. These
6 associations were not confirmed among men but the results indicated the same tendency.
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11 Further, compared to women, men had an overall lower adjusted risk for LTLBP, and a low risk even
12 in the unhealthy reference group (Figure 3). Men with unhealthy lifestyle behaviour had about the
13 same risk for LTLBP as women with optimal healthy lifestyle behaviour. These findings were not
14 aimed to be addressed in the present study and needs to be further investigated.
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20 We found no studies concerning the effects of healthy lifestyle behaviour, defined as a combination of
21 healthy lifestyle factors, on the prognosis of LBP or other types of spinal pain. Nevertheless,
22 considering the risk of developing chronic back pain Pronk and colleagues showed results in line with
23 our study.[2] Studying employees, the authors found that an “optimal lifestyle” decreased the 2-year
24 risk of chronic LBP by 66% compared to employees with an unhealthy lifestyle. Having optimal
25 lifestyle was equal to having all four of the healthy lifestyle factors similar to the ones included in our
26 study: non-smoking, adequate physical activity, five servings of fruit and vegetables per day and
27 limited or no alcohol consumption.
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37 **Strengths and limitations**

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39 To our knowledge this is the first study concerning the influence of healthy lifestyle behaviour (HLB)
40 on the prognosis of LBP assessing men and women separately. Measuring the exposure prior to the
41 outcome and the dose-response relationship found supports the validity of the associations between
42 HLB and LTLBP found among women.[32] We believe the use of a complete study sample, the large
43 sample size and the large number of potential confounders assessed strengthens the internal validity,
44 though we cannot rule out residual or unmeasured confounding. [for example information on health](#)
45 [care services](#). [32] The questions used in this study have, since 1975, been used in several Swedish
46 national and local public health surveys. They have on several occasions been tested (e.g. cognitive
47 testing) and improved by Statistics Sweden’s test centre and several questions have shown to have
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3 acceptable psychometric properties. Moreover, information on education, disposable income, SES,
4 country of birth and marital status were collected from Swedish national registers known to have high
5 quality. The questions concerning leisure physical activity and consumption of fruit and vegetables
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7 have shown to have acceptable validity and reliability, and the method to measure alcohol
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9 consumption has been recommended by Romelsjö and colleagues.[35-38] Despite this the
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11 measurements used may not have been optimal in terms of validity and reliability.
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15 Our study also has limitations. Self-reported exposure information may be hampered by low accuracy.
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17 For example, some participants may wish to present themselves in a favourable light and overestimate
18 their healthy lifestyle (social desirability) or some may have difficulties understanding the questions
19 and therefore report less well.[32, 39, 40] This could lead to misclassification of the exposure which
20 may result in an under- or overestimation of the association. As this potential misclassification is
21 likely to be non-differential it would probably dilute a true association, at least when comparing
22 extremes.[32] Moreover, if men tend to misclassify their healthy lifestyle factors to a greater extent
23 than women this may partly explain why we did not find any associations among men. For example,
24 Dyrstad and colleagues found that men overestimated their self-reported physical activity when
25 compared to accelerometer-measures to a greater extent than women.[41] As we studied a population
26 between 18-84 years old a large proportion of the participants did not provide work related
27 information why we did not assess potential confounding effects from work related variables,
28 something that may have affected the results. About 34% of participants in the baseline survey were
29 not part of the study sample due to attrition and exclusion (Figure 1). Compared to the study sample
30 the 34% missing had the same proportion of men and women, were younger (mean age for both sexes
31 were 43 years) and both men and women had a slightly lower level of education as well as SES.
32 Further, they had ~~These subjects had~~ significantly lower proportions of healthy lifestyle factors than
33 the study sample. This difference may have introduced selection ~~biased to~~ our results if the attrition
34 and the loss to follow-up are related to the exposure as well as to the outcome. If selection bias is
35 present, we believe that it probably leads ~~most probably leading~~ to an underestimation of the
36 associations since these subjects to a higher extent may have developed LTLBP.
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3 Considering strengths and limitations in our study we regard our result as a valid contribution to the
4 body of research showing that a healthy lifestyle affects health problems.[1-5] Our study results
5 showing that healthy lifestyle behaviour influences the prognosis of LBP are new and important
6 knowledge with the potential to have an impact on a very common public health problem and have
7 implications both in a public-health and a clinical perspective. Even though the association for healthy
8 lifestyle behaviour to affect LBP among men was not clear, the results showed the same tendency as
9 for women. Considering this together with the obvious effect of healthy lifestyle on other health
10 problems the work to encourage both men and women to adapt to healthy lifestyle should certainly be
11 continued.
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23 Conclusion

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25 Healthy lifestyle behaviour, defined as combinations of non-smoking, no risk consumption of alcohol,
26 recommended level of leisure physical activity and recommended consumption of fruit and vegetables,
27 seems to decreases the risk of developing long duration troublesome low back pain among women
28 with occasional low back pain. There were no clear associations found among men.
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37 **Contributors:** TB, ES, LA, EV and IJ contributed to the design of the study. JH and LA were part of
38 the expert group responsible for the design and implementation of the SPHC cohort. TB made the
39 statistical analyses and wrote the first manuscript version. All authors contributed to the interpretation
40 of the data and critically revised all versions of the manuscript and finally approved the last version.
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11
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13 (Diary nr. 2013/497-32).
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16 **Data sharing:** No additional data available.
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19 **Transparency:** The lead author (TB) affirms that the manuscript is an honest, accurate, and
20 transparent account of the study being reported; that no important aspects of the study have been
21 omitted; and that any discrepancies from the study as planned have been explained.
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25 26 27 28 **References**

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Figure 1. Flowchart of the inclusion process for the study sample. LBP: low back pain.

Figure 2. Distribution of healthy lifestyle factors. PA: Leisure physical activity. F/V: Fruit and vegetables.

Figure 3. Estimated risk for LTLBP, adjusted for SES and age. Men (n=3646), women (n=4658).