ORIGINAL ARTICLE

Predicting the long term course of low back pain and its consequences for sickness absence and associated work disability

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Background: Low back pain is characterised by a dynamic pattern of episodes and recovery but little is known about the long term course of back pain due to lack of cohort studies with sufficiently long follow up periods.

Methods: A cohort of 523 workers in nursing homes and homes for the elderly was followed for two years. Physical load was measured by observations at the workplace. Psychosocial factors at work, individual characteristics, and low back pain were determined by questionnaire once a year. The effect of work load on low back pain and the transition of low back pain into sickness absence was calculated with logistic regression analysis. A Markov model was used to construct a hypothetical cohort of workers with follow up of 40 years (40 cycles of 1 year) with transitional probabilities between no complaints, low back pain, and sickness due to low back pain. Permanent disability was used as end state of health.

Results: The transitional probability from no complaints to low back pain varied between $p=0.25$ and $p=0.29$, from low back pain to sickness absence between $p=0.09$ and $p=0.25$, and recurrence of sickness absence varied between $p=0.27$ and $p=0.50$, depending on the level of physical load. During a 40 year career, total sickness absence due to low back pain was approximately 140 weeks (6.6%) among workers with high physical load and about 30 weeks (1.4%) among those with low physical load.

Conclusion: The Markov approach illustrated the potential impact of physical load on (permanent) disability due to low back pain among workers with exposure to physical load. These consequences may go unnoticed in cohort studies with follow up periods of a few years.

Low back pain is a common health condition in working populations. Considering the lifetime prevalence of 60–85%, it will eventually affect almost everyone during working life—men and women equally.¹ Low back pain is a frequent reason for medical care seeking with an estimated 6–7% of the adult population annually consulting a general practitioner for their complaints.² In the majority of patients low back pain seems a limiting condition from which 90% of all patients stop consulting their medical practitioner within one month and about 80% recover sufficiently to return to work in about six weeks.^{3–4} Among patients with acute low back pain lasting less than three days 90% reported to be without pain or disability two weeks after first presentation to their general practitioner.⁵

Although these findings suggest that most low back pain problems will have resolved within a few weeks, high recurrence rates have been reported. Within 12 months over 60% of low back pain patients from general practices experienced relapses of pain.³ Croft and colleagues reported that only 25% of all patients with a new episode of low back pain had completely recovered from pain and disability within 12 months of their initial visit to a general practice.² In an occupational cohort the annual recurrence rates of low back pain varied between 64% and 77%, with only few workers consistently reporting the presence or the absence of low back pain during a four year period.⁶ These prospective studies indicate that low back pain is quite persistent with strong fluctuations in severity of complaints, expressed by recurrent episodes interspersed with periods free from pain.⁷

In the past two decades it has been well documented that physical load caused by frequent lifting, awkward back postures, and whole body vibration is a risk factor for the occurrence of low back pain.⁸ However, little is known about

the impact of physical load on the long term course of low back pain and associated consequences for work disability. Frequent lifting has been identified as a risk factor for recurrence of low back pain⁶ and as a determinant in the transition from acute to chronic back pain.⁹ A few studies have shown that physical load was a risk factor for sickness absence due to low back pain^{10–12} whereas other studies have failed to demonstrate an effect of physical load on sickness absence duration.^{13–14} Thus, it remains largely unknown whether work related risk factors for the occurrence of low back pain also are important prognostic factors for aggravation of low back pain and associated disability. This ambiguity may be partly explained by the lack of cohort studies with sufficiently long follow up periods to identify determinants of persistence and/or recurrence of low back pain and subsequent morbidity. However, the information from cohort studies with a limited time horizon may be used to predict the long term course of low back pain in these cohorts. In this regard, a particularly useful technique is a Markov model of prognosis which can be used for health events of discrete nature that happen more than once over time.¹⁵ A Markov model assumes that the patient is always in one of a finite number of health states—for example no complaints, back pain, and sickness absence due to back pain. The course of a disease is modelled by transitions from one state to another during a specified period of time. In a longitudinal study on musculoskeletal symptoms among newspaper workers, this approach was used to demonstrate that during a one year follow up the same proportion of workers improved as worsened in symptoms and that these fluctuations in severity could be described well by transitions between different states of symptoms or disability.¹⁶ In a longitudinal study among forestry workers with three year

follow up, a transition model was also applied, which showed that working with a flexed trunk or working with a hand above shoulder level were consistently associated with the occurrence of current radiating neck pain.¹⁷ This approach may be extended over longer periods than the actually observed follow up period. Under the assumption that the transition probabilities are constant over time, a Markov chain may be created by repeating each cycle a certain number of times to represent a meaningful time interval, for example employment in the same job for 30 years or more.

In order to understand the long term course of back complaints and associated sickness absence and work disability, we studied the dynamic pattern of incidence, recurrence, and severity of back complaints in an occupational cohort study and applied a Markov model to mimic the long term consequences of low back pain in this cohort of workers. The aims of this study were (1) to analyse the effects of work related risk factors, especially physical load, on the occurrence of low back pain and the transition from low back pain into sickness absence due to low back pain, and (2) to predict the long term consequences of prolonged exposure to high levels of work load on low back pain and associated permanent work disability.

MATERIAL AND METHODS

Study population

A longitudinal study was conducted among workers from seven nursing homes and homes for the elderly in the Netherlands who were employed for at least 10 hours per week. During the baseline survey self-administered questionnaires were used and detailed assessments of physical load in each occupation title group were carried out. Follow up questionnaires were applied one and two years after the baseline survey. Of the 1208 subjects invited to enrol in the study, 769 (64%) subjects agreed to participate. This study population consisted of nine different occupational groups: 129 nurses, 264 caregivers, 58 kitchen workers, 49 housekeepers, 14 transportation and technical workers, 9 laundry workers, 38 (physical) therapists, 146 office workers, and 62 miscellaneous workers. At one year follow up 541 (70%) of the 769 subjects responded again, of which 523 (68%) provided sufficient information for the current analysis, resulting in an overall response from baseline invitations of 43%. After two years of follow up 346 out of 541 (64%) subjects responded with 341 (63%) complete questionnaires.

Data collection

Questionnaire survey

A questionnaire was used to collect information on personal characteristics, including age, sex, length, weight, education, family status, and employment history, psychosocial factors at work, and the occurrence of musculoskeletal complaints.⁶

Psychosocial factors at work were derived from the Karasek model on job control and work demands.¹⁸ Job control consisted of 11 questions on decision authority reflected aspects such as influence on the planning of tasks, influence on the pace at work, brief pauses when needed, and decisions on time spent on given tasks (Cronbach's α 0.90), and six questions on skill discretion, such as skills required, task variety, learning new things, and amount of repetitive work (Cronbach's α 0.80). Eleven questions on work demands related to working fast, working hard, excessive work, insufficient time to complete the work, and conflicting demands (Cronbach's α 0.88). The response to each question was scored on a four-point ordinal scale, ranging from "seldom or never" to "always" during a regular workday. For both dimensions a sum score was computed and expressed on a 0–100 scale. A score of 100 was defined as the worst possible situation and 0 as the best possible situation. In the

statistical analysis these scores were dichotomised at the mean of the overall distribution.

Information on the occurrence and nature of low back complaints was gathered with the Nordic questionnaire for the analysis of musculoskeletal symptoms.¹⁹ Low back pain was defined as any episode of pain in the lower back (defined by a drawing with a preshaded area) that had continued for at least a few hours in the previous 12 months. An incident case of low back pain was defined as the presence of an episode of low back pain during the follow up year among subjects who reported the absence of low back pain at baseline. The occurrence of sickness absence due to an episode of low back pain was determined by a questionnaire on frequency and duration of sickness absence which showed a high specificity (97%) and sensitivity (88%), and a good agreement for back pain absence (Cohen's κ 0.65).²⁰

Quantitative assessment of physical load

In a group of 212 workers randomly sampled at baseline, observations were made at the workplace on physical load during work for each of the nine occupations. The proportion of observed subjects per group ranged from 16% for the nurses to 64% for the transportation and maintenance workers, thereby oversampling those occupations with fewer subjects. The primary aim was to have at least 10 workers in each occupation in order to arrive at a reasonable estimate of the average exposure of each group.²¹ In the three largest occupational groups at least 10 workers were sampled in four different nursing homes in order to increase generalisability across homes. An observational multimoment method was used to describe three measures of physical load: trunk flexion between 20° and 45°, trunk flexion over 45°, and lifting or carrying loads over 10 kg, all expressed in percentage of work time. Observations were made on selected workers every 20 seconds during four periods of 30 minutes on a regular workday, thus collecting 360 observations per worker. For every occupational group the exposure to each measure of physical load was calculated as the mean percentage of work time across all subjects selected for observation in that occupational group. Subsequently, the arithmetic mean for the occupational group was used as a proxy for exposure in all subjects, both observed and unobserved, in that occupation. An underlying assumption of this strategy is that the average physical load of the observed workers is equal to the average physical load of the total occupational group.^{22, 23} In order to estimate the average exposure to physical load of each individual worker, the occupation-specific exposure expressed in percentage of work time was multiplied by self-reported number of hours worked per week. A detailed description of the effects of this measurement strategy on dose-response relations between physical load and low back pain has been published elsewhere.²³

Data analysis

A simulation was carried out of a hypothetical cohort of workers in nursing homes and homes for the elderly, all aged 25 years, who were free of low back pain in the previous 12 months and followed up for a period of 40 years. A Markov chain approach was used with one year increments of time during which a subject may make a transition from one health state to another.¹⁵ In this analysis, four health states were defined: healthy subjects, low back pain in the past 12 months, sickness absence in the past 12 months due to low back pain, and permanently work disabled after a prolonged sickness absence of 365 days. The latter health state was considered an absorbing state—that is, transition to another state from within this state is regarded to be impossible. These health states were enumerated in such a

Table 1 Prevalence, incidence, and recurrence of low back pain in the past 12 months and sickness absence due to low back pain in the past 12 months among personnel of nursing homes and homes for the elderly during the first and second year of follow up

	Low back pain			Low back pain with sickness absence		
	Baseline (n=769)	Follow up 1 (n=523)	Follow up 2 (n=341)	Baseline (n=769)	Follow up 1 (n=523)	Follow up 2 (n=341)
Prevalence	57.9% (54.7–61.2)	54.5% (51.3–57.6)	50.2% (46.4–53.9)	9.2% (8.4–9.9)	13.2% (12.1–14.2)	11.4% (10.3–12.6)
Incidence	–	26.4% (23.4–29.4)	25.8% (22.3–29.3)	–	10.7% (9.8–11.6)	7.2% (6.4–8.0)
Recurrence	–	74.9% (70.7–79.1)	70.4% (64.9–75.9)	–	37.5% (29.1–45.9)	36.0% (28.0–44.0)

way that, in any given year, an individual was in one health state only and that the probabilities of the three non-absorbing states sum up to 1. Transition probabilities were assumed to be constant over time—that is, the transition from one health state to another health state in a given year is independent from the health status in earlier one year cycles. Hence, it is assumed that the exposure to work related risk factors is constant over time and has a constant effect on low back pain and sickness absence. The Markov model was used for a cohort simulation whereby a large group of individuals was run through a working life with 40 yearly cycles. At the end of each year the results of all transitions that had occurred were summed up to provide the percentage of the cohort in each state and the incurred sickness absence. At the end of the 40 cycles the total burden of sickness absence in the cohort was calculated and expressed by the average number of weeks of sickness absence of the average worker who continued for 40 years in the same job.

Logistic regression analysis was conducted on the study population that completed the first follow up (n = 523) in order to evaluate the effect of physical work load, psychosocial work load, and individual characteristics on the occurrence of low back pain and sickness absence due to low back pain during the one year follow up period. Three levels of physical load were assigned, based on tertiles of the exposure distributions of trunk flexion between 20° and 45°, trunk flexion over 45°, and lifting or carrying loads over 10 kg.²³ The highest level of physical load was defined as lifting and carrying loads at least 30 minutes per week and trunk flexion over 45° during 75 minutes per week or more. An intermediate level of physical load was defined as lifting and carrying loads at least 30 minutes per week or trunk flexion over 45° during 75 minutes per week or more. The two psychosocial factors were dichotomised at the mean value of their underlying scales. Individual characteristics were sex, age (years), height (cm), weight (kg), body mass index (weight/(height)²), and education. Age, physical load, and psychosocial aspects were forced into a multivariate model, independent of their level of significance. Other

individual characteristics were retained in the model when reaching a level of significance of $p < 0.05$. Wald statistics were used to estimate the 95% confidence intervals around the odds ratios.

The Markov chain approach was based on a polytomous logistic regression analysis on the associations of work related risk factors with low back pain and sickness absence due to low back pain. The simulation approach was restricted to evaluation of the effect of physical load, because a previous analysis demonstrated that physical load was the most important work related risk factor for aggravation of low back pain.²⁴ The polytomous logistic regression model was fitted on data of the study population that completed the first follow up (n = 523). The population that completed the second follow up (n = 341) was used to evaluate whether systematic differences in risk estimates were present between both years of follow up. The odds ratios from the univariate polytomous logistic regression models were converted into transition probabilities for the health states: healthy, low back pain, and sickness absence due to low back pain.²⁵ Since the actual follow up of the study population was too short to determine the risk of becoming permanently disabled due to low back pain (duration of sickness absence exceeds 365 days), the transition probability from sickness absence to permanently disabled was estimated, on average, as $p = 0.01$, derived from a prognostic study among workers with sickness absence due to low back pain.²⁶ This average transition probability was assigned to subjects with exposure to intermediate levels of physical load. Subjects with higher and lower exposure to physical load were assigned transition probabilities weighted by the probability of recurrence of sickness absence due to low back pain.

The estimates of transition probabilities were carried out with proc Catmod in SAS statistical software version 8.2.²⁷ With the Markov chain approach a cohort simulation was conducted with software programme DATA TreeAge Pro.²⁸ The stochastic uncertainty (SE) of the transition probabilities was taken into account by means of a second order Monte Carlo simulation. For each level of physical load the average

Table 2 The association between work related physical factors and psychosocial aspects at baseline and the occurrence of low back pain and sickness absence due to low back pain during a one year follow up among personnel of nursing homes and homes for the elderly (n = 523)

Risk factor	n	Low back pain		Sickness absence due to low back pain	
		OR	95% CI	OR	95% CI
Age (y)	523	0.98	0.96–0.99	0.98	0.95–1.01
Low physical load	273	1.00		1.00	
Intermediate physical load	142	0.97	0.63–1.49	2.00	1.04–3.85
High physical load	108	1.01	0.63–1.63	2.95	1.52–5.71
High work demands (1/0)	277	1.10	0.76–1.58	0.83	0.48–1.44
Low job control (1/0)	234	1.12	0.78–1.60	0.88	0.51–1.51

Figure 1 The Markov process used in the simulation of a hypothetical cohort of workers, all 25 years old and without low back pain, with different levels of exposure to physical load.

number of weeks with sickness absence and the average number of years with permanent work disability was calculated for the average worker during a 40 year working life in the same job.

RESULTS

Of the 769 subjects included at baseline, 246 (32%) were not available to provide suitable outcome information at follow up. The participation rate among the nine professions and seven nursing homes varied considerably, but was not related to the prevalence or severity of low back pain at baseline. Of those lost to follow up, 39 subjects changed jobs to employers not participating in the study. The prevalences of low back pain and sickness absence due to low back pain at baseline among subjects lost to follow up were similar to those among subjects available for follow up. Among those subjects without low back pain at baseline no differences in physical load was found between workers available for follow up and

those lost to follow up. Those lost to follow up, however, were slightly younger and had fewer years of employment at the facility.

In the study population 84% of the subjects were women, and workers had a mean age of 41 years with nine years of employment in their current job. In the total study population the prevalence for low back pain varied between 50% ($n = 171$, second year of follow up) and 58% ($n = 303$, baseline survey) and for sickness absence due to low back pain between 9% ($n = 48$, baseline survey) and 13% ($n = 69$, first year of follow up) (table 1). The estimated one year cumulative incidences of both health states was 26% and 7%–11%, respectively. A high recurrence was observed for both low back pain and sickness absence due to low back pain. During the first year of follow up 43% ($n = 30$) of the subjects with sickness absence due to low back pain reported a total duration of seven days or less, 13% ($n = 9$) reported 8–14 days, and 30% ($n = 30$) reported more than 14 days.

Table 3 Matrix of transition probabilities for three levels of physical load among the distinguished health states for low back pain (LBP) during a one year follow up among personnel of nursing homes and homes for the elderly ($n = 523$)

Baseline		Follow up		
		No LBP	LBP w/o sickleave	LBP with sickleave
Low physical load (L)	No LBP	0.75 (0.04)	0.20 (0.04)	0.05 (0.02)
	LBP w/o sick leave	0.28 (0.04)	0.63 (0.04)	0.09 (0.02)
	LBP with sick leave	0.20 (0.10)	0.53 (0.13)	0.27 (0.11)
Intermediate physical load (I)	No LBP	0.75 (0.05)	0.19 (0.05)	0.06 (0.03)
	LBP w/o sick leave	0.18 (0.05)	0.64 (0.06)	0.18 (0.05)
	LBP with sick leave	0.32 (0.11)	0.32 (0.11)	0.37 (0.11)
High physical load (H)	No LBP	0.71 (0.07)	0.19 (0.06)	0.10 (0.05)
	LBP w/o sick leave	0.25 (0.06)	0.50 (0.07)	0.25 (0.06)
	LBP with sick leave	0.17 (0.11)	0.33 (0.14)	0.50 (0.14)

Figure 2 Projected effect of three levels of physical load (upper solid line, intermediate dashed line, low thin dashed line) on the prevalence of low back pain (LBP) and sick leave due to low back pain and the cumulative proportion of workers with disabling long term sickness absence (>52 weeks) (disability) in a hypothetical cohort with 40 years of follow up among personnel in nursing homes and homes for the elderly.

This distribution was used to set the average duration of an episode of sickness absence due to low back pain in the study population at two weeks.

Work related risk factors were not associated with the occurrence of low back pain during the first year of follow up, but a significant trend was observed for level of physical load and sickness absence due to low back pain (table 2). The psychosocial factors job control and work demand as well as their interaction term were not statistically significant. An increase of one year in age was statistically associated with back pain (OR = 0.98) but not with sickness absence, although a similar magnitude of effect was found. In this study the characteristics sex, height, weight, body mass index, and education were not associated with either low back pain or sickness absence due to low back pain. The analysis of risk factors for low back pain during the second year of follow up showed comparable results but the determinants of sickness absence because of low back pain were highly unstable due to the small number of occurrences ($n = 39$).

Figure 1 describes the Markov simulation of the hypothetical cohort of workers, all 25 years old and without low back pain, with different levels of exposure to physical load. This model incorporates all events of interest with work disability after 52 weeks of sickness absence as absorbing state—that is, recovery from this state was assumed to be impossible. The Markov sign (<) indicates that another cycle of one year will follow.

Table 3 presents the matrix with transition probabilities for different levels of physical load among the distinguished health states, as derived from the polytomous logistic regression analysis on the effect of physical load, adjusted for age and psychosocial aspects. A detailed analysis has shown that physical load was the most important risk factor for aggravation of low back pain with larger relative risks than age or employment duration.²⁴ Among subjects with low back pain the probability to take sick leave was $p = 0.25$ for those exposed to high physical load and $p = 0.09$ for those with a low physical load. Taking sick leave during the follow up among healthy subjects at baseline was higher among those with a high exposure to physical load than those with low exposure, $p = 0.10$ and $p = 0.05$, respectively. A comparable difference was observed for recurrence of sickness absence with $p = 0.50$ and $p = 0.27$, respectively. This latter difference was used to adjust the average transition

Table 4 Work weeks lost because of sickness absence due to low back pain and to permanent disability (>52 weeks sickleave) due to low back pain for the average worker during a 40 year career in nursing homes and homes for the elderly

	Weeks of sickness absence due to low back pain		Weeks of permanent disability due to low back pain	
	Mean	95% CI	Mean	95% CI
Low physical load	6	4–10	22	13–34
Intermediate physical load	11	7–17	57	33–83
High physical load	17	11–26	121	70–191

probability from sickness absence to becoming permanently work disabled of $p = 0.01$ to the level of physical load, resulting in an increased probability of $p = 0.0135$ (0.50/0.37) among subjects with the highest exposure and a decreased probability of $p = 0.007$ (0.27/0.37) among subjects with the lowest exposure.

Figure 2 depicts the results of the simulation of the hypothetical cohort. The prevalence of low back pain in the past 12 months reached a maximum after about five years of exposure to physical load and subsequently remained relatively stable, albeit at different proportions for each level of physical load. A similar pattern was observed for sickness absence due to low back pain, whereas the proportion of subjects becoming permanently work disabled (>52 weeks of sickness absence) increased with linear trend over time. Table 4 summarises the impact of physical load on weeks of work lost during a working life due to sickness absence and permanent work disability. Among workers with the highest exposure to physical load about 6.6% of their working life was lost due to sick leave because of low back pain, whereas the corresponding loss was 1.4% among workers with a low exposure to physical load.

DISCUSSION

In this longitudinal study in a working population we observed 12 month incidences for low back pain of 26%, 12 month prevalences roughly twice as high, and 12 month recurrences approximately threefold the incidence figures. Associated sickness absence was high with 16%–24% of all subjects with low back pain in a given year taking sick leave for these complaints. The level of exposure to physical load was not associated with the occurrence of low back pain but was a risk factor for sickness absence due to low back pain. The excess working lifetime lost due to sickness absence because of low back pain was 6.6% among workers with the highest exposure to physical load compared with 1.4% among those with low exposure to physical load.

As the participation rate among the seven nursing homes was not associated with the characteristics of low back pain in the baseline survey, selective participation at the start of the cohort does not seem to pose an important problem. No differences in the distribution of duration, frequency, and severity of low back pain were found between subjects available and lost to follow up. Subjects were partly lost to follow up due to change of employer, especially during the first years of employment. Non-respondents during the follow up reported slightly less job control and were more likely to have received medical treatment because of low back pain than subjects not lost to follow up. Thus, the presence of selection bias during the follow up cannot be ruled out.

In this study physical load was assessed by detailed observations at the workplace among a random sample of workers within each occupational group. Such an approach is

sensitive to substantial measurement error in exposures with a low frequency of occurrence during worktime. Lifting and carrying loads had a low frequency and the within-subject variance captured up to 80% of the total variance.²³ In order to reduce the influence of within-subject variance the average level of physical load in each occupational group was multiplied by the individual's self-reported number of hours worked per week. In a cross sectional analysis of associations between physical load and low back pain this strategy resulted in the strongest associations, most likely reflecting the smallest attenuation due to random measurement error in exposure.²³

A good consistency was found between prevalence, incidence, and recurrence during the consecutive follow up periods in this occupational cohort. The 12 month prevalence of low back pain in the annual surveys varied between 50%–58% and were within the range of reported prevalences of 42%–76% among nurses in cross sectional studies, using a similar questionnaire on low back pain.^{29–32} The annual incidence of 26% was consistent with other occupational populations.^{6, 33} The high yearly recurrence of low back pain compares well with previous reports and reflects the finding that a history of low back pain is a strong predictor of future episodes.^{3, 6, 32, 34} A disadvantage of this study was that prevalence, incidence, and recurrence of low back pain were determined by a recall period of 12 months. During this long recall period subjects may have experienced several episodes of back pain within the previous year and, thus, an incident case may have had recurrent episodes within that year. In addition, the subjects with persistent pain are a combination of subjects with continuous pain and those who had several recurrences during one year. A shorter recall period would undoubtedly have resulted in lower estimates for incidence and recurrence of low back pain and a better distinction between acute and chronic low back pain.³³

In this longitudinal study physical load and psychosocial factors were not associated with the occurrence of low back pain during the one year follow up, although these risk factors have been associated with the incidence and prevalence of low back pain.⁸ Given the high prevalence and recurrence of low back pain in the study population, this study may have had too little discriminatory power to identify an independent effect of work related risk factors. However, physical load was a clear risk factor for sick leave due to low back pain as observed in other studies,^{11, 35} but the influence of psychosocial aspects could not be corroborated.³⁶ The findings on sick leave may partly reflect the transition from acute to chronic back pain whereby physical load aggravates pain, resulting in increased functional limitations.⁹ The absence of any effect of psychosocial factors in this study population is noteworthy because psychosocial factors are hypothesised to be more important for the risk of recurrence or progression to chronic disability than objective biomechanical measures.³⁶

The input for the modelling approach was limited to the effect of physical load on low back pain and associated health states. Hence, the estimated consequences in terms of total work time lost during working lifetime are influenced by a substantial degree of uncertainty—for example due to the lack of adjustment for other potentially relevant confounders, the assumptions on transition probabilities to permanent disability, the subsequent assumption that permanent work disability was a definite state whereby the worker remains disabled and no rehabilitation was possible, and not taking into account change of job to less strenuous activities. Hence, the confidence intervals of the average number of work weeks lost only reflect the effect of random error in estimates of the transition probabilities. A sensitivity analysis addressing other sources of uncertainty would have resulted in a

much larger range of work weeks lost due to prolonged exposure to physical load. Notwithstanding these uncertainties, it is of interest to note that the hypothetical cohort quickly reaches an equilibrium, with the prevalence of low back pain around 48–54% after 5–6 years, depending on the level of physical load. This complies well with the estimated annual incidence of low back pain of 26% and suggests an average latency period of 5–6 years. The quickly reached equilibrium also illustrates that in longitudinal studies the overall prevalence will remain very stable, whereas individual trajectories of low back pain over time will show a dynamic pattern. Indeed, in a longitudinal study across eight years it was observed that the annual prevalence varied between 73% and 76% and that the proportion of repeated increase of low back pain (19%) was approximately as large as the proportion of repeated decrease of low back pain (17%).³¹ As a consequence, it may be difficult to distinguish incident cases from recurrent cases because the case definition largely depends on the particular time window of study.⁶ This implies that studies on risk factors for low back pain should include both incidence and recurrence of complaints.

The Markov chain used in the current analysis was completely defined by the transition distribution among the distinguished health states of low back pain during the first year of follow up and held constant for 40 years. Other important assumptions were that workers had the same job with similar physical demands over 40 years and that individual characteristics of workers (for example, physical capabilities) also remained unchanged. The first assumption implies that the prediction does not take into account the full history of complaints of an individual worker, such as nature and severity of previous low back pain, although chronicity of low back pain will have a worse prognosis than acute low back pain.^{2, 3, 37} Although the Markov model may be expanded with features such as cycle specific covariates (for example, a lower transition probability for low back pain to sickness absence in the first few years), and non-constant transition probabilities (for example, a progressively higher probability of permanent work disability with increasing cycle number, reflecting an effect of cumulative exposure), in the absence of epidemiological information the risks were considered constant over time. The other assumptions of workers holding the same job for 40 years and unchanged individual characteristics may also not hold true, as workers with back problems may move to other jobs because of these health problems, and a reduced physical capacity after a certain age may change the association between physical load and low back pain among older workers. Epidemiological evidence is too scarce to present meaningful adjustments for these effects in the Markov chain model. Hence, the estimated number of weeks lost to sickness absence due to low back pain among the cohort of personnel in nursing homes highly depends on these assumptions underlying the modelling approach. As the transition probabilities were derived from the population under study, the estimated burden of sickness absence cannot be generalised to occupational populations with other exposure profiles, unless similarity in transition probabilities and associated assumptions has been demonstrated. However, the advantage of the proposed modelling approach is that potential consequences for long term work ability become apparent that may go unnoticed in cohort studies with a few years of follow up. Nevertheless, validation against longitudinal studies with substantial follow up periods of over five years is required to evaluate whether the prediction is a reasonable expression of long term effects on sickness absence and work disability. Given the fact that a relatively small number of individuals will be responsible for the long term sickness absence, a large study population will be required for an accurate estimate of the transition

Key messages

- The Markov model approach is useful in estimating the long term impact of physical load on low back pain and associated sickness absence and disability that may go unnoticed in cohort studies with follow up periods of a few years.
- Among nursing personnel physical load had a modest influence on the occurrence of low back pain but a strong impact on associated sickness absence and work related disability
- During a 40 year career, a worker with high physical load is expected to loose approximately 140 weeks of work time due to sickness absence for low back pain whereas for a worker with low physical load this amounts to 30 weeks.

Policy statements

- The approach of years of work lost is a more adequate description for work related risk factors that accelerate the onset of a more or less inevitable disease, such as low back pain, than relative risks or attributable risk fractions
- The assessment of work time lost, or alternatively expectancy of healthy working life, may be useful to decision makers in appreciating the necessity for workplace interventions.

probability from short term sickness absence to long term disabling sickness absence.

In a traditional statistical analysis odds ratios illustrate the influence of physical load on low back pain and associated work disability, but these measures may not be sufficient for conveying the impact of physical load on public health. The assessment of worktime lost due to back pain, or alternatively expectancy of healthy working life,³⁸ may be more useful to decision makers to appreciate the necessity for workplace interventions. The modelling of a hypothetical cohort presents an assessment of the long term benefits of interventions directed at reducing physical load by calculating the average number of cycles spent in each health state. By applying a quality factor to each state (utility) the expected cumulative utility accrued for the entire Markov process may be compared for alternative intervention strategies in a cost effectiveness analysis. The expected benefits may also be tailored to an existing occupational population by estimating the cohort-specific transition probabilities and by using the actual distribution of health states as the initial composition of the hypothetical cohort to be followed over time.

In conclusion, the Markov model presents a methodology that demonstrates the potential impact of long term exposure to high physical load on low back pain and associated disability. The approach of years of work lost is a more adequate description for work related risk factors that accelerate the onset of a more or less inevitable disease, such as low back pain, than relative risks or attributable risk fractions.³⁹ The perceived significance of a loss of 6.6% of work time during a working life due to high physical load may provide for decision makers a better measure of adverse effect than an odds ratio of 2.95 for sickness absence due to low back pain. The concept of work years lost may also

facilitate a better appreciation of the potential benefits of preventive measures.

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REFERENCES

- 1 **Burton AK**, Clarke RD, Mc Clude TD, *et al.* The natural history of LBP in adolescents. *Spine* 1996;**21**:2323–8.
- 2 **Croft PR**, Macfarlane GJ, Papageorgiou AC, *et al.* Outcome of low back pain in general practice: a prospective study. *BMJ* 1998;**316**:1356–9.
- 3 **Hestbaek L**, Leboeuf-Yde C, Manniche C. Low back pain: what is the long-term course? A review of studies of general patient populations. *Eur Spine J* 2003;**12**:149–65.
- 4 **Waddell G**. A new clinical model for treatment of low-back pain. *Spine* 1987;**12**:632–44.
- 5 **Coste J**, Delecoeuillerie G, Cohen de Lara A, *et al.* Clinical course and prognostic factors in acute low back pain: an inception cohort study in primary care practice. *BMJ* 1994;**308**:577–80.
- 6 **Elders LAM**, Burdorf A. Prevalence, incidence, and recurrence of low back pain in scaffolders during a three year follow-up study. *Spine* 2004;**29**:e101–6.
- 7 **Von Korf M**. Studying the natural course of back pain. *Spine* 1994;**19**:2041–2046S.
- 8 **Burdorf A**, Sorock G. Positive and negative evidence for risk factors of work-related back disorders. *Scand J Work Environ Health* 1997;**23**:243–56.
- 9 **Fransen M**, Woodward M, Norton R, *et al.* Risk factors associated with the transition from acute to chronic occupational back pain. *Spine* 2002;**27**:92–8.
- 10 **Elders LAM**, Heinrich J, Burdorf A. Risk factors for sickness absence due to low back pain among scaffolders: a 3-year follow-up study. *Spine* 2003;**28**:1340–6.
- 11 **Hoogendoorn WE**, Bongers PM, de Vet HC, *et al.* High physical work load and low job satisfaction increase the risk of sickness absence due to low back pain: results of a prospective cohort study. *Occup Environ Med* 2002;**59**:323–8.
- 12 **Wickstrom GJ**, Pentti J. Occupational factors affecting sick leave attributed to low-back pain. *Scand J Work Environ Health* 1998;**24**:145–52.
- 13 **Infante-Rivard C**, Lortie M. Prognostic factors for return to work after a first compensated episode of back pain. *Occup Environ Med* 1996;**53**:488–94.
- 14 **Gatchel RJ**, Polatin PB, Mayer TG. The dominant role of psychosocial risk factors in the development of chronic low back pain disability. *Spine* 1995;**20**:2702–9.
- 15 **Sonnenberg FA**, Beck R. Markov models in medical decision making: a practical guide. *Med Decis Making* 1993;**13**:322–38.
- 16 **Cole DC**, Manno M, Beaton D, Swift M. Transitions in self-reported musculoskeletal pain and interference with activities among newspaper workers. *J Occup Rehabil* 2002;**12**:163–74.
- 17 **Viikari-Juntura E**, Martikainen R, Luukkainen R, *et al.* Longitudinal study on work related and individual risk factors affecting radiating neck pain. *Occup Environ Med* 2001;**58**:345–52.
- 18 **Karasek R**, Baker D, Marxer F, *et al.* Job decision latitude, job demands, and cardiovascular disease: a prospective study of Swedish men. *Am J Public Health* 1981;**71**:694–705.
- 19 **Kuorinka I**, Jonsson B, Kilbom A, *et al.* Standardized Nordic questionnaire for the analysis of musculoskeletal symptoms. *Appl Ergonomics* 1987;**18**:233–7.
- 20 **Burdorf A**, Post W, Bruggeling T. Reliability of a questionnaire on sickness absence with specific attention to absence due to back pain and respiratory complaints. *Occup Environ Med* 1996;**53**:58–62.
- 21 **Hoozemans MJM**, Burdorf A, Beek van der A, *et al.* Group-based measurement strategies in exposure assessment explored by bootstrapping. *Scand J Work Environ Health* 2001;**27**:125–32.
- 22 **Seixas NS**, Sheppard L. Maximizing accuracy and precision using individual and grouped exposure assessments. *Scand J Work Environ Health* 1996;**22**:94–101.
- 23 **Jansen JP**, Burdorf A. Effects of measurement strategy and statistical analysis on dose-response relations between physical workload and low back pain. *Occup Environ Med* 2003;**60**:942–7.
- 24 **Jansen JP**, Morgenstern H, Burdorf A. Dose-response relations between occupational exposures to physical and psychosocial factors and the risk of low-back pain. *Occup Environ Med* 2004;**61**:972–9.
- 25 **Kleinbaum DG**. *Logistic regression. A self-learning text*. New York: Springer, 1994.
- 26 **Watson PJ**, Main CJ, Waddell G, *et al.* Medically certified work loss, recurrence and costs of wage compensation for back pain: a follow-up study of the working population of Jersey. *Br J Rheumatol* 1998;**37**:82–6.

- 27 **SAS Institute.** The SAS system for Windows release 8.2. Cary, NC: SAS Institute, 2001.
- 28 **TreeAge Software Inc.** DATA TreeAge Pro software. Williamstown, MA: TreeAge, 2002.
- 29 **Estryn-Behar M,** Kaminski M, Peigne E, *et al.* Strenuous working conditions and musculo-skeletal disorders among female hospital workers. *Int Arch Occup Environ Health* 1990;**62**:47–57.
- 30 **Mandel JH,** Lohman W. Low back pain in nurses: the relative importance of medical history, work factors, exercise and demographics. *Res Nurs Health* 1987;**10**:165–70.
- 31 **Maul I,** Läubli T, Klipstein A, *et al.* Course of low back pain among nurses: a longitudinal study across eight years. *Occup Environ Med* 2003;**60**:497–503.
- 32 **Smedley J,** Egger P, Cooper C, *et al.* Manual handling activities and risk of low back pain in nurses. *Occup Environ Med* 1995;**52**:160–3.
- 33 **Smedley J,** Egger P, Cooper C, *et al.* Prospective cohort study of predictors of incident low back pain in nurses. *BMJ* 1997;**314**:1225–8.
- 34 **Pengel LHM,** Herbert R, Maher CG, *et al.* Acute low back pain: systematic review of its prognosis. *BMJ* 2003;**327**:323.
- 35 **Rosignol M,** Lortie M, Ledoux E. Comparison of spinal health indicators in predicting spinal status in a 1-year longitudinal study. *Spine* 1993;**18**:54–60.
- 36 **Burton AK,** Erg E. Back injury and work loss. Biomechanical and psychosocial influences. *Spine* 1997;**22**:2575–80.
- 37 **Smedley J,** Inskip H, Cooper C, *et al.* Natural history of low back pain. A longitudinal study in nurses. *Spine* 1998;**23**:2422–6.
- 38 **Nurminen M.** Working population health metrics. *Scand J Work Environ Health* 2004;**30**:339–49.
- 39 **Greenland S.** Relation of probability of causation to relative risk and doubling dose: a methodologic error that has become a social problem. *Am J Public Health* 1999;**40**:17–26.

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