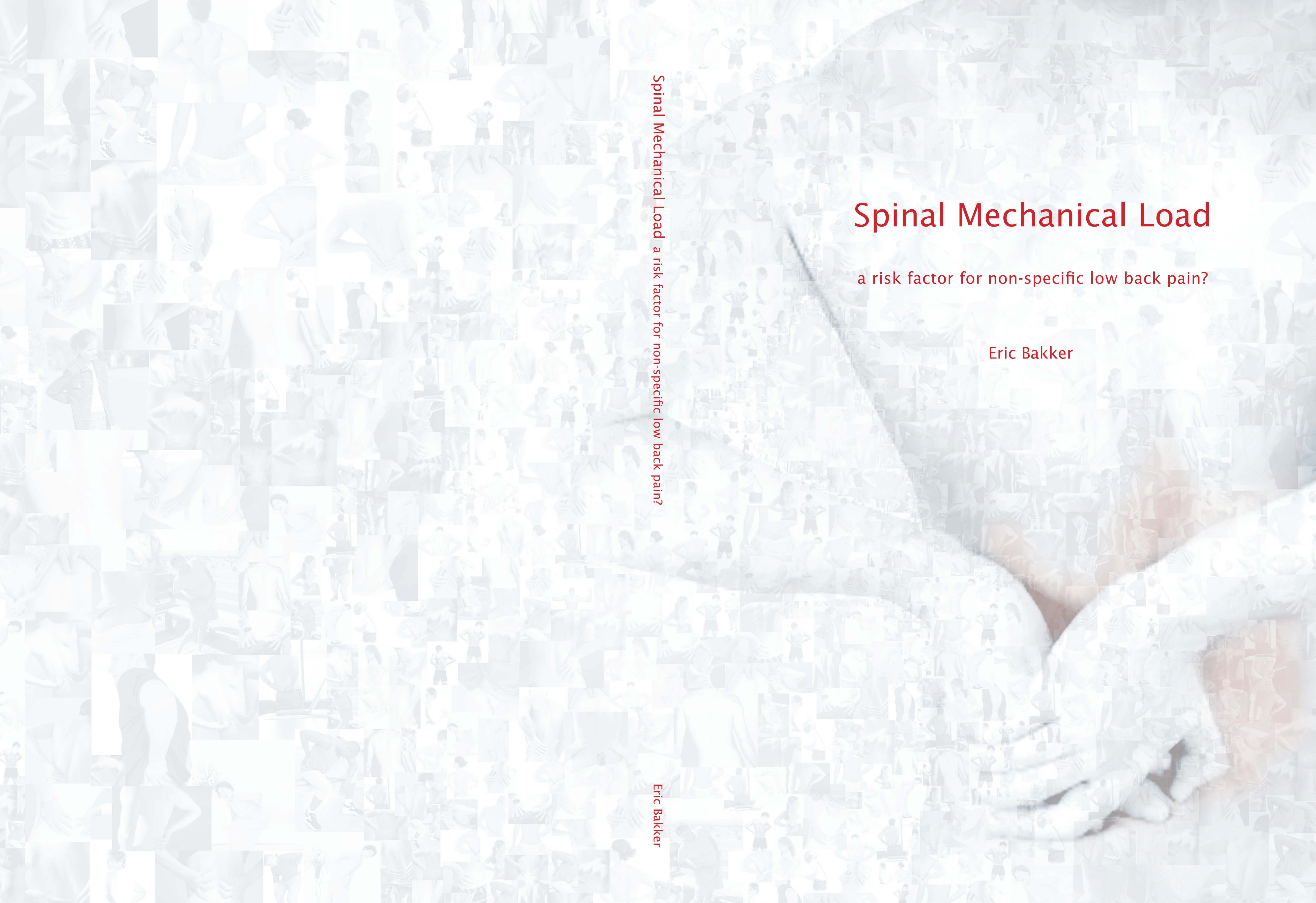

Spinal Mechanical Load

a risk factor for non-specific low back pain?

Eric Bakker

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Spinal Mechanical Load. A risk factor for non-specific low back pain?

Mechanische belasting op de rug. Een risicofactor voor aspecifieke lage rugpijn?

Proefschrift

ter verkrijging van de graad van doctor aan de
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op gezag van de

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Prof.dr. S.W.J. Lamberts

en volgens besluit van het College voor Promoties.

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Voor Joyce, Eline en Axel

Contents

CHAPTER 1

General introduction

General introduction

In 1938 Gilcreest wrote: *'There is no condition which produces more disability and economic loss and, therefore, is so costly to industry as low back pain'* [1]. Seventy years after this statement, a large number of systematic reviews are published concerning the effectiveness of treatments for low back pain [2,3,4,5,6,7,8]. Despite this large amount of evidence regarding the management, low back pain remains a major health problem worldwide [9] with a reported 1-year prevalence ranging from 15% to 40% in a general population [10].

About 85% of the cases with low back pain are labelled as non-specific, i.e. not attributed to recognisable pathology [11]. Acute (i.e. complaints lasting 0-6 weeks) non-specific low back pain is considered a benign self-limiting disease, with a recovery rate of 80-90% within six weeks in the open population, irrespective type of management or treatment [12]. However, recurrence rates are reported as high as 50% in the following 12 months. Therefore, acute non-specific low back pain should be viewed as a persistent condition in many patients [13,14].

Primary as well as secondary prevention might be beneficial in the management of acute low back pain. For prevention, knowledge of the risk factors is essential. Although epidemiological studies have identified many individual, psychosocial and occupational risk factors for the onset of low back pain, their independent prognostic value is usually low [15].

From the physiological point of view the musculoskeletal system of the spine requires a stimulus of movement, such as weight bearing and muscle contraction within the physiological limits as contributing factor for maintaining its physical condition [16]. Conversely musculoskeletal tissues weaken from overuse or disuse [16]. Acute non-specific low back pain might occur if the unavoidable load on the back exceeds these physiological limits and becomes overuse or disuse [16,17,18]. For this purpose it would be helpful to get insight in the mechanical load on the lower back.

The objective of this thesis was to explore spinal mechanical load as a risk factor for low back pain. Therefore we performed a systematic review of prospective cohort studies reporting exposures of spinal mechanical load as a risk factor for incident low back pain (chapter two). Our hypothesis was that the assessment of spinal mechanical load as a risk factor for low back pain should involve all daily activities as well as the posture in the sagittal plane (i.e. a flexed or extended posture), the duration and the magnitude, for each activity separately. In the literature, no valid and reliable instrument which is able to achieve this insight has been described yet. For that reason we developed the 24 Hour Schedule (24HS).

The 24 Hour Schedule (24HS). The 24HS is a one-dimensional questionnaire quantifying spinal mechanical load in the subject at issue. The therapist using the 24HS systematically asks a subject to describe his/her daily physical activities (see Addendum). Of each activity, the position of the back in the sagittal plane (i.e. flexed or extended), the load applied and the duration will be listed chronologically on the standardised registration form (see Addendum). For 'load applied', the following three categories are available: (1) no load applied (e.g. lying), (2) loaded (e.g. sitting) and (3) loaded with movement (e.g. digging). After completing the registration, subject's score for flexed postures must be calculated first. Of each activity, the duration must be multiplied by the weight of the category the activity was scored in. We set the weight of the categories to 1:2:3 [19,20]. All obtained scores must be added up. The resulting figure represents the time the back was loaded in a flexed posture with a load of the first category. The parameter we called schedule hours (range 0 to 72). Subsequently, this procedure must be repeated for the extended posture (range 0 to 72). The 24HS sum score must be obtained by subtracting the total time of the extended postures from the total time of the flexed postures. The resulting figure gives insight into the dominant use (the training activity) of the back (range −72 to +72 schedule hours). Negative sum-scores point to an overall spinal use in extended and positive sum-scores indicates an overall spinal use in flexed postures.

Before introduction, new instruments should be evaluated regarding their reproducibility and validity. Chapter three presents our study on the interobserver reliability of the 24HS. Chapter four describes our case-control study conducted to assess the validity of the 24HS.

Scores on the 24HS could be associated with recurrent or chronic low back pain. Also a modification of high 24HS score towards 'zero' schedule hours might be beneficial in the management of low back pain. Possible, such modification can be achieved through individualised advice based on an assessment with the 24HS. When adding this advice to standard guideline care, an individualised program for the self-management of LBP could be developed. Chapter five describes our study on the prognostic value of 24HS scores on the course of low back pain and modifiability of 24HS scores.

Such a program for the self-management of LBP might be feasible for use in primary care in patients with acute non-specific low back pain and their care givers (physiotherapists, manual therapists). Chapter six presents our survey on feasibility of 24HS based advice additional to standard guideline care among physiotherapists and patients.

In the general discussion (chapter seven) we give our reflection on the methodological strength and weaknesses of the reported studies, and provide some practical considerations and recommendations for future research. Finally we present a summary in English and Dutch.

References

1. Gilcreest EL. Lumbosacral and sacro-iliac strain causing low back pain: a review of one hundred fifty cases. Ann Surg. 1938;107(6):988-95
2. Assendelft WJ, Morton SC, Yu EI, Suttorp MJ, Shekelle PG. Spinal manipulative therapy for low back pain. Cochrane Database Syst Rev. 2004;(1):CD000447
3. Ferreira ML, Ferreira PH, Latimer J, Herbert RD, Maher CG. Does spinal manipulative therapy help people with chronic low back pain? Aust J Physiother. 2002;48:277-84
4. Guzmán J, Esmail R, Karjalainen K, Malmivaara A, Irvin E, Bombardier C. Multidisciplinary rehabilitation for chronic low back pain: systematic review. BMJ 2001;322 1511-16
5. Jellema P, van Tulder MW, van Poppel MN, Nachemson AL, Bouter LM. Lumbar supports for prevention and treatment of low back pain. A systematic review within the framework of the Cochrane Back Review Group. Spine 2001;26(4):377-86
6. Pengel LHM, Maher CG, Refshauge KM. Systematic review of conservative interventions for subacute low back pain. Clin Rehabil. 2002;16(8):811-20
7. Van Tulder M, Malmivaara A, Esmail R, Koes B. Exercise therapy for low back pain. A systematic review within the framework of the Cochrane Collaboration Back Review Group. Spine 2000;25(21):2784-96
8. Van Tulder M, Ostelo R, Vlaeyen JWS, Linton SJ, Morley SJ, Assendelft WJJ. Behavioral treatment for chronic low back pain. A systematic review within the framework of the Cochrane Back Review Group. Spine 2000;25(20):2688-99
9. Björklund L. The Bone and Joint Decade 2000-2010. Inaugural meeting 17 and 18 April 1998, Lund, Sweden. Acta Orthop Scand Suppl. 1998;281:67-80
10. Andersson GB. The epidemiology of spinal disorders. In: Frymoyer JW, Ducker TB eds. The Adult Spine: Principles and Practice. 2nd ed. Philadelphia: Lippincott–Raven; 1997:93-141
11. Chavannes AW, Mens JMA, Koes BW, Lubbers WJ, Ostelo R, Spinnewijn WEM, Kolnaar BGM. NHG-standaard lage rugpijn. Huisarts Wet. 2005;48(3):113-23
12. Faas A, Chavannes AW, Koes BW, Hoogen JMM van den, Mens JMA, Smeele LJM. NHG-standaard lage rugpijn. Huisarts Wet. 1996;39:18-31
13. Waddell G. A new clinical model for the treatment of low back pain. Spine 1987;12:632-44
14. Croft PR, Macfarlane GJ, Papageorgiou AC, Thomas E, Silman AJ. Outcome of low back pain in general practice: a prospective study BMJ 1998;316:1356-59
15. Pengel LH, Herbert RD, Maher CG, Refshauge KM. Acute low back pain: systematic review of its prognosis. BMJ. 2003;327(7410):323
16. Van Tulder M, Koes B, Bombardier C. Low back pain. Best Pract Res Clin Rheumatol. 2002;16(5):761-75
17. Porterfield JA, DeRosa C. Mechanical low back pain: perspectives in functional anatomy. WB Saunders Com. 2nd ed. 1998;1-22
18. Nachemson A, Morris JM. In vivo measurements of intradiscal pressure. Discometry, a method for the determination of pressure in the lower lumbar discs. J Bone Joint Surg Am. 1964;46:1077-92
19. Wilke HJ, Neef P, Caimi M, Hoogland T, Claes LE. New in vivo measurements of pressures in the intervertebral disc in daily life. Spine 1999; 24(8):755-62
20. Nachemson A. Towards a better understanding of low-back pain: a review of the mechanics of the lumbar disc. Rheumatol Rehabil. 1975;14(3):129-43
21. Sato K, Kikuchi S, Yonezawa T. In vivo intradiscal pressure measurement in healthy individuals and in patients with ongoing back problems. Spine 1999;24(23):2468-74

CHAPTER 2

Spinal mechanical load as a risk factor for low back pain. A systematic review of prospective cohort studies

Eric Bakker, Arianne Verhagen, Emiel van Trijffel, Cees Lucas, Bart Koes

Submitted

Abstract

Study Design. Systematic review

Objective. To review and critically evaluate the past literature for spinal mechanical load as risk factor for low back pain (LBP)

Summary of Background Data. LBP is a costly health problem worldwide, and treatments are often unsuccessful. Therefore, prevention might be more beneficial in the management of LBP. With respect to prevention, the knowledge of risk factors is essential. From the literature, exposures involving spinal mechanical load are frequently discussed as a potential risk factor for LBP. For a better understanding of this risk factor, we performed a systematic review of the literature. Additionally, we evaluated exposures of spinal mechanical load for possible dose-response relations with LBP.

Methods. We systematically searched Medline, Embase, PsycINFO, and CINAHL databases (without language restriction) for full-report publications of prospective cohort studies evaluating spinal mechanical load during work and/or leisure time activities as risk factors for non-specific LBP in patients (> 18 years of age) free of LBP at baseline. We assessed the methodology of each article and extracted information on population, response rates, characteristics of LBP, exposures and estimated association(s) using standardised forms. We performed a best evidence synthesis of the obtained information.

Results. In total 18 studies were eligible (all rated as high methodological quality) reporting on 24.315 subjects.

Conclusion. We found strong evidence that leisure time sport or exercises, sitting, and prolonged standing/walking are not associated with LBP. Evidence for associations in leisure time activities (e.g. do-it-yourself home repair, gardening), whole-body vibration, nursing tasks, heavy physical work, and working with ones trunk in a bent and/or twisted position and LBP was conflicting. We found no studies, thus no evidence, for an association between sleeping or sporting on a professional level and LBP.

Introduction

Low back pain (LBP) causes a substantial economic burden to society in countries such as the USA, UK, and The Netherlands [1]. Over the past five years, a large number of systematic reviews have been published concerning the effectiveness of treatments for LBP [2,3,4,5,6,7,8]. However, despite this large amount of evidence regarding LBP management, LBP remains a major health problem worldwide [9]. Therefore, prevention might be beneficial in the management of LBP. For adequate prevention of LBP the knowledge of potential risk factors is essential.

Previous research has identified over one hundred potential risk factors for LBP. Of these, spinal mechanical load is commonly discussed in both laboratory circumstances as well as found in daily (occupational) activities [10]. Despite the large amount of research regarding this particular risk factor, the results of previous systematic reviews remain inconclusive on its association with LBP and often result in a call for additional high-quality prospective studies [11,12].

Therefore, for a better understanding of spinal mechanical load as a risk factor for LBP, we performed a systematic review of only prospective cohort studies that assessed spinal mechanical load as a risk factor for LBP in subjects without LBP at baseline [13]. In addition, we also aimed to evaluate a possible dose-response relationship between spinal mechanical load and LBP.

METHODS

Search strategy. We applied Hoogendoorns' search strategy [14] to identify relevant studies in the Medline (December 1997-September 2007), Embase (November 1997-September 2007), PsycINFO (October 1997-September 2007), and CINAHL (from inception to September 2007) databases. We used the following keywords: back pain, low-back pain, lumbago, backache, intervertebral disk displacement, hernia, herniated disc, sciatica, sciatic pain, risk factors, causality, causative, precipitating factors, determinants, predictor, etiology, aetiology, epidemiology, case-control studies, retrospective studies, case-referent, prospective studies, longitudinal studies, follow-up studies, cohort studies. We imposed no restrictions on language.

Study selection. We considered studies meeting the following criteria: 1) The study design had to be a prospective cohort reporting on incident LBP. 2) Studies had to concern a working- or a community-based population of subjects older than 18 years and free of LBP at study inclusion. 3) Studies could only include patients diagnosed with symptoms or signs of non-specific LBP (i.e. we excluded LBP during pregnancy or LBP due to specific pathologic such as 'red flag' conditions, osteoporosis, rheumatoid arthritis, and sciatica/radicular syndrome). 4) Studies that concentrated on exposures that were independent variables involving spinal mechanical load as present during work and/or leisure time activities. Publications had to be available in full report.

First, two authors (EB, and EvT) independently applied the inclusion criteria to select potentially relevant studies from the titles and abstracts only. After this first selection, we applied the selection criteria on the full text articles of potentially eligible studies. We rated the identified studies as 1) definitely eligible, 2) definitely not eligible, or 3) questionable. Disagreements concerning eligibility were resolved by consensus or, if disagreement persisted, by arbitration by a third reviewer (AV). The reference lists of all the included studies and of earlier reviews identified by our search strategies were carefully hand searched in order to locate additional papers.

Methodological quality assessment. Two reviewers (EB and EvT) scored the methodological quality of the selected studies independently using the validity items of the standardised questionnaire for the appraisal of cohort studies, available on the website of The Dutch Cochrane Centre (http://www.cochrane.nl/index.html). We modified the criteria to specifically suit the topic of our review [15,16,17].

We scored each criterion as '+' for informative description of the criterion at issue, and study meets the criterion, '-' for informative description, but study does not meet the criterion, and '?' for lacking or insufficient information. We arranged a consensus meeting to sort out differences between both reviewers. In case disagreement persisted, a third reviewer (AV) made the final decision. Each study received a total method score, which was the sum of all positive ratings on the questionnaire (score range: 0-10). All criteria were weighed equally. We considered a study high-quality if the methodological quality score was six or more and studies to be low quality if they scored five or less.

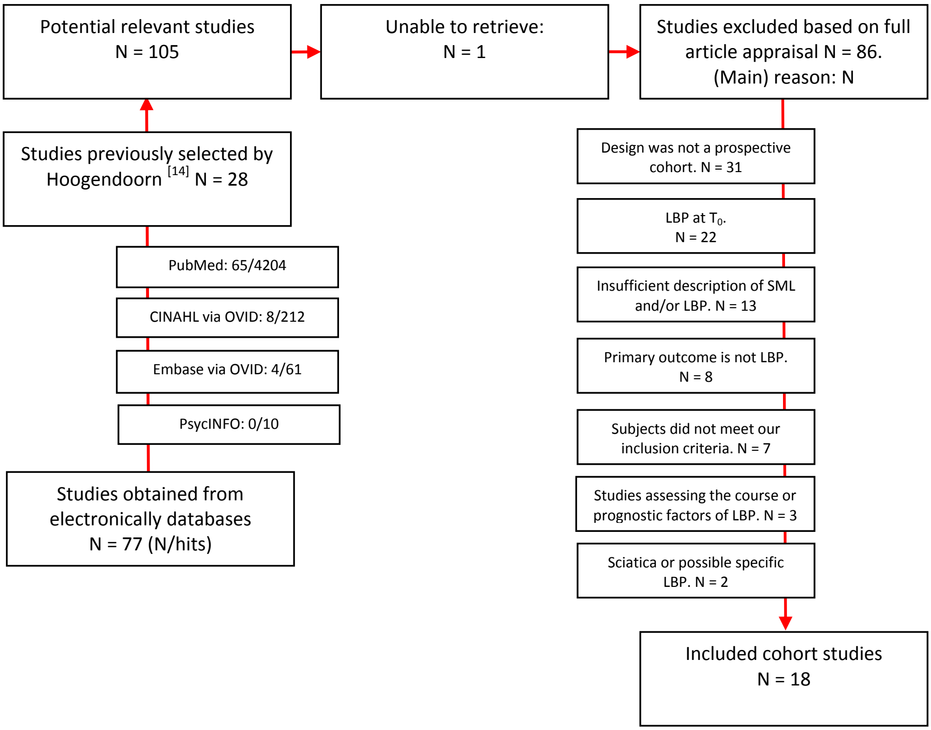
Data extraction and analysis. From all included studies, EB and EvT independently extracted information on population, response rates, characteristics and risk estimate (e.g. relative risk 'RR' or odds ratio 'OR') of spinal mechanical load, information on statistical significance, and where possible a measure of distribution (e.g. confidence interval). Both reviewers analysed each exposure in detail for a dose-response relationship.

Data synthesis. In view of the expected heterogeneity of the study population, exposure measurements, and assessment of LBP, we performed a qualitative synthesis of the available information. We used five levels of evidence based on the number of studies evaluating an exposure, the methodological quality of the studies and the consistency of the available evidence: 1) Strong evidence: consistent findings in two or more high-quality studies. 2) Moderate evidence: consistent findings in one high and one low-quality study, or in two or more low-quality studies. 3) Limited evidence: only one study is available. 4) Conflicting evidence: inconsistent findings in the available studies. 5) No evidence: no studies found. We considered findings as consistent if at least 75% of the available studies reported the same conclusion.

Results

Selection of studies. Our search in the electronical databases yielded 4487 hits. Of these, we obtained 105 studies as full article, including 28 studies previously selected by Hoogendoorn [14]. Based on the full paper appraisal, we included 18 studies [18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35], published in 29 publications [36,37,38,39,40,41,42,43,44,45,46] for this review. The included studies represent 24315 subjects (with an average of 1351 per study, with a range of 144 to 10007) who completed the follow-up and were used to determine the effect estimates. Our selection is presented systematically in a flow chart (Figure 1).

Figure 1. Flow chart showing selection process for identifying prospective cohort studies



Assessment of methodological quality. We rated all included studies as being of high methodological quality. The results of the methodological quality assessment are presented in Table 1. The overall initial agreement between reviewers was moderate (Cohen's Kappa: 0.57) [47], but consensus was reached on all initial disagreements. The data extracted from the studies are presented in Table 2.

Table 1. Results of the methodological assessment of prognostic cohort studies on risk factors for LBP ranked according to methodological quality

Title	1	2	3	4	5	6	7	8	9	10	Score
Croft 1999 (including: 27,36,38,39,40)	+	+	?	+	+	+	+	+	-	+	**8**
Eriksen 1999	+	+	?	+	?	+	+	+	+	+	**8**
Harkness 2003(including 37)	+	+	?	+	+	+	+	+	-	+	**8**
Hoogendoorn 2000	+	+	+	+	?	+	+	+	?	+	**8**
Kopec 2003 (including 47)	+	+	?	+	?	+	+	+	+	+	**8**
Macfarlane 1997 (including: 17,36,38,39,40)	+	+	?	+	+	+	+	+	-	+	**8**
Van Poppel 1998	+	+	?	+	?	+	+	+	+	+	**8**
Yip 2004 (including: 45)	+	+	?	+	+	+	+	+	-	+	**8**
Eriksen 2004	+	+	?	+	?	+	+	+	-	+	**7**
Kujala 1996	+	+	+	+	?	+	?	+	-	+	**7**
Latza 2000 (including: 43)	+	+	?	+	?	+	+	+	+	?	**7**
Leclerc 2003 (including: 44)	+	+	?	+	?	+	+	+	?	+	**7**
Manninen 1995	+	+	?	+	?	+	+	+	-	+	**7**
Van Nieuwenhuyse 2006	+	+	?	+	?	+	+	+	-	+	**7**
Pietri 1992	+	+	?	+	?	+	+	+	-	+	**7**
Smedley 1997 (including:41)	+	+	-	+	-	+	+	+	?	+	**7**
Hartvigsen 2007 (including: 35)	+	+	?	+	-	+	+	+	?	-	**6**
Niedhammer 1994	?	?	?	+	+	+	+	+	-	+	**6**

Key to symbols: + = Yes, - = No, ? = Unclear.

Scored validity items with used criteria (adapted from Cole [15], Von Korff [16], Sackett [17] and modified to cover the topic of the review).

1. Was the study population clearly defined? Positive if at least the following items were given: place of recruitment, time-period of recruitment, age, gender, and sampling frame
2. Could selection bias be sufficiently excluded? Positive if the study population concerned a random sample of the source population with a participation rate at baseline of at least 80%
3. Was the exposure clearly defined? Positive if data on spinal physical load at work/leisure time included duration, intensity, and posture in the sagittal plane (i.e. flexed or extended)
4. Was the exposure-assessment method adequate? Positive if the method used was standardised or valid (data presented or with reference)
5. Was the outcome clearly defined? Positive if the outcome was reproducible in terms of internationally accepted qualification of LBP (i.e. specific, and non-specific LBP)
6. Was the outcome-assessment method adequate? Positive if one or more of the main outcome measures were assessed in a standardised or valid way (data presented or with reference)
7. Was the outcome assessed blinded for the exposure status? Positive if the method used for outcome assessment was performed in a blinded or masked fashion
8. Was the follow-up period sufficiently long? Positive if the time-period baseline follow-up was at least one year
9. Could selective loss-to-follow-up be excluded? Positive if total number of drop-outs/loss to follow-up ≤ 20% at 12 months or if the non-response was not selective (data shown)
10. Were the most important confounders or prognostic variables identified and adequately considered in the study design and analysis? Positive if appropriate univariate or multivariate techniques are used, such as logistic regression analysis or survival analysis for dichotomous outcomes, or linear regression analysis for continuous outcomes.

Maximum score for methodological quality: 10.

Heavy Physical Work. Twelve studies reported 34 exposures regarding heavy physical work e.g. lifting, pushing, (heavy) material handling. Of these, 26 exposures were not statistically significantly associated with LBP. Kujala [25] reported associations in heavy musculoskeletal loading and high general occupational demands, but did not present effect estimates. Two studies described an increased risk for LBP when exposures were from the highest ranked categories: in Latza [26] LBP was increased in subjects that layed 3DF sandstone, and in Eriksen [19] subjects were at increased risk for LBP after lifting and standing, but this was only found in smokers. Macfarlane [28] found an increased risk for LBP in women after lifting/moving objects greater than 25lb (11.3 kg). Kopec [24] identified an increased risk for LBP in men after lifting or carrying light loads or frequently climbing stairs or hills. Kopec also found that men engaged in heavy work or carried very heavy loads as part of their usual daily activity also showed an increased risk for LBP. Seven studies [21,23,27,30,,31,32,33] reported no statistically significant associations between heavy physical work and LBP. We therefore conclude that there is conflicting evidence for heavy physical work as risk factor for LBP.

Sport or Exercises during Leisure Time. We found seven studies reporting 24 different exposures of sport and exercises during leisure time. Croft [18] reported an increased risk for LBP in women performing regular sport. Eriksen [19] found an increased risk for LBP in subjects that exercised less than once a week. Five studies reported no statistically significant associations between sports activities and LBP [24,27,30,33,35]. We conclude that there is strong evidence that leisure time sport and physical exercises is not associated with the development of LBP.

Standing/Walking at Work. We found six studies that addressed this potential risk factor. Kopec [24] reported an increased risk for LBP in men that walked or stood as part of their usual daily activity (including work habits). Macfarlane [28] identified an increased risk for LBP in women that walked/stood more than two hours per day. Four studies reported no statistically significant associations [21,27,32,35]. We conclude that there is strong evidence that prolonged standing/walking is not associated with LBP.

Activities during Leisure Time. We found six studies. Two studies reported an increased risk for LBP: Croft [18] reported increased risk in men that engage in do-it-yourself home repair projects whilst in Eriksen [20] subjects had an increase risk of LBP after performing special tasks of a caring nature (e.g. caring for elderly relatives). In contrast, two studies described a decreased risk for LBP; in Kopec [24] gardening/yard-work in men and Hartvigsen [22] for physical activities (at least once a week) led to a decrease in LBP. Leclerc [27] found no statistically significant association for LBP in do-it-yourself home repair, gardening, non-professional home construction activities, and hobby activities in men. Kujala [25] reported no statistically significant associations for baseline leisure physical activities and LBP. In view of these different findings, we conclude that there is conflicting evidence for leisure time activities as a risk factor for LBP.

Sitting at Work. We found six studies addressing this potential risk factor. Macfarlane [28] described a decreased risk for LBP in women sitting more than two hours. Other studies [19,21,24,27,35] found no statistically significant association in sitting and LBP. Therefore, we conclude that there is strong evidence that sitting at work is not associated with LBP.

Whole-Body Vibration at Work. We found six studies reporting on the effect of whole-body vibration. Van Poppel [33] reported a decreased risk for LBP for riding a forklift truck for more than 10 hours per week. Pietri [32] described an increased risk for driving a car 10-14 hours, and 15-19 hours per week. Pietri found no-associations with the development of LBP and driving a car in the lower, or higher ranked categories. The other studies [27,28,29,30] reported no statistically significant associations. In view of these diverse findings, we conclude that there is conflicting evidence for whole-body vibration as a risk factor for LBP.

Bending/Twisting at Work. Five studies [21,23,27,31,35] reported on bending, rotation, or a bent- or twisted-position of the trunk as possible risk factors for LBP. Leclerc [27] identified that subjects who often bent forward or backward were at increased risk for LBP, whilst van Nieuwenhuyse [31] described an increased risk for subjects that worked with their trunk in a bent or twisted position for more than two hours per day. The other studies reported no statistically significant associations with LBP and 13 different bending or twisting exposures. We therefore conclude that there is conflicting evidence for the association between working with a bent or twisted position of the trunk and the development of LBP.

Nursing Tasks. We found three studies reporting on 23 different exposures concerning nursing tasks. Eriksen [20] assessed an increased risk for LBP for nurses when positioning patients in bed (middle category), lifting, carrying, and pushing heavy objects (5-9 times per average shift), and quantitative work demands (third quintile), but not in the lower or higher categories. Smedley [34] reported an increased risk for LBP in higher exposures (i.e. 5-9, and ≥ 10 times/shift) transfer patient manually between bed and chair, manually move patient around on bed (≥ 10 times/shift), and lift patient in or out of bath with hoist (≥ 5 times/shift). Yip [35] reported no statistically significant associations in nursing tasks and LBP. In view of these findings, we conclude that there is conflicting evidence for nursing tasks as a risk factor for LBP.

Sleeping. We found no studies that evaluated the risk or benefit of sleeping on the development of LBP, therefore we conclude that there is presently no evidence for sleeping as a risk factor for LBP.

Table 2. Summary of the cohort studies on spinal physical load and low back pain

Source	Population	LBP	SML	Crude association	Adjusted association	Adjusted for
Croft 1999 [18]	N = 1649 / 2715 Setting: South Manchester Back Pain Study -UK- (GP population) without LBP > 24 h./past month	New episodes LBP in 12-month follow-up identified by: 1. Primary care, 2. Postal questionnaire at follow-up	Physical stress outside the workplace	**Physical activity** same: $RR_{♂}$ 1.1 (95% CI 0.8-1.4), $RR_{♀}$ 0.9 (95% CI 0.7-1.2), less: $RR_{♂}$ 1.1 (95% CI 0.8-1.6), $RR_{♀}$ 1.1 (95% CI 0.8-1.5). **Regular sport:** $RR_{♂}$ 1.0 (95% CI 0.8-1.3), $RR_{♀}$ 1.3 (95% CI 1.0-1.6). W**alking each day** > 30 min: $RR_{♂}$ 1.0 (95% CI 0.8-1.3), $RR_{♀}$ 1.1 (95% CI 0.9-1.4). **Watching TV daily** > 3 h: $RR_{♂}$ 1.0 (95% CI 0.8-1.3), $RR_{♀}$ 1.0 (95% CI 0.8-1.2). **Lifting (non-work)**: $RR_{♂}$ 1.0 (95% CI 0.7-1.3), $RR_{♀}$ 1.1 (95% CI 0.8-1.3). **Gardening** weekly: $RR_{♂}$ 1.1 (95% CI 0.9-1.5), $RR_{♀}$ 1.0 (95% CI 0.8-1.3). **Do-It-Yourself** occasionally: $RR_{♂}$ 1.4 (95% CI 1.0-1.9), $RR_{♀}$ 1.1 (95% CI 0.8-1.4), often: $RR_{♂}$ 1.6 (95% CI 1.1-2.3), $RR_{♀}$ 0.9 (95% CI 0.6-1.4)	**Do-It-Yourself** occasionally: $RR_{♂}$ 1.38 (95% CI 1.0-2.0), *often: $RR_{♂}$ 1.75 (95% CI 1.2-2.6).* **Regular sport** *$RR_{♀}$ 1.34 (95% CI 1.1-1.7)*	Age ,General Health Questionnaire score, shown variables
Eriksen 2004 [20]	N = 3808 / 4266 nurses (Norway), working > 18 h./ week not or a little bothered by LBP in past three months	Postal questionnaire for intense LBP, LBP related sick leaves > 3 days, LBP related sick leaves > 8 weeks at 3 and 15 months follow up	Heavy physical work		**1. Intense LBP. Positioning patients in the bed** 1-4 per average shift: OR 1.27 (95% CI 0.91-1.78), *5-9: OR 1.63 (95% CI 1.14-2.31),* >10: OR 1.26 (95% CI 0.83-1.91). **Special tasks of caring nature in the leisure time (e.g. caring for elderly relatives or handicapped children)** a little: OR 0.82 (95% CI 0.62-1.09), *rather or very much: OR 1.58 (95% CI 1.03-2.42)*	Supportive culture at work, preschool children, LBP in past 3 months, widespread pain, intensity of (any) musculoskeletal pain, fatigue/ fitness, all other variables

Source	Population	LBP	SML	Crude association	Adjusted association	Adjusted for
					2. Sick leaves (> 3 days). Quantitative work demands 2nd quintile: OR 1.21 (95% CI 0.58-2.51), *3rd: OR 2.27 (95% CI 1.32-3.90)*, 4th: OR 1.23 (95% CI 0.68-2.24), 5th: OR 1.61 (95% CI 0.86-3.01)	Supportive culture at work, fatigue/fitness, changed work (tasks) due to pain, LBP in past 3 months, all other variables
					3. Sick leaves (> 8 weeks). Lifting, carrying, and pushing heavy objects at work 1-4 per average shift: OR 0.99 (95% CI 0.59-1.64), 5-9: *OR 2.21 (95% CI 1.17-4.16)*, >10: OR 2.20 (95% CI 0.94-5.10)	Change of work or work tasks resulting in reduced support at work, LBP in past 3 months, intensity of musculoskeletal pain (any), all other variables
Eriksen 1999 [19]	N = 562 / 708 working responders (Ullensaker, Norway) 1 year without LBP	Nordic questionnaire, 'mannequin' at 4-years follow-up for pain in past week, and year	Dichotomised checklist for work characteristics	**Heavy physical work** either lifting or standing: $OR_{smokers}$ 2.08 (95% CI 0.98-4.38), $OR_{non\text{-}smokers}$ 1.21 (95% CI 0.74-1.98), both lifting and standing: $OR_{smokers}$ 4.10 (95% CI 1.74-9.66) for, $OR_{non\text{-}smokers}$ 1.51 (95% CI 0.92-2.47)	**Heavy physical work** either lifting or standing: $OR_{smokers}$ 1.90 (95% CI 0.82-4.41), $OR_{non\text{-}smokers}$ 1.07 (95% CI 0.61-1.86), both lifting and standing: *ORsmokers 5.53 (95% CI 1.93-15.84)*, $OR_{non\text{-}smokers}$ 1.12 (95% CI 0.48-2.59). **Physical exercise** *< 1 time per week: OR 1.55 (95% CI 1.03-2.33)*	Age, gender, civil status, emotional symptoms, physical exercise, monotonous movements in job, musculoskeletal pain in past year

Source	Population	LBP	SML	Crude association	Adjusted association	Adjusted for
Harkness 2003 [21]	N = 788 / 1186 newly employed workers in 12 occupational settings, free from LBP at baseline.	Self-administered questionnaire for any LBP ≥24 h./past month. Subjects free from LBP at 12 months follow up (n=501) were eligible for 24 months follow-up	During the last working day: 1. Postures (time spent in each position). 2. Manual handling (time spent and weights involved)	Manual handling activities. **Lift or carry with one hand** ≤ 15 lb (6.8 kg): OR 1.4 (95% CI 0.9-2.1), > 15 lb (6.8 kg): OR 1.6 (95% CI 0.98-2.7). **Lift or carry with two hands** ≤ 24 lb (10.9 kg): OR 1.3 (95% CI 0.9-2.1), > 24 lb (10.9 kg): OR 1.8 (95% CI 1.1-2.9). **Carrying on one shoulder** ≤ 30 lb (13.6 kg): OR 1.1 (95% CI 0.7-1.9), > 30 lb (13.6 kg): OR 1.3 (95% CI 0.7-2.4). **Lifting at or above shoulder level** ≤ 23 lb (10.4 kg): OR 1.6 (95% CI 0.9-2.6), > 23 lb (10.4 kg): OR 2.1 (95% CI 1.2-3.8). **Pushing** ≤ 65 lb (29.5 kg): OR 1.3 (95% CI 0.8-2.1), > 65 lb (29.5 kg): OR 1.3 (95% CI 0.7-2.2). **Pulling** ≤ 56 lb (25.4 kg): OR 1.5 (95% CI 0.9-2.6), > 56 lb (25.4 kg): OR 2.1 (95% CI 1.2-3.4). **Sitting** < 2 h: OR 1.0 (95% CI 0.6-1.6) ≥ 2 h OR 0.9 (95% CI 0.6-1.4). Postures. **Standing** < 15 min: OR 1.1 (95% CI 0.6-2.1), ≥ 15 min- < 2 h: OR 1.6 (95% CI 0.8-2.9), ≥ 2 h: OR 1.8 (95% CI 0.9-3.4). **Kneeling** < 15 min: OR 1.4 (95% CI 0.9-2.2), ≥ 15 min: OR 2.1 (95% CI 1.3-3.3). **Squatting** < 15 min: OR 1.1 (95% CI 0.7-1.7), ≥ 15 min: OR 1.8 (95% CI 1.1-3.1). **Bending** < 15 min: OR 1.6 (95% CI 1.1-2.3), ≥ 15 min OR 1.3 (95% CI 0.8-1.9). **Stretching below knee level** yes: OR 1.2 (95% CI 0.9-1.8). **Working with hands above shoulder** < 15 min: OR 1.6 (95% CI 1.1-2.4), ≥ 15 min: OR 1.6 (95% CI 0.99-2.5)	Manual handling activities. **Lift or carry with one hand** ≤ 15 lb (6.8 kg): OR 1.3 (95% CI 0.8-2.0), > 15 lb (6.8 kg): OR 1.1 (95% CI 0.6-1.9). **Lift or carry with two hands** ≤ 24 lb (10.9 kg): OR 1.1 (95% CI 0.7-1.7), > 24 lb (10.9 kg): OR 1.4 (95% CI 0.8-2.5). **Carrying on one shoulder** ≤ 30 lb (13.6 kg): OR 0.9 (95% CI 0.5-1.7), > 30 lb (13.6 kg): OR 0.9 (95% CI 0.5-1.9). **Lifting at or above shoulder level** ≤ 23 lb (10.4 kg) OR 1.3 (95% CI 0.8-2.2), > 23 lb (10.4 kg): OR 1.8 (95% CI 0.9-3.5). **Pushing** ≤ 65 lb (29.5 kg): OR 1.1 (95% CI 0.7-1.9), > 65 lb (29.5 kg): OR 0.9 (95% CI 0.5-1.6). **Pulling** ≤ 56 lb (25.4 kg): OR 1.4 (95% CI 0.8-2.4), > 56 lb (25.4 kg): OR 1.7 (95% CI 0.96-3.1). **Sitting** < 2 h: OR 1.0 (95% CI 0.6-1.7) ≥ 2 h OR 1.0 (95% CI 0.6-1.7). Postures. **Standing** < 15 min: OR 1.0 (95% CI 0.5–1.9), ≥ 15 min to < 2 h: OR 1.4 (95% CI 0.7-2.7), ≥ 2 h: OR 1.5 (95% CI 0.8-3.0). **Kneeling** < 15 min: OR 1.2 (95% CI 0.8–2.0), ≥ 15 min: OR 1.7 (95% CI 1.0–2.9). **Bending** < 15 min: OR 1.3 (95% CI 0.9-2.0), ≥ 15 min: OR 1.0 (95% CI 0.6-1.5). **Stretching below knee level** yes: OR 1.0 (95% CI 0.7-1.4). **Working with hands above shoulder** < 15 min: OR 1.4 (95% CI 0.9-2.2), ≥ 15 min: OR 1.3 (95% CI 0.8-2.2)	All 'crude' associations were adjusted for gender, age group, occupation. In the multivariate model 'manual handling activities' were also adjusted for all other manual handling activities In the multivariate model 'postures' were also adjusted for all other postures

Source	Population	LBP	SML	Crude association	Adjusted association	Adjusted for
Hartvigsen 2007 [22]	N = 1387 Danish twins aged ≥ 70 years. Setting: Longitudinal Study of Aging Danish Twins without LBP in past month	Interviewed (modified) Nordic questionnaire for any LBP/ past year, and LBP > 30 days/ past year at 2-years follow-up	Engagement in physical activity		***For any LBP.* Physical activity** light: OR 1.26 (95% CI 0.65-2.47), *all strenuous physical activity: OR 0.59 (95% CI 0.42-0.83),* less than once a week strenuous physical activity: OR 0.71 (95% CI 0.24-2.07), *at least once a week strenuous physical activity: OR 0.66 (95% CI 0.48-0.92)* ***For LBP > 30 days in ♂/♀.*** **Physical activity** light: OR 0.85 (95% CI 0.46-1.60), *all strenuous physical activity: OR 0.51 (95% CI 0.32-0.83),* less than once a week strenuous physical activity: OR 0.65 (95% CI 0.15-2.77), *at least once a week strenuous physical activity: OR 0.15 (95% CI 0.32–0.81)*	Stratified analysis by gender available by author (data not shown)

Source	Population	LBP	SML	Crude association	Adjusted association	Adjusted for
Hoogendoorn 2000 [23]	N = 861 / 1192 Dutch workers of 34 companies working ≥ 24 h./ week with no LBP at baseline. Setting: Study on Musculoskeletal disorders, Absenteeism, Stress, and Health- cohort (SMASH)	LBP reported in one of the annual self-administered postal follow-up questionnaires (3-year follow-up)	Observations of video-recordings and force measurements for physical load (at work). Questionnaire for 1. Vehicle driving (work and leisure time) 2. Physical load during leisure time	**Trunk flexion < 30°** 5-10(%): RR 0.98 (95% CI 0.68–1.41), > 10(%): RR 1.17 (95% CI 0.86-1.59). **Trunk flexion ≥ 30°** 5-10(%): RR 0.98 (95% CI 0.68–1.41), > 10(%) and ≤ 5(%) ≥ 60°: RR 1.08 (95% CI 0.77-1.53), > 5(%) ≥ 60°: RR 1.42 (95% CI 0.88-2.30). **Trunk rotation ≥ 30°** 5-10(%): RR 1.10 (95% CI 0.81-1.50), > 10(%): RR 1.26 (95% CI 0.77-2.06). **Number of lifts** never ≥ 10 kg (22 lb): RR 1.01 (95% CI 0.66-1.53), never ≥ 25 kg (55 lb): RR 0.95 (95% CI 0.67-1.36), 1-15 times ≥ 25 kg (55 lb): RR 0.87 (95% CI 0.56-1.35), > 15 times ≥ 25 kg (55 lb): RR 1.59 (95% CI 0.98-2.60). **Number of lifts ≥ 25 kg (55 lb)** 1-15 times: RR 0.88 (95% CI 0.60-1.31), >15 times: RR 1.62 (95% CI 1.04-2.53). Exposures in: % of working time (%) / per 8h working day (8h/d).	**Trunk flexion < 30°** 5-10(%): RR 1.04 (95% CI 0.70-1.54), > 10(%): RR 1.19 (95% CI 0.86-1.65). **Trunk flexion ≥ 30** 5-10(%): RR 1.05 (95% CI 0.71-1.54), > 10(%) and ≤ 5(%) ≥ 60°: RR 1.09 (95% CI 0.76-1.58), > 5(%) ≥ 60°: RR 1.48 (95% CI 0.90-2.42). **Trunk rotation ≥ 30°** 5-10(%): RR 1.08 (95% CI 0.78-1.50), > 10(%): RR 1.29 (95% CI 0.77-2.15). **Number of lifts** never ≥ 10 kg (22 lb): RR 0.92 (95% CI 0.60-1.42), never ≥ 25 kg (55 lb): RR 0.98 (95% CI 0.67-1.42), 1-15 times ≥ 25 kg (55 lb): RR 0.83 (95% CI 0.52-1.33), > 15 times ≥ 25 kg (55 lb): RR 1.57 (95% CI 0.90-2.75). **Number of lifts ≥ 25 kg (55 lb)** 1-15 times: RR 0.86 (95% CI 0.57-1.30), >15 times: RR 1.62 (95% CI 0.97-2.69). Exposures in: % of working time (%) / per 8h working day (8h/d).	Age, gender, smoking habits, BMI, vehicle driving, % working time sitting, quantitative job demands, decision authority, skill discretion, supervisor support, co-worker support, job security Leisure time: exercise behaviour, moving heavy loads, frequent flexion and/or rotation of the upper part of the body, vehicle driving

Source	Population	LBP	SML	Crude association	Adjusted association	Adjusted for
Kopec 2004 [24]	N = 10007/ 11063 general male and female household populations free of back problems at baseline Setting: Canadian National Population Health Survey (NPHS)	LBP lasted or expected to last ≥ 6 months in 2-year follow-up diagnosed by a health professional. Excluding arthritis	Questions for usual daily activities (including work habits)	Following Specific Physical Activities, categorised (none, low, high) in time / past 3 months, were not associated with LBP in the univariate model (association not given): walking for exercise/ errands, swimming, bicycling, popular or social dancing, playing home exercises, home exercises, skating, downhill skiing, jogging or running, golfing, attended exercise class or aerobics, cross-country skiing, bowling, playing baseball or softball, playing tennis, weight-training, fishing, volleyball, yoga or tai-chi	**Usual daily activity (including work habits)** 1) usually sit during the day and do not walk about very much (referent), 2) stand or walk about quite a lot during the day but do not have to carry or lift things very often: *$OR_♂$ 1.59 (95% CI 1.11-2.28),* 3) usually lift or carry light loads or have to climb stairs or hills often: *$OR_♂$ 1.61 (95% CI 1.03-2.51)*, 4) do heavy work or carry very heavy loads *$OR_♂$ 1.84 (95% CI 1.14-2.99)*. **Gardening/yard work** *< 3 h/ month: $OR_♂$ 0.62 (95% CI 0.40-0.94), ≥3 h/month $OR_♂$ 0.55 (95% CI 0.38-0.80)*.	Age, height, self-rated health, usual daily activity, gardening or yard work, chronic stress index
Kujala 1996 [25]	N = 262/456 adults (Turku, Finland) aged 25, 35, 45 and 55 years, without LBP	Postal questionnaire for whole-life and past 5 years history of LBP	Postal questionnaire for leisure-time and occupational physical loading	Leisure physical activities not associated with LBP. Associations found in baseline occupational demands (P = 0.0036), heavy occupational musculoskeletal loading (P = 0.005) and high general occupational physical demands (P = 0.036), effect estimates not reported		Age, gender

Source	Population	LBP	SML	Crude association	Adjusted association	Adjusted for
Latza 2000 [26]	N = 230 / 285 male construction workers without LBP. Setting: Hamburg (Germany) construction worker study	Structured interview for 12 months prevalence of LBP preceding the 3 years follow up	Work tasks grouped by job category	***General tasks*, scaffolding** > 0 to < 0.5: PR 0.9 (95% CI 0.5-1.8), 0.5 to 3.0: PR 1.4 (95% CI 0.8-2.3). **Tasks of carpenters, sawing wood** > 0 to 1.0: PR 2.0 (95% CI 1.0-4.3), > 1.0 to 4.0: PR 1.5 (95% CI 0.8-3.2). **Erecting roof structures** > 0 to 0.7: PR 1.3 (95% CI 0.6-2.8), > 0.7 to 4.0: PR 1.6 (95% CI 0.8-3.2). **Laying 3DF sandstone** > 0 to < 2.0: PR 1.1 (95% CI 0.5-2.2), 2.0 to 8.5: PR 1.5 (95% CI 0.8-2.7). **Stone load** intermediate: PR 0.7 (95% CI 0.3-1.5), high: PR 1.4 (95% CI 0.8-2.5). **Laying > 3DF stones** yes PR 1.7 (95% CI 0.5-5.2). Exposure in hours/shift.	***General tasks*, scaffolding** > 0 to < 0.5: PR 0.9 (95% CI 0.4-2.0), 0.5 to 3.0: PR 1.4 (95% CI 0.8-2.6). **Tasks of carpenters, sawing wood** > 0 to 1.0: PR 1.7 (95% CI 0.6-4.8), > 1.0 to 4.0: PR 1.0 (95% CI 0.3-3.0). **Erecting roof structures** > 0 to 0.7: PR 1.1 (95% CI 0.4-2.9), > 0.7 to 4.0: PR 0.9 (95% CI 0.3-2.6). **Laying 3DF sandstone** > 0 to < 2.0: PR 1.8 (95% CI 0.7-4.7), *2.0 to 8.5: PR 2.6 (95% CI 1.1-6.5)*. **Stone load** intermediate: PR 1.8 (95% CI 0.3-9.3), high: PR 4.0 (95% CI 0.8-19.8). **Laying >3DF stones** yes PR 1.7 (95% CI 0.5-5.7). Exposures in hours/shift.	Age, sitting height (cm) BMI, self reported occupation
Leclerc 2003 [27]	N = 841 men 12 months free from self reported LBP. Setting: GAZEL cohort (French national electricity and gas company)	Postal questionnaire for experienced LBP at least 1 day in the previous year	Questionnaire about working conditions	Bivariate not associated with LBP: sport activities, gardening, nonprofessional home construction activities, do-it-yourself home repair, hobby activities, and the following postural and other physical constraints at work: prolonged sitting, and standing, carrying loads, pulling or pushing heavy loads, trunk rotations, kneeling and squatting (effect sizes not presented).	**Bending forward and backward** sometimes: OR 1.10 (95% CI 0.69-1.70), *often OR: 2.20 (1.40–3.40)*. **Driving 2 hours** more than once a week: OR 1.30 (95% CI 0.75-2.20), daily: OR 1.10 (95% CI 0.73-1.70)	Age

Source	Population	LBP	SML	Crude association	Adjusted association	Adjusted for
Macfarlane 1997 [28]	N = 784 / 1412 employed subjects free of LBP Setting: South Manchester Back Pain Study -UK- (GP population)	New episodes LBP in the 12-month follow-up identified by GP consultation and postal questionnaire	Questionnaire on physical load		**Standing/walking > 2h** ♂$_{\text{consulters}}$ OR 2.1 (95% CI 0.7-6.4), ♂$_{\text{non-consulters}}$ OR 0.9 (95% CI 0.6-1.5), *♀consulters OR 3.5 (95% CI 1.4-8.8), ♀non-consulters OR 1.8 (95% CI 1.1-2.8).* **Sitting > 2h** ♂$_{\text{consulters}}$ OR 0.5 (95% CI 0.2-1.3), ♂$_{\text{non-consulters}}$ OR 1.5 (95% CI 0.9-2.4), *♀consulters OR 0.3 (95% CI 0.1-0.6), ♀non-consulters OR 0.6 (95% CI 0.4-0.9)*. **Digging** ♂$_{\text{consulters}}$ OR 0.6 (95% CI 0.1-4.5), ♂$_{\text{non-consulters}}$ OR 0.6 (95% CI 0.2-1.6), ♀$_{\text{non-consulters}}$ OR 4.4 (95% CI 0.4-5.0). **Driving a car > 4h** ♂$_{\text{consulters}}$ OR 0.9 (95% CI 0.3-3.3), ♂$_{\text{non-consulters}}$ OR 1.3 (95% CI 0.7-2.4), ♀$_{\text{consulters}}$ OR 1.6 (95% CI 0.2-1.4), ♀$_{\text{non-consulters}}$ OR 1.4 (95% CI 0.3-5.9). **Driving a truck** ♂$_{\text{consulters}}$ OR 0.9 (95% CI 0.1-7.2), ♂$_{\text{non-consulters}}$ OR 1.2 (95% CI 0.5-3.1). **Lifting/moving > 25lb (11.3 kg)** ♂$_{\text{consulters}}$ OR 1.2 (95% CI 0.5-3.0), ♂$_{\text{non-consulters}}$ OR 1.1 (95% CI 0.7-1.7), *♀consulters OR 2.3 (95% CI 1.1-5.0), ♀non-consulters OR 2.5 (95% CI 1.5-4.1)* ***LBP associated with duration of exposure.*** **Standing/walking > 2h** *1-7 years ♂: OR 2.0 (95% CI 1.1-2.7),* 1-7 years ♀: OR 1.6 (95% CI 0.9-2.9), 8-18 years ♂: OR 1.4 (95% CI 0.7-3.0), *8-18 years ♀: OR 2.2 (95% CI 1.2-4.1),* > 18 years ♂: OR 1.3 (95% CI 0.6-2.9), > 18 years ♀: OR 2.0 (95% CI 1.0-4.2). **Lifting/moving > 25lb (11.3 kg)** 1-7 years ♂: OR 2.0 (95% CI 1.0-3.8), 1-7 years ♀: OR 1.5 (95% CI 0.8-2.8), 8-17 years ♂: OR 1.5 (95% CI 0.8-2.8), *8-17 years ♀: OR 2.7 (95% CI 1.5-5.1),* > 17 years ♂: OR 1.3 (95% CI 0.7-2.4), > 17 years ♀: OR 1.0 (95% CI 0.4-2.6).	Age

Source	Population	LBP	SML	Crude association	Adjusted association	Adjusted for
Manninen 1995 [29]	N = 363 /537 Finnish farmers aged 45-54 not reporting LBP in the past year	Self-reported unspecified LBP and sciatic pain in the past year of 12-year follow-up	Questionnaire for use of a tractor	No association found between baseline use of a tractor and LBP at follow-up		
Niedhammer 1994 [30]	N = 210/469 female acute care nurses without musculoskeletal disorders. Setting: 10 (France) public sector hospitals	Self-reported first occurrence of LBP in 12 months preceding follow up	Questionnaire on physical work load		**Sports activities** OR 1.11 (NS). **Commuting** ≥ 2 h/day: OR 2 (P = 0.08). **Physical workload**: OR 1.24 (NS)	Age, sports activities, the presence of children < 3 years old, tobacco consumption, symptoms of psychological disorders
Van Nieuwenhuyse 2006 [31]	N = 716 / 972 healthcare or distribution workers < 30 years free of LBP lasting ≥ 7 days in past year	Self reported LBP lasting > 7 consecutive days in the past twelve months	Questionnaire on physical workload, sporting activities, construction and embellishment work at home, motor vehicle driving (km/ year)	**Working with trunk in bent and twisted position** ≤ 2 h/day: RR 1.26 (95% CI 0.80-1.97) > 2 h/ day: RR 1.94 (95% CI 1.17-3.23). **Inability to change posture regularly**: RR 2.49 (95 % CI 1.65–3.76). **Pushing or pulling heavy loads** <1 time/h: RR 1.40 (95% CI 0.86-2.27), ≥ 1 time/h: RR 1.70 (95% CI 1.07-2.72). **Lifting or carrying loads** ≤ 10 kg (22 lb): RR 1.35 (95% CI 0.62-2.91), 10-25 kg (22-55 lb) ≤ 12 times/h: RR 1.25 (95% CI 0.61-2.56), 10-25 kg (22-55 lb) > 12 times/h: RR 1.42 (95% CI 0.60-3.40), > 25 kg (55 lb) ≤ 12 times/h: RR 1.28 (95% CI 0.69-2.36), > 25 kg (55 lb) > 12 times/h: RR 3.13 (95% CI 1.18-8.33)	**Working with the trunk in bent and twisted position** ≤ 2 h/day: RR 1.30 (95% CI 0.77-2.2), *> 2 h/ day: RR 2.21 (95% CI 1.2-4.07).* **Inability to change posture regularly:** *RR 2.11 (95% CI 1.26- 3.54*	Standing work for long periods, recreational sports, possibilities to develop skills, psychological job demands, perceived general health, family situation, BMI, age, sex, pain related fear, complaints in neck, back, upper or lower limbs in past year

Source	Population	LBP	SML	Crude association	Adjusted association	Adjusted for
Pietri 1992 [32]	N = 627/1381 commercial travellers (France) who never had LBP	First life time symptoms of LBP during the year of follow-up	Self-declaration of physical constrains at work		**Time driving/week** *10-14 hours: OR 4.0 (95% CI 1.1-14.3), 15-19 hours: OR 4.8 (95% CI 1.4-16.4),* 20-24 hours: OR 3.3 (95% CI 0.9-12.0), ≥ 25 hours: OR 3.7 (95% CI 0.9-14.0). **Carrying loads:** OR 0.9 (95% CI 0.5-1.5). **Standing:** OR 0.8 (95% CI 0.5-1.4)	Sociodemographic data (age, marital status, number of children, educational level), life-style (sport, consumption of coffee, tobacco alcohol), weight, height, BMI, general work conditions (duration of employment as commercial traveller, time per week spent at work and driving, number of kilometres per year, type and comfort of the vehicle), physical constraints at work (carrying loads, standing, climbing stairs). Information about the vehicle used at work, psychosomatic factors
Van Poppel 1998 [33]	N = 238 / 380 workers from a Dutch airline cargo department without self-reported LBP	Questionnaire on the occurrence of LBP and sick leave due to LBP	Questionnaire on manual lifting tasks, riding a forklift truck, exercise(s)	**Riding forklift truck** > 10 h/week: OR 0.7 (95% CI 0.6-0.98). **Exercise:** P-values > 0.2. **Manual lifting tasks:** P-values > 0.2	***Riding forklift truck (h/week).*** *> 10 h/week: OR 0.7 (95% CI 0.5-0.99)*	Age, BMI, trunk muscle strength, history of LBP, general health status, job satisfaction, smoking, exercise habits, attitude to influence own health, time spent on various working tasks, interventions (lumbar support and education, education only, lumbar support only)

Source	Population	LBP	SML	Crude association	Adjusted association	Adjusted for
Smedley 1997 [34]	N = 838 / 961 hospital based nurses (♀) without LBP in the past month. Setting: Southampton University Hospitals Trust (England)	Self-reported LBP > 1 day not in association with pregnancy, menstruation, or febrile illness	Postal questionnaire for activities in nurses' current job.		**Transfer patient on canvas and poles** 1-4: OR 0.8 (95% CI 0.6-1.1), ≥ 5: OR 1.4 (95% CI 0.8-2.3). **Manually transfer patient between bed and chair** 1-4: OR 1.3 (95% CI 0.9-1.7), *5-9: OR 1.6 (95% CI 1.1-2.3), ≥ 10: OR 1.6 (95% CI 1.1-2.3)*. **Transfer patient between bed and chair with hoist** 1-4: OR 1.5 (95% CI 1.0-2.1), ≥ 5: OR 1.6 (95% CI 0.8-3.0). **Manually move patient around on bed** 1-4: OR 1.3 (95% CI 0.8-1.9), 5-9: OR 1.5 (95% CI 1.0-2.3), ≥ *10: OR 1.7 (95% CI 1.1-2.5)*. **Manually lift patient up off floor** ≥ 1: OR 1.1 (95% CI 0.9-1.5). **Lift patient from floor with hoist** ≥ 1: OR 1.3 (95% CI 0.8-2.0). **Manually lift patient in or out of bath** ≥ 1: OR 0.9 (95% CI 0.6-1.4). **Lift patient in or out of bath with hoist** 1-4: OR 1.4 (95% CI 1.0-1.9), ≥ 5: *OR 2.1 (95% CI 1.2-3.6)*	Age, height, history of LBP, symptoms other than LBP at baseline headache, period pain, fatigue, low mood, stress)

Source	Population	LBP	SML	Crude association	Adjusted association	Adjusted for
Yip 2004 [35]	N = 144 / 224 full-time working nurses without LBP >12 months. Setting: six Hong Kong district hospitals	New LBP in the 12-months follow-up period	Telephonically questionnaire on handling materials and patients, self-reported posture and leisure-time physical activity	***Patient handling activities.*** **Transfer patient onto a trolley:** lowest tertile P = 0.62. **Transfer patient between bed and chair:** middle tertile P = 0.51. **Position patient on bed**: middle tertile P = 0.77. **Assist patient on/off toilet:** middle tertile P = 0.44. **Assist patient in or out of the bath:** lowest and middle tertile P = 0.51. **Assist patient while ambulating:** middle tertile P = 0.05 ***Material handling activities (number of times per shift).*** **Move instrument / furniture:** middle tertile P = 0.10. **Move bed:** middle tertile P = 0.11. **Carry a piece of equipment weighing ≥5 lb (2.3 kg):** middle tertile P = 0.38. **Carry a piece of equipment weighing ≥30 lb (13.6 kg):** middle tertile P = 0.83 ***Work posture.*** **Bend to lift item from floor level:** middle tertile P = ≤ 0.01. **Twisting position:** middle tertile P = 0.24. **Hands raised above shoulder level:** middle tertile P = 0.75. **Standing (< 2 h):** P = 0.19. **Sitting (< 2 h):** P = 0.47. **Walking (4 h):** P = 0.37. **Physical activity in leisure time** active: P = 0.35	**Bend to lift an item from floor level:** middle tertile: RR 0.66 (95% CI 0.25-1.75), highest tertile RR 2.76 (95% CI 1.0-7.22). **Assist patient while ambulating:** middle tertile: RR 2.10 (95% CI 0.88-5.01), highest tertile RR 0.87 (95% CI 0.30-2.48)	Age

N. is presented as the number of participants used in the effect size/number of participants included at baseline. Multivariate statistically significant associations are shown in Italic.
Abbreviations: h, hour(s); BMI, body mass index (weight / height^2); RR, relative risk; $RR_{♂}$: relative risk in men; $RR_{♀}$: relative risk in women; 95% CI, 95% confidence interval; PR, prevalence ratios; HR, hazard ratios; CIR, cumulative incidence ratios; OR, odds ratios; NS, not significant.

Sports (professional). Our search yielded no studies reporting on the association between professional sports and the development of LBP, we therefore conclude that there is presently no evidence for sporting on a professional level as a risk factor for LBP.

Risk factors for first-time-ever LBP. We found three studies reporting on 16 exposures as potential risk factors for first-time-ever LBP. Macfarlane [28] described associations for first-time-ever LBP in women for standing/walking > 2 hours, sitting > 2 hours, and lifting /moving > 25 lb (11.3 kg). Pietri [32] reported associations in 10-14 hours, and 15-19 hours driving/week for first-time-ever LBP. Croft [18] reported seven exposures, but none were significantly associated with first-time-ever LBP.

Dose-Response. In all studies, the exposures of the potential risk factors for LBP were either dichotomised or presented on a categorical scale (3-5 categories). For the categorical risk factors, the highest categories of exposure often yielded more risk factors for LBP. In leisure time activities the risk for LBP decreased by more intensive gardening/yard work (<3, and ≥ 3 hours/month) [24]. In nursing tasks, Smedley [42] reported a dose-response association for the middle (5-9) and highest (≥ 10 times) ranked categories of manually transfer patient between bed and chair.

Macfarlane [28] examined whether a cumulative exposure of years of standing/walking and lifting/moving > 25 lb. (11.3 kg.) was associated with LBP. For standing/walking, the first category (1-7 years) was associated with LBP in men, but there was no excess risk in 8-18, and > 18 years. In women, the middle category (8-18 years) of this exposure was associated with LBP. Also in women, 8-17 years exposed to lifting/moving > 25 lb. (11.3 kg.) was associated with LBP (other categories: never, 1-7, and > 17 years). In whole-body vibration, Pietri [32] reported limited support for a dose-response for LBP in male occupational drivers. In this study, the middle categories (i.e. 10-14, and 15-19 hours driving/week) were associated with LBP (other categories: < 10, 20 to 24, and > 25 hours driving/week). Apparently, an increased duration in the exposure tended to decrease the risk for LBP.

Discussion

We systematically reviewed 18 prospective cohort studies of high methodological quality for this best evidence synthesis of spinal mechanical load as a risk factor for incident LBP. The included studies reported a total of 133 dichotomised or categorised exposures of spinal mechanical load in 24315 subjects without LBP a baseline. In view of the heterogeneity in population, exposures, outcome measures and data presentation, we performed a qualitative data synthesis. Our results show strong evidence that LBP is not associated with leisure-time sport or exercises, sitting or prolonged standing/walking. We found conflicting evidence for associations between LBP and leisure time activities, whole-body vibration, nursing tasks, heavy physical work, and working with ones trunk in a bended and/or twisted position. Finally, we found no studies, indicating no evidence that sleeping or sporting on a professional level are associated with LBP.

Strengths and limitations. We used a sensitive search strategy without language restrictions for all relevant databases, and hand searched the reference lists of all included studies for additional papers. Despite our precision in obtaining all possible relevant literature, we could still have missed important studies due to human error or databases to which we did not have access. Moreover, publication bias could have occurred where studies with significant results were more likely to be published and therefore we may have missed information from non-published data.

In view of the heterogeneity in study populations, measurement methods (exposures and outcomes), operationalisation of LBP, duration of follow-up, and adjustment for confounders we performed a qualitative data synthesis based on the number, the quality, and the outcome of the studies. We adapted criteria for quality assessment [15,16,17] and modified these to cover the topic of the review. Still, our well-considered criteria and cut-off points may have been arbitrary, for example for criteria on the number of subjects lost to follow-up it was suggested to minimise bias an acceptable 'total number of drop-outs/loss to follow-up would be ≤ 20% at 12 months'; however only four studies fulfilled this criterion. In all studies, we considered a follow-up period of 1 year as sufficiently long. Therefore, this criterion did not differentiate in the quality-scores. Therefore, our manner to achieve total methods score and thus our rating in high versus low quality studies could be arguable. Nevertheless, we believe it is more likely that the results of our quality assessment (all studies were rated high-quality) are a direct consequence of including large scale prospective cohort studies with a considerable period of follow-up than the inability of our rating system to differentiate in high- versus low-quality studies.

Prior to the study we chose the score 6/10 to be determinant of high methodological quality studies; we considered this score as robust. Although any cut-off point is an arbitrary one, in this review a cut-off point of 5/10 would not have changed our results since the lowest score for methodological quality from the 18 included studies was 6/10. Also a cut off point of 7/10 would not have changed our conclusions in heavy physical work, sport or exercises during leisure time, activities during leisure time, and whole-body vibration at work.

In the original publications, 'activities during leisure time' involved exposures varying from watching TV on a daily basis to activities such as gardening. In our data synthesis, we did not differentiate between these incomparable exposures; therefore, conclusion for this exposure should be interpreted cautiously.

Previous systematic reviews. Earlier published reviews on this topic identified a need for additional high-quality prospective studies to assess the association of spinal mechanical load and LBP. Therefore, in this review we only included such studies. Moreover, due to our inclusion criteria we obtained more homogeneity in the reviewed study populations and operationalisation of LBP compared to previous reviews e.g. by excluding studies including children and studies concentrating on LBP related compensation claims as outcome. As a result, our conclusions are more moderate than most of the previous made conclusions e.g. three reviews based mostly on cross-sectional studies [12,14,48] concluded that an association between whole-body vibration and LBP could be plausible. From this review, we conclude conflicting evidence (i.e. increased/decreased risk or no-association) for this exposure. For sitting as an exposure, two previous reviews [14,49] concluded that there is no evidence that prolonged sitting was a risk for LBP. Whereas our conclusion is that strong evidence exists that sitting is not associated with LBP. Where Hoogendoorn [14] concluded that there is strong evidence that manual materials handling and moderate evidence for high level of physical activity were risk factors for back pain. In contrast, we conclude that there was conflicting evidence for these exposures.

Measurements of exposures. In all the included studies, the exposures were dichotomised or categorised (qualitatively, e.g. sometimes, usually, quite a lot or quantitatively, e.g. hours per day) for assessment. The duration of these quantitatively categorised exposures varies from 15 minutes or more per day [21] to 2.0 - 8.5 hours per shift [26]. Thus, the assessed exposures represent at best 35% of the total exposure time possible per day. Interactions with other daily exposures are likely and the 65% missing exposure time could have considerable effect for the assessed risk factor(s) for LBP. Therefore, it has been suggested that research on spinal mechanical load as risk factor for LBP should involve all (daily) physical activities measured over 24 hours per day [50].

Conclusion

We conclude that there is strong evidence that there is no association between leisure time sport or exercises, sitting, and prolonged standing/walking and LBP. There is conflicting evidence for associations between leisure time activities, whole-body vibration, nursing tasks, heavy physical work, and working with ones trunk in a bended and/or twisted position and the development of LBP. There is no evidence for sleeping, and sporting on a professional level and LBP.

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References

1. Maetzel A, Li L. The economic burden of low back pain: a review of studies published between 1996 and 2001. Best Pract Res Clin Rheumatol 2002, 16(1):23-30
2. Assendelft WJ, Morton SC, Yu EI, Suttorp MJ, Shekelle PG. Spinal manipulative therapy for low back pain. Cochrane Database Syst Rev. 2004;(1):CD000447
3. Ferreira ML, Ferreira PH, Latimer J, et al. Does spinal manipulative therapy help people with chronic low back pain? Aust J Physiother 2002, 48:277-284
4. Guzmán J, Esmail R, Karjalainen K, et al. Multidisciplinary rehabilitation for chronic low back pain: systematic review. BMJ 2001;322 1511-1516
5. Jellema P, van Tulder MW, van Poppel MN, et al. Lumbar supports for prevention and treatment of low back pain. A systematic review within the framework of the Cochrane Back Review Group. Spine 2001, 26(4):377-386
6. Pengel HM, Maher CG, Refshauge KM. Systematic review of conservative interventions for sub-acute low back pain. Clin Rehabil. 2002;16(8):811-20
7. Van Tulder M, Malmivaara A, Esmail R, et al. Exercise therapy for low back pain. A systematic review within the framework of the Cochrane Collaboration Back Review Group. Spine 2000a, 25(21):2784-2796
8. Van Tulder M, Ostelo R, Vlaeyen JWS, et al. Behavioral treatment for chronic low back pain. A systematic review within the framework of the Cochrane Back Review Group. Spine 2000b, 25(20):2688-2699
9. Björklund L. The Bone and Joint Decade 2000-2010. Inaugural meeting 17 and 18 April 1998, Lund, Sweden. Acta Orthop Scand Suppl. 1998;281:67-80
10. Bakker EW, Koning HJ, Verhagen AP, et al. Interobserver reliability of the 24-hour schedule in patients with low back pain: a questionnaire measuring the daily use and loading of the spine. J Manipulative Physiol Ther. 2003;26(4):226-32
11. Garg A, Moore JS. Epidemiology of low-back pain in industry. Occup Med. 1992;7(4):593-608
12. Lings S, Leboeuf-Yde C. Whole-body vibration and low back pain: a systematic, critical review of the epidemiological literature 1992-1999. Int Arch Occup Environ Health. 2000;73(5):290-7
13. Nachemson A, Vingård E. Influences of individual factors and smoking on neck and back pain. In: Nachemson A, Jonsson E. (Ed.), Neck and Back Pain: the scientific evidence of causes, diagnosis, and treatment. Lippincott Williams Wilkins, Philadelphia, 2000;(4)79-95
14. Hoogendoorn WE, van Poppel MN, Bongers PM, et al. Physical load during work and leisure time as risk factors for back pain. Scand J Work Environ Health 1999; 25: 387-403
15. Cole DC, Hudak PL. Prognosis of nonspecific work-related musculoskeletal disorders of the neck and upper extremity. Am J Ind Med. 1996;29(6):657-68
16. Von Korff M. Studying the natural history of back pain. Spine. 1994;19(18 Suppl):2041S-2046S
17. Sackett DL, Haynes RB, Guyatt, GH et al. Clinical Epidemiology: A Basic Science for Clincal Medicine. 2nd edn ed. Boston, Mass: Little Brown & Co Inc; 1991
18. Croft PR, Papageorgiou AC, Thomas E, et al. Short-term physical risk factors for new episodes of low back pain. Prospective evidence from the South Manchester Back Pain Study. Spine. 1999;24(15):1556-61
19. Eriksen W, Natvig B, Bruusgaard D. Smoking, heavy physical work and low back pain: a four-year prospective study. Occup Med (Lond). 1999;49(3):155-60
20. Eriksen W, Bruusgaard D, Knardahl S. Work factors as predictors of intense or disabling low back pain; a prospective study of nurses' aides. Occup Environ Med. 2004;61(5):398-404
21. Harkness EF, Macfarlane GJ, Nahit ES et al. Risk factors for new-onset low back pain amongst cohorts of newly employed workers. Rheumatology (Oxford). 2003;42(8):959-68
22. Hartvigsen J, Christensen K. Active lifestyle protects against incident low back pain in seniors: a population-based 2-year prospective study of 1387 Danish twins aged 70-100 years. Spine. 2007;32(1):76-81 1
23. Hoogendoorn WE, Bongers PM, de Vet HC et al. Flexion and rotation of the trunk and lifting at work are risk factors for low back pain: results of a prospective cohort study. Spine. 2000;25(23):3087-92
24. Kopec JA, Sayre EC, Esdaile JM. Predictors of back pain in a general population cohort. Spine. 2004;29(1):70-8
25. Kujala UM, Taimela S, Viljanen T, et al. Physical loading and performance as predictors of back pain in healthy adults. A 5-year prospective study. Eur J Appl Physiol Occup Physiol. 1996;73(5):452-8

26. Latza U, Karmaus W, Sturmer T, et al. Cohort study of occupational risk factors of low back pain in construction workers. Occup Environ Med. 2000;57(1):28-34
27. Leclerc A, Tubach F, Landre MF, et al. Personal and occupational predictors of sciatica in the GAZEL cohort. Occup Med (Lond). 2003;53(6):384-91
28. Macfarlane GJ, Thomas E, Papageorgiou AC, et al. Employment and physical work activities as predictors of future low back pain. Spine. 1997;22(10):1143-9
29. Manninen P, Riihimäk H, Heliövaara M. Incidence and risk factors of low-back pain in middle-aged farmers. Occup Med (Lond). 1995;45(3):141-6
30. Niedhammer I, Lert F, Marne MJ. Back pain and associated factors in French nurses. Int Arch Occup Environ Health. 1994;66(5):349-57
31. Van Nieuwenhuyse A, Somville PR, Crombez G, et al. The role of physical workload and pain related fear in the development of low back pain in young workers: evidence from the BelCoBack Study; results after one year of follow up. Occupational and Environmental Medicine. 2006 ; 63(1): 45-52
32. Pietri F, Leclerc A, Boitel L, et al. Low-back pain in commercial travelers. Scand J Work Environ Health. 1992;18(1):52-8
33. Van Poppel MN, Koes BW, Deville W, et al. Risk factors for back pain incidence in industry: a prospective study. Pain. 1998;77(1):81-6
34. Smedley J, Egger P, Cooper C, et al. Prospective cohort study of predictors of incident low back pain in nurses. BMJ. 1997;314(7089):1225-8
35. Yip VY. New low back pain in nurses: work activities, work stress and sedentary lifestyle. J Adv Nurs. 2004;46(4):430-40
36. Christensen K, Holm NV, McGue M, et al. A Danish population-based twin study on general health in the elderly. J Aging Health. 1999;11(1):49-64
37. Croft PR, Papageorgiou AC, Ferry S, et al. Psychologic distress and low back pain. Evidence from a prospective study in the general population. Spine. 1995;20(24):2731-7
38. Nahit ES, Pritchard CM, Cherry NM, et al. The influence of work related psychosocial factors and psychological distress on regional musculoskeletal pain: a study of newly employed workers. J Rheumatol 2001;28:1378–84
39. Papageorgiou AC, Macfarlane GJ, Thomas E, et al. Psychosocial factors in the workplace--do they predict new episodes of low back pain? Evidence from the South Manchester Back Pain Study. Spine. 1997;22(10):1137-42
40. Papageorgiou AC, Croft PR, Thomas E, et al. Influence of previous pain experience on the episode incidence of low back pain: results from the South Manchester Back Pain Study. Pain. 1996;66(2-3):181-5
41. Papageorgiou AC, Croft PR, Ferry S, et al. Estimating the prevalence of low back pain in the general population. Evidence from the South Manchester Back Pain Survey. Spine. 1995;20(17):1889-94
42. Smedley J, Egger P, Cooper C, et al. Manual handling activities and risk of low back pain in nurses. Occup Environ Med. 1995;52(3):160-3
43. Statistics Canada. NPHS Public Use Microdata Documentation. Statistics Canada, 1995. Available at http://www.statcan.ca/english/freepub/82F0068XIE/82F0068XIE1997001.htm. Accessed December 30, 2007
44. Stürmer T, Luessenhoop S, Neth A, et al. Construction work and low back disorder. Preliminary findings of the Hamburg Construction Worker Study. Spine. 1997;22(21):2558-63
45. Tubach F, Leclerc A, Landre MF, et al. Risk factors for sick leave due to low back pain: a prospective study. J Occup Environ Med. 2002 May;44(5):451-8
46. Yip Y. A study of work stress, patient handling activities and the risk of low back pain among nurses in Hong Kong. J Adv Nurs 2001; 36 (6): 794-804
47. Landis JR, Koch GG. The measurement of observer agreement for categorical data. Biometrics. 1977;33(1):159-74
48. Waters T, Genaidy A, Deddens J, et al. Lower back disorders among forklift operators: an emerging occupational health problem? Am J Ind Med. 2005;47(4):333-40
49. Hartvigsen J, Leboeuf-Yde C, Lings S, et al. Is sitting-while-at-work associated with low back pain? A systematic, critical literature review. Scand J Public Health. 2000 Sep;28(3):230-9
50. Bakker EW, Verhagen AP, Lucas C, et al. Daily spinal mechanical loading as a risk factor for acute non-specific low back pain: a case-control study using the 24-Hour Schedule. Eur Spine J. 2007a;16(1):107-13

CHAPTER 3

Interobserver reliability of the 24 Hour Schedule in patients with low back pain: a questionnaire measuring the daily use and loading of the spine

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Abstract

Study design. Reliability Study

Objective. To assess the interexaminer reliability of the 24 Hour Schedule (24HS) in patients with low back pain.

Summary of background data. Low back pain is a major health problem in western industrialised countries. The 24HS is an instrument, which intends to obtain insight in the use (i.e. posture and applied load) of the back. It consists of a questionnaire, a series of photos and a registration form. The purpose of this study was to investigate the interexaminer reliability of the 24HS.

Methods. People with low back pain were included in the study. Sample-size calculation indicated that 40 participants would be sufficient in order to answer the research question. Participants were coded to remain anonymous and after giving informed consent they completed a questionnaire. Two trained examiners assessed each participant independently. In total five examiners participated.

Results. In total 40 participants were analysed. In our study population the use of the back was approximately ten times more in a flexed position compared to a lordotic position. Flexed activity was registered in all 80 assessments, but in 39 assessments there was no registration of any activity in a lordotic posture. In only one participant (diagnosed with Bechterew's disease) the use of the back was more in a lordotic than in a flexed posture. The Intra Class Correlation Coefficient of the assessment was 0.81 (95% confidence interval = 0.67–0.89), corresponding with a high level of agreement between the examiners.

Conclusion. The Inter-observer Reliability of the 24HS appeared to be high.

Introduction

Low back pain is a major health problem in western industrialized countries [1] and a common condition in primary care. In the UK, 7% of the adult population consult a general practitioner for this condition each year [2]. About 85% of low back pain is nonspecific (i.e. low back pain is not attributed to recognisable pathology) [3]. In general, it is believed that low back pain is a benign self-limiting disease, with a recovery rate of 80% to 90% within 6 weeks, irrespective of the management or type of treatment [4]. Conversely, there are indications that low back pain should be viewed as a chronic condition, since only 25% of the patients are completely free of pain and disability after 1 year [5]. Recurrence rates for low back pain are reported as high as about 50% within 12 months [6]. In 1995 in the US, an estimated $8.8 billion was spent on claims for occupational low back pain [7]. Despite this burden on patients and society, a clear aetiology of low back pain has not yet been found [3]. Even though there is strong evidence that manual materials handling, bending, twisting, and whole-body vibration can be regarded as risk factors for low back pain [8], in general the risk factors are poorly understood [9].

From the physiological point of view, the musculoskeletal system of the spine requires a stimulus of movement, such as weight bearing and muscle contraction within the physiological limits, as a contributing factor for maintaining its physical condition. Conversely, musculoskeletal tissues weaken from overuse or disuse [10]. In addition, the shape of the vertebrae, the intervertebral disks, and the ligaments will adjust to the dominant type of load: a specific adaptation to imposed demand [10,11,12]. The quality of this physiological musculoskeletal adaptation seems to be determined by the magnitude of the load [13].

Prevention of acute low back pain might be possible if there is an indication whether the unavoidable load on the back exceeds these physiological limits and becomes overuse or disuse [10,12,14]. For this purpose, it would be helpful to get insight into the use (i.e. posture and applied load) of the lower back. In the literature, no valid instrument which is able to achieve this insight has yet been described. Therefore, the 24 Hour Schedule (24HS) has been developed by a multidisciplinary research team of experts (physiotherapists, manual therapists, medical doctors) working with this group of patients on a regular basis. We consider the 24HS to have face and expert validity. The 24HS is an instrument which intends to measure the dominant use (the training activity) of the back. New instruments should be evaluated regarding their reliability and validity. Because of the absence of a gold standard to assess criterion validity of the 24HS, we chose to start validity testing of the 24HS with assessing the interobserver reliability. The purpose of this study was to assess the interobserver reliability of the sum score of postures obtained by the 24HS in patients with low back pain.

Methods

Subjects. People with either acute or chronic low back pain were eligible for inclusion in the study. Exclusion criteria were age (< 18 years) and insufficient knowledge of the Dutch language. People were recruited by means of a call for participants in a local newspaper. Sample size calculation indicated that a number of 40 participants would be sufficient in order to answer the research question. Participants were invited to come to a local research centre. After informed consent, all participants completed a questionnaire focusing on the patient history and demographic data. The participants were coded to remain anonymous. For measuring the pain intensity, an 11-point Likert scale [15] was used.

Assessment. The measurements of the 40 participants using the 24HS were performed on 2 separate days; each day, 20 participants were assessed, and a total of 5 examiners participated. All examiners were physiotherapists who had been involved in the development of the 24HS. Each day, 4 examiners were available to perform the measurements. Each participant was scheduled to 2 examiners using a random procedure of blind drawing of numbered cards by the research coordinator. After completing the first measurement, each participant was immediately invited for the second measurement by the second examiner. The second examiners were blinded to the previous outcome of the first examiner.

The 24 Hour Schedule. The 24HS consists of a questionnaire, a series of photos, and a registration form (see Addendum). The trained examiner systematically asks the participant to describe one's daily activities in episodes of at least 30 minutes. These daily activities should represent the average daily use of the back for the last 10 weeks [16]. Regular weekly activities are registered if the total time of that activity was more than 30 minutes per day, spread over 7 days. For each activity, the examiner first determines the posture in the sagittal plane (i.e. flexed or lordotic position of the back) [17] during this activity. In case of uncertainty, series of standardized photos are used to verify the exact posture. Next, the examiner classifies the applied load on the back during this activity. For this purpose, 3 categories are available: (1) unloaded, no load applied (e.g., lying); (2) loaded (e.g., sitting); and (3) loaded with movement (e.g., digging or sauntering). Finally, the examiner determines the duration of the activity, with a minimum of 30 minutes. From all daily activities the participant describes, the posture, the category of load, and the duration of the activity are chronologically listed on the standardised registration form, as shown the addendum.

When the registration was completed, we calculated the total time of the flexed and the lordotic postures. To come to one distinct outcome, the scores of a posture in the second and third category were recalculated to a score of a posture in the first category. For reasons of feasibility, we assumed a relationship between the training activity in these categories of 1 :

2 : 3. For example, an activity that scored 5 hours in the second category on the registration form becomes 10 hours when recalculated to the first category. An activity that scored 5 hours in the third category will be recalculated to 15 hours in the first category. After the recalculation, the scores from the flexed and lordotic positions are summed. As a result, the outcome represents the use of the back in a flexed or lordotic posture respectively. Subsequently, the total time of the lordotic postures is subtracted from the total time of the flexed postures. The resulting figure gives insight into the dominant use of the back. The used parameter is hours per day recalculated to an unloaded posture in the sagittal plane, schedule hours.

A consequence of this recalculation to the unloaded postures is that the outcome could easily exceed the 24 hours of a day. The theoretically maximum outcome is 72 schedule hours flexed posture per day, meaning that this person is, for example, digging during 24 hours per day. The procedure of the 24HS is easy to learn. All examiners are trained in using the 24HS in 2 sessions of 90 minutes. The time required for the total evaluation of a single patient is about 15 minutes.

Analysis. SPSS/Windows version 10 (SPSS Inc, Chicago, Ill) was used for the analysis of the collected data. The data analyst (AV) was blinded concerning the subjects and the examiners. The intraclass correlation coefficient (ICC) was used to measure the agreement between the examiners. Each patient was rated by a different set of 2 examiners, randomly selected from a larger set of 5 examiners, resulting in a 1-way random effects analysis of variance (ANOVA). The data used to compute our ICC were the sum scores. Beforehand, we determined an ICC greater than 0.7 as a high level of agreement. An ICC between 0.7 and 0.5 was determined as a moderate level of agreement, and an ICC under 0.5 was determined as a low level of agreement [18,19].

Results

A total of 40 participants (N = 40) were included and analyzed. The characteristics of the study population are presented in Table 1.

To describe the history of the participants' low back pain, they were asked for the duration of their low back pain, the mean duration of complaints. Six participants answered this question with years, which has been altered into 5 years. Subsequently, participants were asked if their low back pain was constantly present or occurred in periods. To describe the duration of the present complaints, the answers were categorized according to their duration: acute (<6 weeks), subacute (6-12 weeks), or chronic (>12 weeks) [20]. In 17 participants (42.5%), the duration of the current pain episode lasted for over 1 year.

Table 1. Characteristics of the study population

	Total number (%)	Mean (SD)	Min.	Max.
Male	17 (42.5%)			
Female	23 (57.5%)			
Age (year)		56.3 (± 11.9)	35	81
Pain NRS (0 - 10)		5.9 (± 1.9)	2	10
Total duration of complaints (year)		14.8 (± 11.6)	0.5	40
Duration current episode:				
Acute (< 6 weeks)	9 (22.5%)			
Sub acute (6 – 12 weeks)	7 (17.5%)			
Chronic (> 12 weeks)	24 (60.0%)			
Pain constantly present	24 (60.0%)			
Pain occurs in periods	16 (40.0 %)			
Radiation (in one or both legs)	9 (22.5 %)			

NRS, Numeric rating scale.

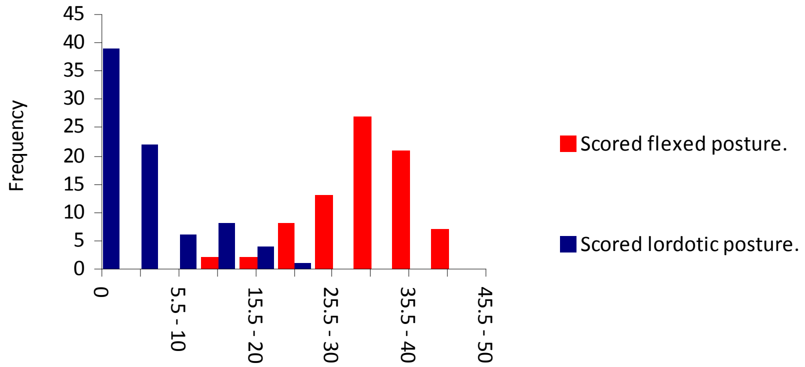
Assessed postures. Flexed postures were registered in all assessments and they were most frequently scored between 20.5 to 30 schedule hours (26 times) and between 30.5 to 40 schedule hours (33 times). In 7 assessments, the outcome exceeded 40 schedule hours. The maximum assessed flexed posture was 42 schedule hours (scored 3 times). In 39 of the 80 assessments (48.8%), there was no registration of any lordotic activity at all. The maximum assessed lordotic posture in a single participant was 21 schedule hours. These differences are primarily responsible for the remarkable difference between the use of the back in a flexed position (mean: 32.1 [±6.4] schedule hours) versus the use of the back in a lordotic position (mean: 3.7 [±5.3] schedule hours) in our study population.

The scored flexed and lordotic postures are presented in Figure 1. In this figure, the measured posture in schedule hours (intervals of 5 schedule hours) is shown horizontally and the frequency a posture is measured is shown vertically.

According to the procedure of the 24HS, from each assessment, the total time of the assessed lordotic posture is subtracted from the total time of the assessed flexed posture. The resulting figure gives insight into the participant's dominant use of the back (in schedule hours). The results of all 80 measurements in our study group using the 24HS are presented in Figure 2. The negative figures indicate an average use of the back more in a lordotic than in a flexed posture.

Excessive outcomes. The maximum measured outcome, assessed by both examiners, was 42 schedule hours in a flexed posture. This was the result of a wheelman on a hoisting crane who was an amateur farmer in his spare time. Only 1 participant had a negative result, – 7 schedule

Figure 1. Scored flexed and lordotic postures the 24HS in 80 assessments (40 participants)

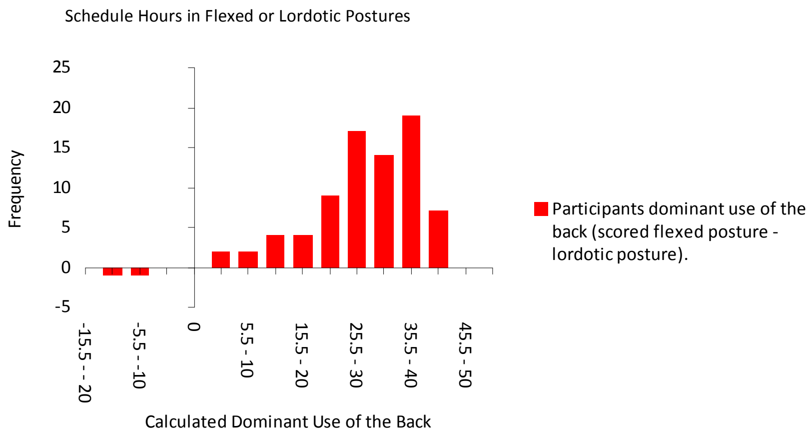


hours, indicating that the average use of the back was more in a lordotic than a flexed posture. For this participant, the outcome of the first assessment was −10.5 schedule hours (measured flexed posture 10.5 schedule hours minus the measured lordotic posture 21 schedule hours), and the outcome of the second assessment was −3.5 schedule hours (measured flexed posture 11.5 schedule hours minus the measured lordotic posture 15 schedule hours). It concerned someone who was diagnosed with ankylosing spondylitis (Bechterew disease). This participant fulfilled a Bechterew training program, consisting of extension exercises and bed rest daily.

Comparing scores. The results of the first and second measurements are shown in Figure 3. Each dot represents 1 participant (40 altogether). In 62 assessments, the difference in outcome between the 2 examiners was less than 5 schedule hours. The results of the assessment with the 24HS were questionable in 1 participant. Both examiners, independent of each other, described on their registration form the constant alteration of answers of the participant. For this participant, the difference in the outcome between the examiners appeared to be considerable (23 schedule hours). In 1 other participant, the difference in outcome between the examiners was also more than 20 schedule hours, and in 2 participants, the difference was more than 10 schedule hours. In our evaluation, it appeared that these differences were also caused by altered information and pointing out different postures on the series of photos by the participant.

The intraclass correlation (40 subjects and 80 classifications) was 0.81 (95% confidence interval 0.67 to 0.89), corresponding with a moderate to high level of agreement. The correlation between pain and the 24HS score appeared to be low: 0.12 (Pearson correlation coefficient).

Figure 2. Calculated posture according the 24HS in 80 assessments (40 participants)



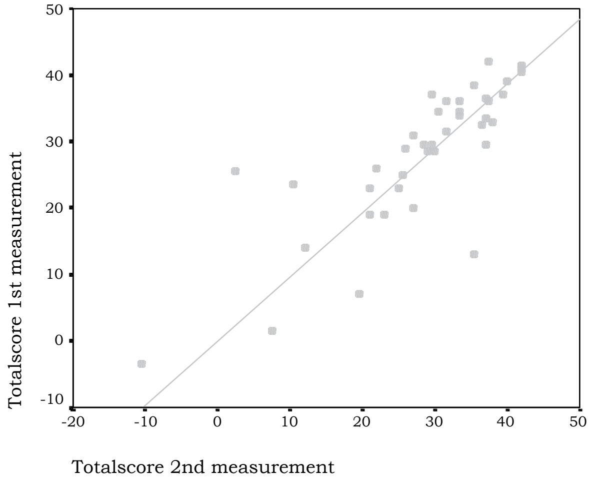
Discussion

Little is known about the relationship between low back pain and physical activity, including posture [21]. To investigate this relationship, reliable and valid instruments are needed. In the literature, multiple instruments have been described, which are able to give an insight into the physical activity and use of the back. These instruments appear to have a low reliability, such as a questionnaire, [22] or are complicated (e.g., the use of a force plate) [23]. But most often, they are invasive and therefore only applicable in laboratory circumstances, such as measurement of electromyographic activity [24] or in vivo measurement of the intradiscal pressure [14,25,26]. With the 24HS, we believe it is possible to achieve insight into the 24 hour physical activity (i.e. flexed or lordotic posture and applied load) of the back in a simple manner. In the literature, no valid instrument has been found which is able to gain insight into the use of the back in a similar manner.

Before instruments like the 24HS are introduced for use in daily practice, their reliability and validity should be assessed. Because of the absence of a gold standard to assess criterion validity of the 24HS, we chose to start validity testing of the 24HS with assessing the inter-observer reliability. Further reliability and validity testing will be performed in the future. The present study focused only on the interobserver reliability of the 24HS. Because the 24HS is meant to be used in patients with low back pain, the 24HS was tested on patients and not on healthy volunteers. The examiners were all professionals (physiotherapists, manual therapists) working with this group of patients on a regular basis.

The 24HS is used to gain insight into the physical activity (i.e. flexed or lordotic posture and applied load) of the back and is also easy to implement in general practice. Consequently, some

Figure 3. Comparing scores of 1st and 2nd measurement



compromises have been made. The procedure of the 24HS includes a standardised interview. It theoretically may occur that a registered posture is not according to the actual posture of the patient. This could be caused by misinterpretation from the received information by the examiner or invalid information given by the patient.

To avoid complexity of the 24HS, only activities which are continued for over 30 minutes are registered. Activities which involve frequently alternating postures in the sagittal plane (e.g., most sports activities or light household activities) are registered as neutral. We assumed that during these activities the total time in a flexed posture equals the total time in a lordotic posture. In addition, by using the 24HS, no quantification of the degree of flexion or extension is possible. The posture is lordotic or flexed irrespective of the exact angle or degree.

It is unusual to use time as a parameter for applied load. The 24HS measures the daily time and intensity in which a posture of the back is used. In fact, the 24HS measures the training intensity of that posture. The musculoskeletal adaptation can be seen as a consequence of training. In this perspective, time is seen as the appropriate parameter.

Probably the 24HS would be more accurate if the scores of the used categories of load were registered separately. In practice, this is more complex and the results are less illustrative for the patient.

The potential advantages of this instrument are diverse. The 24HS makes it possible to define the load applied on the back during an average day. By definition, we included the probable load during work-related activities, in leisure time activities, and sleep. The 24HS instrument is non-invasive and easy to apply. The procedure of the 24HS is easy to learn, and the time required for the total evaluation is about 15 minutes; therefore, the relative costs are low, making the instrument suitable for implementation in general practice.

In our study group, there appeared to be an enormous difference between the use of the back in a flexed position and a lordotic position (31.9 versus 3.7 schedule hours). A flexed or a lordotic posture will affect the musculoskeletal system of the lumbar spine in a different way [17,27,28]. From a physiological point of view, the back will adjust to the dominant type of load by a musculoskeletal modification. With a long-time intensive use of the back in a flexed posture, it is likely that the back will become well adapted for operating in this posture [11,29]. Considering the almost complete absence in our study population of structural lordotic activity, a regression of the quality of the musculoskeletal system that is involved in a lordotic posture can be expected [11,29]. In this situation, it is likely that the impact of what are considered to be normal lordotic activities could easily lead to complaints [10]. In the literature, several studies support this suggested relation between (sudden) lordotic activity and the occurrence of acute low back pain [23,30,31].

Further studies on the 24HS are recommended to determine the validity of the 24HS and, for example, whether the 24HS has a predictive value for the occurrence of acute low back pain.

Conclusion

The 24HS is a non-invasive instrument with which it is possible to achieve insight into the daily use of the back in a simple way. The interobserver reliability of the 24HS appeared to be high.

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References

1. Van Tulder MW, Koes BW, Bouter LM. A cost-of-illness study of back pain in The Netherlands. Pain. 1995;62(2):233-40
2. McCormick A, Fleming D, Charlton J. Morbidity statistics from general practice. Fourth national study 1991-1992. Office of Population Censuses and Surveys. London: HMSO; 1995. Series MB5 No 3
3. Faas A, Chavannes AW, Koes BW, Van den Hoogen JMM, Mens JMA, Smeele LJM. NHG-standaard lage rugpijn. Huisarts Wet. 1996;39:18-31 (in Dutch)
4. Waddell G. A new clinical model for the treatment of low-back pain. Spine. 1987;12(7):632-44
5. Croft PR, Macfarlane GJ, Papageorgiou AC, Thomas E, Silman AJ. Outcome of low-back pain in general practice: a prospective study. BMJ. 1998;316(7141):1356-9
6. Croft PR, Papageorgiou A, McNally R. In: Low-back pain, Radcliffe Medical Press, Oxford (UK) 1997:93-162
7. Murphy PL, Volinn E. Is occupational low back pain on the rise? Spine. 1999;24(7):691-7
8. Hoogendoorn WE, van Poppel MN, Bongers PM, Koes BW, Bouter LM. Physical load during work and leisure time as risk factors for back pain. Scand J Work Environ Health. 1999;25(5):387-403
9. Andersson GB. The epidemiology of spinal disorders. In: Frymoyer JW, Ducker TB eds. The Adult Spine: Principles and Practice. 2nd ed. Philadelphia: Lippincott–Raven; 1997:93-141
10. Porterfield JA, DeRosa C. Mechanical low back pain: perspectives in functional anatomy. WB Saunders Com. 2nd ed. 1998;1-22
11. Conroy BP, Earle RW. Bone, muscle and connective tissue adaptations to physical activity. In: T.R. Baechle and R. Earle, Editors, Essentials of strength training and conditioning/National Strength Conditioning Association (2nd ed.), Human Kinetics, Champaign (IL) 2000:57-72
12. Nachemson A, Morris JM. In vivo measurements of intradiscal pressure. Discometry, a method for the determination of pressure in the lower lumbar discs. J Bone Joint Surg Am. 1964;46:1077-92
13. Pettersson U, Nordström P, Lorentzon R. A comparison of bone mineral density and muscle strength in young male adults with different exercise level. Calcif Tissue Int. 1999;64(6):490-8
14. Wilke HJ, Neef P, Caimi M, Hoogland T, Claes LE. New in vivo measurements of pressures in the intervertebral disc in daily life. Spine. 1999;24(8):755-62
15. Jeaschke R, Singer J, Guyatt GH. A comparison of seven-point and visual analogue scales. Control Clin Trials. 1990;11(1):43-51
16. Vandenborne K, Elliott MA, Walter GA, Abdus S, Okereke E, Shaffer M, Tahernia D, Esterhai JL. Longitudinal study of skeletal muscle adaptations during immobilization and rehabilitation. Muscle Nerve. 1998;21(8):1006-12
17. Adams MA, Hutton WC. The effect of posture on the lumbar spine. J Bone Joint Surg Br.1985;67(4):625-9
18. Jadad AR, Moore RA, Carroll D, Jenkinson C, Reynolds DJ, Gavaghan DJ, McQuay HJ. Assessing the quality of reports of randomized clinical trials: is blinding necessary? Control Clin Trials. 1996;17(1):1-12
19. Verhagen AP, de Vet HC, de Bie RA, Kessels AG, Boers M, Knipschild PG. Balneotherapy and quality assessment: interobserver reliability of the Maastricht criteria list and the need for blinded quality assessment. J Clin Epidemiol. 1998;51(4):335-41
20. Von Korff M, Saunders K. The course of back pain in primary care. Spine. 1996;21(24):2833-9
21. Keen S, Dowell AC, Hurst K, Klaber Moffett JA, Tovey P, Williams R. Individuals with low back pain: how do they view physical activity? Fam Pract. 1999;16(1):39-45
22. Burdorf A, Laan J. Comparison of methods for the assessment of postural load on the back. Scand J Work Environ Health. 1991;17(6):425-9
23. Mannion AF, Adams MA, Dolan P. Sudden and unexpected loading generates high forces on the lumbar spine. Spine. 2000;25(7):842-52
24. Dolan P, Earley M, Adams MA. Bending and compressive stresses acting on the lumbar spine during lifting activities. J Biomech. 1994;27(10):1237-48
25. Ledet EH, Sachs BL, Brunski JB, Gatto CE, Donzelli PS. Real-time in vivo loading in the lumbar spine: part 1. Interbody implant: load cell design and preliminary results. Spine. 2000;25(20):2595-600
26. Sato K, Kikuchi S, Yonezawa T. In vivo intradiscal pressure measurement in healthy individuals and in patients with ongoing back problems. Spine. 1999;24(23):2468-74

27. Adams MA, Dolan P, Hutton WC. The lumbar spine in backward bending. Spine. 1988;13(9):1019-26
28. Dolan P, Adams MA, Hutton WC. Commonly adopted postures and their effect on the lumbar spine. Spine. 1988;13(2):197-201
29. Arnheim DD. Modern principles of athletic training, C.V. Mosby, St. Louis. 1985
30. McGill SM. Distribution of tissue loads in the low back during a variety of daily and rehabilitation tasks. J Rehabil Res Dev. 1997;34:448-58
31. Adams MA, Mannion AF, Dolan P. Personal risk factors for first-time low back pain. Spine. 1999;24(23):2497-505

CHAPTER 4

Daily spinal mechanical loading as a risk factor for acute non-specific low back pain. A case-control study using the 24 Hour Schedule

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Abstract

Study design. Case-control study

Objective. To assess the daily loading of the spine as a risk factor for acute non-specific low back pain (acute LBP).

Summary of Background Data. Acute LBP is a benign, self-limiting disease, with a recovery rate of 80-90% within six weeks irrespective treatment type. Unfortunately, recurrence rates are high. Therefore, prevention of acute LBP could be beneficial. The 24 Hour Schedule (24HS) is a questionnaire developed to quantify physical spinal loading, which is regarded as a potential and modifiable risk factor for acute and recurrent low-back pain.

Methods. 100 cases with acute LBP and 100 controls from a primary care setting were included. Cases and controls completed questionnaires regarding acute LBP status and potential risk factors. Trained examiners blinded to subjects' disease status (acute LBP or not) assessed spinal loading using the 24HS.

Results. The mean difference of 24HS sum-scores between groups was statistically significant ($p<0.0001$). After multivariate regression analysis, previous episode(s), the 24HS, and the Nottingham Health Profile were associated with the presence of acute LBP.

Conclusion. High 24HS scores, indicating longer and more intensive spinal loading in flexed position, are strongly associated with acute LBP.

Introduction

In the Netherlands, 15% of the total working-age population currently claim disability insurance [1]. Each year, low back pain accounts for 13% of all new cases [2]. Despite this burden for patient and society, a clear aetiology of low back pain is unknown. About 85% of the cases with low back pain are labelled as non-specific, i.e. not attributed to recognisable pathology [3]. Acute non-specific low back pain (acute LBP) is considered a benign self-limiting disease, with a recovery rate of 80–90% within 6 weeks in the open population, irrespective of the type of management or treatment [4]. Nevertheless, recurrence rates are reported as high as 50% in the following 12 months [5]. Prevention might be beneficial in the management of acute LBP. For prevention, knowledge of the risk factors is essential, but in general these are poorly understood [6]. Nonetheless, there are indications that physical activities, i.e. manual material handling, bending, twisting (heavy load) and whole-body vibration, are possibly risk factors for acute LBP [7,8,9]. Quantification of mechanical load, posture and spinal load applied could be useful to identify the physical risk factors. For this purpose, the 24 Hour Schedule (24HS) was developed [10]. The 24HS is a one-dimensional questionnaire measuring spinal mechanical load in the subject at issue. The 24HS has face and content validity, and the interobserver reliability was shown to be high [10].

The purpose of this study was to investigate the 24HS scores as potential independent risk factor for acute LBP.

Methods

Study population. Forty general practitioners in the city of The Hague, The Netherlands, referred patients diagnosed with acute (i.e. an episode lasting less than 6 weeks) non-specific low back pain (acute LBP) to one of the assessors in one of the four local research centres. Patients were eligible for inclusion if an assessor confirmed the 'diagnosis' (acute LBP) and the presence of exclusion criteria were excluded. Exclusion criteria were: insufficient understanding of the Dutch language, previous episode(s) of acute LBP in the past 12 months, low back pain after a recent trauma, pregnancy, spinal surgery and known pathology suspicious for/or specific low back pain. Definitions used in this study are in accordance with the Dutch Guideline for General Practitioners 'Low Back Pain' and internationally accepted [3].

For every case, a subject for the control group was recruited, having a pain-free and unlimited function of the back for a period of at least 12 months. The first new patient with any condition who entered a research centre for physical therapy (ergo after inclusion of a case) was in principle eligible as a control. Exclusion criteria were: insufficient understanding of the Dutch language, pregnancy, complaints of the spine, i.e. pain or stiffness in rest or during activities, and a previous assessment in this study. For all subjects, participation in the study was strictly on a voluntary basis.

Assessment. All 18 assessors were physiotherapists trained in using the 24HS. An assessor performed the inclusion procedure, in which all subjects signed informed consent and were coded to remain anonymous. Questionnaires focusing on subjects' history, demographical data and known risk factors (i.e. heavy load, whole-body vibration, gender, age, bodyweight [11], smoking habits, length [12] and previous episode(s) of low back pain—hereafter called previous episode(s) [13]) were completed. Scoring of previous episode(s), whole-body vibration, heavy load and smoking was dichotomised into present (subject indicated having experienced the risk factor) or not present (subject did not indicate having the risk factor). If relevant, the period (in years) between the last episode of low back pain and the assessment was registered: the pain-free interval. The generic health-related quality of life measure, Nottingham Health Profile (NHP) - Dutch version [14], was used for the measurement of psychosocial risk factors [15]. The scores of the six domains of the NHP I and II were summed (range 0–7). The spinal pain intensity was measured with an 11-point Numeric Rating Scale (NRS) [16]. Subjects were asked to choose one of the available categories: 'sitting', 'standing', 'walking', 'variable', or 'heavy physical' to represent their most important physical activity during daily occupation or profession.

A second assessor, uninformed of subject's status (i.e. being a case or a control subject), exclusively performed the 24HS measurement. This assessor systematically asked the subjects to describe their daily activities. In each activity, the position of the back in the sagittal plane (i.e. flexed or extended), the load applied and the duration were listed chronologically on the standardised registration form (see Addendum). For 'load applied' three categories were available: (1) no load applied (e.g. lying), (2) loaded (e.g. sitting) and (3) loaded with movement (e.g. digging). After completing the registration, subject's flexed-posture score was first calculated. For each activity, the duration was multiplied by the weight of the category the activity was scored in and all obtained scores were added up. The weight of the categories, based on Nachemsons' findings [17], was set to 1:2:3 [10]. For example, an activity scored 5 hours in the second category on the registration form becomes 10 hours when recalculated to the first category. An activity scored 5 hours in the third category will be recalculated to 15 hours in the first category. The resulting figure represents the time the back was loaded in a flexed posture with a load of the first category. The parameter we called schedule hours ranges from 0 to 72. Subsequently, this procedure was repeated for the extended posture (range 0–72). The sum-score was obtained by subtracting the total time of the extended postures from the total time of the flexed postures. The resulting figure gives insight into the dominant use (the training activity) of the back (range − 72 schedule hours to + 72 schedule hours). Negative sum-scores point to an overall spinal use in extended postures and positive sum-scores indicate an overall spinal use in flexed postures.

During the assessment, subjects were asked explicitly not to inform the assessor about their role in the study. Subsequently, for the cases, their first assessor explained the outcome of the assessment and summarised this in an information brochure named 'About Your Back'. Controls received no additional information. The total time required for the assessment was 30 minutes.

In this study, the dependent variable was the presence of acute LBP. The independent variables were the 24HS sum-scores and the following risk factors for acute LBP: gender, age, weight, length, smoking, whole-body vibration, heavy load, previous episode(s) and the NHP.

Analysis. The odds ratio (OR) was used to express the association between the dependent and the independent variables. For the association between the dependent variable (acute LBP or not) and the mean 24HS sum-scores, an OR of 1.5 was considered clinically relevant. Power analysis indicated that (using an alpha of 0.05 and a power of 0.80) 200 participants (100 cases and 100 controls) would be sufficient to detect such difference with statistical significance.

After blinded, double data entry, all analyses were carried out using SPSS 11.0. First, frequencies of risk factors are presented with their mean and standard deviation (SD). In case of skewed distributions, median and interquartile range (IQR) were used. Next, groups were compared using the Independent Samples T Test or, in case of skewed distributions, the non-parametric Mann–Whitney U Test. A logistic regression analysis was used for calculating the associations between the presence of acute LBP and the independent variables. After a univariate regression analysis, a multivariate logistic regression model (backward Wald) was run on the independent variables that showed a relation to the presence of acute LBP. Threshold for entry of independent variables in the multivariate model was $P < 0.05$ and for removal $P > 0.1$ [18]. The Nagelkerke R^2 was used to assess the explained variance of the model.

The procedures followed were approved by the Medical Ethics Committee of the Erasmus Medical Centre (Rotterdam, The Netherlands), in accordance with the Research Code of the Academic Medical Centre (Amsterdam, The Netherlands).

Results

From October 2003 to October 2004 a total of 100 cases and 100 controls were included. The characteristics of the study population are presented in Table 1.

Table 1. Characteristics of the Study Population (n = 200)

Baseline characteristics	Case	Control
Male	52/100	58/100
Age (range, SD)	40.7 (15-82, 13.5)	39.8 (18-76, 13.5)
Weight in kg. (range, SD)	75.2 (45-115, 14.5)	74.4 (47-108, 13.3)
Length in cm. (range, SD)	176.2 (152-200, 10.6)	175.4 (154-200, 10.0)
Whole-body vibration	8/100	5/100
Heavy load	35/100	22/100
Smoking	34/100	18/100
Previous episode(s) of low back pain	70/100	39/100
Pain Free Interval (median, range)	2(.5-25)	3 (0-30)
Pain NRS, (median, range)	6 (0-10)	0 (0-1)
Pain radiating in one or both legs	35/100	0/100
NHP Sum Score (mean, SD)	2.88 (2.2)	1.15 (1.6)
24HS Flexed Postures (mean, SD)	35.2 schedule hours (SD 5.5)	21.1 schedule hours (SD 5.8)
24HS Extended Postures (median, IQR)	0 schedule hours (0–0 schedule hours)	10 schedule hours (4.5–14 schedule hours)
24HS Sum-Score (mean, SD)	34.4 (8.2)	11.4 (9.7)

The controls were recruited from patients who were newly referred for physical therapy. The majority (*n* = 54) of controls had a complaint in the lower limb, and 16 were referred with shoulder problems. More serious pathology occurred in eight controls (i.e. fracture in four, postoperative in three and both in one). No specified complaints occurred in 12, and missing values in 10 controls.

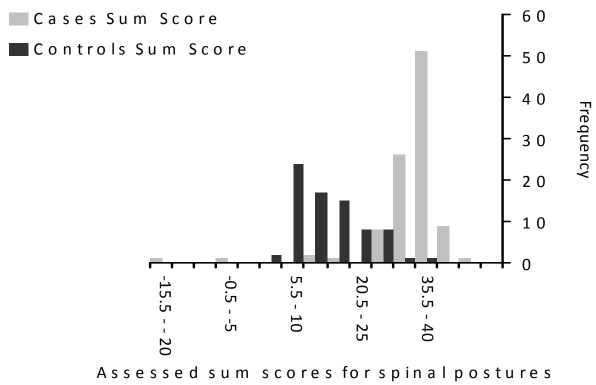
Two subjects in the case group indicated no pain during the assessment and in contrast, 28 scored NRS ≥ 8 of which two indicated the maximum pain score. Two cases and six controls did not fulfil the inclusion criteria completely. Four subjects (two cases and two controls) experienced low back pain in the previous 12 months and four controls reported minor low back pain (NRS = 1) during the assessment. Retrospectively, confronted with these incorrect included subjects we decided to analyse all included subjects.

For daily occupation or while-at-work, 57 cases (mean score 34.7 schedule hours) and 56 controls (mean score 10.3 Schedule hours) were 'sitting'. 'Variable work' occurred in 28 cases (mean score 32.1 schedule hours) and 32 controls (mean score 12.0 schedule hours), 'heavy physical' indicating daily heavy loading of the spine in 35 cases (mean score 36.4 schedule hours) and 22 controls (mean score 14.3 schedule hours). There was no statically significant association between the outcome, the presence of acute LBP and the categories representing subjects' most significant physical activity during their daily occupation or profession. Also, there was no statistically significant difference in median years that controls and cases performed their daily activities preceding the moment of assessment; here the values from 11 controls and 12 cases were missing. Three cases indicated an unrestricted spinal function, while they were experiencing low back pain, of which one indicated NRS = 7.

Assessed postures. Flexed postures were registered in all 200 assessments. The mean difference of 14.1 schedule hours between cases and controls was statistically significant ($P < 0.0001$). No extended postures were measured in 9 controls and 88 cases. The difference between the groups was statistically significant ($P < 0.0001$).

Sum-scores. In the case group, two negative sum-scores were assessed, while the other cases scored 14 Schedule hours or more. Twelve negative sum-scores were found in the control group, see Figure 1. The mean difference in sum-scores (23.0 schedule hours) between cases and controls was statistically significant ($P < 0.0001$).

Figure 1. Assessed Sum-Scores



Risk factors for low back pain. First, a univariate regression analysis was performed including the ten potentially relevant independent variables: gender, age, weight, length, whole-body vibration, heavy loading, smoking, previous episode(s), NHP and 24HS sum-scores. Of these, the 24HS sum-scores, NHP, previous episode(s), heavy loading and smoking were univariate significantly related to the outcome, the presence of acute LBP. After a multivariate regression analysis, the 24HS sum-scores as well as the previous episode(s) and the NHP scores remained significantly associated with acute LBP. Table 2 presents the results of the univariate and multivariate analyses.

The OR for previous episode(s) is 5.55. The other predictors (NHP and 24HS) are continuous values. Consequently, the OR for acute LBP increases by a factor of 1.26 for every additional 24HS score and 2.40 for every additional NHP score. Therefore, the smallest association was for the NHP scores and acute LBP, and the strongest association for 24HS scores and acute LBP, as shown in Table 3.

The percentage of the total log likelihood for LBP explained by the significant independent variables (i.e. 24HS sum-scores, previous episode(s) and NHP) amounted 78.7% (Nagelkerke R^2).

Table 2. Results of Regression Analysis

Predictors	Exp B, Univariate (95% CI)	Exp B, Multivariate (95% CI)
Gender	.784 (.45-1.37)	–
Age	1.01 (.96-1.03)	–
Weight	1.00 (.98-1.02)	–
Length	1.01 (.98-1.04)	–
Whole-body vibration	1.65 (.52-5.24)	–
Heavy loading	1.91 (1.02-3.57)	.69 (.09-5.3)
Smoking	2.35 (1.21-4.53)	3.08 (.43-22.06)
Previous Episodes	3.65 (2.03-6.66)	5.55 (1.72-17.87)*
Nottingham Health Profile	1.60 (1.34-1.92)	2.40 (1.33-4.30)*
24HS Sum Score	1.25 (1.18-1.33)	1.26 (1.14-1.38)*

*– = Variable not taken into multivariate analysis ($p > 0.1$) * = variable statistically significant in multivariate analysis. Predictors for acute LBP expressed in exponent β (OR) with their 95% confidence interval, in univariate and multivariate analysis*

A subgroup analysis was performed in the group of subjects with a previous episode of acute LBP evaluating the pain-free interval. Only in the univariate model was the influence of the pain-free interval significantly associated with acute LBP. However, this association was not statistically significant in the multivariate model (OR 0.95, 95% CI 0.85–1.07).

Table 3. Progress of the OR for acute LBP in successive 24HS and NHP scores

Subjects 24HS score (Schedule hours)	Related OR for LBP (95% CI)	Subjects NHP score	Related OR for LBP (95% CI)
1	1.3 (1.2 - 1.3)	1	1.4 (1.0 - 1.9)
10	9.1 (5.0 - 16.7)	1.7*	1.8 (1.1 - 3.0)
23*	161 (40 - 652)	3	2.7 (1.1 - 6.7)

** mean difference*

Discussion

High 24HS scores were strongly associated with acute LBP in this study. The odds for having acute LBP are 1.26 to 1, and increase by this factor for every additional schedule hour. The few and mostly small extended scores of the cases could explain this high association. In a previous reliability study the difference between the flexed and extended scores was also substantial [10]. Although the study population differs, these findings are consistent with the results in the present study.

In view of the assessed association, we have to bear in mind the following limitations. Results of 'case–control studies' are likely to be overestimated [19]. Bias is expected using retrospective data for subjects' description of 'an average day'. The reproducibility of the 24HS was high [10]. Nevertheless, the accuracy of the assessor will determine the results. A questionnaire was used to quantify the mechanical load of the back. The results might be different when using more quantitative measuring methods. Therefore, the obtained scores are considered a conscientious indication of the mechanical load.

Hypothetically, serious pathology in the control group and severe acute LBP in the case group could possibly reveal an indication of the subject's disease status to assessors. Initially, we did not recognise that this could endanger blinding and possibly bias the results. For this reason, we did not collect any data indicating that the assessor was aware of the subjects' status (case or control). Theoretically, blinding could have been insufficient in 36/200 (18%) of the assessments. Nevertheless, the association between 24HS scores and the presence of acute LBP seems substantial. Of course, this finding needs replication in other studies and populations. If high 24HS scores are indeed associated with acute LBP, this may be a target for preventive measures [10]. Whether these measures (i.e. focusing on the reduction of flexed postures in patients) are effective or not needs to be investigated in controlled studies.

Psychosocial risk factors were measured with the generic health-related quality of life measure (NHP). To avoid bias, controls were recruited from patients with a variety of other complaints. Thus, the contrast between cases and controls was minimised in all aspects. The association between acute LBP and 24HS, NHP and other risk factors could be higher if more 'extreme groups' were included in this study. Previous episodes were associated with acute LBP, but a long pain-free interval is probably a protective factor for recurrences.

A flexed and an extended position will affect the musculoskeletal system of the lumbar spine in different ways [20,21,22]. From the physiological point of view, the musculoskeletal system of the spine weakens from overuse or disuse [23]. In our study population, cases indicated an intensive use of the back in a flexed position. It seems plausible that the musculoskeletal system of the back, in the flexed position, might constitute overuse, causing acute LBP. Then cases also indicated an absence of use in an extended position. Thus, disuse of the musculoskeletal system of the back involved in an extended position is also a plausible explanation for acute LBP. In the literature, several studies support this suggested relation between (sudden) lordotic activity and the occurrence of low back pain [24,25,26].

There was no statically significant association between the presence of acute LBP and the categories representing subjects' most important physical activity during their daily occupation or profession. As for 'sitting', Hartvigsen et al. [27] concluded that sitting-while-at-work is not associated with low back pain. Our findings are consistent with that conclusion. Sitting-while-at-work or daily occupation occurred in 57 cases (mean score 34.7 schedule hours) and 56 controls (mean score 10.3 schedule hours). Apparently, the controls modified their 24HS sum-score by common daily activities, e.g. through sleeping posture, sport, leisure time or a maintained lordotic posture of the lumbar spine during sitting. Consequently, sitting-while-at-work as potential risk factor for acute LBP cannot be regarded independently of other daily activities.

Considering the difference between cases and controls in 24HS sum-scores, the value of isolated physical risk factors could be limited due to the weight of common daily activities on spinal load, when identifying mechanical load as risk for low back pain. Therefore, we suggest involving all daily physical activities when exploring mechanical load as a risk factor in low back pain.

When present in other studies, the association between smoking and low back pain is expected to be weak and clearly apparent only in large study samples [28]. Not including smoking as a risk factor in the multivariate analysis is most likely due to the sample size.

The above mentioned risk factors for acute LBP could also have value as prognostic factor for recurrent or chronic low back pain. This should, however, be evaluated in a further prognostic study.

Generalisability. The cases were recruited from subjects consulting their general practitioner for acute LBP. Due to the inclusion criteria and definitions, as described in the Dutch Guideline for General Practitioners [3], the subjects represented a good reflection of the source population in primary care. To improve understanding in the risk factors for acute LBP, a 'first-time-ever' population could be ideal. We also considered patients with a pain-free and unlimited function of the back, for at least 1 year, eligible to enter the study. Subjects with recent exacerbations and/or chronic low back pain were excluded. In this manner, bias of the potential prognostic factors on the development of acute LBP was avoided. Finally, no matching was applied for the selection of cases and controls. Instead, logistic regression was used to assess the influence of potential risk factors on the presence of acute LBP.

Conclusion

High 24HS scores, indicating increased daily loading of the spine in flexed position, was associated with the presence of acute LBP in this study. This finding warrants further study of its use identifying the physical risk factors for acute LBP, which might enable preventive strategies to be developed.

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The procedures followed in this study were approved by the Medical Ethics Committee of the Erasmus Medical Centre (Rotterdam, The Netherlands), and in accordance with the Research Code of the Academic Medical Centre, (Amsterdam, The Netherlands).

References

1. Netherlands Economic Illusions (2004) May 2nd 2002 survey: the economist print edition. http://www.economist.com/printedition/displayStory.cfm?Story_ID=1098153. Accessed November 11, 2004
2. Ziektediagnosen bij uitkeringen voor arbeidsongeschiktheid: statistische informatie over medische classificaties in WAO, WAZ en Wajong 1999. Lisv 2001, Amsterdam, Lisv; 10. Available at: http://www.uwv.nl/Images/Ziektediagnosen%20bij%20AO%202002_tcm3–1739.pdf. Accessed November 3, 2004
3. Faas A, Chavannes AW, Koes BW, Van den Hoogen JMM, Mens JMA, Smeele LJM. NHG-standaard lage rugpijn. Huisarts Wet. 1996;39:18-31 (in Dutch)
4. Waddell G. A new clinical model for the treatment of low-back pain. Spine. 1987;12(7):632-44
5. Croft PR, Papageorgiou A, McNally R. In: Low-back pain, Radcliffe Medical Press, Oxford (UK) 1997:93-162
6. Andersson GB. The epidemiology of spinal disorders. In: Frymoyer JW, Ducker TB eds. The Adult Spine: Principles and Practice. 2nd ed. Philadelphia: Lippincott–Raven; 1997:93-141
7. Hartvigsen J, Bakketeig LS, Leboeuf-Yde C, Engberg M, Lauritzen T. The association between physical workload and low back pain clouded by the “healthy worker” effect: population-based cross-sectional and 5-year prospective questionnaire study. Spine. 2001;26(16):1788-93
8. Hoogendoorn WE, van Poppel MN, Bongers PM, Koes BW, Bouter LM. Physical load during work and leisure time as risk factors for back pain. Scand J Work Environ Health. 1999;25(5):387-403
9. Lings S, Leboeuf-Yde C. Whole-body vibration and low back pain: a systematic, critical review of the epidemiological literature 1992-1999. Int Arch Occup Environ Health. 2000;73(5):290-7
10. Bakker EW, Koning HJ, Verhagen AP, Koes BW. Interobserver reliability of the 24 hour schedule in patients with low back pain: a questionnaire measuring the daily use and loading of the spine. J Manipulative Physiol Ther. 2003;26(4):226-32
11. Heliövaara M. Risk factors for low back pain and sciatica. Ann Med. 1989;21(4):257-64
12. Feldman DE, Shrier I, Rossignol M, Abenhaim L. Risk factors for the development of low back pain in adolescence. Am J Epidemiol. 2001;154(1):30-6
13. Croft PR, Macfarlane GJ, Papageorgiou AC, Thomas E, Silman AJ. Outcome of low back pain in general practice: a prospective study. BMJ. 1998;316(7141):1356-9
14. Erdman RA, Passchier J, Kooijman M, Stronks DL. The Dutch version of the Nottingham Health Profile: investigations of psychometric aspects. Psychol Rep. 1993;72(3 Pt 1):1027-35
15. Linton SJ. Psychological risk factors for neck and back pain. In: Nachemson A, Jonsson E (eds) Neck and back pain: the scientific evidence of causes, diagnosis, and treatment. Lippincott Williams & Wilkins, Philadelphia 2000:57–78
16. Jaeschke R, Singer J, Guyatt GH. A comparison of seven-point and visual analogue scales. Data from a randomized trial. Control Clin Trials. 1990;11(1):43-51
17. Nachemson A. Towards a better understanding of low-back pain: a review of the mechanics of the lumbar disc. Rheumatol Rehabil. 1975;14(3):129-43
18. Altman DG. Relation between several variables. In: Altman DG (ed) Practical statistics for medical research. Chapman & Hall/CRC, Boca Raton 1997:325-61
19. Lijmer JG, Mol BW, Heisterkamp S, Bonsel GJ, Prins MH, van der Meulen JH, Bossuyt PM. Empirical evidence of design-related bias in studies of diagnostic tests. JAMA. 1999;282(11):1061-6
20. Adams MA, Hutton WC. The effect of posture on the lumbar spine. J Bone Joint Surg Br. 1985;67(4):625-9
21. Adams MA, Dolan P, Hutton WC. The lumbar spine in backward bending. Spine. 1988;13(9):1019-26
22. Dolan P, Adams MA, Hutton WC. Commonly adopted postures and their effect on the lumbar spine. Spine. 1988;13(2):197-201
23. Porterfield JA, DeRosa C. Mechanical low back pain: perspectives in functional anatomy, 2nd edn. WB Saunders, Philadelphia 1998:1–22
24. Adams MA, Mannion AF, Dolan P. Personal risk factors for first-time low back pain. Spine. 1999;24(23):2497-505
25. Mannion AF, Adams MA, Dolan P. Sudden and unexpected loading generates high forces on the lumbar spine. Spine. 2000;25(7):842-52

26. McGill SM. Distribution of tissue loads in the low back during a variety of daily and rehabilitation tasks. J Rehabil Res Dev. 1997;34(4):448-58
27. Hartvigsen J, Leboeuf-Yde C, Lings S, Corder EH. Is sitting-while-at-work associated with low back pain? A systematic, critical literature review. Scand J Public Health. 2000;28(3):230-9
28. Leboeuf-Yde C. Smoking and low back pain. A systematic literature review of 41 journal articles reporting 47 epidemiologic studies. Spine. 1999;24(14):1463-70

CHAPTER 5

Spinal mechanical load: a predictor of persistent low back pain? A prospective cohort study

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Abstract

Study Design. Prospective inception cohort

Objective. To assess the prognostic value of spinal mechanical load, assessed with the 24 Hour Schedule (24HS), in subjects with acute non-specific low back pain (acute LBP) and to examine the influence of spinal mechanical load on the course of acute LBP.

Summary of Background Data. In view of the characteristics of the natural course of ALBP, this should be viewed as a persistent condition in many patients rather that a benign self-limiting disease. Therefore, secondary prevention could be beneficial. Spinal mechanical load is a risk factor for acute LBP and possibly a (modifiable) prognostic factor for persistent (i.e. recurrent and/or chronic) LBP.

Methods. 100 patients from primary care with acute LBP were eligible for inclusion. At six months, 88 subjects completed the follow-up. For the follow-up assessment a research assistant, unaware of our interest in the prognostic factors, contacted subjects by telephone. Questionnaires were completed focusing on changes in demographical data and on the course and current status of acute LBP.

Results. Persistent LBP occurred in 60%. After multivariate regression analysis smoking (harmful) and advanced age (protective) were associated with persistent LBP. Differences in 24HS scores at baseline and follow-up were univariate related to persistent LBP.

Conclusion. Spinal mechanical load, quantified with the 24HS, is not a prognostic factor for persistent LBP. For secondary prevention, modification of spinal mechanical load in terms of 24HS scores could be beneficial for secondary prevention in patients with acute LBP.

Introduction

Low back pain (LBP) is a common condition. On any given day 12–33% of the people report some back pain [1]. It was suggested that acute LBP is a benign self-limiting disease with a recovery rate of 80–90% within 6 weeks irrespective of the management or type of treatment [2], but a recent systematic review did not find any evidence for this [3]. In view of the characteristics of the natural course, acute LBP should be viewed as a persistent condition in many patients [4]. In 1998, the direct costs of back pain were 0.19% and indirect cost between 0.12 and 0.58% of the United Kingdoms' Gross Domestic Product [5]. Secondary prevention, i.e. prevention of recurrent episodes, might be beneficial in the management of LBP. For secondary prevention, knowledge of the prognostic factors is essential. In the literature, prognostic factors for persistent LBP vary from measures of LBP itself, psychological indicators to socio-demographic factors [6]. In a previous study, spinal mechanical load quantified with the 24 Hour Schedule (24HS), was independently associated with the occurrence of acute non-specific LBP. Consequently, spinal mechanical load was regarded as a risk factor for LBP -[7].

The 24HS is a one-dimensional questionnaire developed for quantifying spinal mechanical load (posture and spinal load applied) in the subject at issue. The 24HS has face, content and construct validity and the inter-observer reliability was shown to be high [7,8].

The purpose of this prospective study was to assess the prognostic value of spinal mechanical load, quantified with the 24HS, for predicting persistent (i.e. recurrent and/or chronic) LBP in subjects with acute LBP, and to examine the influence of changes in spinal mechanical load, quantified with the 24HS, on the course of LBP.

Methods

Study population. An inception cohort was formed of subjects diagnosed with acute (i.e. an episode of LBP lasting less than 6 weeks) non-specific LBP [9]. Forty general practitioners (GP) in the city of The Hague, The Netherlands were asked to refer patients with LBP to one of the assessors in one of the four local research centres. Non-specific LBP was applicable if the anamnesis and physical examination ruled out specific pathologic ('red flag' conditions such as tumour, infection, or fracture), and sciatica/radicular syndrome. The physical examination includes localisation of the pain, the assessment of spinal movements, and Straight Leg Raising test [10,11]. Patients were eligible for inclusion if an assessor confirmed the 'diagnosis' LBP. Exclusion criteria were: insufficient understanding of the Dutch language, previous episode(s) of LBP in the past 12 months, LBP after a significant trauma, pregnancy, spinal surgery, and known pathology suspicious of specific LBP. Definitions used in this study are in accordance with the

Dutch Guideline for General Practitioners 'Low Back Pain' and internationally accepted [10,11].

Baseline assessment. All 18 assessors were physiotherapists. All subjects signed informed consent and were coded for anonymity. Questionnaires were completed focusing on subjects' demographic data and the following known prognostic factors: factors related to the episode of LBP: pain intensity at consultation [12], duration of symptoms (maximum 6 weeks), radiating leg pain (below the knee) [13], and restricted spinal movement [14]. The following prognostic factors present before the onset of the episode LBP were also listed: gender, age [15], previous episode(s) of LBP (longer than 12 months ago) [12], and smoking [13]. Social and psychological factors [16,17] were measured with the Nottingham Health Profile -Dutch Version- (NHP) [18] and the Acute Low Back Pain Screening Questionnaire, Dutch version (ALBSQ) [19]. (Un-) employment [13] and job satisfaction [20] were assessed separately.

Radiating leg pain, smoking, and unemployment were dichotomised as: YES if subjects indicated to experience the prognostic factor and NO if subjects indicated not to experience the prognostic factor. Pain intensity at consultation, job satisfaction, and restricted spinal movement were measured with an 11-point Numeric Rating Scale, where '0' indicates a minimum or poor and '10' a maximum or good score [21]. The scores of the six domains of the NHP I and II were summed (range 0 to 7). Finally, the 24HS was used for the assessment of spinal mechanical loading.

The procedure of the 24HS measurement. An assessor, trained in using the 24HS, systematically asked the subjects to describe their daily activities. Of each activity, the position of the back in the sagittal plane (i.e. flexed or extended), the load applied and the duration, were listed chronologically on the standardised registration form (see Addendum 'the 24HS registration form'). For 'load applied', the following three categories were available: (1) no load applied (e.g. lying), (2) loaded (e.g. sitting) and (3) loaded with movement (e.g. digging). After completing the registration, subject's flexed-posture score was calculated first. Of each activity, the duration was multiplied by the weight of the category the activity was scored in and all obtained scores were added up. The weight of the categories, based on Nachemsons' findings modified by Sato [22,23], was set to 1:2:3 [8]. For example, an activity scored 5 hours in the second category on the registration form, becomes 10 hours when recalculated to the first category. An activity scored 5 hours in the third category will be recalculated to 15 hours in the first category. The resulting figure represents the time the back was loaded in a flexed posture with a load of the first category. The parameter we called schedule hours ranges from 0 to 72. Subsequently, this procedure was repeated for the extended posture (range 0 to 72). The sum-score was obtained by subtracting the total time of the extended postures from the total time of the flexed postures. The resulting figure gives insight into the dominant use (the training activity) of the back (range −72 to +72 schedule hours). Negative sum-scores point to an overall spine use in extended and positive sum-scores indicates an overall spine use in flexed postures.

After baseline measurement, all subjects received guideline-based information [10,11], including reassuring the patient of a favourable prognosis, encouraging the patient to stay active and discouraging bed rest [24]. Finally, the outcome of the assessment was explained. All information was summarised in a brochure, which patients received. The total time required for the assessment was 30 minutes; including 10 minutes for guideline-based information, explanation and summarising.

Follow-up. After 6 months, a research assistant contacted subjects by telephone. This research assistant was trained in the assessment of the 24HS, but not how to interpret it. Furthermore, the assistant was unaware of our special interest in the prognostic factors assessed. In this manner we tried to achieve an objective, unbiased measurement. During this interview the subjects answered questions focusing on changes in the subjects' demographical data as work or daily occupation and possible pregnancy, the characteristics of the initial episode LBP (duration of the complaints, care seeking including receiving physical therapy [25]), and (if relevant) the characteristics of the recurrence episode(s). Finally, the subjects were asked for their opinion of the received 'hands-off' strategy for LBP, as advised in the Guideline for General Practitioners 'Low Back Pain' [10,11]. Subjects' opinion was measured with an 11-point Numeric Rating Scale [21]. The 24HS was assessed in order to quantify changes in spinal mechanical loading compared to the baseline measurement.

In this study, the primary dependent variable was persistent LBP. Persistent LBP was applicable if a subject experienced a recurrence episode(s) and/or subjects' episode of LBP was labelled chronic, i.e. subjects' episode lasted longer than 12 weeks [6]. Persistent LBP was dichotomised and was regarded positive if the subject did experience a recurrent episode and/or subject s' episode of LBP lasted longer than 12 weeks. If the subject did not experience a recurrent episode or subject s' episode of LBP did not last longer than 12 weeks, the variable persistent LBP was scored as NO. To determine if a subject had persistent LBP or not, the variables recurrence episode(s) and chronicity were separately assessed. These variables were also dichotomised; YES, if subject did experience a recurrent episode or subjects' episode LBP lasted longer than 12 weeks. NO, if subject did not experience a recurrent episode or subjects' episode LBP did not last longer than 12 weeks. The independent variables were the following prognostic factors: the 24HS sum scores, gender, age, previous episode(s) of LBP, smoking, NHP, ALBSQ, (un-) employment, job satisfaction, pain intensity at consultation, duration of symptoms of the baseline episode LBP, radiating leg pain, restricted spinal movement, and receiving physical therapy.

Sample size. The odds ratio (OR) was used to express the association between the dependent and the independent variables. For the association between the dependent variables and the mean 24HS sum-scores, an OR of 1.5 was considered clinically relevant. Power analysis indicated that (using an alpha of 0.05 and a power of 0.80 and an expected 15% dropout [26] 100 participants would be sufficient to detect such difference with statistical significance.

Analysis. A logistic regression analysis was used for calculating the associations between the dependent variables (persistent LBP, recurrence episode(s) or chronicity) and the independent variables. After a univariate regression analysis, a multivariate logistic regression (model Backward Wald) was run on the independent variables that showed a relation to persistent LBP, recurrence episode(s) or chronicity. Threshold for entry of independent variables in the multivariate model was $P < 0.05$ and for removal $P > 0.1$ [27]. The Nagelkerke R^2 was used to assess the explained variance of the model.

To assess the association between the dependent variable persistent LBP and the continue predictor changes in 24HS score (i.e. difference in baseline and follow-up 24HS scores), a univariate regression analysis was used.

After the blinded, double data entry, all analyses were carried out in SPSS 11.0. First, frequencies of risk factors are presented with their mean and standard deviation (SD). In case of skewed distributions median and Interquartile Range (IQR) were used. Differences between the groups completing the follow-up versus those lost-to-follow-up were compared using the Paired-Samples T Test or, in case of skewed distributions, the non-parametric Mann-Whitney U test.

The Medical Ethics Committee of the Erasmus Medical Centre (Rotterdam, The Netherlands) approved the study.

Results

Patients. One hundred subjects were eligible for entering the study of which three subjects were excluded. Two had a previous episode LBP in the past 12-months, and one had complaints lasting longer than 6 weeks. A total of 97 subjects were included. The median duration of LBP when included was 1 week (IQR 0–3 weeks). At 6 months, nine subjects dropped out, of which one did not want to participate, and two moved outside the Netherlands. We were not able to contact six subjects, resulting in 88 subjects completing the study. The baseline characteristics of all 97 subjects as well as subjects completing the 6-months follow-up and dropouts are shown in Table 1. The nine dropouts differ statistically significant from the subjects that completed the follow-up in: gender (more women), previous episode(s) (higher prevalence) and ALBPSQ scores (higher). Therefore, it is likely that this group is somewhat more at risk for persistent low back pain.

Table 1. Characteristics of the Study Population

Prognostic factors	'Baseline' N=97	'Lost-to-follow-up' N=9	'Follow-up' N=88
Male (%)	52/97 (54)	3/9 (33)	49/88 (56)
Age, mean (minimum–maximum, SD)	40.7 (15-82, 13.5)	37.4 (26-56, 9.4)	41 (15-82, 14)
Previous episode(s) LBP (%)	70/97 (72)	8/9 (88)	58/88 (67)
Smoking (%)	34/97 (35)	5/9 (56)	29/88 (33)
24HS sum-scores, mean (SD)	34.4 (8.2)	32.5 (9.0)	34.6 (8.1)
NHP sum-scores, mean (SD) Range: 0-7.	2.88 (2.2)	2.7 (1.7)	2.87 (2.3)
ALBPSQ, median (IQR). Range: 12-192	65 (42-84)	84 (46-94)	64 (42-78)
Unemployment (%)	7/97 (7)	1/9 (11)	6/88 (7)
Job satisfaction, mean (SD)	7.5 (2.5)	7 (2.9)	7.6 (2.5)
Pain NRS, median (minimum–maximum). Range: 0-10	6 (0-10)	6 (0-10)	5 (0-9)
Duration of symptoms in days, mean (SD)	11.7 (6.7)	11.3 (6.7)	11.8 (6.7)
Pain radiating in one or both legs (%)	35/97 (36)	4/9 (44)	31/88 (35)
Spinal movement, mean (SD)	6.3 (2.2)	6.1 (3.0)	6.5 (2.2)
As for daily occupation or while at work: 'Sitting'	57	5	52
As for daily occupation or while at work: 'Variable work'	27	2	25
As for daily occupation or while at work: 'Heavy spinal loading'	7	1	6
As for daily occupation or while at work: 'Other' ('Missing')	3 (3)	(1)	3 (2)

Column 'baseline' represents the characteristics of the entire study population, the columns 'lost-to-follow-up' and 'follow-up' represents the characteristics of the subject's who were 'lost-to-follow-up' and 'followed-up' separately.

Recurrent LBP. All recurrent episodes were labelled as non-specific LBP. Pregnancy did not occur in the group who completed the follow-up. In this group, recurrent episode(s) occurred in 37 (42%) subjects and 4 (5%) subjects had recurrent episode(s) lasting longer than 12 weeks (chronic). The median number of recurrent episode(s) was 1 (IQR 0–3). Thirty-five subjects (40%) reported no further complaints after the baseline LBP episode. As a result, the proportion persistent LBP in the group who completed the follow-up was 60% (see flow chart) Figure 1.

Changes in demographical data. A total of eight people (9%) changed work or daily occupation during the follow-up period, of which four (5%) became unemployed. Including the five subjects who were unemployed at baseline, the proportion of (un-) employed in the follow-up group was nine (10%).

Figure 1. Flow Chart

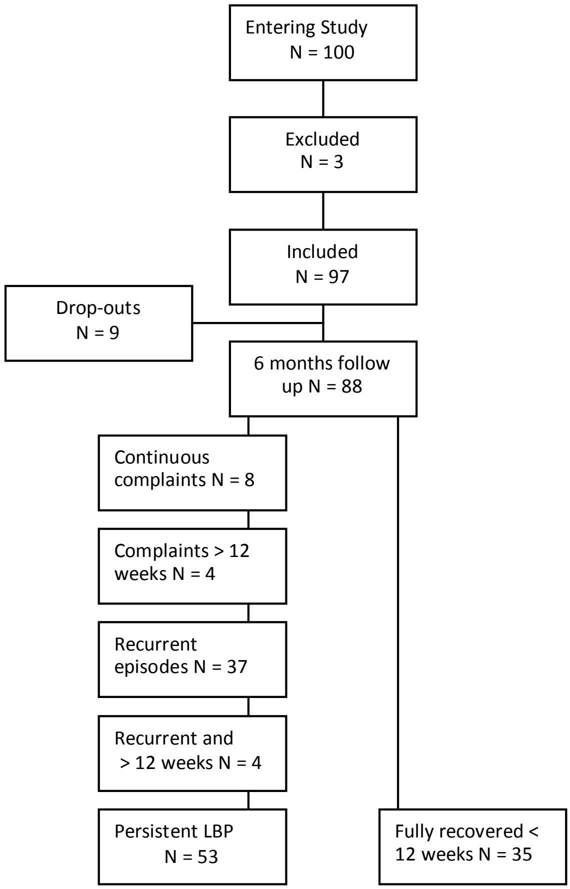


Table 2. Subjects' Care Seeking for Baseline and Recurrent LBP

	Baseline LBP N = 88	**Recurrent LBP* N = 41**
Consultation GP	• Once 7 (8 %) • Twice 3 (3 %)	• Once 8 (20 %)
Referral or Treatment GP	• Neurology 1 (1 %) • Orthopaedic 2 (2 %) • Other (no-medical) 6 (7 %)	• Other (no-medical) 6 (15 %) • Medication 1 (2 %)
Other Treatment	• No treatment 59 (67 %) • Physical therapy 14 (16 %) • Manual therapy 6 (7 %) • Other 5 (6 %) • Missing 4 (5 %)	• No treatment 38 (93 %) • Physical therapy 6 (15 %) • Manual therapy 1 (2 %) • Other 1 (2 %) • Missing 4 (10 %)

** Total number recurrent episodes (N = 37) and recurrent episodes lasting longer than 12 weeks (N = 4).*

Table 3. Results of Regression Analysis for 'Persistent LBP', 'Recurrent LBP' or 'Chronicity'

	Persistent LBP N = 53		**Recurrent LBP N = 37**		**Chronicity N = 16**	
Predictors	**Exp B, Univariate (95% CI)**	**Exp B, Multivariate (95% CI)**	**Exp B, Univariate (95% CI)**	**Exp B, Multivariate (95% CI)**	**Exp B, Univariate (95% CI)**	**Exp B, Multivariate (95% CI)**
24HS sum-scores	1.07* (.99-1.15)	1.05 (.97-1.14)	1.08 (.97-1.17)	1.08 (.98-1.18)	1.00 (.93-1.09)	-
Gender	1.61 (.68-3.82)	-	1.6 (.68-3.70)	-	1.13 (.33-3.89)	-
Age	.97 (.94-1.00)	.96* (.93-.99)	.97 (.94-.99)	.97 * (.94-99)	.99 (.96-1.04)	-
Previous episode(s) of LBP	1.37 (.55-3.37)	-	1.11 (.46-2.70)	-	2.76 (.56-13.50)	-
Smoking	3.71 (1.32-10.41)	4.41* (1.50-12.95)	2.08 (.84-5.16)	-	2.30 (.67-7.90)	-
NHP scores	1.06 (.87-1.29)	-	1.11 (.92-1.34)	-	.93 (.70-1.23)	-
ALBSQ scores	.99 (.97-1.01)	-	.99 (.98-1.01)	-	1.00 (.97-1.03)	-
(Un-) employment	2.04 (.51-8.21)	-	2.16 (.50-9.24)	-	1.3 (.15-1.38)	-
Job satisfaction	.89 (.75-1.08)	-	.92 (.77-1.09)	-	1.02 (.79-1.31)	-
Pain intensity at consultation	.97 (.80-1.18)	-	.98 (.81-1.18)	-	1.09 (.82-1.46)	-
Duration of symptoms	.99 (.94-1.06)	-	1.00 (.94-1.07)	-	1.01 (.92-1.11)	-
Radiating leg pain	.96 (.84-1.09)	-	.97 (.87-1.08)	-	.56 (.14-2.24)	-
Restricted spinal movement	.89 (.72-1.09)	-	.88 (.72-1.08)	-	1.02 (.77-1.36)	-
Physical therapy	2.04 (.65-6.37)		1.06 (.38-3.01)		3.24 (.89-11.84)	

*– = Variable not taken into multivariate analysis (p > 0.1) * = variable statistically significant in multivariate analysis*

Predictors for Persistent LBP, Recurrent LPB and Chronicity expressed in exponent B (OR) with their 95% confidence interval, in univariate and multivariate analysis.

The total number of GP-consultations reported in this study was 109, including the index consult. The proportion of GP-consultations per person was 1.2 (109/88). Eighteen (21%) subjects received physical therapy (unspecified) for baseline LBP or recurrent episodes. Subjects were highly satisfied with the 'hands-off' strategy for LBP (10 IQR 8–10) received.

Prognostic factors for persistent low back pain. First, a univariate regression analysis was performed on persistent LBP as dependent variable and the 14 (previously mentioned) potentially relevant independent variables. Of these, the 24HS sum-scores, smoking and age were univariate significantly related to persistent LBP. After a multivariate regression analysis, age and smoking remained significantly associated with the outcome. The OR for the dichotomised variable smoking was 4.4. The OR for persistent LBP increased by a factor 0.96 for every additional year of age. The explained variance of this model was 16.9% (Nagelkerke R^2).

Table 4. 24HS Mean Sum-Scores in schedule hours at Baseline and Six Months Follow-up

24HS Sum-Score at	Persistent LBP N = 53	No-Persistent LBP N = 35	Mean Difference	P
Baseline (SD)	36.1 (3.5)	32.6 (11.8)	3.5	.04*
Follow-up (SD)	5.4 (14.2)	-5.8 (11)	11.2	< 0.0001*
Change (SD)	30.7 (13.7)	38.3 (14.2)	7.6	.01*

** mean difference statistically significant.*

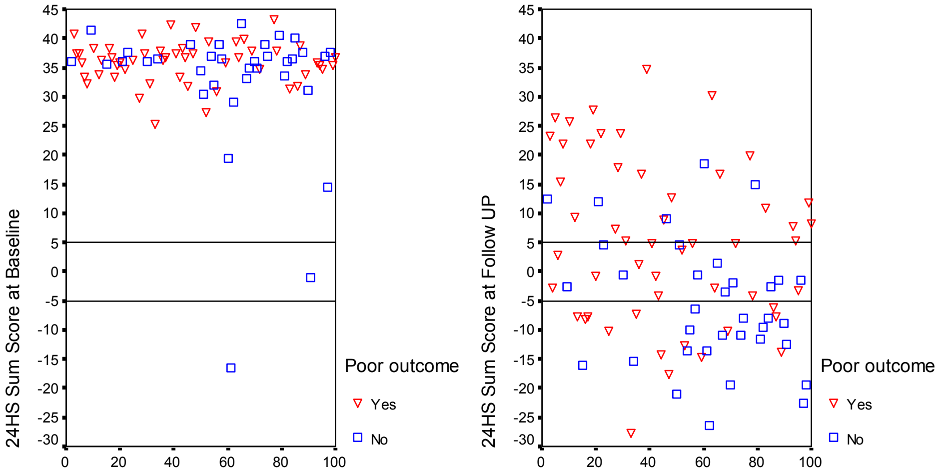
This procedure was repeated for recurrent LBP as dependent variable. Here only 24HS sum-scores and age were univariate significantly related to the outcome. After a multivariate regression analysis, age remained significantly associated with recurrent LBP. In the third univariate regression analysis only receiving physical therapy was univariate-related to chronicity ($P < 0.1$). Table 3 presents the results of the univariate and the multivariate analyses.

Assessed postures. 'Cohorts' mean 24HS score at baseline was 34.4 (SD 8.2) schedule hours, and at follow-up 1.1 (SD 14.1) schedule hours. All assessed 24HS scores differed significantly between the groups (persistent LBP or not). See also Table 4, where scores are separately presented.

The differences in distribution of 24HS sum-scores at 'baseline' and 'follow-up' are illustrated in Figure 2. The individual scores were either marked for persistent LBP or not.

A univariate regression analysis was performed to assess the association between changes in 24HS scores (at baseline and follow-up) and the dependent variable persistent LBP. The OR for persistent LBP was 0.96 (95% C.I. 0.93–0.99), indicating a protective effect for changes in 24HS scores.

Figure 2. Distribution of subjects' 24HS Sum-Scores at Baseline and Follow-up



Discussion

In our cohort, 35 (40%) of the patients with LBP recovered fully within 12 weeks and did not experience a recurrent episode within 6 months. This rate of recovery was also observed in comparable primary care studies [13]. The continuous variable age and the dichotomised variable smoking were identified as prognostic factors. Since it was hypothesised that an advanced age is associated with an increased risk of chronic pain (relative risk increased by 1.36 for each 10-year age) [28], this result is noticeable. Still, a similar association was described previously, although not statistically significant [12].

At baseline, all subjects received guideline-based information. This information was summarised in a folder, which the subjects received. It is thinkable that elder subjects were more seriously in their coping behaviour regarding these advises. Possibly the protective effect of advanced age on chronicity could be explained by subjects' coping behaviour. The mean number of GP consultations per person for LBP recorded in this study was 1.2 including the index consult, which is less compared with the 1.6 reported in Great-Britain [29]. Possibly, the strategy described is beneficial in terms of cost effectiveness. However, a controlled study is required to enable a statement regarding the cost effectiveness.

Receiving physical therapy was univariate associated with chronicity (P < 0.1). As suggested in the Dutch Guideline for General Practitioners 'Low Back Pain', physical therapy can be considered for episodes LBP lasting longer than 6 weeks [10]. In this view, receiving physical therapy can be seen as a consequence of the recommendations of the evidence-based guideline, rather then a prognostic factor for chronic LBP.

As risk factor, 24HS scores were strongly associated with the occurrence of LBP [7], but as prognostic factor, subjects' 24HS scores at baseline were not associated with persistent LBP. Changes in all 24HS scores (between baseline and follow-up) were statistically significant. The univariate analysis indicated a significant association between changes in 24HS scores and persistent LBP. The odds ratio for persistent LBP reduced significantly with a factor of 0.96 for every schedule hour the follow-up score changed from the baseline score. Consequently, the greater the subjects' change in baseline-follow-up 24HS score the smaller the odds for persistent LBP. This could indicate that mechanical load of the spine is a modifiable factor in the prognosis of LBP. Whether mechanical loading indeed is a modifiable factor and an effective intervention should be examined in future controlled studies.

Because 24HS score changes were not present at baseline this variable was not regarded a prognostic variable. Therefore, this variable was excluded from the multivariate model.

The classification of low back pain into acute, sub-acute (6–12 weeks), and chronic (>12 weeks) is a simplification of reality, but necessary for scientific studies and useful in clinical practice [30]. To understand the prognostic factors for the development of persistent LBP, we recruited a cohort of subjects with acute LBP in particular without a pervious episode in the past year. By this, we avoided bias [31] due to a mixed cohort of patients with acute low back pain, recent exacerbations and chronic low back pain. We used blinded assessment and performed statistical adjustment for prognostic factors.

Despite being consecutive primary care patients, the population studied cannot be considered representative of the general population of acute low back pain patients. All the subjects sought medical care, which may be related to various socioeconomic factors. The exclusion criteria may have led to an under representation of poorly educated and foreign origin patients. However, the study population represented the source population in primary care.

The data used for the 24HS were obtained from interviews using retrospective data for subjects' description of 'an average day', and the quality may therefore be questioned. For that reason, the 24HS scores are considered as an indication of the mechanical load.

Conclusion

Mechanical loading of the spine, quantified with the 24HS, at baseline is not a prognostic factor for chronicity or recurrent episodes. Possibly modification of spinal mechanical loading in terms of 24HS scores might be beneficial for secondary prevention in patients with acute LBP.

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References

1. Walker BF. The prevalence of low back pain: a systematic review of the literature from 1966 to 1998. J Spinal Disord. 2000;13(3):205-17
2. Waddell G. A new clinical model for the treatment of low back pain. Spine. 1987;12:632-44
3. Pengel LHM, Herbert RD, Maher CG, Refshauge KM. Acute low back pain: systematic review of its prognosis. BMJ. 2003;327(7410):323
4. Croft PR, Macfarlane GJ, Papageorgiou AC, Thomas E, Silman AJ. Outcome of low back pain in general practice: a prospective study. BMJ. 1998;316(7141):1356–59
5. Maniadakis N, Gray A. The economic burden of back pain in the UK. Pain. 200;84(1):95-103
6. Dunn KM, Croft PR. Epidemiology and natural history of low back pain. Eura Medicophys. 2004;40(1):9-13
7. Bakker EWP, Verhagen AP, Lucas C, Koning JCMF, Haan de RJ, Koes BW. Daily spinal mechanical loading as a risk factor for acute non-specific low back pain. 2007;16(1):107-13
8. Bakker EWP, Koning JCMF, Verhagen AP, Koes BW. Interobserver reliability of the 24 hour schedule in patients with low back pain. JMPT. 2003;26(4):226-32
9. Frymoyer JW. Back pain and sciatica. N Engl J. 1988;Med 318:291-300
10. Faas A, Chavannes AW, Koes BW, Hoogen JMM van den, Mens JMA, Smeele LJM. NHG-standaard lage rugpijn. Huisarts Wet. 1996;39:18-31
11. Chavannes AW, Mens JMA, Koes BW, Lubbers WJ, Ostelo R, Spinnewijn WEM, Kolnaar BGM. NHG-standaard lage rugpijn. Huisarts Wet. 2005;48(3):113-23
12. Schiottz-Christensen B, Nielsen GL, Hansen VK, Schodt T, Sorensen HT, Olesen F. Long-term prognosis of acute low back pain in patients seen in general practice: a 1-year prospective follow-up study. Fam Pract. 199; 16:223-32
13. Thomas E, Silman AJ, Croft PR, Papageorgiou AC, Jayson MI, Macfarlane GJ. Predicting who develops chronic low back pain in primary care: a prospective study. BMJ. 1999;19 318(7199):1662-67
14. Koes BW, van Tulder MW, Ostelo R, Kim Burton A, Waddell G. Clinical guidelines for the management of low back pain in primary care: an international comparison. Spine. 2001;26(22):2504-13
15. Dionne CE, Koepsell TD, Von Korff M, Deyo RA, Barlow WE, Checkoway H. Predicting long-term functional limitations among back pain patients in primary care settings. J Clin Epidemiol. 1997 50(1):31-43
16. Pincus T, Burton AK, Vogel S, Field AP. A systematic review of psychological factors as predictors of chronicity/disability in prospective cohorts of low back pain. Spine. 2002;27:E109-20
17. Reis S, Hermoni D, Borkan JM, Biderman A, Tabenkin C, Porat A. A new look at low back complaints in primary care: a RAMBAM Israeli Family Practice Research Network study. J Fam Pract. 1999;48:299-303
18. Erdman RA, Passchier J, Kooijman M, Stronks DL. The Dutch version of the Nottingham Health Profile: investigations of psychometric aspects. Psychol Rep. 1993;72(3 Pt 1):1027-35
19. Vlaeyen JWS, Heuts PHTG. Gedragsgeoriënteerde behandeling bij lage rugpijn. Bohn Stafleu Van Loghum, Houten/Diegem. 2000
20. Papageorgiou AC, Macfarlane GJ, Thomas E, Croft PR, Jayson MIV, Silman AJ. Psychosocial factors in the work place—do they predict new episodes of low back pain? Spine. 1997;22:1137-42
21. Jeaschke R, Singer J, Guyatt GH. A comparison of seven-point and visual analogue scales. Control Clin Trials. 1990;11:43-51
22. Nachemson A. Towards a better understanding of low-back pain: a review of the mechanics of the lumbar disc. Rheumatol Rehabil. 1975;14(3):129-43
23. Sato K, Kikuchi S, Yonezawa T. In vivo intradiscal pressure measurement in healthy individuals and in patients with ongoing back problems. Spine. 1999;24(23):2468-74
24. Koes BW, van Tulder MW, Ostelo R, Kim Burton A, Waddell G. Clinical guidelines for the management of low back pain in primary care: an international comparison. Spine. 2001;26(22):2504-13
25. Hoogen van den HJ, Koes BW, Deville W, van Eijk JT, Bouter LM. The prognosis of low back pain in general practice. Spine. 1997;1 22(13):1515-21
26. Altman DG. Statistics and ethics in medical research: III. How large a sample. Br Med J. 1980;281:1336-38

27. Altman DG. Relation between several variables. In: Altman DG (ed) Practical statistics for medical research. Chapman & Hall/CRC, Boca Raton. 1997;325-61
28. Rossignol M, Suissa S, Abenhaim L. Working disability due to occupational back pain: three years follow-up of 2300 compensated workers in Quebec. J Occup Med. 1988;30:502-5
29. OPCS (1994) Office of Population Censuses and Surveys. Monitor MB5 94/1 Morbidity Statistics from General Practice 1991/2 (MSGP4). HMSO, London
30. Waddell G. The back pain revolution, 2nd edn. Churchill Livingstone, London. 2004
31. Sackett DL, Haynes RB, Guyatt GH, Tugwell P. Clinical epidemiology, a basic science for clinical medicine. Little, Brown, Boston. 1991

CHAPTER 6

Individual advice in addition to standard guideline care in patients with acute non-specific low back pain. A survey on feasibility among physiotherapists and patients

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Abstract

Study design. Feasibility study

Objective. To determine the feasibility of individual preventive advices based on an assessment of spinal mechanical load in first line healthcare providers and patients.

Summary of background data. The medical costs associated with low back pain (LBP) potentially pose an enormous economic burden to society. Prevention (secondary) might be beneficial when there is no definitive conclusion on the most appropriate intervention. For this purpose, individual advice focusing on modification of spinal mechanical load obtained with the 24 Hour Schedule -24HS- (an instrument for quantifying spinal mechanical load) in addition to standard care of guideline-recommendations might be effective. Naturally, this should be examined in controlled studies. Considering the costs involved carrying out a controlled study, the feasibility of 24HS advice should be assessed first.

Methods. We performed two surveys in primary care setting in 97 patients with acute (<6 weeks) non-specific LBP (who received a 24HS assessment and 24HS advice at baseline), and 18 physiotherapists (all involved in 24HS baseline assessments). Patients and physiotherapists were first contacted by telephone after 6 months by a research assistant and requested to complete a questionnaire developed to assess feasibility. During this interview patients again completed a follow-up 24HS assessment.

Results. Eighty-eight patients and 17 physiotherapists participated in the follow-up. The median score of patients' questionnaire was 7 (interquartile range 5.9–8.3) and of physiotherapists' questionnaire 8 (interquartile range 7–8.5). Both questionnaires exceeded the criteria for feasibility, which we had previously set at seven or higher (out of 10).

Conclusion. The 24HS advice was considered feasible for use in primary care healthcare providers and patients with LBP. In patients, the absence of LBP during the follow-up period and in physiotherapists 'lack of time' were identified as factors that could potentially threaten the feasibility in 24HS advice.

Introduction

Low back pain (LBP) causes an economic burden to society in countries such as the USA, UK and The Netherlands [1]. Recently, a large number of systematic reviews were published concerning the effectiveness of treatments for LBP [2,3,4,5,6,7]. Despite the large amount of evidence on LBP management, a definitive conclusion on the most appropriate intervention is not currently available. Prevention of recurrences and chronicity, however, was identified as an important goal in the management of LBP [8].

A previous study indicated that longer lasting and more intensive spinal loading in flexed positions, quantified with the 24 Hour Schedule (24HS: a questionnaire developed for quantifying subjects' individual spinal mechanical load), was strongly associated with the occurrence of acute LBP [9,10]. Modification of this spinal mechanical load may theoretically prevent recurrent episodes in patients with acute LBP [10,11]. Such modification can be achieved through individualised advice, in addition to standard guideline care, using the results of the 24HS assessment [10]. This way an individualised program for the self-management of LBP was developed. It is proposed that adding this 24HS advice to the standard care in guideline recommendations may prove beneficial to patients. Whether this approach for LBP indeed is an effective intervention should be examined in controlled studies.

The costs involved in a full scale randomised controlled trial can be considerable. Before starting a controlled study, the feasibility of an intervention should be examined. For example, non-compliance with therapeutic recommendations may be problematic in patients as well as in healthcare professionals [12,13]. In patients, variables related to the characteristics of the prescribed treatment could result in non-compliance with the treatment regimen [14]. In healthcare professionals, new therapeutic recommendations do not necessarily lead to practice changes unless these are accepted as valid and useful, and the benefits of the practice changes are expected to outweigh the difficulties linked to such changes [15]. Therefore, the feasibility of 24HS advice for use in clinical practice should be assessed first.

The objective of this study was to assess the feasibility of 24HS advice in additional to standard care in patients with LBP and in healthcare providers in primary care physiotherapy and manual therapy.

Methods

A survey using a structured questionnaire was conducted among patients with LBP and their caregivers.

Study population. Patients (n=97) were participants of an inception cohort with acute (i.e. an episode of LBP lasting less than 6 weeks) non-specific LBP [10,11,16]. All patients were referred by general practitioners of the city of The Hague (The Netherlands) to an assessor in one of the four local research centres. Patients were eligible for inclusion if the assessor confirmed the 'diagnosis' acute LBP and the presence of exclusion criteria were expelled. Exclusion criteria were: insufficient understanding of the Dutch language, previous episode(s) of acute LBP in the past 12 months, low back pain after a recent trauma, pregnancy, spinal surgery, and known pathology suspicious for/or specific low back pain. Definitions used in this study are in accordance with the Dutch Guideline for General Practitioners 'Low Back Pain' and internationally accepted [17,18].

After inclusion, all subjects signed informed consent, were coded to remain anonymous, and completed questionnaires focusing on subjects' demographic and clinical data. The 24HS was used for the assessment of spinal mechanical loading (baseline measurement).

Therapists. All assessors (n=18) were physiotherapists trained in using the 24HS in two 90 min sessions and involved in previous studies with the 24HS.

The procedure of the 24HS measurement. An assessor, trained in using the 24HS, systematically asked the patients to describe their daily activities. In each activity, the position of the back in the sagittal plane (i.e. flexed or extended), the load and duration applied were registered chronologically on the standardised registration form (see Addendum). For 'load applied' three categories were available: 1. No load applied (e.g. lying), 2. Loaded (e.g. sitting) and 3. Loaded with movement (e.g. digging). After completing the registration, subject's flexed-posture score was calculated. Of each activity, the duration was multiplied by the weight of the category the activity was scored in and all obtained scores were added. The weight of the categories, based on Nachemsons' findings modified by Sato[19,20], was set to 1:2:3, respectively [9]. For example, an activity scored 5 hours in the second category on the registration form, becomes 10 hours when recalculated to the first category. An activity scored 5 hours in the third category will be recalculated to 15 hours in the first category. The resulting figure represents the time the back was loaded in a flexed posture with a load of the first category. This parameter called schedule hours, ranges from 0 to 72. Subsequently, this procedure was repeated for the extended posture (range: 0–72). The sum score was obtained by subtracting the total time of the extended postures from the total time of the flexed postures. The resulting figure gives insight in the dominant use (the training activity) of the back (range: −72 schedule hours to +72 schedule hours). Negative sum scores point to overall spinal use in extended positions and positive sum scores indicate overall spinal use in flexed postures.

Treatment procedure. After the assessment, all patients received standard care consisting of guideline-based information. First all patients were informed concerning the benign nature and unknown cause of the pain. Patients were encouraged to stay active and stimulated to resume all activities as normal. Finally, patients were reassured of a favourable prognosis and bed rest was discouraged [17,18,21]. Next the outcome of the assessment of the 24HS was explained in non-technical language. This included a short explanation of the 24HS and how the sum score was obtained. Personalised advice was given to modify the 24HS sum score when indicated. Subjects were then encouraged to implement these recommendations in their daily activities and maintain those consequently even in absence of LBP. In case of persistent and/or exacerbated symptoms (including radiating leg pain), or experiencing adverse effects of the treatment, subjects were explicitly advised to consult their general practitioner (GP). Finally, all information was summarised in a brochure, which patients received. The mean total time required for the assessment was about 20 minutes; including 10 minutes for guideline based information, explanation, and summarising.

Follow-up--patients. After 6 months, a research assistant contacted subjects by telephone to evaluate the feasibility of the prescribed recommendations. Also again the 24HS was assessed and scores were compared with the baseline scores. This way, a quantitative indication of compliance was obtained. Regarding the course of subjects' LBP, the duration of the complaints and recurrent episode(s) were also noted.

Further, an eight-item questionnaire was used to assess factors, which could threaten the feasibility. A thorough search in electronic databases PubMed and Embase identified the following factors: the understanding of the diagnosis and causes of LBP and the prescribed regime, subjects' expectations about the treatment, the belief that treatment was unnecessary or was no longer needed, ineffectiveness of treatment, and experience of adverse effects [13,22,23,24,25,26,27]. The questionnaire contained two open format questions and six questions were phrased as statements. Responses were given on an 11-point Numeric Rating Scale (NRS) [28] ranging from 0 to 10. All questions were formulated in order to link the recommendations and procedures of the treatment. The number of GP consultations for persistent and/or exacerbated symptoms (including radiating leg pain), and/or experiencing adverse effects was registered.

Follow-up--therapists. A questionnaire survey was administered by 17 physiotherapists of whom 11 were trained manual therapists to evaluate how they valued using the 24HS during the study and whether they continued using it after the study period was finished. An 11-item questionnaire for healthcare professionals covered three domains relating to the use of the 24HS advice in primary care: workload in daily practice (four items), usefulness of using individualised advice based on the 24HS (four items), and patients' reactions (three items) [15]. The questions were phrased as statements and responses were on an 11-point NRS that ranged from strongly disagree (0) to strongly agree (10). Furthermore, demographical data, experience, specialisation(s) and work setting were registered. Two open format questions were used to determine the most positive and most negative perceived characteristics of 24HS advice concerning the implementation of this treatment in primary care practice. The questionnaire was completed during a telephone interview performed after completing the survey in patients by a research assistant.

Analyses. All analyses were carried out in SPSS 14.0. Subjects' baseline data, 24HS scores differences (baseline minus follow up), are presented with their mean and standard deviation (SD). In case of skewed distributions median and interquartile range (IQR) were used. Firstly, we decided by consensus that 24HS advice is feasible in patients with LBP if the median score over all six questions of the questionnaire was seven or higher. All domains were equally weighted. Questionnaire scores are presented with their median and IQR. For each question we presented the number of patients that scored a 7 or higher (agree–strongly agree) separately. Responses on the open format questions were collected and ranked in order of reported frequency.

Next, the personal characteristics of the therapists were analysed and presented with their mean and SD or in case of skewed distributions the median and IQR were used. A priori, we decided by consensus that the 24HS would be feasible for use in a primary care setting when the median score of all 11 questions was seven or higher. All domains were equally weighted. The scores of the three domains of the questionnaire are presented with their median and IQR. For each question we presented the number of physiotherapists that scored a 7 or higher (agree–strongly agree) separately. The responses on the open format questions were collected and ranked in order of reported frequency.

Both respondents and research assistant were uninformed of the evaluation method used (in particular the threshold applied) to assess feasibility.

The Medical Ethics Committee of the Erasmus Medical Centre (Rotterdam, The Netherlands) approved the study.

Results

Patients. Of the 97 subjects of the original cohort, 88 had completed the follow-up and were interviewed again [10,11]. The baseline characteristics of all subjects are shown in Table 1. Mean 24HS score at baseline of patients completing the follow-up was 34.6 (SD 8.1) and at follow-up was 1.1 (SD 14.1). The 24HS score difference was 33.6 (SD 14.4). Chronicity of LBP (complaints lasting longer than 12 weeks) occurred in 12 (14%) subjects, of whom 8 (9%) had persistent complaints over the 6-month period. Recurrent episode(s)—all labelled as non-specific LBP—occurred in 41 (47%), of whom 4 (5%) subjects had recurrent episode(s) lasting longer than 12 weeks. The median number of recurrent episode(s) was 1 (IQR 0–3).

Table 1. Baseline characteristics of the original cohort (n=97) and completing the follow-up (n=88)

Male (%)	49/88 (56)
Age, mean (minimum–maximum, SD)	41 (15-82, 14)
Previous episode(s) LBP (%)	58/88 (67)
24HS sum-scores, mean (SD)	34.6 (8.1)
Pain intensity at inclusion, median (minimum-maximum)	5 (0-9)
Duration of symptoms in days, mean (SD)	11.8 (6.7)
Radiating leg pain (%)	31/88 (35)

SD: standard deviation; LBP: low back pain

The results of the questionnaire, assessing the feasibility and the recommendations are shown in Table 2. For persistent and/or exacerbated symptoms (including radiating leg pain) and/or those experiencing adverse effects, seven (8%) subjects consulted their GP once and three subjects (3%) twice for baseline LBP. Similar, eight (20%) single consultations were registered for recurrent LBP. For the item understanding what could possibly cause LBP, two (2%) subjects had the lowest score (0) in contrast with 40 (45%) subjects with the highest score (10), meaning that almost half of all subjects understood completely how applied spinal mechanical load could cause LBP. For the understanding of the prescribed regimen, also an open format question was used. Here, subjects were asked to reproduce in their own wording the main issue of the treatment. In total, 76 (86%) subjects answered correctly by mentioning altering posture as an important part of the advices. Ten subjects (12%) described solitarily issues like lifting techniques or exercises. Two subjects (2%) stated to remember nothing.

To determine whether the received treatment met subjects' expectations, again an open format question was used. Subjects were asked for 'missing items'. In this question, 83 subjects (94%) answered 'nothing missing'. To indicate the likelihood that their LBP becomes a chronic condition, 15 subjects (17%) scored 'absolute unlikely' and six (7%) had the maximum score (10), meaning they were convinced that their LBP would become chronic.

Forty-nine (55.7%) subjects had a median score of seven or higher over all items of this questionnaire. The median score over all items of this questionnaire was 7 (IQR 5.9-8.3) reaching the threshold for feasibility that was set at seven or higher.

Table 2. Domains, which could threaten the feasibility with the 24HS advice in 88 subjects with LBP

Domains	Assessment	Score
Understand possible cause	Question: 'I understand what could cause my LBP' (0=strongly disagree – 10=strongly agree). Note: Information concerning the 'diagnosis' non-specific low back pain was considered as standard guideline care and therefore not evaluated in this questionnaire.	9 (IQR 7-10)
Understand regime	Question: 'I am able to prevent a recurrent episode LBP with the received advises'	7.0 (SD 2.5)
Subjects' expectations	Question: Please give your grade for the received therapy.	10 (IQR 8-10)
Advice unnecessary or no longer needed	Question: 'To which extend did you continue applying the advices consequently during the 6-months follow-up period as advised?' Note: as part of the treatment, subjects were instructed to continue applying the advices with or without complaints.	5.6 (SD 2.6)
	Question: 'Will you resume complying with the advices in case of a recurrent episode?'	8 (IQR 6-10)
Ineffectiveness	Question: 'Please estimate the likelihood that your LBP becomes a chronic condition'	4.4 (SD 2.9)
Experience adverse effects	The number of GP consultations for persistence and/or exacerbation(s) of symptoms (including radiating leg pain) and/or experiencing adverse effects	Baseline; Once: 8% (7/88) Twice: 3% (3/88). Recurrent; Once: 20% (8/41)

LBP: low back pain; 24HS: 24 Hour Schedule; NRS: numeric rating scale. Questions presented (original in Dutch) as used in the questionnaire. The median scores with interquartile range (IQR) of the responses given on the 11-point NRS (0=strongly disagree to 10=strongly agree).

Healthcare professionals. From the 18 assessors, one stopped working as a physiotherapist, thus 17 completed the questionnaire. Seven (41%) were male and mean age was 40.6 (SD 9.1; range 22-52). Median number of years of working experience was 19 (IQR 8-25). All care providers were working in a primary care physiotherapy practice setting. The mean number of new patients with low back pain seen over a one-month period was 10 (SD 5). The median number of 24HS assessments since the start of our study in subjects with acute non-specific LBP was 30 (IQR 14-70), taking about 10.6 minutes on average per assessment (SD 2.4). Median time required for 24HS based advice was 10 minutes (IQR 9.5-15). The results of the questionnaire assessing the feasibility of the 24HS are shown in Table 3.

To gain more insight in what the therapists experiences were when using the 24HS, two open format questions were used. They were asked for their most important motivation to continue or to stop using the 24HS after completing the study. The advantage of visualising and illustrating subjects' spinal mechanical load was mentioned 12 times as a motivation for continuing using the 24HS. Confronting and alerting patients were mentioned four times and individualising advice once. Reasons mentioned for stopping using the 24HS were lack of

Table 3. Domains, which could threaten the feasibility of the 24HS advice in 17 healthcare professionals

Domains	Question	Score (IQR)	Scores of 7 or higher (%)
Workload	The 24HS procedure is easy to learn	9 (8-9.5)	17 (100)
	A 24HS assessment is easy to carry out	8 (7.5-8)	17 (100)
	When informing and advising a patient with LBP thoroughly, using the 24HS spares me time	7 (6-8)	11 (64.7)
	Considering the workload and (dis-) advantages of the 24HS, new patients with LBP can be referred to me for a 24HS assessment	9 (7.5-10)	14 (82.4)
Usefulness	Using the 24HS I am able to illustrate clearly patients spinal use and applied mechanical load	8 (7.5-9)	17 (100)
	Using the 24HS I am able to explain clearly how patients could alter the applied spinal mechanical load	8 (8-9)	17 (100)
	I will continue using the 24HS in patients with LBP	8 (5-8)	12 (70.6)
	Individual preventive advice is lacking in all present LBP guidelines, but should be added to these	8 (7-10)	16 (94.1)
Patients' reactions	Patients reactions were positive on the received information and 24HS advice	8 (7-9)	17 (100)
	Patients with LBP could be reassured of a favourable prognosis with the received information and 24HS advice	8 (7-8.5)	15 (88.2)
	Considering patients questions and reactions during the 24HS, estimate how many of your patients understood the information and advises completely	8 (7-8)	15 (88.2)

LBP: low back pain. 24HS: 24 Hour Schedule. NRS: numeric rating scale. Questions presented (original in Dutch) as used in the questionnaire. The median scores with interquartile range (IQR) of the responses given on the 11-point NRS (0=strongly disagree – 10=strongly agree)

time (10 times), hardly seeing subjects with LBP (twice) and difficulties with the registration form (twice). Not considering to 'stop using the 24HS' was mentioned three times.

The median score on all 11 questions was 8 (IQR 7–8.5) exceeding the threshold for feasibility a priori set at 7 or more. Three (18%) questionnaire scores were less than 7 (range: 6.6–6.9). The scores for the domains 'workload', 'usefulness' and 'patients' reactions' were 8.3 (IQR 7–8.6), 8

(IQR 6.8–8.8), and 7.7 (IQR 7–8.3), respectively. All domains of the questionnaire exceeded the criteria for feasibility separately.

Discussion

From the results of this study, surveying patients with acute non-specific LBP as well as their treating physiotherapists, it can be concluded that the 24HS based advice is feasible in patients with LBP and in primary care physiotherapy. The overall score for feasibility for patients with LBP that received advice was 7 and the assessed score for feasibility in healthcare providers was 8. Therefore, a controlled study to assess the effectiveness of 24HS based advice in patients with LBP can be considered.

After 6 months, subjects indicated to be highly satisfied with the described approach with a median score of 10 (strongly agree). They also indicated with a score of 9 to understand how applied mechanical load (as a consequence of spinal use) could possibly cause LBP. Nevertheless, the subjects experienced difficulties in 'applying the advices consequently'. At the same time, subjects also indicated (with a median score of 8) to resume complying with the advices in case of a recurrent episode. These scores suggest that the absence of LBP was most threatening the feasibility with the 24HS advice in this cohort.

In advance, especially the absence of LBP was considered a potential threat for the compliance with the advice given, because asymptomatic or chronic conditions were identified as important determinants for non-compliance in diverse treatment modalities and pain syndromes [14,29]. Expecting this problem, attempts were incorporated in the procedure of 24HS advice in order to improve the compliance. For this, subjects must consider the suggested advises as feasible for implementation in their daily activities. If agreement was reached on this issue, subjects were instructed to maintain the advice even in absence of LBP. In addition, subjects were informed about possible consequences of non-compliance [13]. Finally, all information was summarised in a brochure, which subjects received [31]. Despite all effort, the score for 'applying the advice consequently' was only moderate. Unfortunately, this study provides insufficient information to understand the rationale of such moderate compliance. For further improvement of the compliance in 24HS based advice, in depth interviews are necessary to further explore this phenomenon.

In therapists the domain 'usefulness' was assessed as good (8). Also the responses in the open format question: the most important motivation for continuing using the 24HS after completing the study, were all associated with this domain. The score for the domain 'workload' had the highest score (8.3). Still improvement in logistics of 24HS assessments could be considered, since in the open format question 'lack of time' was mentioned frequently as potential reason to end using the 24HS. Because the therapists were highly experienced this critical comment was taken seriously. The 24HS assessments were achieved within a standardised treatment setting of 30 minutes [10]. For example, a special fee for 24HS assessments could make extra time available and overcome this potential threat to feasibility.

In advance (non-) compliance with 24HS advice was considered to be an important independent variable in this specific treatment. This study identified subjects' compliance and potential treats for compliance. In general, compliance with 24HS advice can be considered to be satisfactory. Nevertheless, improvements regarding the compliance especially in pain free episodes can easily be made.

In view of the available literature concerning non-compliance as threat in prescribed treatment regimes [30], non-compliance should be seen as an important independent variable affecting the effectiveness of treatments. Therefore, this variable should be objectified and considered as acceptable before introducing (new) treatments.

In the literature no valid method to assess feasibility suitable for use in this study has been described as far as we know. It was unexpected that no valid method to assess feasibility was available in literature. For that reason the authors developed the method as used. Hereby the threshold based on median scores of the questionnaires (all domains were weighted equally, and 7 or higher means feasible) was set by consensus. We considered our method to have face- and expert validity. In this manner sufficient insight was achieved in the strong and weak points in 24HS advice related feasibility as well as in patients as in healthcare professionals.

Illiteracy is perhaps the most substantial barrier to successful patient education initiatives [29]. The study population of consecutive primary care patients cannot be considered representative for the general population of LBP patients. All subjects actively sought medical care, which may be related to various socioeconomic factors. Therefore, poorly educated and foreign origin patients were possible underrepresented in this study. The feasibility with 24HS advice in this group of patients may differ from the results of this study.

Theoretically, the scores of the questionnaire for healthcare professionals could be overestimated (bias), since all participating physiotherapists were involved in previous studies with the 24HS. Still, the question assessing subjects' opinion for the received treatment was evaluated by healthcare providers with 8 and by patients with 10. Since subjects had no such interest in the 24HS, the extend of this potential treat for internal validity could be limited. Nevertheless, the use of the 24HS should therefore be repeated in a different population.

The data used for the 24HS was obtained from interviews using retrospective data for subjects' description of 'an average day' the quality may therefore be questioned. For that reason, the 24HS scores are considered as an indication of the 'true' mechanical load only.

Conclusion

We consider 24HS advice feasible for use in primary care healthcare providers and patients with LBP. The absence of LBP during the follow-up period in subjects and 'lack of time' of care providers were identified as risk factors that could potentially threaten the feasibility in 24HS advice.

Conflict of interest

None

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References

1. Maetzel A, Li L. The economic burden of low back pain: a review of studies published between 1996 and 2001. Best Pract Res Clin Rheumatol. 2002;16(1):23-30
2. Ferreira ML, Ferreira PH, Latimer J, Herbert R, Maher CG. Does spinal manipulative therapy help people with chronic low back pain? Aust J Physiother. 2002;48(4):277-84
3. Guzmán J, Esmail R, Karjalainen K, Malmivaara A, Irvin E, Bombardier C. Multidisciplinary rehabilitation for chronic low back pain: systematic review. BMJ. 2001;322(7301):1511-6
4. Jellema P, van Tulder MW, van Poppel MN, Nachemson AL, Bouter LM. Lumbar supports for prevention and treatment of low back pain. A systematic review within the framework of the Cochrane Back Review Group, Spine. 2001;26 (4):377-86
5. Pengel HM, Maher CG, Refshauge KM. Systematic review of conservative interventions for subacute low back pain. Clin Rehabil. 2002;16(8):811-20
6. van Tulder M, Malmivaara A, Esmail R, Koes B. Exercise therapy for low back pain: a systematic review within the framework of the cochrane collaboration back review group. Spine. 2000;25(21):2784-96
7. van Tulder MW, Ostelo R, Vlaeyen JW, Linton SJ, Morley SJ, Assendelft WJ. Behavioral treatment for chronic low back pain: a systematic review within the framework of the Cochrane Back Review Group. Spine. 2000;25(20):2688-99
8. Dugan SA. The role of exercise in the prevention and management of acute low back pain. Clin Occup Environ Med. 2006;5(3):615-32, vi-vii
9. Bakker EW, Koning HJ, Verhagen AP, Koes BW. Interobserver reliability of the 24 hour schedule in patients with low back pain: a questionnaire measuring the daily use and loading of the spine. J Manipulative Physiol Ther. 2003;26(4):226-32
10. Bakker EW, Verhagen AP, Lucas C, Koning HJ, de Haan RJ, Koes BW. Daily spinal mechanical loading as a risk factor for acute non-specific low back pain: a case-control study using the 24 Hour Schedule. Eur Spine J. 2007;16(1):107-13
11. Bakker EW, Verhagen AP, Lucas C, Koning HJ, Koes BW. Spinal mechanical load: a predictor of persistent low back pain? A prospective cohort study. Eur Spine J. 2007;16(7):933-41
12. Bishop PB, Wing PC. Compliance with clinical practice guidelines in family physicians managing worker's compensation board patients with acute lower back pain. Spine J. 2003;3(6):442-50
13. Gold DT, McClung B. Approaches to patient education: emphasizing the long-term value of compliance and persistence. Am J Med. 2006;119(4 Suppl 1):S32-7
14. Turk DC, Rudy TE. Neglected topics in the treatment of chronic pain patients--relapse, noncompliance, and adherence enhancement. Pain. 1991;44(1):5-28
15. Geyman JP, Gordon MJ. Learning outcomes and practice changes after a postgraduate course in office orthopedics. J Fam Pract. 1982;15 (1):131-36
16. Frymoyer JW. Back pain and sciatica. N Engl J Med. 1988;318(5):291-300
17. Faas A, Chavannes AW, Koes BW, Hoogen JMM van den, Mens JMA, Smeele LJM. NHG-standaard lage rugpijn. Huisarts Wet. 1996;39:18-31
18. Chavannes AW, Mens JMA, Koes BW, Lubbers WJ, Ostelo R, Spinnewijn WEM, Kolnaar BGM. NHG-standaard lage rugpijn. Huisarts Wet. 2005;48(3):113-23
19. Nachemson A. Towards a better understanding of low-back pain: a review of the mechanics of the lumbar disc. Rheumatol Rehabil. 1975;14(3):129-43
20. Sato K, Kikuchi S, Yonezawa T. In vivo intradiscal pressure measurement in healthy individuals and in patients with ongoing back problems. Spine. 1999;24(23):2468-74
21. Koes BW, van Tulder MW, Ostelo R, Kim Burton A, Waddell G. Clinical guidelines for the management of low back pain in primary care: an international comparison. Spine. 2001;26(22):2504-13
22. Darnell JC, Murray MD, Martz BL, Weinberger M. Medication use by ambulatory elderly. An in-home survey. J Am Geriatr Soc. 1986;34(1):1-4
23. Floyd DL, Prentice-Dunn S, Rogers RW. A meta-analysis of research on protection motivation theory. J Appl Soc Psychol. 2000;30: 407-20
24. Glanz K, Rimer BK. Theory at a glance: a guide for health promotion practice (2nd ed.), National Cancer Institute, Bethesda MD NIH. Publication No. 97-3896;2005

25. Lombas C, Hakim C, Zanchetta JR. Compliance with alendronate treatment in an osteoporosis clinic. Presented at the American Society for Bone and Mineral Research (ASBMR) 23rd Annual Meeting, Phoenix, AZ, 12–16 October 2001
26. Park DC, Hertzog C, Leventhal H, Morrell RW, Leventhal E, Birchmore D, Martin M, Bennett J. Medication adherence in rheumatoid arthritis patients: older is wiser. J Am Geriatr Soc. 1999;47(2):172-83
27. Silva RR, Muñoz DM, Daniel W, Barickman J, Friedhoff AJ. Causes of haloperidol discontinuation in patients with Tourette's disorder: management and alternatives. J Clin Psychiatry. 1996;57(3):129-35
28. Jeaschke R, Singer J, Guyatt GH. A comparison of seven-point and visual analogue scales. Control Clin Trials. 1990;11:43-51
29. Miller NH. Compliance with treatment regimens in chronic asymptomatic diseases. Am J Med. 1997;102(2A):43-9
30. Sackett DL, Snow J.C. The magnitude of compliance and noncompliance. In: R.B. Hayes, W.B. Taylor and D.L. Sackett, Editors, Compliance in healthcare, Johns Hopkins University Press, Baltimore. 1979;11-22
31. Schaffer SD, Tian L. Promoting adherence: effects of theory-based asthma education. Clin Nurs Res. 2004;13(1):69-89

CHAPTER 7

General discussion

General Discussion

Primary as well as secondary prevention could be beneficial in the management of low back pain. For prevention knowledge of risk factors is essential. For that purpose we performed a systematic review of studies reporting exposures of spinal mechanical load as a risk factor for low back pain. In this review we noticed that all reported exposures were dichotomised or categorised: qualitatively (e.g. occasionally, sometimes, usually, quite a lot, very often) or quantitatively (e.g. percentage of working time per eight-hour working day, hours per day). The duration of the quantitatively categorised exposures ranges from 15 minutes or more per day [1] to 2.0 – 8.5 hours per shift [2]. Thus, the assessed exposures represent at best 35% of the total exposure time possible per day.

Nachemson demonstrated that mechanical load on the spine is present at all times in variable magnitude [3]. Categorising exposures could result in a loss of important information necessary for the understanding of spinal mechanical load as a risk factor for low back pain. Mechanical load applied in a flexed or a lordotic posture will affect the musculoskeletal system of the lumbar spine differently [4,5,6]. Thus as well as duration and magnitude of an exposure, as the position of the spine in the sagittal plane (i.e. flexed or a lordotic posture) could be important variables when exploring spinal mechanical load as a potential risk factor for low back pain. In our systematic review one exposure provided this type of information and was statistically significant associated with low back pain: 'working with the trunk in bent and twisted position more than 2 hours/day' [7]. Remarkable that an exposure lasting two hours per day (8%) could be considered a risk factor for low back pain. Interactions with other exposures are likely, and the 92% missing exposure time could have considerable effect for the assessed risk factor(s) for low back pain. Therefore, we argue that research on spinal mechanical load should involve all (daily) physical activities measured over 24 hours.

The literature is characterised by the non-uniformity of methods used to measure spinal mechanical load. The indicators for the exposures range from job title [8,9,10], through descriptions of work tasks [11], and measures of posture and load [12,13,14], to measures of muscle activation [15,16]. But no valid instrument that is able to achieve insight in all (daily) physical activities has been described or used. Of course, low back pain has multi factorial causation [17], but we believe the true impact of spinal mechanical load as a risk factor for low back pain is still unknown.

The 24 Hour Schedule. The 24 Hour Schedule (24HS) is our newly developed structured questionnaire, which intends to measure the mean spinal mechanical load of all daily exposures over a 10 week period. In his manner we believe that an objective and valid indication can be obtained of all daily exposures essential for the assessment of spinal mechanical load as a risk factor for low back pain. As in most studies assessing spinal mechanical load, the parameter is expressed as the duration of the exposure (expressed in schedule hours).

The 24HS is intended for use in primary care. Therefore compromises were made to avoid complexity of the 24HS. It is likely that these compromises did decrease the precision of the 24HS. We categorised exposures of spinal mechanical load in three categories: 1. Unloaded; no load applied (e.g. laying), 2. Loaded (e.g. sitting) and 3. Loaded with movement (e.g. digging or sauntering), and assumed the ratio for training's intensity of the back of these categories is 1 : 2 : 3. By this the various exposures could be weighted in the sum score. We realise that the empirical evidence for this assumption is poor. The 24HS could be more accurate if exposures are registered separately instead of categorising them. This procedure would be more complex, and the comparability of the different exposures could be problematical. In practice the results are less illustrative for the patient.

Also the reliability of questionnaire methods for the assessment of postural load in epidemiologic studies is probably not very high [9]. Observational methods for example as used by Hoogendoorn et al. [12] could be used as a reference test to determine the precision of this estimation (i.e. criterion validity). However for this, multiple twenty-four hours' period observations are required. Other more objective methods (e.g. automatic registration of posture and load) are conceivable, but such instruments should be developed and tested first.

Clinimetrics. Beforehand we considered the 24HS has face- and expert validity, because the way is was developed (expert consensus). The 24HS is a new instrument that should be evaluated thoroughly regarding reproducibility and validity. We assessed the interobserver reliability of the 24HS in 40 subjects with low back pain, and the Intra Class Correlation Coefficient was 0.81 (95% confidence interval 0.67 to 0.89), which could be considered as relatively high compared with other questionnaires [18,19] or systematic observation and direct measures techniques [20] used to evaluated spinal mechanical load as a risk factor for low back pain.

Noticeable in this study were the 24HS scores of the assessed postures; Flexed postures were registered in all assessments (mean: 32.1 schedule hours), but in 39 of the 80 assessments (48.8 %) there was no registration of any lordotic activity of the lumbar spine (mean: 3.7 schedule hours).

Our next interest was the validity of the 24HS. Therefore, we explored the association of 24HS scores on the presence of low back pain by comparing the 24HS scores of 100 cases diagnosed with acute (i.e. an episode lasting less than 6 weeks) non-specific low back pain and 100 controls free of low back pain. For two subjects with a difference in 24HS sum scores of 1 schedule hour, the odds ratio for low back pain is 1.26 (95% confidence interval 1.14 to

1.38). Consequently high 24HS scores are strongly associated with acute low back pain. We critically reviewed these findings on potential bias. We considered the use of retrospective data and our blinding procedures. Moreover we minimised the contrast between groups by including subjects with musculoskeletal complaints newly referred for physiotherapy by a general practitioner. We believe that our estimated association was quite robust. In view of these results we concluded that the 24HS has construct validity, and is a valid instrument for the assessment of spinal mechanical load as a risk factor for low back pain.

The 24HS estimates spinal mechanical load in vivo, but the precision of this estimation is unknown, because a reference test to assess the criterion validity was not available. Consequently, 24HS scores should be considered as a conscientious indication of the mechanical load.

Scoring. The 24HS scores of our reproducibility study are comparable with the 24HS scores of our case control study. In both studies, subjects with low back pain had high 24HS scores in flexed postures (reproducibility study: 32.1 schedule hours, case control: 35.2 schedule hours) in contrast with 24HS scores of the extended postures (reproducibility study: 3.7 schedule hours, case control: 0 schedule hours). A flexed and an extended position will affect the musculoskeletal system of the lumbar spine in a different way [4,5,6]. From the physiological point of view, the musculoskeletal system of the spine weakens from overuse or disuse [21]. In the studied populations, all subjects with low back pain intensively used the spine in a flexed position. It seems plausible that the musculoskeletal system of the back, in the flexed position might constitute overuse, causing low back pain. Then extended postures were barely present in this population. Therefore, disuse of the musculoskeletal system of the back involved in an extended position could also be a plausible explanation for (new episodes of) low back pain. In the literature, several studies support a relation between (sudden) lordotic activity and the occurrence of low back pain [22,23]. Possibly a gradual onset of low back pain can be attributed to overuse of the back in the flexed position, and a sudden onset to a disuse of the back in the extended position.

Prognostic value. Our next interest was the prognostic value of baseline 24HS scores on the course of low back pain in subjects with acute low back pain. In an inception cohort of subjects with acute non-specific low back pain, we concluded that subjects' 24HS scores at baseline (34.6 schedule hours) were not associated with recurrent episode(s) and/or chronic low back pain at six-month follow-up. At follow-up the mean 24HS score was reduced to 1.1 schedule hours, indicating subjects modified their 24HS scores substantially. We studied the effect of this change (baseline minus follow-up) in 24HS scores on the course of low back pain. The odds ratio for recurrent episode(s) and/or chronic low back pain was 0.96 (95% confidence interval 0.93 to 0.99). Thus the odds ratio reduced exponentially for every schedule hour difference in follow-up and baseline score. The greater subjects' difference in 24HS baseline and follow-up scores the smaller the odds for persistent low back pain. This could indicate that modification of spinal mechanical load might be beneficial on course of low back pain. Such modification can be achieved by individualised advice based on a 24HS assessment. When adding such individual advice to standard guideline care, an individualised program for the self-management of low back pain can be obtained. We also observed that the number of GP consultations per person for LBP recorded in this study was less compared with other studies. Thus, the strategy described could also be beneficial in terms of cost effectiveness. Whether this approach indeed is a (cost-) effective intervention should be examined in future controlled studies.

The costs involved in a full scale randomised controlled trial can be considerable. Before conducting a full scale trial it is important to know if this approach (i.e. using the 24HS) is feasible in patients and primary care healthcare providers. Therefore we performed a survey to assess the feasibility of 24HS advice additional to standard care in patients with low back pain and their caregivers. In this study, the threshold for feasibility was set at 7 or more (scale 0-10). Based on the results, we concluded that the 24HS advice is feasible in patients with low back pain and in primary care physiotherapy. The absence of low back pain during the follow-up period in subjects and 'lack of time' of care providers were identified as variables that could potentially threaten the feasibility of this approach. Strategies to improve feasibility in these items could be considered.

Implications for future studies. This thesis obtained new insight in assessment of exposures involving spinal mechanical load as a risk factor for low back pain. Spinal mechanical load is a modifiable risk factor. Such modification of spinal mechanical load might be beneficial in patients with acute non-specific low back pain. A randomised controlled trail could assess the (cost-) effectiveness of this therapy. A new prospective cohort study in subjects without low back pain at baseline could obtain further insight in 24HS scores as potential risk factor for low back pain.

References

1. Harkness EF, Macfarlane GJ, Nahit ES, Silman AJ, McBeth J. Risk factors for new-onset low back pain amongst cohorts of newly employed workers. Rheumatology (Oxford). 2003;42(8):959-68
2. Latza U, Karmaus W, Stürmer T, Steiner M, Neth A, Rehder U. Cohort study of occupational risk factors of low back pain in construction workers. Occup Environ Med. 2000;57(1):28-34
3. Nachemson A, Morris JM. In vivo measurements of intradiscal pressure. Discometry, a method for the determination of pressure in the lower lumbar discs. J Bone Joint Surg Am. 1964;46:1077-92
4. Adams MA, Dolan P, Hutton WC. The lumbar spine in backward bending. Spine 1988;13(9):1019-26
5. Adams MA, Hutton WC, The effect of posture on the lumbar spine. J Bone Joint Surg [Br] 1985;67(4):625-9
6. Dolan P, Adams MA, Hutton WC. Commonly adopted postures and their effect on the lumbar spine. Spine 1988;13(2):197-201
7. Van Nieuwenhuyse A. Somville PR. Crombez G. Burdorf A. Verbeke G. Johannik K. Van den Bergh O. Masschelein R. Mairiaux P. Moens GF. The role of physical workload and pain related fear in the development of low back pain in young workers: evidence from the BelCoBack Study; results after one year of follow up. Occupational and Environmental Medicine. 2006 ; 63(1): 45-52
8. Bergenudd H, Nilsson B. Back pain in middle age; occupational workload and psychologic factors: An epidemiologic survey. Spine 1988:13:589-60
9. Burdorf A, Laan J.Comparison of methods for the assessment of postural load on the back. Scand J Work Environ Health. 1991;17(6):425-9
10. Ozguler A, Leclerc A, Landre M, Pietri-Taleb F, Niedhammer I. Individual and occupational determinants of low back pain according to various definitions of low back pain. J Epidemiol Comm Health 2000;54:215-20
11. Riihimaki H Viikari-Juntura E, Moneta G, Kuha J, Videman T, Tola S. Incidence of sciatic pain among men in machine operating, dynamic physical work, and sedentary work. Spine 1994;19:138-42
12. Hoogendoorn WE, Bongers PM, de Vet HC, Douwes M, Koes BW, Miedema MC, Ariëns GA, Bouter LM. Flexion and rotation of the trunk and lifting at work are risk factors for low back pain: results of a prospective cohort study. Spine. 2000;25(23):3087-92
13. Punnett L, Fine LJ, Keyserling WM, Herrin GD, Chaffin DB. Back disorders and non-neutral trunk postures of automobile assembly workers. Scand J Work Environ Health 1991:17:337-46
14. Vingard E, Alfredsson L, Hagberg M, Kilbom A, Theorell T, Waldenstrom M, Hjelm EW, Wiktorin C, Hogstedt C and the MUSIC-Norrtalje Study Group. To what extent do current and past physical and psychosocial occupational factors explain care-seeking for low back pain in a working population? Spine 2000;25:493-500
15. Bigos SJ, Battie MC, Spengler DM, Fisher LD, Fordyce WE, Hansson TH, Nachemson AL, Wortley MD. A prospective study of work perceptions and psychosocial factors affecting the report of back injury. Spine 1991;16:1-6
16. Kerr MS, Frank JW, Shannon HS, Norman RWK, Wells RP, Neumann WP, Bombardier C, and the Ontario Universities Back Pain Study Group. Biomechanical and psychosocial risk factors for low back pain at work. Am J Public Health 2000;91:1069-75
17. Borkan J, Van Tulder M, Reis S, Schoene ML, Croft P, Hermoni D. Advances in the field of low back pain in primary care. A report from the fourth international forum. Spine. 2002;27:E128-E132
18. Wiktorin C, Karlquist L, Winkel J. Validity of self-reported exposures to work postures and manual materials handling. Scand J Work Environ Health 1993;19:208-14
19. Wiktorin C, Hjelm E, Winkel J, Kostner M. Reproducibility of a questionnaire for assessment of physical load during work and leisure time. J Occup Environ Med 1996;38:190-201
20. Neumann WP, Wells RP, Norman RW, Kerr MS, Frank J, Shannon HS, OUBPS Working Group. Trunk posture: reliability, accuracy, and risk estimates for low back pain from a video based assessment method. Internat J Indus Ergonomics 2001;28:355-65
21. Porterfield JA, DeRosa C. Mechanical low back pain: perspectives in functional anatomy. WB Saunders Com. 2nd ed. 1998; 1-22
22. Andersson GB. The epidemiology of spinal disorders. In: Frymoyer JW, Ducker TB eds. The Adult Spine: Principles and Practice. 2nd ed. Philadelphia: Lippincott–Raven; 1997:93-141
23. Mannion AF, Adams MA, Dolan P. Sudden and unexpected loading generates high forces on the lumbar spine. Spine. 2000;25(7):842-52

Summary

Summary

Chapter 1, general introduction. Low back pain remains a major health problem worldwide with a reported 1-year prevalence ranging from 15% to 40% in a general population. About 85% of the cases with low back pain are labelled as non-specific, i.e. not attributed to recognisable pathology. Acute (complaints lasting 0-6 weeks) non-specific low back pain is considered a benign self-limiting disease, with a recovery rate of 80-90% within six weeks in the open population, irrespective type of management or treatment. However, recurrence rates are reported as high as 50% in the following 12 months. Therefore, acute non-specific low back pain should be viewed as a persistent condition in many patients. Primary as well as secondary prevention might be beneficial in the management of acute low back pain. For prevention, knowledge of the risk factors is essential. Although epidemiological studies have identified many individual, psychosocial and occupational risk factors for the onset of low back pain, in general the risk factors are poorly understood. The objective of this thesis is to investigate spinal mechanical load as a potential risk factor for low back pain.

Chapter 2 presents the results of a systematic review of prospective cohort studies reporting exposures of spinal mechanical load as a risk factor for incident low back pain. After a data synthesis of 18 high-methodological quality studies, we found strong evidence that leisure time sport or exercises, sitting, and prolonged standing/walking were not associated with low back pain. Evidence was conflicting for associations in leisure time activities (e.g. do-it-yourself, gardening), whole-body vibration, nursing tasks, heavy physical work, and working with the trunk in a bent and/or twisted position and low back pain. We found no studies, thus no evidence, for an association between sleeping posture or sporting on a professional level and low back pain. In all studies, the exposures were dichotomised or categorised for assessment. Consequently, the assessed exposures represented at best 35% of the total exposure time possible per day, and the 65% missing exposure time could have considerable effect for the assessed risk factor(s) for low back pain. Therefore, it was suggested that research on spinal mechanical load as risk factor for low back pain should involve all (daily) physical activities measured over 24 hours per day.

In the literature, no valid instrument, which is able to achieve this insight, has been described yet. Therefore, a multidisciplinary research team of experts (physiotherapists, manual therapists, medical doctors) developed the 24 Hour Schedule (24HS). The 24HS is an instrument, which intends to measure the spinal mechanical load. We considered the 24HS to have face and expert validity. New instruments should be evaluated regarding their reliability and validity. Therefore, we assessed the interobserver reliability of the 24HS in patients with low back pain. We presented the results of this study in **chapter 3**. For this study, we included 40 patients (first responders on a call for participants in a local newspaper) with low back pain. Two different ex-

aminers independently assessed each patient, using the 24HS. Both examiners were blinded for each other's outcome. We found an Intra Class Correlation Coefficient of 0.81 (95% confidence interval 0.67 to 0.89), corresponding with a high level of agreement between the examiners. Noticeable was that the participants in the study used their back approximately ten times more in a flexed position than in a lordotic position. Flexed activity was registered in all 80 assessments, but in 39 assessments there was no registration of any activity in a lordotic posture.

To assess the validity of the 24HS we conducted a case-control study in patients with and without acute non-specific low back pain recruited from a primary care setting. In this study we assessed if 24HS scores were associated with the occurrence of low back pain. We presented the results of this study in **chapter 4**. Included were 100 cases with acute (i.e. an episode lasting less than 6 weeks) non-specific low back pain and 100 controls. Cases and controls completed questionnaires regarding acute low back pain status and potential risk factors. Trained examiners blinded to subjects' disease status (low back pain or not) performed the 24HS assessment. After a multivariate regression analysis previous episode(s) of low back pain (odds ratio 5.55), the Nottingham Health Profile (odds ratio 2.40), and the 24HS scores (odds ratio 1.26) were statistically significant associated with low back pain. For two subjects with a difference in 24HS scores of 1 schedule hour, the odds ratio for low back pain is 1.26 (95% confidence interval 1.14 to 1.38). For two subjects with the mean difference in 24HS scores (23 schedule hours), the odds ratio for low back pain was 161 (1.26^{23}; 95% confidence interval 40 to 652). We concluded that high 24HS scores, indicating increased daily loading of the spine in flexed position, were strongly associated with acute low back pain.

We found no-associations in low back pain and the categories representing subjects' most important physical activity during their daily occupation or profession. Possible the significance of these categories could be limited due to interactions with other common daily exposures involving spinal mechanical load. The difference in 24HS scores between groups supported this hypothesis. Therefore, we suggested involving all daily physical activities when exploring mechanical load as a risk factor for low back pain.

Chapter 5 describes our study on the prognostic value of 24HS scores on the course of low back pain. An inception cohort was formed by 100 the cases included for the case-control study. At baseline, the cases completed questionnaires regarding potential prognostic factors. Additional standard guideline care was provided and the outcome of the 24HS assessment was explained in non-technical language. This included a short explanation of the 24HS and how the sum score was obtained. Personalised advice was given to modify the 24HS sum score when indicated. The information was summarised in a brochure which patients received. At six months follow-up, 88 subjects completed a 24HS assessment and questionnaires regarding low back pain status by telephone. Thirty-five (40%) of them recovered fully within 12 weeks and did not experience recurrent episode(s). In the multivariate analysis the variable age (odds ratio 0.96, 95% confidence interval 0.93 to 0.99), and smoking (yes/no) (odds ratio 4.41, 95% confidence interval 1.50 to 12.95) were identified as prognostic factors. We concluded that subjects' 24HS scores at baseline (34.6 schedule hours) were not associated with recurrent episode(s) and/or chronic low back pain.

At follow-up, cohorts' mean 24HS score was 1.1 schedule hours, indicating subjects modified their 24HS scores substantially (from 34.6 to 1.1 schedule hours). We studied the effect of this change in 24HS scores on the course of low back pain. The odds ratio for recurrent episode(s) and/or chronic low back pain was 0.96 (95% confidence interval 0.93 to 0.99). Thus the odds ratio reduced exponentially for every schedule hour difference in baseline - follow-up score. This could indicate that modification of spinal mechanical load might be beneficial on the course of low back pain.

Whether modification of spinal mechanical load in terms of 24HS scores indeed is an effective intervention should be examined in future controlled studies. Considering the costs involved performing a controlled study, the feasibility of this treatment should be assessed first. In **chapter 6** we presented the results of our survey on feasibility of 24HS based advice additional to standard guideline care among physiotherapists and patients. We used questionnaires (completed during a telephone interview) covering factors which could threaten the feasibility. In patients the following factors were considered: the understanding of the diagnosis and causes of low back pain and the prescribed regime, expectations about the treatment, the belief that treatment was unnecessary or was no longer needed, ineffectiveness of treatment, and the experience of adverse effects. In healthcare professionals we considered workload in daily practice, usefulness of using individualised advice based on the 24HS, and patients' reactions. In patients, the absence of low back pain during the follow-up period and in physiotherapists 'lack of time' were identified as factors that could potentially threaten the feasibility in 24HS advice. Yet, 24HS advice additional to standard guideline care exceeded the criteria for feasibility, which we had previously set at seven or higher (scale: 0 to 10) for both questionnaires. 24HS based advice was considered feasible for use in primary care healthcare providers and patients with low back pain.

The general discussion (**chapter 7**) addresses the findings in this thesis and recommendations for further research. We substantiated that categorising exposures could result in a loss of important information necessary for the understanding of spinal mechanical load as a risk factor for low back pain. The missing exposure time could have considerable effect for the assessed categorised risk factor(s) for low back pain. We believe that research on spinal mechanical load should involve all (daily) physical activities. With respect to the physiology of the musculoskeletal system we developed the 24HS. The 24HS is an instrument measuring spinal

mechanical load. We considered the 24HS a valid and reliable instrument for the assessment of spinal mechanical load as a risk factor for low back pain. Modification of 24HS scores might be beneficial in the management of low back pain. This procedure was considered feasible for use in primary care healthcare providers and patients with low back pain. The effectiveness of this intervention should be examined in future controlled studies.

Samenvatting

Samenvatting

Hoofdstuk 1, algemene introductie. Met een prevalentie van 15% tot 40% in de openbevolking blijft lage rugpijn wereldwijd een omvangrijk gezondheidsprobleem. Ongeveer 85% van de lage rugpijn wordt beschouwd als aspecifiek, d.w.z. er is geen aanwijsbare pathologie. Acute (klachten tot 6 weken) aspecifieke lage rugpijn wordt gezien als een goedaardige aandoening. In de openbevolking herstelt 80-90% van de patiënten hiervan binnen zes weken, ongeacht het beleid of de gevolgde behandeling. Toch is het aantal recidieven circa 50% binnen een jaar. Daarom zou in veel gevallen acute aspecifieke lage rugpijn als een chronische aandoening moeten worden beschouwd. Primaire en secundaire preventie kan effectief zijn bij de behandeling van acute lage rugpijn. Voor preventie is kennis van de risicofactoren essentieel. In epidemiologische studies zijn menige individuele, psychosociale en werkgerelateerde risicofactoren voor lage rugpijn beschreven, maar in het algemeen zijn deze nauwelijks begrepen. Het doel van deze thesis was om inzicht te krijgen in mechanische belasting van de rug als risicofactor voor lage rugpijn.

Hoofdstuk 2 beschrijft de resultaten van een systematisch literatuuronderzoek van 18 prospectieve cohortstudies over mechanische belasting van de rug als risicofactor voor incidente lage rugpijn. Alle studies waren van een hoge methodologische kwaliteit. Na een kwalitatieve datasynthese werd sterk bewijs gevonden dat vrijetijdssporten of oefeningen, zitten, langdurig staan of lopen niet met lage rugpijn was geassocieerd. Het bewijs voor associaties tussen lage rugpijn en vrijetijdsbezigheden zoals doe-het-zelven of tuinieren, totale lichaamsvibraties, verpleegkundigentaken, zwaar fysieke werk, en werken met de rug in gebogen en/of gedraaide positie was conflicterend. Wij vonden geen studies, dus geen bewijs, voor associaties tussen lage rugpijn en houding tijdens het slapen of sporten op een professioneel niveau. In alle studies was de mechanische belasting op de rug gedichotomiseerd of gecategoriseerd. De beoordeelde risicofactoren vertegenwoordigden hierdoor maximaal 35% van de totale expositietijd die per dag mogelijk is. De mechanische belasting, aanwezig tijdens de ontbrekende 65% expositietijd, kan een aanzienlijke risicofactor zijn voor lage rugpijn. Daarom adviseren wij om alle voorkomende (dagelijkse) activiteiten te betrekken bij het beoordelen van mechanische belasting als risicofactor voor lage rugpijn.

In de literatuur was geen valide instrument beschreven, dat hiertoe instaat is. Daarom is door een multidisciplinair team van deskundigen (fysiotherapeuten, manuele therapeuten, artsen) het 24 Uur Schema (24US) ontwikkeld. Het 24US meet het dominante gebruik (de trainingsactiviteit) van de rug. Op het eerste gezicht lijkt het 24US een valide instrument, maar nieuwe instrumenten moeten nauwkeurig beoordeeld worden op hun betrouwbaarheid en validiteit. Daarom bepaalden wij de inter-beoordelaars betrouwbaarheid van het 24US bij patiënten met lage rugpijn. De resultaten van deze studie worden in **hoofdstuk 3** beschreven. Voor deze studie includeerden wij 40 patiënten (eerste respondenten naar aanleiding van een oproep naar deelnemers in een lokale krant) met lage rugpijn. Iedere patiënt werd tweemaal beoordeeld met het 24US door twee verschillende onderzoekers. Beide onderzoekers waren geblindeerd voor elkaars uitkomst. We vonden een *Intra Class Correlation Coefficient van* 0.81 (95% betrouwbaarheid interval 0.67 tot 0.89), corresponderend met een hoge mate van overeenkomst tussen de beoordelaars. Noemenswaardig was, dat de deelnemers aan deze studie hun rug ongeveer tien keer meer in een gebogen positie gebruikten dan in een gestrekte positie. Een gebogen positie werd in alle 80 metingen geregistreerd, maar in 39 metingen was er geen gestrekte houding meetbaar.

Om de validiteit van het 24US te bepalen, hebben we in een eerstelijns setting een patiëntcontrole onderzoek uitgevoerd, met 200 proefpersonen. In deze studie bestudeerden we of scores van het 24US geassocieerd waren met acute aspecifieke lage rugpijn. De resultaten van deze studie staan in **hoofdstuk 4** beschreven. Geïncludeerd werden 100 patiënten met acute aspecifieke lage rugpijn en 100 patiënten zonder rugpijn, maar met andere klachten aan het bewegingsapparaat. Beide groepen beantwoorden vragenlijsten om de status van de rug en de aanwezigheid van potentiële risicofactoren voor rugpijn te bepalen. Onderzoekers, geblindeerd voor de expositiestatus van de proefpersoon (lage rugpijn of niet) voerden het onderzoek met het 24US uit. Na een multivariate regressie analyse waren eerdere episodes lage rugpijn (odds ratio 5.55), de Nottingham Health Profile (odds ratio 2.40) en de 24US score (odds ratio 1.26) statistisch significant geassocieerd met lage rugpijn. Voor twee personen met een verschil in 24US score van 1 schema uur, was de odds ratio voor lage rugpijn 1.26 (95% betrouwbaarheidsinterval 1.14 tot 1.38). Voor twee personen met een verschil van 23 schema uren (het gemiddelde verschil tussen beide groepen), was de odds ratio lage rugpijn 161 (1.26^{23}; 95% betrouwbaarheidsinterval 40 tot 652). We concludeerden dat hoge scores van het 24US, wijzend op een hoge dagelijkse belasting van de rug in een gebogen positie, sterk geassocieerd waren met de aanwezigheid van lage rugpijn. We vonden geen associaties tussen lage rugpijn en de categorieën die de dagelijkse bezigheden of werkzaamheden van de proefpersonen vertegenwoordigen. Mogelijk omdat het onderscheidend vermogen van deze categorieën beperkt werd door interacties met andere dagelijkse bezigheden. Het verschil in 24US scores tussen de groepen ondersteunde deze hypothese. Daarom suggereerden wij om de totale dagelijkse belasting van de rug te betrekken bij het onderzoek naar mechanische belasting op de rug als risico factor voor lage rugpijn.

Hoofdstuk 5 beschrijft onze studie naar de prognostische waarde van 24US scores op het verloop van lage rugpijn. Een inceptie cohort werd geformeerd met de 100 patiënten uit het patiëntcontrole onderzoek. Bij de baseline metingen werden vragenlijsten ingevuld, om de aanwezigheid van potentiële prognostische variabelen vast te kunnen stellen. Na afloop van de baseline meting kregen de patiënten de standaard behandeling volgens de richtlijn van het

Nederlands Huisartsen Genootschap (NHG). Aanvullend werd de uitkomst van de 24US meting in begrijpelijke taal besproken, inclusief het tot stand komen van de 24US som score. Indien geïndiceerd, werd individueel aangegeven hoe de 24US som score kon worden gemodificeerd met als doel de kans op recidieven te verminderen. Alle informatie werd samengevat in een folder, die de patiënten na afloop ontvingen. Bij de follow-up meting na zes maanden completeerden 88 patiënten telefonisch vragenlijsten over de status van de lage rugpijn. Vijfendertig (40%) van hen waren volledig hersteld binnen 12 weken en ondervonden geen recidief. In de multivariate analyse werden de continue variabele leeftijd (odds ratio 0.96, 95% betrouwbaarheidsinterval 0.93 tot 0.99) en de dichotome variabele roken (odds ratio 4.41, 95% betrouwbaarheidsinterval 1.50 tot 12.95) geïdentificeerd als prognostische factoren. We concludeerden, dat de 24US baseline score van de patiënt (34.6 schema uren) niet geassocieerd was met het voorkomen van recidief klachten en/of chronische (klachten langer dan 12 weken) lage rugpijn.

Tijdens de follow-up meting was de gemiddelde 24US score van het cohort 1.1 schema uur. Dit wijst erop, dat de proefpersonen in staat waren hun 24US te modificeren (van 34.6 naar 1.1 schema uren). We onderzochten het effect van deze modificatie op het verloop van de rugpijn. De odds ratio voor recidief klachten en/of chronische (> 12 weken) lage rugpijn was 0.96 (95% betrouwbaarheidsinterval 0.93 to 0.99). Dus de odds ratio vermindert exponentieel voor ieder schema uur verschil tussen baseline en follow-up score. Dit kan betekenen, dat het modificeren van de mechanische belasting op de rug een gunstig effect kan hebben op het verloop van de lage rugpijn. Of een modificatie van de mechanische belasting op de rug inderdaad een effectieve interventie is, zal onderzocht moeten worden in een gecontroleerde experimentele studie. Gezien de kosten, die met zo een studie gemoeid zijn, zal eerst bepaald moeten worden of deze behandeling haalbaar is.

In **hoofdstuk 6** presenteren we de resultaten van het onderzoek onder fysiotherapeuten en patiënten naar de haalbaarheid van individueel advies gebaseerd op een meting met het 24US naast de standaard NHG-richtlijn behandeling. Tijdens een telefonisch interview werden vragenlijsten afgenomen met items die de haalbaarheid potentieel kunnen beïnvloeden. Onder patiënten werden de volgende items overwogen: het begrijpen van het voorschreven regime, de diagnose en de oorzaak van lage rugpijn, de verwachting van de behandeling, het idee dat de behandeling onnodig is of niet langer noodzakelijk, of het ervaren van bijwerkingen van de behandeling. Onder de behandelaars werden de volgende items overwogen: de werkdruk in de dagelijkse praktijk, het nut van het gebruik van individueel advies gebaseerd op een 24US meting en de reacties van de patiënt. Bij de patiënten werd de afwezigheid van lage rugpijn tijdens de follow-up periode en bij de fysiotherapeuten tijdgebrek, geïdentificeerd als potentiële bedreigingen voor de haalbaarheid van 24US advies. Toch haalde 24US advies naast de standaard richtlijn behandeling de vooraf gestelde drempel voor haalbaarheid van 7 (schaal: 0-10). Advies gebaseerd op het 24US werd beschouwd als een haalbare interventie in de eerste lijn voor zowel de patiënt met lage rugpijn, als de behandelaars.

De algemene discussie (**hoofdstuk 7**) beschrijft de bevindingen van dit proefschrift en de aanbevelingen voor verder onderzoek. We hebben aannemelijk gemaakt, dat het categoriseren van mechanische belasting op de rug, leidt tot het verlies van belangrijke informatie, noodzakelijk voor het beoordelen en begrijpen van deze risicofactor voor lage rugpijn. Wij menen, dat bij de beoordeling van mechanische belasting op de rug als risicofactor voor lage rugpijn, alle dagelijkse fysieke activiteiten moet worden betrokken. Conform de fysiologie van het bewegingsapparaat hebben wij het 24US ontwikkeld. Het 24US is een één-dimensionaal instrument, dat de dagelijkse belasting (trainingsactiviteit) van de rug meet. Wij beschouwen het 24US een betrouwbaar en valide instrument voor het meten van mechanische belasting op de rug. Modificatie van 24US scores kan een effectieve interventie zijn bij de behandeling van lage rugpijn. Deze behandeling is haalbaar in de eerste lijn. De werkzaamheid van deze interventie moet worden vastgesteld met een gecontroleerde experimentele studie.

Addendum

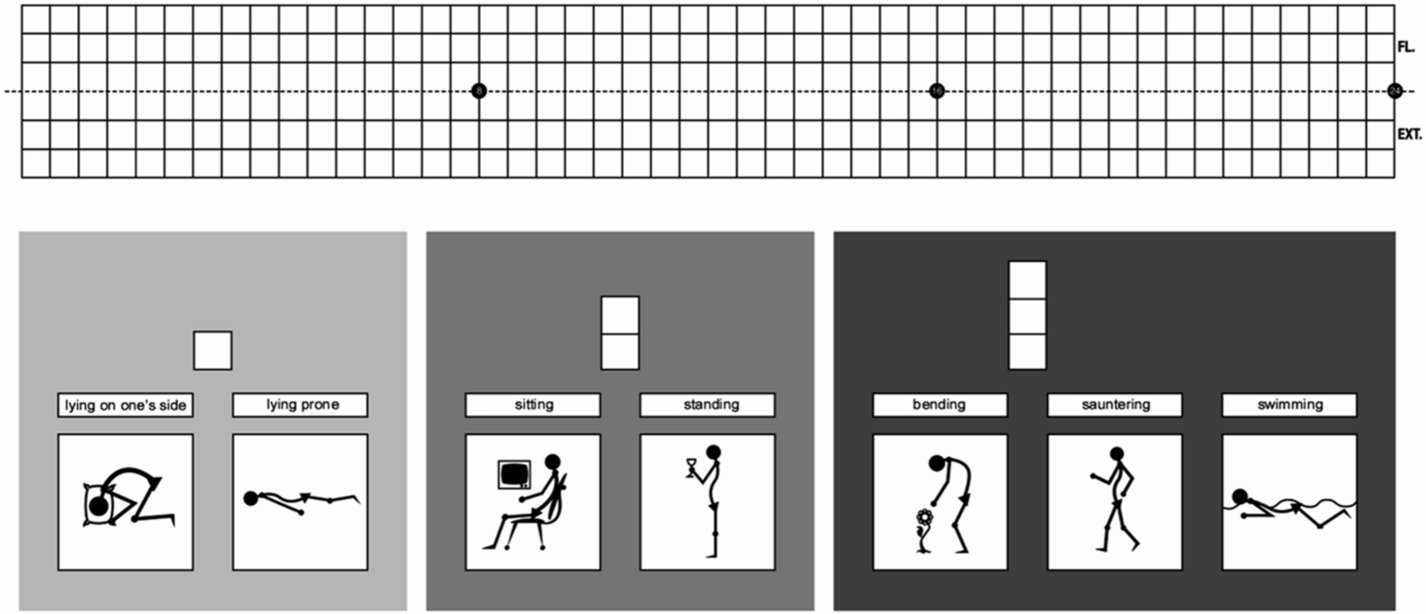
Addendum

The 24 Hour Schedule questionnaire: Assume an average day. This day should be representative for the use of your back for the last 10 weeks.

- What time do you get out of bed?
- How long does it take for you to make your morning toilet, get dressed, eat your breakfast et cetera?
- Do you work? If so, how do you go to your work and how long does that take?
- How do you spend your morning? Which activities are taken on?
- What time does your lunch break start? How long does it last? What are your activities during your lunch break?
- How do you spend your afternoon? Which activities are taken on?
- How often and how long do you perform sports activities during a week?
- How do you spend your evening? Which activities are taken on?
- What time do you go to bed? In which posture do you sleep?
- Are there any other activities taken on during a week which you think should be mentioned?

Note: when patients notify that they are sitting, stooping, lifting, standing, or sleeping, use the series of standardized photos to verify the exact posture.

The 24HS Registration Form



Notes:

Dankwoord

Dankwoord

Je bent fysiotherapeut, manueel therapeut en wordt verondersteld deskundig te zijn op het gebied van lage rugpijn. Ik heb er geen moment aan getwijfeld dat dit een terechte veronderstelling was tot het moment dat ik zelf met rugpijn werd geconfronteerd en niet instaat bleek het ontstaan van mijn klachten te verklaren. Naarmate ik als "ervaringsdeskundige" meer met rugpijn werd geconfronteerd, kreeg ook het 24-Uur Schema vorm en daarmee het idee om dat schema wetenschappelijk te toetsen. Dr. R. Starmans werkzaam aan de faculteit Huisartsgeneeskunde van het Erasmus Medisch Centrum te Rotterdam introduceerde mij daartoe bij zijn collega Prof.dr. B.W. Koes.

Beste Bart, ons eerste gesprek staat mij nog goed voor ogen. Gesterkt door het feit dat Richard Starmans mij verzekerde dat ik niet direct de deur zou worden gewezen heb ik een uiteenzetting gegeven over mijn ideeën betreffende het 24-Uur Schema. Als voorbeeld heb ik jouw dagelijkse belasting geobjectiveerd. Zo kon ik aangeven waarom jij mogelijk tijdens squashen rugklachten had gekregen, maar ook hoe dat mogelijk voorkomen had kunnen worden. Aangemoedigd door jouw enthousiaste reactie "dat zou geweldig zijn" stelde ik voor te onderzoeken of deze toepassing ook therapeutische winst kon opleveren. "Nou, niet zo snel" was jouw getemperde reactie. Deze terughoudende wetenschappelijke benadering heeft uiteindelijk geleid tot het voorliggende resultaat. Bijzonder dankbaar ben ik je voor de keren dat je bereid was om mee te gaan om toelichting te geven voor een mogelijke subsidie ten behoeve van ons onderzoek of voor een presentatie met als hoogtepunt uiteraard de lustrumlezing voor de Universitaire Masterstudie Evidence Based Practice in het AMC. Ik zie het als een voorrecht om onder jouw hoede te mogen promoveren.

Bijzonder dankbaar ben ik mijn copromotor Dr. A.P. Verhagen.

Beste Arianne, van iedereen betrokken bij mijn thesis heb jij verreweg het meeste bijgedragen. Gedecideerd loodste jij mij door mijn moeizame poging een eerste artikel te schrijven. Mijn concept van de introductie sectie kreeg ik van je terug met het bemoedigende commentaar 'goede eerste aanzet'. Na openen van het document zag het rood van je correcties en een 'accept all changes' toonde een nagenoeg leeg oorspronkelijk document. Maar jouw geduld met mijn concepten, je kritische blik, kennis van methodologie en vooral je streven naar perfectie, hebben in hoge mate bijgedragen aan 'het geluk' dat mij ten deel viel bij de snelle acceptaties van onze artikelen. Ik hoop dat de plannen die ik, met het 24-Uur Schema heb, realiseerbaar zijn, zodat onze samenwerking zich ook na mijn dissertatie zal voortzetten.

De nieuwe opleiding tot klinisch epidemioloog, aangeboden door de Universitaire Masterstudie Evidence Based Practice (AMC-UVA) bleek een perfecte keuze. Door mijn enthousiaste medestudenten/collega's en de inspirerende leiding van Dr. C. Lucas heb ik deze studie met veel plezier doorlopen.

Beste Cees, toen ik in 2002 met je kennis maakte, had ik er geen idee van dat de toekomst een intensieve samenwerking zou brengen. Niet alleen werk ik nu voor jou als universitair docent aan de Master Opleiding, maar ben jij ook mijn copromotor. Je wijze lessen, relativeringsvermogen, humor, schrijfvaardigheid, deskundige en kritische kanttekeningen zijn een onmisbare steun voor mij geweest, en dat niet alleen bij het completeren van dit proefschrift.

Drs. E. van Trijffel was een van mijn medestudenten van het eerste uur.

Beste Emiel, als extern promovendus miste ik dikwijls de contacten met lotgenoten. Dit werd deels ondervangen door onze wekelijkse ontmoeting rondom de colleges in het AMC, eerst beiden als student en later als docent. Samen met collega docent Sander de Wolf ben jij voor mij een waardevol klankboard tijdens mijn promotieonderzoek geweest. Ik voel mij gesteund dat jij samen met Victor van Dongen, (zelf ook gegrepen door het promotievirus), mijn paranimf wilt zijn.

Uiteraard was de verdere ontwikkeling en de openrationalisatie van het patiëntgebonden onderzoek niet mogelijk geweest zonder de enthousiaste hulp van mijn Haagse collega's uit het Intercollegiaal Overleg Fysiotherapie Duinoord, Zeeheldenkwartier en Statenkwartier. Hierbij met name te noemen de leden van de vaste werkgroep: Karin van Baaren, Birgitta van Dijk, Aukje de Hair, en Brigitte Sluimer onder voorzitterschap van Hans Koning.

Door hun onmisbare bijdrage mogen niet onvermeld blijven: Dennis Mollee voor zijn ontwerp en vormgeving van het 24-Uur Schema registratie formulier en Mariska Maris als onderzoeksassistent.

De leden van de beoordelingscommissie: Prof.dr. W.J.J. Assendelft, Dr. A. Burdorf en Prof.dr. H.J. Stam en wil ik oprecht bedanken voor het lezen en het beoordelen van mijn proefschrift.

Lieve Axel, Eline en natuurlijk Joyce, onmisbaar voor het schrijven van deze thesis was jullie jarenlange onvoorwaardelijke steun, begrip, warmte en liefde. Mijn grenzeloze dank daarvoor laat zich niet uitdrukken in woorden op papier; daar zijn nog veel familieavondjes voor nodig.

List of publications

List of publications

Darby J Weir A, Inklaar H, Bakker EWP, Kruiswijk C, Moen M de Winter DC, Tol JL. The inter and intra observer reliability in six clinical tests for core stability. Submitted for publication.

Bakker EWP, Verhagen AP, van Trijffel E, Lucas C, Koes BW. Spinal mechanical load as risk factor for low back pain. A systematic review of prospective cohort studies. Submitted for publication.

Weir A, Veger SAS, van de Sande HBA, Bakker EWP, de Jonge S, Tol JL. A manual therapy technique for chronic adductor-related groin pain in athletes: a case series. Scand J Med Sci Sports. 2008 Aug 5. [Epub ahead of print]

Bakker EWP, Weir A, de Winter DC. Bilateral pain at the anterior site of the tibia. An unusual case of referred pain by osteoarthritis of the hip. A case **r**eport. Submitted for publication.

Bakker EWP, Verhagen AP, van Trijffel E, Lucas C, Koning JCMF, Koes BW. Individual advice in addition to standard guideline care in patients with acute non-specific low back pain: A survey on feasibility among physiotherapists and patients. Manual Therapy 2007 Dec 28; [Epub ahead of print].

Bakker EWP, Verhagen AP, Lucas C, Koning JCMF, Koes BW. Spinal Mechanical Load: a Predictor of Persistent Low Back Pain? A prospective cohort study. European Spine Journal 2007;16(7):933-41.

Bakker EWP, Verhagen AP, Lucas C, Koning JCMF, de Haan RJ, Koes BW. Daily spinal mechanical loading as a risk factor for acute non-specific low back pain. 'A case-control study using the 24 Hour Schedule'. European Spine Journal 2007;16(1):107-13.

Bakker EWP, Koning JCMF, Verhagen AP, Koes BW. Interobserver reliability of the 24 hour schedule in patients with low back pain. Journal of manipulative and physiological therapeutics 2003;26(4):226-32.

Struijs PAA, Damen PJ, Bakker EWP, Blankevoort L, Assendelft WJJ, Van Dijk CN. Manipulation of the wrist for treatment of tennis elbow. Physical therapy 2003;83(7):608-16.

Curriculum Vitae

Curriculum Vitae

Eric Wilhelmus Petrus Bakker werd geboren op 11 augustus 1959 te Voorburg. Na het behalen van zijn HAVO diploma aan het Huygens Lyceum te Voorburg (1978) studeerde hij fysiotherapie aan de Haagse Academie voor Lichamelijke Opvoeding en Fysiotherapie. Sinds 1982 is hij als vrijgevestigd registerfysiotherapeut werkzaam in Den Haag met als specialisaties manuele therapie (Utrecht) en all round sportfysiotherapie. Vanaf 1999 verrichtte hij parttime promotieonderzoek naar mechanische belasting als risicofactor voor aspecifieke lage rugpijn aan de faculteit huisartsgeneeskunde van het Erasmus Medisch Centrum te Rotterdam.

In 2005 behaalde hij zijn MSc-graad (Universitaire Masterstudie "Evidence Based Practice") aan van de Universiteit van Amsterdam en sinds 2006 is hij ook als docent aan deze opleiding verbonden. Vanaf 2007 is hij tevens als docent en onderzoeker verbonden aan de faculteit huisartsgeneeskunde van het Leids Universitair Medisch Centrum.

Stellingen behorend bij het proefschrift

Mechanische belasting op de rug. Een risicofactor voor aspecifieke lage rugpijn?
Spinal Mechanical Load. A risk factor for non-specific low back pain?

1. Bij het beoordelen van mechanische belasting op de rug als risicofactor voor lage rugpijn moeten alle dagelijkse activiteiten worden betrokken
2. Het dichotomiseren of categoriseren van de mechanische belasting op de rug leidt tot het missen van associaties tussen deze potentiële risicofactor en lage rugpijn
3. Het 24 Uur Schema is een betrouwbaar instrument voor het meten van de mechanische belasting op de rug bij patiënten met lage rugpijn in de eerstelijn
4. Hoge scores op het 24 Uur Schema zijn sterk geassocieerd met incidente lage rugpijn maar niet met recidiverende en/of chronische lage rugpijn
5. Advies met als doel het verlagen van hoge scores op het 24 Uur Schema is een haalbare preventieve interventie
6. Bij systematische reviews moeten containertermen zoals ‘vrijetijdsbezigheden’ worden vermeden
7. De individuele en maatschappelijke last ten gevolge van lage rugpijn is met name te reduceren met preventie
8. In tegenstelling tot overbelasting is onderbelasting als risicofactor voor lage rugpijn onderbelicht
9. Het verbeteren van de therapietrouw tijdens de afwezigheid van lage rugpijn zal een belangrijk onderdeel moeten worden van interventies gericht op secundaire preventie
10. Voor introductie in de praktijk zullen meetinstrumenten eerst zorgvuldig getest moeten worden op hun validiteit en betrouwbaarheid
11. Het is niet noodzakelijk om ervaringsdeskundige te zijn over je promotie onderwerp, maar het inspireert wel