Health Council of the Netherlands

Manual lifting during work

2012/36E

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Gezondheidsraad
Health Council of the Netherlands

To the Minister of Social Affairs and Employment

Subject : presentation of advisory report *Manual lifting during work*
Your reference : ARBO/A&V/2007/22676
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Dear Minister,

Your predecessor requested advice on a number of working conditions-related risks by letter. I am pleased to offer you the advisory report on manual lifting during work. The advisory report was drafted by the Committee on the Identification of Workplace Risks.

Physical burden is one of the largest health risks for employees in the Netherlands. This advisory report answers the question of whether it is possible to determine health-based or safety-based occupational exposure limits for manual lifting during work. The Committee concludes that a safe limit below which health risks are not present cannot be determined. The Committee does recommend the use of the internationally accepted method by the National Institute of Occupational Safety and Health (NIOSH) in lifting situations in order to prevent new complaints from developing as much as possible.

The Committee used comments received on a public draft of this advisory report and assessments obtained from the Standing Committee on Health and the Environment.

I have also forwarded this advisory report to the Minister of Health, Welfare and Sport for informational purposes.

Yours sincerely,
(signed)
Prof. dr. W.A. van Gool,
President

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Manual lifting during work

Committee on the Identification of Workplace Risks
a Committee of the Health Council of the Netherlands

to:

the Minister of Social Affairs and Employment

No. 2012/36E, The Hague, December 20, 2012

The Health Council of the Netherlands, established in 1902, is an independent scientific advisory body. Its remit is "to advise the government and Parliament on the current level of knowledge with respect to public health issues and health (services) research..." (Section 22, Health Act).

The Health Council receives most requests for advice from the Ministers of Health, Welfare & Sport, Infrastructure & the Environment, Social Affairs & Employment, Economic Affairs, and Education, Culture & Science. The Council can publish advisory reports on its own initiative. It usually does this in order to ask attention for developments or trends that are thought to be relevant to government policy.

Most Health Council reports are prepared by multidisciplinary committees of Dutch or, sometimes, foreign experts, appointed in a personal capacity. The reports are available to the public.

The Health Council of the Netherlands is a member of the European Science Advisory Network for Health (EuSANH), a network of science advisory bodies in Europe.

The Health Council of the Netherlands is a member of the International Network of Agencies for Health Technology Assessment (INAHTA), an international collaboration of organisations engaged with health technology assessment.

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Executive summary

The request for advice

At the request of the Minister of Social Affairs and Employment, the Health Council of the Netherlands has investigated whether there are current or longer term options for deriving concrete health-based or safety-based occupational exposure limits for manual lifting. This advisory report is one of a series of advisory reports in which the Committee on the Identification of Workplace Risks examines various occupational risks covered by the Dutch Working Conditions Act and its associated regulations. To answer the Minister's questions, the Committee studied the scientific data on the adverse health effects of manual lifting. The Committee's focus was on results from longitudinal research, as these provide the most reliable picture.

Scope of the problem

In 2011, almost one in five Dutch workers indicated to perform work that regularly requires application of a lot of force, such as lifting. Sectors in which manual lifting is common are construction, agriculture, industry, transport and health care. In 2005, 840,000 workers indicated they regularly have to lift weights of over 25 kg.

Studies show that workers who regularly lift may develop health complaints. The most common complaint is low back pain at some point during the past 12 months. It is known that nearly a quarter of the people with lower back complaints are likely to develop chronic complaints with obvious adverse health effects. This may not only affect daily well-being, but also result in a loss of productivity at work and sick leave.

NIOSH lifting equation

The Dutch Working Conditions Act does not contain a legal occupational exposure limit for manual lifting. Both European and international guidelines as well as Inspectorate SZW guidelines refer to the 1991 revised NIOSH lifting equation. This is a formula defined by the National Institute for Occupational Safety and Health (NIOSH) that is commonly used worldwide to assess whether certain lifting situations are associated with safety and health risks for workers.

According to NIOSH, in order to prevent health damage (to the back), the safe weight that may be lifted manually by a worker lies between 5 and 23 kilograms, with 23 kilograms applying when lifting occurs under optimal circum-stances. The NIOSH lifting equation is based on biomechanical, physiological and psychophysiological research. According to the Committee, the lifting equation provides a solid guideline for the interpretation of various factors of lifting that affect health. The NIOSH lifting equation does not provide an unequivocal relationship between the maximum allowable lifting weight and the health damage that can be prevented by adhering to it.

Health risks due to manual lifting

The consequences of manual lifting have been studied extensively since the 1990s. In many studies information about the degree of exposure and health complaints is obtained via self-reporting.

The Committee concluded that, based on available scientific data, indicating how much can be lifted without health complaints developing is impossible. It is possible, however, to gain insight into the size of the additional risk of health complaints due to occupational lifting. To this end, the results from available studies were combined in a meta-analysis.

The meta-analysis mapped out the relationship between manual lifting and low back pain. This showed that (regularly) lifting 23 kilograms increases the number of workers with low back pain by 3.3 per 100 workers per year. Several guidelines for manual lifting in the Netherlands use a maximal lifting weight of 25 kilogram. Consequently, the number of workers with low back pain due to lifting is increased from 3.3 to 3.7 per 100 per year.

In nearly a quarter of these workers the complaints will develop into chronic low back pain.

According to the Committee, it is likely that lifting did not occur under optimal circumstances in the epidemiological studies described. This means that the meta-analysis provides an estimate of health effects to be expected due to lifting 23 kilograms under non-optimal conditions. If these 23 kilograms were to be lifted under optimal conditions, in accordance with the NIOSH lifting equation, the risk of low back pain will be lower than calculated in the meta-analysis.

In addition to low back pain, complaints of the hips, knees, neck-shoulder region or arms might develop due to occupational lifting.

Committee recommendations

Workers mainly develop low back pain due to lifting. The Committee examined whether a threshold level for manual lifting could be determined below which lower back complaints can be prevented. This proved impossible.

Current Dutch legislation and regulations refer to the NIOSH lifting equation for the prevention of low back pain due to manual lifting. The Committee is of the opinion that the NIOSH method is an internationally accepted calculation method for preventing a high-risk burden during lifting. It therefore recommends continued application of the NIOSH lifting equation as the best available instrument for preventing the development of new complaints.

Chapter 1

Introduction

In 2011, almost one in five Dutch employees indicated they perform work that regularly requires a lot of force, such as manual lifting.[1] Sectors in which lifting is common are construction, agriculture, industry, transport and health care. Employees consider manual lifting during work an important risk factor for musculoskeletal complaints. The consequences of these complaints for society in terms of rehabilitation, sick leave and work disability are costly. In this advisory report, the Committee on the Identification of Workplace Risks of the Health Council of the Netherlands examines whether it is possible to derive concrete occupational health-related or safety-related exposure limits for manual lifting during work.

1.1 Lifting: a definition

There are various definitions for lifting. The European guideline refers to *manual materials handling*.[2,3] The National Institute for Occupational Safety and Health (NIOSH) defines manual lifting as *manually grasping an object of definable size and mass with two hands, and vertically moving the object without mechanical assistance*.

Lifting is a form of dynamic physical burden that may be quantified in terms of duration, frequency and intensity. This occupational risk is particularly prevalent in heavy physical labour, and often combined with other activities such as walking, applying force, pushing and pulling.

This advisory report is focused on manual lifting, including carrying (walking with a load), as lifting and carrying are impossible to separate in many workplace situations. Applying force, pushing and pulling are addressed in a separate advisory report.

Any reference to lifting in this advisory report pertains to manual lifting during work.

1.2 Scope of lifting during work

As previously mentioned, in 2011 almost one in five Dutch employees indicated they perform work that regularly requires the application of force, such as lifting, pushing and pulling.[1] This figure is much higher in construction, in-patient care, homecare, child care, industry and agriculture. Employees in professions that involve frequent lifting, carrying, pushing and pulling are bricklayers, carpenters and other construction workers (61%), livestock farmers (53%) and nurses and carers (52%).[1] Percentages for lifting alone are not available.

Lifting is primarily associated with heavy physical work.[1,4,5] In the Netherlands, 32% of employees indicate they perform heavy physical work; application of force for lifting a load is part of this. Youths in particular perform heavy physical work: 40% of youths ages 15 to 25 years regularly perform heavy physical work. This percentage drops as people get older (the percentage is over one quarter for the 55-65 age group). Men perform (significantly) more heavy physical work than women: over 33% of men compared with 28% of women. In 2005, 840,000 employees (12% of the working population) indicated they regularly have to lift weights of over 25 kilograms, and over 250,000 employees regularly have to lift over 40 kilograms.[1,4,5]

1.3 The request for advice

This advisory report is one in a series of reports on possible limits for various occupational risks. On 10 July 2007, the Minister of Social Affairs and Employment asked the Health Council of the Netherlands to:

- Periodically report whether there are *currently* new (international) scientific insights regarding concrete health-based and/or safety-based occupational exposure limits.
- Periodically report whether any new (international) scientific insights regarding concrete health health-based and/or safety-based occupational exposure limits are *expected*.

Additionally, the Minister requested *existing* scientific insights be considered. The full request for advice has been included as Annex A to this advisory report.

On 14 March 2008, the Committee on the Identification of Workplace Risks was appointed for this task. The Committee is composed of experts in the fields of working conditions, health, safety and occupational disease. The chairman and members of the Committee and its working group are listed in Annex B.

1.4 The Committee's methods

Existing health-based and/or safety-based occupational exposure limits, both in The Netherlands and internationally, were used as a starting point for the advisory report. If limits and/or legal frameworks are present, the Committee first examines whether these have a health-related or safety-related foundation.

Subsequently, the Committee explores the scientific literature using review publications. This allows the Committee to gain insight in the health and safety issues resulting from lifting (Annex C). This initial phase is a starting point for the second phase, in which the Committee performs a systematic literature review (Annex D), and collects primary scientific publications on the potential negative effects of lifting during work on health and/or safety.

Finally, a draft of the advisory report is released for comments by third parties. Received comments are integrated in the finalisation of the advisory report (Annex E).

1.5 Reading guide

In the second chapter, the Committee provides an overview of applicable national and international laws and guidelines. In the third chapter, the Committee describes the results of the systematic literature review on the health effects of lifting during work, and the significance of these outcomes for the possibilities for deriving concrete occupational health-related or safety-related exposure limits. Chapter four addresses the significance of musculoskeletal complaints: how serious are they? Chapter five provides the results of a meta-analysis. In this chapter, the Committee discusses the degree to which lifting during work is a risk factor for the development of health issues in greater detail. Finally, conclusions are formulated in Chapter six.

Chapter 2

Laws and guidelines

This chapter provides an overview of legislation and regulations relating to the occupational risk of lifting. The Dutch Working Conditions Act includes rules for employers and employees designed to protect and promote the health, safety and welfare of employees and independent entrepreneurs. There are also international and European guidelines on lifting, in regard of which the Committee's main focus in this chapter will lie on the lifting equation of the National Institute for Occupational Safety and Health.

2.1 Working Conditions Decree and Provisions

Sections 5.1 through 5.6 of the Working Conditions Decree relate to physical burden. These sections do not define legal occupational health-based or safety-based occupational exposure limits for lifting.[6]

2.2 The Supreme Court ruling of 2007

In 1998, a restaurant employee was asked to help two colleagues lift a heavy oven (200 kilograms). Sometime later, he developed back pain and became fully work disabled. He held his employer liable. The employer refused to compensate the employee for the damage, at which point the employee went to court. The judge ruled in favour of the employee and ordered the employer to pay damages. On appeals, the court ruled in favour of the employer: the court stated that there were no standards for the maximum weight to be lifted in 1998. The court referred to a report by a consulted expert, who called the circumstances for lifting optimal. This expert noted that lifting 50 kg bags of cement was considered a normal and widely accepted task in construction for decades. That a lifting limit of 25 kg has been in place in construction since 2003 was not considered relevant by the court, as it was not applicable in 1998 and, furthermore, was related to structural or repeated lifting. In 2007, the Supreme Court ultimately overturned the court ruling.[7] The Supreme Court noted that the commentary on the Working Conditions Decree refers to the 1981 National Institute for Occupational Safety and Health (NIOSH) equation.[8,9] This NIOSH equation (see Section 2.4) is a calculation method developed in the United States that is widely used worldwide, including in the Netherlands, in order to determine whether lifting situations are associated with health and safety risks for employees. The NISOH equation does not indicate how great these health and safety risks for employees are. The equation shows that, under optimal circumstances, a maximum weight of 23 kg may be lifted. The Supreme Court was of the opinion that the employee was under the obligation, even in 1998, to ensure an employee responsible for lifting a heavy load (of around 50 kg) as part of his work had access to mechanical aids or personal protective materials in order to prevent injury. The Supreme Court considered it was generally known that lifting of such weights by an individual who did not normally engage in such activities represented a serious health risk for developing back complaints.

The Supreme Court, as well as employer, employee and sector organisations appear to follow a maximum load of 23 kg for lifting under optimal circumstances, in accordance with the NIOSH equation. Nevertheless, the scientific debate surrounding the evidence for this lifting standard rages on.

2.3 European and International limits and standards

The European Commission obligated member states to elaborate the requirements for physical burdens when using a machine in the Machinery Directive. The EN1005-2 standard was developed for lifting, a harmonised standard that provides guidelines for machine and machine part designers.[10] The EN1005-2 (titled *Safety of Machinery – Human Physical Performance Part 2: Manual handling of machinery and component parts of machinery*) is largely based on the NISOH equation, with a few additions. Unlike the NISOH equation, the basic limit for lifting is set to 25 kg rather than 23 kg for the adult working population, the latter being based on 50 US pounds (0.454 kilograms each). The basic limit of 25 kg is reduced if the lifting situation is suboptimal in terms of frequency, duration and distance. These factors are largely similar to the factors used in the NIOSH equation. EN1005-2 was not enacted into law in the Netherlands, but is used as a guideline.

In addition to the European standard EN1005-2 for lifting, there is also an international standard: ISO11228. The first part of this standard is relevant to lifting (*Ergonomics – Manual handling – Part 1: Lifting and carrying*).[11] The standard applies to lifting loads weighing more than three kilograms. This standard is also based on the NIOSH equation and assumes one individual working eight hours per day while standing without combining different tasks. ISO11228-1 provides values that account for the intensity, frequency and duration of the task. Holding loads, pushing or pulling, lifting with one hand or while sitting and lifting with multiple people are not addressed. The basic limit for lifting in this standard is 25 kilograms for the adult working population, a weight that is reduced under suboptimal circumstances. Based on a number of questions, a risk analysis is performed in five steps, based in part on the NIOSH equation, in order to determine a recommended lifting weight. If the risk analysis demonstrates the recommended weight is exceeded, suitable measures are required to reduce the risk, for example the use of aids, adjustment of the load, workplace, task, organisation and/or working environment, and training employees how to safely lift loads or people. The absolute limits defined in ISO11228-1 are: maximum weight of 25 kg, maximum frequency of 15 times per minute, maximum total weight carried (cumulative) of 10,000 kg per day. ISO11228-1 was not enacted into law in the Netherlands, but is used as a guideline.

2.4 The National Institute for Occupational Safety and Health

The previously described Dutch and international legislation and regulations repeatedly refer to the NIOSH equation. The Committee discusses the NIOSH equation and its evidence base below.

2.4.1 *NIOSH equation definition**

NISOH defines lifting as the act of manually grasping an object of definable size and mass with two hands, and vertically moving the object without mechanical assistance. Based on scientific evidence, primarily obtained from biomechanical, physiological and psycho-physiological research, the NIOSH formulated an equation for calculating the recommended maximum lifting weight in 1981.[8] The equation was later updated and presented during an American conference in 1994 (A national strategy for occupational musculoskeletal injury prevention – Implementation issues and research needs).[9] The recommended maximum lifting weight is the weight that most healthy employees (90% of working adults, 99% of men and 75% of women) can lift for a substantial period of time (a maximum of 8 hours) without it being an undue burden for the back. There are two versions of the NIOSH equation: one for single-task lifting jobs, and one for multi-task lifting jobs. The NIOSH single-task equation is the most well-known and is most frequently applied, as manually lifting a specific load can be considered a single-task lifting job. This NIOSH equation allows the difficulty of a lifting task to be calculated based on six components
(Figure 1):[9,12]

- H, the horizontal distance from the object to the ankles (cm);
- V, the vertical distance from the object to the ankles (cm);
- D, the displacement of the object or vertical travel distance (cm);
- F, the frequency and duration of the lift (number per minute and number of hours);
- A, the rotation of the body or trunk angulation (degrees); and C, contact with the object.

Depending on the contribution of each component to the difficulty of the lifting job, it is expressed as a factor between 1 (favourable and optimal situation) and 0 (unfavourable situation). The recommended weight limit (RWL) is calculated by multiplying the load constant (LC) of 23 kilograms by these six factors:

RWL (kilogram) = 23 x Hf x Vf x Df x Ff x Af x Cf

* The full title of this NIOSH equation is: ‘Applications manual for the revised NIOSH lifting equation’ (1994).

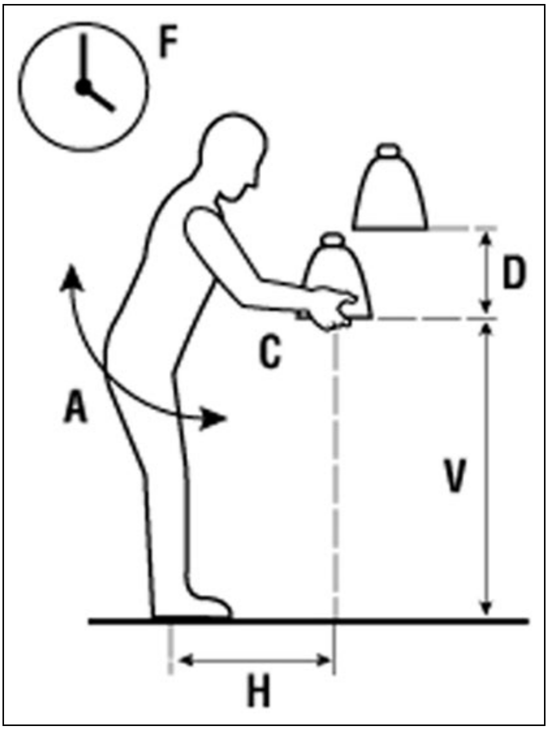

Figure 1 the six components of the NIOSH equation.

in which:

Hf = (25/H) (minimum 25 cm, maximum 63 cm; Hf = 1 if H ≤ 25 cm)

Vf = 1 – (0.003 x |V-75|) (maximum 175 cm; Vf = 1 if V = 75 cm)*

Df = 0.82 + (4.5/D) (Df = 1 if D ≤ 25 cm)

Ff = number of times per minute (at least 0.2/min) and duration (≤ 1 hour, 1 – ≤ 2 hours, 2 – ≤ 8 hours)

Af = 1 – (0.0032 A) (in °) (rotation must be <135°; Af = 1 if there is no rotation)

Cf = 0.90 for poor, 0.95 for normal, and 1 for good.

* Vf cannot be negative.

The relationship between the weight to be lifted and the recommended weight limit is given as the NIOSH lifting index*. In the original 1981 formula, a maximum weight of 40 kg instead of 23 kg was used for lifting under optimal circumstances to calculate the recommended weight limit (RWL) under less than optimal conditions. Lowering of this maximum was primarily due to increasing the minimum horizontal displacement (Hf) from 15 to 25 cm. Under optimal circumstances for the entire lifting task, with all factors being optimal (so equal to 1), the recommended weight limit is 23 kilograms. The amount of 23 kg is derived from the conversion of 50 US pounds, each 0.454 kg, into kilograms (i.e. 22.7 kg). However, as factors are rarely all optimal in practice, the recommended weight limit is generally lower than 23 kilograms.

Under optimal circumstances, 23 kilograms is the weight 75% of women and 99% of men can safely lift (i.e. without undue burden for the back) according to NIOSH. Under extremely unfavourable circumstances, about 5 kilograms is the weight 90% of women and 99% of men can safely lift. This is about 1 kilogram less than the recommended weight limit derived from Snook and Cirello's extensive psychophysiological testing (1991).[30] The use of the six elements of the NIOSH equation means there is a linear relationship between the safe lifting weight under extremely unfavourable circumstances of 5 kg and the maximum safe lifting weight of 23 kg.

An example: the maximum weight someone may lift onto a 75 cm tall table from the floor once per minute, for 8 hours, is 10kg, provided that person is standing straight in front of the table. If the person needs to rotate the object over a 90-degree angle, the recommended weight limit is 7 kilograms, or 8 kilograms if the individual does it for less than 2 hours per day. Whether a lifting job may endanger health depends on a number of occupational factors, such as the previously mentioned distance to the object, lift height and angulation of the body, as well as individual employee factors including age, sex, constitution, physical condition and limiting factors such as handicaps.

The use of the NIOSH equation is bound by a number of conditions. For example, it cannot be applied to:

- one-handed lifting
- repeated lifting during a working day longer than 8 hours
- lifting while kneeling or sitting

* Lifting index: LI = L/RWL.

- lifting with limited room for manoeuvring
- for unstable loads
- lifting with aids
- lifting that involves high acceleration.

The equation also cannot be used if the distances or angulation become too great (>135°). The assumption is also made that the employee's contact with the floor is solid (no unstable contact or slippery floor) and that climatological conditions remain within certain margins, i.e. the temperature does not drop below 19 °C or rise above 26 °C, and relative humidity is no lower than 35% or higher than 50%. Additionally, the NIOSH equation is based on the assumption that activities other than lifting, such as pushing, pulling, carrying, walking or climbing, make a negligible contribution (of less than 10%) to the employee's overall activity.

Due to the multiple components and conditions, the application of the NIOSH equation is usually complex and extremely time consuming, particularly where multi-task (and varied) lifting jobs are performed by a large population of employees.

2.4.2 *Substantiation, usability and validity of the NIOSH equation*

In 1995, the Health Council of the Netherlands published an advisory report on the health risks of (manual) lifting, which focused on the usability and validity of the NIOSH equation.[13]

The NIOSH used different kinds of information to create the equation. Biomechanical, psycho-physiological and physiological research findings contributed to the choices made by the equation's creators. Only limited epidemiological research data was available. In 1995, the Health Council noted that the risk of health damage was associated with lumbar-sacral load. The Health Council concluded that it was impossible to base a weight limit or equation on exact data regarding the health damage that could be avoided at the individual or group level. The equation does allow valid categorisation by burden for various lifting situations. This makes it an instrument that can play a valuable role in the prevention of health damage.

Elfeitrui and Taboun (2002) used psycho-physiological and biomechanical data to examine the validity of the NIOSH equation.[14] They concluded that both the original and the revised NIOSH equation from 1991 are of limited usefulness for predicting the development of health complaints due to certain types of lifting tasks. Two studies examined the predictive value of the NIOSH equation for low back pain.[15,16] In a large-scale, cross-sectional study in the United States, the incidence of lower back pain in professions with an average lifting index (1 to 3) was over 3 times higher, and even 4.6 times higher for professions with a lifting index greater than 3.[15] In a cross-sectional study among 284 employees at 4 companies, the incidence of back complaints was significantly elevated in employees with a lifting index of 2 to 3 (OR 2.45). For even higher lifting indices, this effect was no longer significant.[16] A study by Yeung et al (2003) found that a higher subjective physical burden was associated with a higher NIOSH lifting index.[17]

Various exposure components are included in the NIOSH equation. However, lifting with one hand is not examined. Research by Kingma et al (2004) showed that one-handed lifting, particularly if the other hand is used for support, leads to lower compression loads than two-handed lifting.[18] On the other hand, one-handed lifting leads to increased angular force. What this means for the incidence of low back pain was not examined in this study. The biomechanical interaction between horizontal and vertical position of the load is also not included in the NIOSH equation. However, this interaction is an important predictor for compression loads on the lower back, with the horizontal position having minimal impact for low vertical positions but a significant influence for higher vertical positions.[19] Additionally, asymmetry plays a major part in the NIOSH equation, though there is no evidence for such effects. There are conflicting reports in the literature with regard to the effects of asymmetry on compression loads in the lower back.[20,21] The effect as quantified in the NIOSH equation appears to be overestimated.[14]

2.5 Other advisory reports

The Inspectorate SZW bases its assessments of lifting and carrying on the Working Conditions Decree and Provisions.[22] As previously described, the Working Conditions Act does not have any specific standards for how much an employee may lift. In practice, lifting and carrying a load may not endanger the safety and/or health of the employee. The Inspectorate SZW uses the NIOSH equation in its supervision. Additionally, the Inspectorate SZW applies the regulations for construction workers . In the construction industry, employer and employee organisations have agreed that the NIOSH equation is used to determine healthy working conditions. This was recorded in the so-called *Arbouwblad* (Construction working conditions paper) which sets the maximum weight limit to 25 kilograms. This limit is not substantiated. Furthermore, this paper states that goods heavier than 50 kg may not be moved manually, including by multiple employees.

In child care, employers and employees have signed a covenant stating that goods and children heavier than 23 kg may not be lifted. Scientific substantiation for this standard is not given in the covenant.

The Guidelines for Pre-Employment Medical Examinations [*Leidraad Aanstellingskeuringen*] describe lifting as a special job requirement if an employee must lift loads of over 20 kilograms with an average frequency of 15 times per day or more.[23] This value is based on a consensus between various partners and may be considered an actionable value for performing a medical pre-employment examination (which is only permitted under Dutch law if performance of the job in question requires the potential employee to meet specific physical capacity requirements[24]). The Guideline does not provide any information about the extent of the health or safety risks for the employee in relation to this actionable value.

The Netherlands Center for Occupational Diseases (NCvB) applies registration guidelines that indicate the causal link between conditions and exposure (during work) to occupational factors. These registration guidelines were developed based on recent scientific literature derived from various data sources. The NCvB's expert network is also asked to provide relevant publications. The scientific literature is not always collected in a systematic manner. Various NCvB occupational health guidelines apply to lifting. The registration guideline Non-specific Lower Back Complaints [*Aspecifieke lage rugklachten*], based on a review and a decision analysis derived from this review[25] indicates that employees are at increased risk for work-related non-specific lower back pain if:
- they lift or carry more than 15 kilograms for more than 10% of a working day
- they lift or carry more than 5 kilograms more than twice per minute during a total of more than 2 hours per working day or
- they lift or carry more than 25 kilograms more than once per working day.[26]

Additionally, the NCvB indicates that employees are at risk for work-related knee osteoarthritis if they lift 10 kilograms for more 10 times per week for at least 1 year.[26] Finally, the registration guideline Hip Osteoarthritis (Cox Osteoarthritis) [*Artrose van de heup (coxartrose)*] states that employees run the risk of work-related hip osteoarthritis if they lift more than 10 kilograms or more 10 times per week for at least 1 year.[26]

2.6 Conclusion

The Working Conditions Act does not state any legal limits for lifting. European and international guidelines as well as Inspectorate SZW guidelines refer to the NIOSH equation. In order to prevent health damage (to the back), the NIOSH equation sets the weight an employee can safely lift manually between 5 kg and 23 kg, with 23 kg being applicable under the most optimal circumstances. The NIOSH equation is based on biomechanical, physiological and psycho-physiological research. According to the Committee, the equation can provide solid guidance when interpreting various factors involved in lifting that may harm health. However, it is impossible to clearly link the recommended weight limit to the health damage that may be prevented by the weight limit. In the opinion of the Committee, such an association is not easy to make.

Chapter **3**

Health effects of lifting during work

The Committee performed a literature review based on the following two main questions: 1) what health problems develop due to the occupational risk of lifting during work, and 2) to what degree is exposure (in terms of duration, frequency and/or intensity) to this occupational risk related to these problems?

3.1 Broad literature exploration

Many scientific literature reviews have been published on the development of occupational health issues relating to lifting during work.[25,27-40] The Committee did not find any reviews examining safety-related issues due to lifting during work. Therefore, the potential safety-related issues relating to lifting during work are not addressed in this advisory report.

In many of the reviews found, both the degree of lifting and health effects are obtained through self-report. Based on a number of reviews and reports, the Committee notes there is a consensus that lifting may be associated with an elevated risk of lower back and lower limb complaints. There was one exception: Wai et al, based on a meta-analysis of 35 studies, concluded that an association between lifting during work and low back pain was insufficiently substantiated.[40] However, the Committee has reservations about the scientific quality of this study.[41,42]

One review of biomechanical factors involved in work-related low back pain reported that a large proportion of the people with lower back pain have a damaged intervertebral disc.[43] Compression forces and twisting and turning of the spinal column during (heavy) lifting appear to play a role in this respect.

Annex C provides an overview of the reviews identified.

3.2 Systematic literature review

After the broad exploration, the Committee performed a systematic literature review to investigate recent developments. The emphasis lay on the development of low back pain and lower and upper limb complaints due to lifting during work. Annex D acknowledges the search strategy and how studies were selected and described based on quality.

The Committee decided only to consider longitudinal studies. In longitudinal research, exposure is determined prior to the health effect. This lowers the risk of bias when examining associations between exposure and effect, providing the most reliable picture. In case-control studies, minimal bias may be expected if the determination of exposure is blinded from patient status. Case-control studies in which exposure is based on questionnaires or interviews have problems similar to those of cross-sectional research, in which self-reported exposure may be affected by health status. Therefore, the Committee places a greater value on the results of longitudinal studies.

3.3 Health damage due to lifting during work

Lower back pain

Eleven longitudinal studies examined the relationship between lifting and low back pain.[44-54] In most of the studies included, the amount of lifting and low back pain were reported by the employees themselves. Low back pain are defined as pain during the past year occurring in the lower back and lasting for more than one day. All of the studies on the consequences of lifting during work on the lower back are briefly described in Annex F and summarised in two tables in Annex G and Annex H.

Table 1 Overview of exposure-response relationships for low back pain due to lifting (expressed as lifting weight) in longitudinal studies.

Exposure	Comments	Risk measure (95%CI)	Reference
≤6.8kg	during last working day with 1 hand	1.3 (0.8-1.9)	46
≤10kg	per hour	1.4 (0.6-2.9)	54
≤10.5kg	≥ shoulder height	1.3 (0.8-2.2)	46
≤11kg	during last working day with 2 hands	1.1 (0.7-1.7)	46
>6.8kg	During last working day with 1 hand	1.1 (0.6-1.9)	46
>10kg	5 min per week	1.05 (0.9-1.2)	49
>10kg	15 min per week	1.2 (0.8-1.8)	49
>10kg	30 min per week	1.3 (0.6-3.0)	49
>10kg	45 min per week	1.3 (0.4-4.2)	49
>10kg	<1 x per week	<8 days sick: 1.0 (0.8-1.2) ≥8 days sick: 1.5 (0.8-2.9)	53
>10kg	>1 x per week	<8 days sick: 1.1 (0.9-1.5) ≥8 days sick: 1.9 (1.0-3.7)	53
>10kg	every day	<8 days sick: 1.3 (1.0-1.8) ≥8 days sick: 4.1 (2.2-7.5)	53
>10.5kg	during last working day ≥ shoulder height	1.8 (0.9-3.5)	46
≥11kg	during working day	men: 1.1 (0.7-1,7) women: 2.5 (1.5-4.1)	50
>11kg	during last working day with 2 hands	1.4 (0.8-2.5)	46
11-25kg	≤12 x per hour	1.3 (0.6-2.7)	54
11-25kg	>12 x per hour	1.4 (0.6-3.4)	54
>18kg	during last working day	2.0 (0.7-6.0)	52
≥25kg	1-15 x per working day	0.8 (0.5-1.3)	47
≥25kg	>15 x per working day	1.6 (0.9-2.8)	47
>25kg	≤12 x per hour	1.3 (0.7-2.4)	54
>25kg	>12 x per hour	3.1 (1.2-8.3)	54
>25kg	during working day	<40 years old: 1.4 (1.0-2.1) 40-49 years old: 1.0 (0.7-1.4) >50 years old: 0.9 (0.6-1.5)	51
1-49kg/hour cumulative	≥ shoulder height	1.2 (0.6-2.2)	44
≥50kg/hour cumulative	≥ shoulder height	1.0 (0.5-2.0)	44
1-99kg/hour cumulative		1.4 (0.9-2.0)	44
≥100kg/hour cumulative		1.9 (1.3-2.78)	44

CI = Confidence Interval; kg = kilogram; min = minutes.

The overview of exposure-response relationships for low back pain (Table 1) shows that while few studies showed significant effects, lifting was associated with an increased risk of lower back pain in most studies (point estimates for the risk measure greater than 1). The Committee suspects the absence of statistical significance is likely due to the study design: the large variation (within each individual) in exposure is difficult to quantify and self-reported exposure adds to the uncertainty. This limits the power of the studies.

Statistically significant associations between lifting and low back pain were found in three studies. One of these studies found that employees who lift more than 10 kg per day are at higher risk of more than 8 sick days per year due to low back pain (RR=4.1; 95% CI 2.2-7.5).[53] Another study found that lifting 11 kilograms or more led to a significantly higher incidence of low back pain in the past year among female employees.[50] The third study found that employees who lift 25 kg or more over 12 times per hour were 3 times as likely to develop low back pain than employees who do no lifting.[54] The other studies did not find statistically significant associations between lifting and low back pain. Both exposure and effects were self-reported by employees for all of the studies listed in Table 1. The results of the studies listed in Table 1 do not allow conclusions to be drawn about the level of exposure below which no back complaints develop. Purely based on statistical significance, there appears to be a threshold of 10 kilograms per 8-hour working day. However, the Committee would like to point out that information about duration and frequency of lifting is lacking.

Lower limb complaints

Two longitudinal studies examined the relationship between lifting and lower limb complaints (lower limbs are the legs from the hip to the foot).[44,55] Both studies on the effects of lifting on lower limb complaints are described briefly in Annex I and summarised in a table in Annex K. The overview of exposure-response relationships (Table 2) shows that lifting is statistically significantly associated with an elevated risk of lower limb complaints. The first study shows that cumulative lifting of up to 99 kg per hour resulted in a significantly elevated risk of such complaints.[44] The second study found that lifting more than 9 kilograms with one hand (information on frequency and duration is lacking) and lifting above shoulder height resulted in a statistically significantly increased risk of knee complaints.[55] The same study showed that lifting with two hands did not result in a statistically significantly increased risk of lower limb complaints.

Table 2 Overview of exposure-response relationships for lower limb complaints due to lifting in longitudinal studies.[a]

Exposure	Comments	Risk measure (95%CI)	Reference
<9 kg	with 1 hand	2.1 (1.3-3.2)	55
<12.2 kg	with 2 hands	1.2 (0.7-2.1)	55
<12.7 kg	≥ shoulder height	1.8 (1.1-2.9)	55
>9 kg	with 1 hand	1.7 (1.03-2.8)	55
>12.2 kg	with 2 hands	1.6 (0.9-2.7)	55
>12.7 kg	≥ shoulder height	0.9 (0.5-1.7)	55
1-49 kg/hour cumulative	≥ shoulder height	1.4 (0.8-2.7)	44
≥50kg/hour cumulative	≥ shoulder height	2.0 (1.1-3.5)	44
1-99 kg/hour cumulative		1.6 (1.1-2.3)	44
≥100 kg/hour cumulative		1.98 (1.2-2.8)	44

[a] Lower limbs refer to the legs from the hip to the foot.
CI = confidence interval; kg = kilograms.

Upper limb complaints

Four longitudinal studies examined the relationship between lifting and upper limb complaints (upper limbs are the arms from shoulder to hand).[44,56-58] These studies are briefly described in Annex J and summarised in a table in Annex K. Most studies did not distinguish between neck and shoulder complaints.

The overview of exposure-response relationships for upper limb complaints (Table 3) shows that lifting is associated with an increased risk of such complaints, with statistically significant associations found in all studies. One of the studies found that cumulative lifting of 100 kilograms or more per hour resulted in a significantly increased risk of (neck and) shoulder complaints.[44] The other studies found that (neck and) shoulder complaints occur following exposure to less than 10 kilograms of lifting weight.[56-58]

Birth issues

Four longitudinal studies examined the relationship between lifting and pregnancy difficulties and outcomes, such as premature births and miscarriages.[59-62] These studies are briefly described in Annex L and summarised in a table in Annex M. These studies showed that lifting is

Table 3 Overview of exposure-response relationships for upper limb complaints due to lifting in longitudinal studies.[a]

Exposure	Comments	Risk measure (95%CI)	Reference
≤9 kg	≥ shoulder height	2.0 (1.2-3.3)	57
≤10 kg	with 2 hands	1.9 (1.2-3.1)	57
>9 kg	≥ shoulder height	2.2 (1.2-3.9)	57
>10 kg	with 2 hands	2.2 (1.3-3.8)	57
≥25 kg	≥ 75% working day ≥ 75% sedentary work	2.4 (0.1-39.4)	56
≥25 kg	≥ 75% working day 25-50% sedentary work	1.4 (0.3-5.8)	56
≥25 kg	≥ 75% working day < 25% sedentary work	2.4 (1.1-5.0)	56
≥25 kg	25-50% working day ≥ 75% sedentary work	0.2 (0.0-1.4)	56
≥25 kg	25-50% working day 25-50% sedentary work	1.6 (0.8-3.2)	56
≥25 kg	25-50% working day < 25% sedentary work	1.4 (0.9-2.7)	56
≥25 kg	<25% working day ≥ 75% sedentary work	1.5 (1.1-2.2)	56
≥25 kg	<25% working day 25-50% sedentary work	1.4 (1.0-2.0)	56
>25 kg		2.0 (1.2-3.4)	58
1-49 kg/hour cumulative	≥ shoulder height	1.2 (0.7-2.2) 0.9 (0.4-2.2)	44
≥50kg/hour cumulative	≥ shoulder height	2.1 (1.3-3.5) 2.2 (1.1-4.3)	44
1-99 kg/hour cumulative		1.4 (0.9-1.9) 1.3 (0.8-2.1)	44
≥100 kg/hour cumulative		1.9 (1.3-2.7) 1.6 (0.9-2.7)	44

[a] The upper limbs refer to arms from the shoulder to the hand.
CI = confidence interval; kg = kilograms; % = percentage.

associated with increased risks (point estimates), but that the differences are not statistically significant. Only one study found a statistically significant association with premature work cessation during pregnancy.[62]

3.4 Areas for attention in epidemiological research

Discussion of the findings

While studying the epidemiological data, the Committee noticed a number of key problems. The diversity in exposure measures for lifting makes the studies difficult to compare with each other. Information about the duration and frequency of lifting is also lacking, and exposure to lifting is primarily expressed as lifting weight. Additionally, the wide variety of health measures used is a problem. Furthermore, the Committee noted that many studies lack the statistical power to demonstrate statistically significant associations between lifting and the occurrence of musculoskeletal complaints.

Self-reported exposure and complaints

In all epidemiological studies, exposure was reported by the study subjects via questionnaires or interviews. Various studies show that exposure recorded through self-report is less reliable than measured exposure.[63,64]

Self-reported exposure to lifting entails a risk of overestimation of this exposure. However, clear relationships with health complaints were seen: as exposure increases, complaints increase. The Committee therefore considers self- report of exposure to be an acceptable method. The health effects were also primarily self-reported, particularly where local (pain) complaints were concerned. Physical examinations were also performed in a number of longitudinal studies. In the opinion of the Committee, gathering data on local non-specific (pain) complaints is only possible via self-report.

Potential confounders

The Committee notes that a number of potential confounders must be considered when interpreting the data. For example, available research into lifting does not sufficiently differentiates exposure to other physically demanding occupational circumstances.

The Committee cannot rule out that low back pain relating to lifting are (in part) caused by repeated unfavourable trunk posture. The selected epidemiological studies do not report on this sufficiently. Additionally, occupational exposure often includes exposure to multiple risk factors for the same health complaints. For example, back complaints may not only be caused by lifting, but also by other physical risk factors such as working in a standing, kneeling or squatting position or pushing and pulling. This is often not discussed in the studies.

3.5 Different outcomes for broad literature exploration and longitudinal studies

The broad literature exploration found that exposure to lifting can be associated with an increased risk of low back pain. This relationship is less clear in the more recent longitudinal studies reviewed by the Committee. Only three of the eleven longitudinal studies found statistically significant associations between lifting and low back pain. The other eight studies showed no statistically significant associations between lifting and low back pain, although the point estimates for the risk measure were elevated. According to the Committee, this difference in outcomes between the general literature review and single more recent, longitudinal studies may lie in the changing workplace lifting situations in recent years. For example, attention for ergonomic measures to limit employee exposure to lifting and carrying have increased.[65,66] Another relevant development is team lifting, in which several employees perform a lifting task together. This also leads to a reduction in biomechanical and physical burden during manual lifting of a load.[67,68]

3.6 Conclusion

Although the Committee has access to several longitudinal studies, it is impossible to derive a occupational health-related exposure limit for lifting based on the data. The Committee concludes that the epidemiological data currently available do not allow a safe threshold for this risk to be determined based on scientific evidence. The data on the harmful health effects of low exposure levels are too limited to allow reliable conclusions to be drawn.

Chapter **4**

Meaning of musculoskeletal complaints

Many people occasionally have musculoskeletal complaints. When are such complaints serious and can they be considered a negative health effect? In other words: what value should be given to the complaints measured in the epidemiological research? This chapter addresses this issue.

4.1 Temporary of chronic complaints

If back or shoulder complaints persist for more the 12 weeks without interruption, they are considered chronic. This is a clear example of a negative health effect.[69] However, the longitudinal studies into the effects of lifting predominantly focus on pain complaints (concerning the lower back, the lower and upper limbs) that persisted for at least 24 hours in the past year.

The ICF (International Classification of Functioning, Disability and Health) model developed by the World Health Organization (WHO) shows that disease-related factors, such as pain complaints (in addition to environmental and personal factors) may affect functional limitations and participation in daily life and work (sick leave and work resumption).[70] In order to indicate to what degree (brief) episodes of pain complaints are a presage for chronic complaints, and what consequences of such complaints are, the Committee examined the data on prevalence and prognosis of the complaints described, as well as the disease burden and absenteeism.

4.2 Prevalence

In order to assess the relevance of the complaints that develop due to lifting, the Committee compared the results of the epidemiological studies with the prevalence of such complaints among the general population. Prevalence is defined as the occurrence (number of cases) of a specific condition in a population of employees or the general population. The prevalence may be expressed for a specific moment in time (point prevalence) or for a period such as a year (year prevalence).

Low back pain

The prevalence of low back pain* in a sample of the Dutch population aged 25 years and older was 44% over a 12-month period; point prevalence was 27%. Over 21% of people with lower back pain reported chronic pain, with 3.5% describing it as 'continuous severe' and 20% as 'continuous mild'. About 63% (15% of whom reported it as 'recurring severe' and 48% as 'recurring mild') indicated that the pain complaints recurred.[71] Only 5% indicated the pain complaints were a one-off event.

Lower limb complaints

In the sample of the Dutch population, the prevalence over a 12-month period was 13% for hip complaints, 22% for knee complaints, 9% for ankle complaints and 9% for foot complaints. Point prevalence figures were 9% (hip), 15% (knee), 5% (ankle) and 6.5% (feet), respectively. For chronic complaints, the figures were: 7%, 12%, 3.5% and 5%, respectively.[72] Of the people with hip or knee complaints, 5% described the pain as 'continuous severe', 28% as 'continuous mild', 10% as 'recurring severe' and 46% as 'recurring mild'. For ankle and foot complaints, these percentages were 6%, 30%, 12% and 35%, respectively. In another publication, the investigators reported prevalence figures of 10% for knee osteoarthritis and 4% for hip osteoarthritis.[72]

In conclusion, it may be stated that chronic pain complaints make up roughly one quarter of the 12-month prevalence of musculoskeletal complaints. Of these people, about 5% indicate the level of pain is 'severe'.

* Self-reported via the questionnaire 'Have you had lower back pain in the past twelve months'.

Upper limb complaints

In 2007, 26% of the Dutch population aged 25 and above had complaints of the arm, neck and/or shoulder (CANS) in the previous year.[73] In a survey of about 3,500 Dutch people aged 25 years and above, the following prevalence figures were found for upper limb complaints:

- over a 12-month period: neck 31%, shoulder 30%, upper back 19%, elbow 11%, wrist-hand 18%, CANS* 37%
- at a random moment (point prevalence): neck 21%, shoulder 21%, upper back 9%, elbow 7.5%, wrist-hand 13%, CANS 26%
- for chronic pain in the past 12 months: neck 14%, shoulder 15%, upper back 6%, elbow 5%, wrist-hand 9%, CANS 19%.[71,74]

Over 43% of individuals with CANS had these symptoms in more than one body part.[74]

4.3 Prognosis

The prognosis of the complaints caused by lifting may be evaluated based on data on the course of such complaints.

Low back pain

In the majority of cases, back pain is short-lasting and disappears after a few weeks.[73] Furthermore, back complaints are known to often present with multiple episodes,[75] which may turn into a chronic condition.[76,77]

In a longitudinal study performed in back pain patients in general practice in Amsterdam and surroundings, patients were followed for one year using monthly questionnaires. The median time to recovery was 7 weeks. After 12 weeks, 35% of patients still had complaints, and after one year this dropped to 10%.[78] Furthermore, the study showed that 75% of patients had to deal with recurring complaints, and that on average, they had two episodes of relapsing symptoms, the first after about 7 weeks.

It is internationally accepted that back complaints persisting for over 3 months may be considered chronic, although the precise definition is still under

* CANS, complaints of the arm, neck and/or shoulder not caused by acute trauma or chronic disease.

debate.[4,77] The prevalence of chronic pain* in the lower back in a sample of the Dutch population aged 25 years and older was 21%.[4,71]

In a Spanish study published in 2005, investigators proposed distinguishing between acute (0 to 14 days) and subacute (from 14 days) back complaints, as patients who experience pain for more than 14 days had a worse prognosis and were at higher risk of developing chronic back complaints.[79] A recent Dutch study found that a constant nature of the pain's intensity and the degree of disability during the first 3 months are reasonably good predictors for the development of chronic low back pain (37% of the variance accounted for). In this study, chronic low back pain were defined as ‘persistent pain with an intensity of ≥4 on the Numerical Rating Scale from 0 to 10 at baseline, and ≥4 at 3 and 6 months of follow-up’.[4]

Lower limb complaints

A longitudinal study among patients with knee complaints in Dutch general practice found that after 3 months, 25% of patients had recovered, with the percentage rising to 44% after 12 months. The average pain score (WOMAC**) had improved by 36% after 3 months, and by 46% after 12 months. Scores for physical functions (WOMAC) improved by comparable percentages.[80] Recovery from knee complaints after 3 months was primarily dependent on sex, shorter duration of symptoms, lower stiffness score (WOMAC), and menopause. Predictive factors for recovery after 12 months were: no previous episodes of knee complaints and a lower pain score (WOMAC).

Upper limb complaints

A sample of the Dutch population showed that only 6% of the people with neck, shoulder or upper back complaints, and only 7.5% of the people with elbow or wrist pain experienced a single episode of pain.[71] Of the people with neck, shoulder or upper back complaints, 47% reported recurring mild pain; the percentage was 43% for people with elbow or wrist complaints. 26% of respondents had continuous mild pain in the neck, shoulders or upper back, and 29% in the elbow or wrist. Severe pain complains were less common: recurring severe neck, shoulder or upper back pain was reported by 8% of respondents, and

* Defined as: existing pain that persists for more than 3 months.

** The Western Ontario and McMaster Universities (WOMAC) developed a set of questions for evaluating patients with hip and knee osteoarthritis.

11% complained of elbow or wrist pain. Continuous severe pain in the neck, shoulders or upper back was experienced by 3%; the figure was 4% for the elbow or wrist.

4.4 Sick leave and disease burden

A third measure to assess the meaning and severity of complaints due to lifting are data on sick leave and disease burden.

Low back pain

Although the prevalence of low back pain in the general population is high, with 33% of people stating it affected their daily life, 70% of people with back complaints had not taken sick leave in a one-year period, 8% missed less than one week, 10% one to four weeks, and 6% more than four weeks of work. [*71] In a year, 32% of the people with low back pain visit the GP.

In 2007, the National Institute for Public Health and the Environment (RIVM) estimated disease burden for the entire Dutch population and the proportion of disease burden that is related to working conditions. As a measure for this calculation, investigators used Disability Adjusted Life Years (DALY).[73] One DALY of health loss means one healthy life year lost due to premature mortality and/or loss of quality of life. In a recent Dutch study, investigators calculated a DALY of 0.06 for each year with daily low back pain.[81] The annual disease burden due to back complaints in the total population was estimated at 34,800 DALYs, or 1.2% of the total disease burden in the Netherlands. The estimated disease burden for the potential and actual working population were 26,300 and 16,700 DALYs, respectively.

Lower limb complaints

Prevalence figures were slightly better for hip and knee complaints in the general population: 30% of people felt limited by complaints in daily life. For 80%, the complaints did not lead to missing work, 5% missed over a week, 4% one to four weeks and 4% more than four weeks of work. [**71] In a year, 33% of the people with hip or knee complaints visit the GP. This percentage is 40% for ankle and

* If work was missed due to low back pain, 34% of people in the group missed less than one week, 41% one to four weeks and 25% more than four weeks of work.

** If work was missed due to hip or knee complaints, 36% of people in the group missed less than one week, 33% one to four weeks and 31% more than four weeks of work.

foot complaints. Five percent of respondents were (partially) unfit for work due to hip or knee complaints. The disease burden caused by knee osteoarthritis (multiple causes) in the general population was 56,400 DALYs.[73]

Upper limb complaints

Of the people in the Dutch population with neck, shoulder or upper back complaints, 41% had visited the GP, 30% had consulted a medical specialist and 33% had seen a physiotherapist in the past year. 27% of them used medication.[71] For people with elbow or wrist complaints, these percentages were 34%, 27%, 22% and 18%, respectively. Of the people with neck, shoulder or upper back complaints, 72% had not missed work in the past year, 8% had missed less than one week, 8% had missed one to four weeks, and 6% had missed more than four weeks of work[*]. Of the people with elbow or wrist complaints, 78% had not missed work in the past year, 5% had missed less than one week, 6% had missed one to four weeks, and 5% had missed more than four weeks of work[**]. Partial occupational disability was reported by 6% of people with neck, shoulder or upper back complaints and by 4% of people with elbow or wrist complaints.

4.5 Conclusion

The Committee considers lifting to be a relevant occupational risk for musculoskeletal complaints, including low back pain and upper and lower limb complaints. The Committee considers musculoskeletal complaints to be a relevant health effect. A significant proportion of the working population experience serious pain complaints that occur almost daily. The experienced work-related limitations may lead to absenteeism.

* If work was missed due to neck, shoulder or upper back complaints, 36% of people in the group missed less than one week, 36% one to four weeks and 28% more than four weeks of work.

** If work was missed due to elbow or wrist complaints, 30% of people in the group missed less than one week, 37% one to four weeks and 33% more than four weeks of work.

Chapter **5**

Meta-analysis

As the results of the longitudinal studies showed either barely significant or barely non-significant associations between lifting and low back pain, the Committee decided to perform a meta-analysis. Combining the results of individual studies in one meta-analysis increases statistical power. In this chapter, the Committee presents the results of the meta-analysis and translates the risk measure identified for the Dutch (work) situation.

5.1 Conditions and assumptions

Studies must meet a number of conditions for meta-analyses to be conducted. For example, it is necessary for exposure and health effects in various studies to be comparable. In the selected longitudinal studies, the influence of lifting weight was the primary measure. For both exposure and health effects, minor variations in definitions were accepted.[82] The Committee set the following conditions for the epidemiological studies:

- a comparable reference group (i.e.: not or minimally exposed)
- a comparable method for measuring exposure to lifting (self-report)
- a comparable definition of a health outcome
- a comparable method for measuring the health outcome (self-report).

Given the different cut-offs for lifting exposure used in the longitudinal studies, the Committee decided to convert the exposure-response relationships in these studies into an equivalent risk measure of 10 kg of lifting weight. This cut-off was frequently used in the studies described.

The Committee previously noted that the NIOSH equation does not provide any information about specific health risks associated with the upper limit of the recommended weight that may be lifted under optimal circumstances. Therefore, the Committee decided to also convert the exposure-response relationships from these studies to a comparable risk measure of 23 kilograms of lifting weight. These calculations were performed for each study using SPSS 16.0.*

The Committee also made two assumptions in order to perform the meta-analyses. The Committee believes that, based on the results in Table 1 (see Section 3.1), it is reasonable to assume an increasing risk for increasing lifting weight. Posture, movements and physical burden (part of physical occupational risks) are part of natural human motion. It is likely that both the lack of any physical burden as well as excessive burden may yield health risks. In such cases, the exposure-response relationship is U-shaped curve.[85]

For lifting, a number of longitudinal studies indicate a linear relationship exists with low back pain.[44-46,50-52] The NIOSH equation also assumes linearity.[9,12] The Committee therefore assumed a linear relationship between lifting intensity (lifting weight) and lower back pain as a starting point. The individual studies included in the meta-analysis had a maximum of three data points for exposure-response relationships, so the Committee did not feel evaluating exposure-response curves other than the assumed linear relationship would be useful.

The second assumption is that the reference group has not been exposed to the studied occupational risk (prevalence or incidence of musculoskeletal complaints in the general population).[71,72]

* If different risk measures were used for sequential exposure categories within one study: the slope of the exposure-response curve was calculated using a log linear regression model [$y = e^{\alpha + \beta X + \log(N)}$ in which: Y = number of people with new complaints (incident cases), X = exposure measure for lifting, N = study population size]. The exposure measure was expressed as an odds ratio [exp (X)].] In each study, the middle value per broad exposure category was used as a point estimate for exposure. If a single risk measure was presented within a study: the risk measure was converted to the risk for 10 and 23 kg increase of exposure to lifting.

5.2 Execution

Considering the available studies and exposure measures used, a meta-analysis could only be performed for low back pain. The Committee calculated a pooled risk in order to evaluate the effect on low back pain due to exposure to 10 kilograms of weight lifted. The meta-analysis was performed using the calculated slope of the exposure-response curve and expressed as a regression coefficient with associated standard error. In the meta-analysis, these regression coefficients were weighted for variance in order to account for discriminating power (based, among other things, on the size of the study population and the number of incident cases) of the original studies.

5.3 Results

The systematic literature review identified four longitudinal studies with lower back pain as an outcome measure that were sufficiently comparable for inclusion in a meta-analysis.[46,50,52,54] Two of these four studies used young and beginning employees as a study population. All four longitudinal studies used similar reference groups (no exposure to lifting) and a similar definition for low back pain, namely *any pain, ache, symptom or discomfort in the (lower) back region for at least one day in the past month or in the past 12 months*. Exposure to lifting (expressed as lifting weight) was self-reported by employees in all studies. Less is known about duration and frequency of lifting in these studies.

Table 4 presents various exposure-response relationships in the four selected longitudinal studies that were converted to comparable risk measures for 10 kg of lifting weight. The meta-analysis assumed that the estimated risk is applicable to both the incidence of new episodes of low back pain in the past 12 months and the incidence of new episodes in the past month.

Using the meta-analysis (based on four longitudinal studies), the Committee calculated the size of the risk measure for lifting per 10 kg of exposure. This pooled risk measure is 1.13 (95% CI 1.01-1.27). This means that for 23 kilograms, the risk measure is 1.32 (95% CI 1.01-1.73).

Table 4 The four longitudinal studies selected for the meta-analysis.

Exposure Weight	Frequency/duration	Risk measure (95%CI[a])	Reference
≤6.8 kg	During last working day with 1 hand	1.3 (0.8-1.9)	46
≤10 kg	Once per hour	1.35 (0.62-2.91)	54
≤11 kg	During last working day with 2 hands	1.1 (0.7-1.7)	46
≥11 kg	During working day	men: 1.1 (0.7-1,7) women: 2.5 (1.5-4.1)	50
>11 kg	During working day with 2 hands	1.4 (0.8-2.5)	46
11-25 kg	Less than 12 times per hour	1.25 (0.61-2.56)	54
>18 kg	During last working day	1.98 (0.66-5.97)	52
>25 kg	Less than 12 times per hour	1.28 (0.69-2.36)	54

a CI = confidence interval; kg = kilograms

This result is consistent with the outcomes of a similar exercise performed by a Canadian research group.[83,84] The investigators had access to individual employee data from a large number of studies. The meta-analysis found an increased risk of low back pain due to lifting during work. The pooled odds ratios for the relationships between various types of biomechanical exposure (lifting) and lower back pain were greater than one (1.4 to 1.6). These increased risks for back complaints were statistically significant.[83] In the meta-analysis, a distinction between exposure to 'lifting' and 'heavy lifting' was made.

The Committee would like to draw attention to the fact that various components play a role in a lifting task, including lifting weight, duration and frequency. However, the available exposure measures from the four longitudinal studies meant the Committee could only include lifting weight in the meta-analysis. Information on the other determinants involved in a lifting task, such as duration, frequency and vertical distance to the load, is lacking. The Committee is of the opinion this is a limitation of the meta-analysis performed. What is clear is that the meta-analysis relates to regular (at least daily) lifting during work.

5.4 The meaning of the risk measure for the Dutch situation

Based on the results of the meta-analysis, the Committee concludes that lifting 10 kilograms may lead to an increased risk of about 13% for episodes of lower back pain in the past year (pooled risk 1.13; 95% CI 1.01-1.27). For 23 kilograms, the maximum weight that may be lifted under optimal conditions according to the NIOSH equation, this risk is about 32% (pooled risk 1.32; 95% CI 1.01-1.73).

In order to provide an impression of the degree to which lifting affects the incidence of lower back pain in the Netherlands, the Committee calculated how many additional cases of lower back pain occur due to lifting 10, 15, 20, 23 and 25 kilograms (Table 5). The calculations are based on the pooled risk measure from the meta-analysis, and the data from the longitudinal studies on the incidence of low back pain after one year of exposure. The calculated lifting weights fall within the measurement range of the longitudinal studies. In order to gain insight into the consequences of the risks found for the situation in the Netherlands, the Committee sought out data on the incidence of low back pain among the Dutch working population with no relevant exposure (in the past 12 months) to physical burden. Based on data from general practice registries, the estimated incidence of low back pain requiring medical care is 6.75%. The number of people with back complaints in the Dutch working population is underestimated by these figures, as it is likely that mostly employees with severe back complaints will consult a GP. The best estimates for the number of back complaints without physical burden are provided by a large study by Hoogendoorn et al. The annual incidence of new cases of low back pain in the average working population in this study is 13%. This relates to the incidence of low back pain in a working population exposed to a certain degree of physical burden.

The calculations show that 10 kilograms of weight to be lifted leads to 1.4 new cases of low back pain per year per 100 employees. 23 kilograms of weight to be lifted leads to 3.3 additional new cases of low back pain per year per 100 employees. In other words: 13 out of every 100 employees develop low back pain per year. Due to daily lifting, 1.4 (10 kilograms) or 3.3 (23 kilograms) additional employees are affected.

Table 5 Calculated (additional) incidence of low back pain in the Netherlands in 12 months due to lifting based on 4 longitudinal studies.

Low back pain		Lifting (kilograms)				
	None	10 kilograms	15 kilograms	20 kilograms	23 kilograms	25 kilograms
Pooled incidence per year (%)	13.0	14.4	15.1	15.9	16.3	16.7
Additional incidence (%)		1.4	2.1	2.9	3.3	3.7

A number of existing guidelines for Dutch occupational situations set a recommended weight limit of 25 kilograms instead of 23 kilograms. In order to reflect this, the Committee also calculated the number of additional cases of low back pain for that lifting weight. Lifting 25 kilograms daily results in 3.7 additional employees with low back pain per 100 employees per year. Therefore, the difference between regularly lifting 25 kg and 23 kg amounts to roughly 4 new employees with low back pain per 1,000 employees per year.

Chapter 6

Conclusions

The Minister of Social Affairs and Employment asked the Health Council whether there are any new scientific insights with regard to health-based (and safety-based) limits for lifting during work. This advisory report answers this question. The Committee's starting point is that a limit must prevent negative health effects due to lifting from developing.

6.1 The consequences of lifting for the lower back

The consequences of lifting for the occurrence of lower back pain have been studied extensively in the epidemiological literature. Although longitudinal in design, many of these studies have limitations. Both the amount of lifting and the low back pain in available research are often self-reported. In addition, the Committee cannot rule out concurrent exposure to other physical occupational risks. However, the longitudinal data does allow the conclusion to be drawn that lifting is associated with an increased risk of low back pain. However, the Committee is of the opinion that available research does not allow determination of the degree of lifting that can safely be performed without low back pain developing.

In order to attempt to quantify the size of the risk of developing low back pain due to lifting, the Committee combined the results of four longitudinal studies in a meta-analysis. The meta-analysis maps out the relationship between lifting and low back pain. This showed that (regular) lifting of 10 kg leads to 1.4

additional new employees with low back pain per 100 employees per year. Regular lifting of 23 kilograms increases the number of employees with lower back pain by 3.3 per 100 employees per year. A number of existing guidelines applicable to Dutch daily practice set 25 kilograms as the recommend weight limit. The Committee also calculated the number of additional employees who will develop lower back pain in one year for that maximum weight: the number of employees with low back pain related to lifting increases from 3.3 (23 kg) to 3.7 (25 kg) per 100 employees per year. It is known that in about a quarter of these employees, the complaints will develop into chronic low back pain.

The major limitation of this analysis is that the degree of lifting was only defined by the weight lifted. The circumstances under which lifting occurred in the included studies is unknown. However, according to the Committee, it is likely that lifting did not occur under optimal circumstances in the studies described. This means that the meta-analysis provides an estimate of health effects to be expected due to lifting 23 kilograms under *non-optimal* conditions. If 23 kilograms were lifted under *optimal* conditions, the Committee believes the risk of low back pain would be lower than the risk estimate obtained from the meta-analysis; i.e. fewer than 3.3 new employees with lower back pain due to lifting per 100 employees per year.

6.2 Effects of lifting on lower limb complaints

Only two longitudinal studies are available on the effects of lifting on the occurrence of hip and knee pain. Here too, both exposure to lifting and lower limb complaints were measured via self-report, and the Committee cannot rule out concurrent exposure to other physical occupational risks in either study. Based on the available data, the Committee concludes that lifting during work appears to lead to pain complaints in hips and knees. However, the Committee was unable to combine the results of the two studies in a meta-analysis due to the differences in exposure measures used.

6.3 Effects of lifting on upper limb complaints

The consequences of lifting for the occurrence of neck, shoulder and arm pain were studied in four prospective cohort studies. The previously mentioned limitations apply here as well. Based on the available data, the Committee concludes that lifting during work leads to pain complaints in the neck and shoulders. However, the Committee was unable to combine the results of the four studies in a meta-analysis due to the differences in exposure and outcome measures used.

6.4 Effects of lifting on pregnancy and delivery

Four prospective cohort studies examined the effects of lifting during pregnancy. Among other things, growth of the unborn child and the occurrence of abortion or premature birth were examined. No statistically significant effect of lifting was found for any of these effects. The effect was only statistically significant for early work suspension during pregnancy.

6.5 Committee recommendations

The Committee concludes that lifting during work poses a health risk. Employees mainly develop lower back pain due to lifting. In about one quarter of these employees, the complaints may develop into chronic complaints. The Committee examined whether a threshold level for lifting could be determined below which low back pain can be prevented. This proved impossible.

Current Dutch legislation and regulations refer to the NIOSH equation for the prevention of lower back pain due to lifting. The Committee is of the opinion that the NIOSH equation is an internationally accepted calculation method for preventing a high-risk burden during lifting. In addition to lifting weight, this equation considers other factors, such as duration or frequency of lifting and vertical distance to the load. These factors are important for the development of lifting-related health complaints. Based on biomechanical, psychophysiological and physiological research, the NIOSH equation determined that 23 kilograms is the maximum weight that may be lifted *under optimal circumstances*. However, the NIOSH equation is not based on knowledge about the extent of health damage that may be prevented by use of the equation. Ideally, a limit or equation should be based on data on the health damage that it may prevent on both individual and group levels. However, this epidemiological data was unavailable at the time the NIOSH equation was formulated.

Although a great deal of epidemiological research has been published since the NIOSH method was published, the Committee concludes it is still impossible to determine how much health damage is prevented by using the NIOSH equation. What is clear is that, in addition to lifting weight, other components of exposure play a role in the development of complaints. The Committee would therefore like to point out that a recommended maximum weight of 23 kg, for example, is not enough to prevent health complaints. It therefore recommends using the NIOSH equation, which accounts for various components of lifting tasks, as the best available instrument for preventing new complaints as much as possible.

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A	Request for advice
B	The Committee
C	Broad literature exploration
D	Systematic literature review
E	Comments on the public review draft
F	Low back pain
G	Extraction table low back complaints (meta-analyses)
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I	Lower limb complaints
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L	Birth issues
M	Extraction table birth issues

Annexes

Annex **A**

Request for advice

In a letter dated 10 July 2007, reference number ARBO/A&V/2007/22676, the Minister of Social Affairs and Employment wrote to the President of the Health Council of the Netherlands:

On 26 September 2006, during deliberation in the Dutch House of Representatives of a bill to modify the Working Conditions Act, a motion by House members Koopmans and Stuurman was adopted[1]. This motion requests the government to promptly set up a work programme yielding health-based and safety-based limit values (regulations comprising concrete figures), to which end advice is to be requested of the government's social partners.

In the debate in the Dutch House of Representatives the former State Secretary for Social Affairs and Employment indicated, in reference to this motion, that it was not the government's intention to include an unbridled number of scientific limit values for every conceivable work risk in the Working Conditions Act. This would undermine the essential nature of the Act and run counter to the government's active policy of stimulating customisation in enterprises and sectors, reducing regulatory overhead, and slimming down Dutch supplements to European legislation on working conditions. During the debate the motion's proposers confirmed that it was not their intention that the motion lead to an unbridled number of new concrete regulations in the legislation and regulation, but that the motion would help to support, facilitate and curtail that which the government specified in a working programme.

In a letter of 18 January 2007 to the Dutch House of Representatives on the status of the Working Conditions Act, a proposal was made for the further elaboration of the motion. During its General Consultations of 7 February 2007 the Dutch House of Representatives made no remarks on this elaboration, but it did indicate that it wished to be informed on the different phases sketched therein:

- a committee shall be established within an independent scientific institute, which can survey the scientific domain of working conditions
- this committee shall provide periodic reports of any new (international) scientific insights into concrete health-based or safety-based limit values
- on the basis of the results of these reports the Ministry of Social Affairs and Employment can initiate, where appropriate, further scientific research into health-based and / or safety-based limit values
- the Ministry of Social Affairs and Employment will then assess the need for and desirability of including a limit value (as a concrete regulatory paragraph) in the Working Conditions Act and associated regulations. The department will hereby observe the provisions given in the Explanatory Memorandum on the Working Conditions Act, which stipulate that scientific limit values will be included in the legislation and regulation if these are generally recognised, have broad social support, and are generally applicable
- the Ministry of Social Affairs and Employment will then present its opinion on the inclusion or otherwise of a limit value in the Working Conditions Act and associated regulations to the Social and Economic Council of the Netherlands (SER) for advice
- on the basis of the advice put forward by the SER, a decision will be taken on whether to actually adopt the limit value in the Working Conditions Act and its associated regulations.

In accordance with the stipulations of the motion, consultations have been held with the government's social partners. It is important that the evaluation of the revision of the Working Conditions Act can be sent to the Dutch House of Representatives within five years of the coming into force of the amendment of the law – that is to say, before 1 January 2012. This evaluation must comprise a report on the practical effects and efficacy of the Working Conditions Act.

On 21 February 2007 we consulted on the possibility of the Health Council establishing a committee comprising experts on working conditions, health, safety, and occupational disease, and the Health Council indicated its willingness to establish such a committee. I therefore request that you establish a committee for the purposes of surveying the scientific domain of working conditions and examining the following subjects:

1 periodic reports on whether *at this moment* new (international) scientific insights exist with regard to concrete health-based and / or safety-based limit values
2 periodic reports on whether *in due course* new (international) scientific insights may be expected with regard to concrete health-based and / or safety-based limit values.

The focus shall be on the first part, periodic reports of current new (international) scientific insights into concrete health-based and / or safety-based limit values. In the first instance, these reports will be based on those working condition risks included in the Working Conditions Act and its associated regulations. Other risks may be taken into consideration at a later date.

Please initiate the establishment of the committee and a Plan of Approach for the period 2007 to 2012, which should include reference to all the subjects mentioned above and comprise a budget. I should like to receive the Plan of Approach before next 1 September. The Health Council's Plan of Approach requires the approval of the Ministry of Social Affairs and Employment.

With regard to the periodicity of reporting, I would consider it important to publish an annual report. With this in mind I look forward to receiving the first of these annual reports before the end of 2007.

Yours sincerely,
The Minister of Social Affairs and Employment,
(signed)
J.P.H. Donner

Annex **B**

The Committee

- Professor T. Smid, *chairman*
  Endowed Professor of Working Conditions, VU Medical Center, Amsterdam and working conditions advisor, KLM Health Services, Schiphol-East
- Professor A.J. van der Beek
  Professor of Epidemiology of Work and Health, EMGO Institute, VU Medical Center, Amsterdam
- Professor A. Burdorf
  Professor of Occupational Epidemiology, Erasmus MC, Rotterdam
- Professor M.H.W. Frings-Dresen
  Professor of Occupational Health, Coronel Institute for Work and Health, AMC, Amsterdam
- Professor D.J.J. Heederik
  Professor of Health Risk Analysis, Institute for Risk Assessment Sciences, Utrecht
- Professor J.J.L. van der Klink
  Professor of Social Medicine, Work and Health, UMC, Groningen
- Dr. T. Spee
  Occupational Hygiene policy advisor, the Arbouw Foundation, Amsterdam
- J. van der Wal
  Head of Safety, Shell Europa Exploration and Production, Nederlandse Aardolie Maatschappij (NAM), Assen

- H.J. van der Brugge, *observer*
  Ministry of Social Affairs and Employment, The Hague
- dr. P.C. Noordam, *observer*
  senior advisor, Labour inspectorate, The Hague
- Dr. A.S.A.M. van der Burght, *scientific secretary*
  Health Council of the Netherlands, The Hague
- Dr. V. Gouttebarge, *scientific secretary*
  Health Council of the Netherlands, The Hague

The Committee established the Working Group *Physical occupational risks* for the purpose of preparing the advisory report. The Working Group was composed of the following experts:

- Professor A. Burdorf, *chairman*
  Professor of Occupational Epidemiology, Erasmus MC, Rotterdam
- Professor A.J. van der Beek
  Professor of Epidemiology of Work and Health, EMGO Institute, VU University Medical Center, Amsterdam
- Professor M.H.W. Frings-Dresen
  Professor of Occupational Health, Coronel Institute for Work and Health, AMC, Amsterdam
- Professor J.H. van Dieën
  Professor of Biomechanics, VU University, Amsterdam
- Dr. A.S.A.M. van der Burght, *scientific secretary*
  Health Council, The Hague
- Dr. V. Gouttebarge, *scientific secretary*
  Health Council, The Hague

The Health Council and interests

Members of Health Council Committees are appointed in a personal capacity because of their special expertise in the matters to be addressed. Nonetheless, it is precisely because of this expertise that they may also have interests. This in itself does not necessarily present an obstacle for membership of a Health Council Committee. Transparency regarding possible conflicts of interest is nonetheless important, both for the chairperson and members of a Committee and for the President of the Health Council. On being invited to join a Committee, members are asked to submit a form detailing the functions they hold and any other material and immaterial interests which could be relevant for the Committee's work. It is the responsibility of the President of the Health

Council to assess whether the interests indicated constitute grounds for non-appointment. An advisorship will then sometimes make it possible to exploit the expertise of the specialist involved. During the inaugural meeting the declarations issued are discussed, so that all members of the Committee are aware of each other's possible interests.

Annex **C**

Broad literature exploration

The goal of this literature exploration is to obtain an overview of and insight into recent developments regarding the development of health and safety issues relating to lifting during work. To this end, recent review articles were consulted exclusively, preferably published in peer-reviewed journals. Where possible, the Committee also made use of reports from renowned national and international institutes or organisations.

Findings

Burdorf and Sorock studied the epidemiological literature spanning 1980 to 1996 in order to identify occupation-related risk factors for back complaints.[27] Following an extensive literature search strategy in 5 databases, 35 articles were included. A positive relationship between manual load handling, particularly lifting, and the development of back complaints was found in 16 of the 19 studies included. The degree of association (odds ratio) between lifting and the occurrence of back complaints in these studies varied from 1.12 to 3.07, with the two highest odds ratios for 'lift often' versus 'never lift' (OR = 3.06; 95% CI 1.11-8.67), and for lifting more than 18 kg versus lifting less than 18 kg (OR = 3.07; 95% CI 1.19-7.88). According to the authors, a major limitation of many of the included studies was the way in which health effects and exposure (to lifting) were measured, namely using questionnaires (self-report). Additionally, the authors noted that few studies used a longitudinal design, which appears ideal for epidemiological research into the effects of work-related factors on musculoskeletal complaints and conditions.

A relationship between lifting and back complaints was also identified in 1997 by a committee of the National Institute for Occupational Safety and Health (NIOSH).[38] Risk factors for low back pain were identified based on 42 selected epidemiological studies from various countries (the Netherlands, Sweden, Finland, the United States) that examined employees in various sectors, such as health care, construction or transport. This report concluded there is strong evidence in the scientific literature for the positive relationship between lifting and the development of back complaints, with odds ratios of 1.12 ($p<0.001$) to 5.21 (95% CI
1.1-25.5).

For their literature review, Cole and Grimshaw searched three databases for studies published between 1980 and 2002 looking at epidemiological and etiologic factors for low back pain and lifting. The authors noted that manual handling of loads, or lifting, has "potential hazardous implications" for vertebral structure, which may lead to back complaints.[29]

Manual load handling, or lifting, was also identified as a risk factor for the development of low back pain in other literature reviews.[25,31,32,35] Kuiper et al performed a systematic review of the association between manual load handling (including lifting) and back complaints.[35] Relevant epidemiological studies published between 1980 and 1997 were identified in six databases and evaluated based on five quality criteria. The included studies showed that employees exposed to lifting had an increased risk of developing back complaints, with odds ratios between 1.3 (95% CI 1.0-1.6) and 4.2 (95% CI 2.3-7.7). Based on their findings, the authors expressed their doubts about what they felt were inadequate methods for measuring exposure, and the potential interference caused by confounders, which may result in overestimation or underestimation of the effect of lifting on lower back complains in various reviews.

By performing a systematic review of the literature (with quality assessment) in seven databases, Hoogendoorn et al searched the literature from 1966 to 1997 in order to identify work-related risk factors for back complaints.[32] According to Hoogendoorn et al, employees are 1.5 to 3.1 times more likely to develop back complaints if they lift compared to if they do not lift, and the risk of back complaints is 1.6 (95% CI 1.1-2.3) times higher if 25 kg are lifted more than 15 times. In this review, the authors excluded cross-sectional studies, as measurement of the outcome measure (health effect) occurred at the same moment as measurement of exposure in these studies, which they stated is a limitation of many other studies and reviews.

Lötters et al examined primary articles published between 2000 and 2002, in combination with existing literature reviews, leading to the inclusion of 40 studies in a meta-analysis.[25] The authors were able to conclude that frequent lifting of 5 kilograms, or lifting 25 kilograms at least once per day, was associated with back complaints with an odds ratio of 1.3 (95% CI 1.1-1.7), and that lifting 15 kilograms for at least 10% of the work day was associated with back complaints with an odds ratio of 1.9 (95% CI 1.6-2.3).

In 2005, TNO Quality of Life, commissioned by FNV, released a report on the state of knowledge regarding lifting.[37] Following a sensitive search strategy in one database (PubMed), epidemiological studies and systematic reviews that met certain quality criteria were included. Their literature review showed the results described previously, leading TNO to conclude that there are sufficient studies of good quality demonstrating that exposure to lifting increases the risk of health complaints. Nevertheless, TNO states that: "*however, the published dose-response relationships were created with data that was often partly derived from studies of less high quality and show broad confidence intervals*."[37]

Reviews on the occurrence of other complaints due to lifting, namely hip and knee complaints, have also recently been published. In 2008, Jensen published a systematic literature review in which the influence of a number of activities, including lifting, on hip osteoarthritis was mapped out.[34] Using a systematic search strategy deployed in four databases, epidemiological literature between 1966 and 2007 was searched for relevant studies. After applying a number of inclusion and quality criteria, 22 studies were included, with 14 studies on hip osteoarthritis and heavy lifting. Jensen found a positive correlation between lifting and hip osteoarthritis, with an odds ratio of 1.9 (95% CI 1.1-3.4) to 8.5 (95% CI 1.6-45.3) and a relative risk of 1.5 (95% CI 1.1-3.4) to 12.4 (95% CI 6.7-23.0). A case-control study found that male employees who lifted over 10, 25 and 50 kilograms at least 10 times per week, had a 2.3, 2.7 and 3.2 times higher risk of hip osteoarthritis, respectively, than male employees who did not lift.[28]

In a similar manner, Jensen also performed a systematic literature review in 2008 in order to examine the influence of a number of activities, including lifting, on knee osteoarthritis.[33] After applying a number of inclusion and quality criteria, 20 studies were included, including 17 on knee osteoarthritis and heavy lifting. Jensen found a positive correlation between lifting and knee osteoarthritis in 9 of these 17 studies, with an odds ratio of 1.9 (95% CI 1.0-3.3) to 7.3 (95% CI 2.0-26.7) and a relative risk of 1.9 (95% CI 1.3-2.9) to 14.3 (95% CI 8.1-25.4). A case-control study found that male and female employees who lifted more than 10 kg more than 10 times per week had a 5.8 (95% CI 3.1-10.8) and 3.0 (95% CI 2.2-4.1) times higher risk of knee osteoarthritis, respectively, than employees who did not lift.[36] As reported in the previously mentioned reviews, Jensen warns about the risk of confounding in the results, as studies that find an effect of a certain risk (lifting) on health are more likely to be published than studies that find no effect. The self-report method used to measure exposure and diagnose hip and knee complaints is also mentioned as a limitation.

Multiple systematic literature reviews were recently published in which the association between lifting at work and the occurrence of musculoskeletal complaints were examined. In 2010, van Rijn et al searched for relevant original studies on the association between a number of workplace risks (including lifting) and specific shoulder conditions.[39] Using a search strategy in three databases (Medline, Embase and the Cochrane Central Register of Controlled Trials), two original studies of good methodological quality were identified that demonstrated a statistically significant association between force (including lifting) and subacromial impingement syndrome (risk measure of 2.8 [95% CI 1.4-5.7] to 4.2 [95% CI 1.7-10.4]).

In 2010, Wai et al published a literature review on the association between lifting during work and the occurrence of low back pain.[40] Using a systematic search strategy in five databases, literature published between 1966 and 2008 was searched for relevant publications. The Bradford-Hill criteria (strong, moderate, limited and conflicting evidence) were used to assess causality. Based on 35 included studies (9 longitudinal, 18 cross-sectional and 8 case-control studies), the authors concluded that their systematic literature review yielded no studies of high methodological quality that substantiated the association between lifting during work and low back pain.

Another systematic literature review based on longitudinal studies was performed by Da Costa et al in 2010, for which the authors searched four databases (1997 to 2008) for relevant studies on the association between various risk factors and various musculoskeletal complaints.[30] The associations found were classified as strong, moderate and insufficient evidence. Insufficient evidence was found for the association between lifting and neck complaints, and moderate evidence was found for the association between lifting and lower back, hip and knee complaints.

Conclusions

The broad literature exploration revealed many scientific studies have been published on the occurrence of health problems caused by lifting during work. The Committee found no review articles on the development of safety-related problems due to lifting during work. Based on a number of reviews and reports, the Committee notes there is a good consensus that exposure to lifting may be associated with an elevated risk of low back pain and hip and knee osteoarthritis. The literature notes that employees exposed to lifting are about 1.5 to 3 times as likely to develop low back pain and hip osteoarthritis, and 3 to almost 6 times as likely to develop knee osteoarthritis. Various scientific literature reviews identified in this broad literature exploration measured both exposure to lifting and the health effect via self-report.

Annex **D**

Systematic literature review

The goal of this literature review is to obtain, in a systematic manner, scientific data from epidemiological studies on the relationship between *lifting during work* and the development (both in the short term and the longer term) of health-related or safety-related problems.

1 Question

The following questions were formulated for this literature review:

a What health problems develop due to lifting during work?

b To what degree is exposure (in terms of duration, frequency and/or intensity) to lifting during work related to these problems?

2 Databases searched

Given the broad literature exploration, this systematic literature review searched for English-language and Dutch-language publications in international databases Medline (via PubMed; 1966-2010) and Embase (via Ovid; 1980-2010).

3 Search terms

The international databases were searched for terms related to the concepts *lifting*, *work-related* and *health effects*.

4 Search strategy

4.1 Zoekstrategie Medline

#1= lifting[MeSH] OR carrying[tiab] OR "manual material handling"[tw] OR weightlifting[tw]
#2= work-related[tw] OR occupations[MeSH] OR occupational exposure[MeSH] OR occupation*[tw] OR work[MeSH] OR workplace[MeSH] OR work*[tw] OR vocation*[tw] OR job[tw] OR employment[MeSH] OR industr*[tw] OR business[tw] OR profession*[tw] OR trade*[tw] OR enterprise*[tw]
#3= "health effects"[tw] OR occupational health[MeSH] OR occupational diseases[MeSH] OR musculoskeletal diseases[MeSH] OR "occupational risk factor"[tw] OR safety[MeSH] OR safet*[tw] OR safety management[MeSH] OR risk management[MeSH] OR sprains and strains[MeSH] OR wounds and injuries[MeSH] OR health[tw] OR disorder[tw] OR disorders[tw] OR syndrome[tw] OR disease[tw] OR diseases[tw] OR wounds[tw] OR injuries[tw] OR injury[tw] OR sprains[tw] OR strains[tw] OR pain[tw] OR discomfort[tw] OR risk[MeSH]
4= #1 AND #2 AND 3#

4.2 Zoekstrategie Embase

#1= lifting.ti,ab OR carrying.ti,ab OR "manual material handling".ti,ab OR weightlifting.ti,ab
#2= work-related OR occupation$ OR work$ OR vocation$ OR job OR industr$ OR business OR profession$ OR trade$ OR enterprise$
#3= "health effects" OR "occupational risk factor" OR safet$ OR health OR disorder OR disorders OR syndrome OR disease OR diseases OR wounds OR injuries OR injury OR sprains OR strains OR pain OR discomfort
#4= #1 AND #2 AND 3#

5 Inclusion and exclusion criteria

In order to include articles from the results of the search strategy, the following inclusion criteria were applied:

1. the study is a prospective study (not an intervention study)
2. the study describes the degree of exposure to lifting, in combination with carrying or alone, in a quantitative manner (duration, frequency and/or intensity)
3. the study describes short-term and/or long-term effects on health due to lifting at work
4. and the study describes a degree of association between lifting and the development of health complaints in terms of relative risk, attributive risk, prevalence ratio or odds ratio.

6 Selection procedures

After the search strategy was performed in the databases, the inclusion criteria were applied to titles and abstracts of various studies by two evaluators (independently). If there were doubts about the inclusion or exclusion of a study based on title and abstract, it was included. The entire text of the included titles and abstracts was requested and the inclusion criteria were applied to the entire text, again by two evaluators (independently). In the event of doubt about inclusion or exclusion of a study, a third evaluator was consulted. In addition to the search strategy, the publication by Shannon et al (2008) was also searched for relevant prospective or retrospective studies on the association between lifting and the occurrence of low back pain.[83] Additionally, the final reference list of included articles was presented to four experts with the request to determine whether additional studies should be added.

7 Data extraction

Data extraction for included studies was classified per effect type in a standardised table listing the following information:

- 1st column: first author and year of publication
- 2nd column: study population (number, age, gender, profession, country)
- 3rd column: study design and any confounders
- 4th column: effect of the occupational risk on health or safety (prevalence or incidence data)

- 5th column: exposure parameters (definition of the exposure and reference groups used)
- 6th column: degree of association between occupational risk and effect on health.

8 Quality description

The quality of included original longitudinal studies was described based on four criteria drafted based on existing and accepted sources (IJmker et al, 2007, Von Elm et al 2007; Dutch Cochrane Centre 2008). These quality criteria may be found in Table 6.

Table 6 Quality criteria.

1. Study population
   - \+ An appropriate definition and description (eligibility criteria, methods of selection and possible selection bias) of the subject groups involved in the study is clearly stated.
   - \- An appropriate definition and description (eligibility criteria, methods of selection and possible selection bias) of the subject groups involved in the study is not given.
   - ? Unclear information.

2. Outcome
   - \+ The outcome of interest is clearly defined and assessed with standardized instrument(s) of acceptable quality (reliability and validity).
   - \- The outcome of interest is not clearly defined and not assessed with standardized instrument(s) of acceptable quality (reliability and validity).
   - ? Unclear information or other.

3. Statistical analyses
   - \+ The statistical analyses applied are appropriated to the outcome studied.
   - \- The statistical analyses applied are not appropriated to the outcome studied.
   - ? Unclear information.

4. Results
   - \+ Risk estimates and their precision are reported.
   - \- Risk estimates and their precision are not reported.
   - ? Unclear information.

9 Results of the search strategy

The previously defined search strategy was performed in PubMed and Embase in late 2010. Based on various selection steps using titles and abstracts, a total of 238 full-text articles were assessed based on inclusion criteria. Following the final selection step, 17 original longitudinal studies were included.[44,46-51,55-62,85,86] Two hundred and five articles were excluded for two reasons: not a longitudinal study and no quantification of exposure to lifting. Many reviews were also included, 15 of which appeared in the past five years.[30,33,34,39,87-96] The reference check with four experts did not yield any additional longitudinal studies. Four original longitudinal studies from the Shannon et al paper (2008) were added.[45,52-54] In the end, a total of 21 original articles were processed in four extraction tables.

10 Results of quality description

The quality of 21 original studies from the search strategy was described based on the five quality criteria. Table 7 provides an overview of the quality description for these studies.

Table 7 Quality description for included original longitudinal studies.

Author	Study population	Exposure	Outcome	Statistical analysis	Results
Andersen[44]	+	s	?	+	+
Bonzini[59]	+	s	+	+	+
Feveile[56]	?	s	+	?	+
Florak[60]	?	s	+	+	+
Harkness[85]	+	s	?	+	+
Harkness[46]	+	s	?	+	+
Harkness[57]	+	s	?	+	+
Hoogendoorn[47]	+	m	+	+	+
Hoogendorn[48]	+	m	+	+	+
Jansen[49]	?	m	+	+	+
Jones[55]	+	s	?	+	+
Karpansalo[86]	+	s	+	+	+
Macfarlane[50]	+	s	+	+	+
Magann[61]	-	s	+	+	+
Miranda[51]	+	s	+	+	+
Miranda[58]	+	s	+	+	+
Strand[62]	+	s	+	+	+
Eriksen[45]	+	s	?	+	+
Nuwayhid[52]	-	s	+	+	+
Tubach[53]	+	s	+	?	+
van Nieuwenhuyse[54]	+	s	+	+	+

Exposure: s = self-reported; m = measured.

Annex E

Comments on the public review draft

A draft of the present advisory report was released in 2012 for public review. The following organisations and persons have commented on the draft document:

- Mr. Van Eijk, OCÉ Technologies B.V., Venlo
- Mr. Fraanje, NVTB, Nieuwegein
- Mr. Niemöller, Probasys Benelux, Krimpen aan den IJssel
- Mr. Peerenboom, VHP Ergonomie, Den Haag
- Mrs. Schreibers, ErgoS Engineering & Ergonomics, Enschede
- Mr. Schyns, De Commandeursmolen B.V., Mechelen
- Mr. Van Veelen, FNV, Amsterdam
- Mrs. Van der Velden, FNV Bondgenoten, Utrecht

The Committee has considered these commentaries in finalyzing its report.

The comments and the replies by the Committee can be found (in Dutch) at the website of the Health Council: www.gr.nl.

Annex **F**

Low back pain

A total of 11 longitudinal studies examined the relationship between lifting during work and low back pain.[44-54] In most included studies, low back pain were described as pain occurring in the past year in the lower back and persisting for longer than one day. Although not all studies present statistical degrees of association, lifting during work appears to present an increased risk of lower back pain. All of the studies on the consequences of lifting during work on the lower back are briefly described in Annex G and Annex H.

Andersen et al (2007) examined the relationship between lifting and low back pain in a longitudinal study with a 2-year follow-up period in a cohort of 4006 participants.[44] In this study, exposure to cumulative lifting (sub-weights unknown) and low back pain in the past 12 months were self-reported. After 2 years of follow-up, 10.6% of employees reported the incidence of new low back pain, with the pain varying from moderate to severe per individual. Based on their study, Andersen et al found that employees who (cumulatively) lift up to 99 kg per hour (n=479) did not run a statistically significantly increased risk (HR = 1.4; 95% CI 0.9-2.0) of low back pain compared with employees who do not lift (n=684). Employees who (cumulatively) lift more than 99 kg per hour daily (n=290) did have a statistically significantly increased risk (HR = 1.9; 95% CI 1.3-2.8) of low back pain compared with the same reference group.

Miranda et al (2008) examined the relationship between lifting and the occurrence of low back pain in a longitudinal study with a 1-year follow-up period in a cohort of almost 4,000 employees in various sectors, categorised by age into 3 groups: <40 years, 40-49 years, and ≥50 years old.[51] In this study, exposure to lifting (> 25 kg) and low back pain (more than 7 days in the past 12 months, no data on severity) were self-reported by participants. Of the participants who did not report any complaints at the start of the study, 21% experienced low back pain for at least 7 days in the past year. Miranda et al found that employees in all age groups who were exposed to lifting more than 25 kg during a working day (n=85-311) did not run a statistically significantly increased risk of low back pain compared with employees who were not exposed to lifting more than 25 kg during a working day (n=373-599). In this study, the increased risk of low back pain decreased with higher employee age (healthy worker effect).

Eriksen et al (2004) examined the relationship between lifting, carrying or pushing loads (weight unknown, 1-4 times per working day, 5-9 times per working day, ≥10 times per working day) and low back pain in a longitudinal study with a 15-month follow-up in a cohort of 4266 participants employed in nursing (4092 women and 171 men).[45] In this study, exposure to lifting and low back pain (in the past three months) were self-reported by participants. Only lifting, carrying or pushing loads 5-9 times per working day was associated with a significantly increased risk (OR=2.2; 95% CI 1.2-4.2) of serious low back pain compared with employees who were not exposed. At a rate of 1-4 times per working day (OR = 1.0; 95% CI 0.6-1.6) and ≥10 times per working day (OR=2.2, 95% CI 0.9-5.1), lifting, carrying or pushing was not associated with significantly elevated risk. The broad confidence interval for the latter finding indicates inaccuracy in estimation of the effect.

Harkness et al (2003) examined the relationship between lifting/carrying with 1 hand, 2 hands and above shoulder level and low back pain (at least 1 day in the past month) in a longitudinal study with a 2-year follow-up in a cohort of 100-235 participants (64% men, 36% women) employed in 12 different sectors.[46] In this study, exposure to lifting/carrying and low back pain were self-reported. No statistically significantly increased risks were found in any of the 3 groups compared with employees who were not exposed.

Hoogendoorn et al (2003) examined the relationship between lifting and low back pain in a longitudinal study with a 3-year follow-up in a cohort of 861 participants employed in various different sectors (70% men, 30% women).[47] In this study, exposure to lifting was determined via continuous observation during 1 working day, and low back pain (persistent pain in the past 12 months) were measured using a questionnaire. Of the participants who did not report any complaints at the start of the study, 26.6% experienced low back pain after 3 years. Based on their study, Hoogendoorn et al (2000) found no significantly increased risk of low back pain associated with lifting ≥10kg per working day (n=268) and lifting ≥25kg per working day (n=57-135) compared with employees who never lift during work (n=233). No significantly increased risk of low back pain were associated with lifting ≥25kg per working day compared with employees who lift 1-15kg or >15kg per working day.

Jansen et al (2004) examined the relationship between lifting and carrying >10 kg and the occurrence low back pain in a longitudinal study with a 1-year follow-up in a group of 523 participants.[49] In this study, exposure to lifting was determined via continuous observation during 1 working day, and low back pain (a few hours in the past 12 months) were measured using a questionnaire. Of the participants who did not report any complaints at the start of the study, 26.4% experienced 1 episode low back pain in the past year. Jansen et al (2004) examined both low back pain and low back pain combined with disabilities (for various durations of lifting per week). No statistically significantly increased risk was found for any of the comparisons with employees not exposed to lifting and carrying.

Macfarlane et al (1997) examined the relationship between lifting/moving weights during a working day (11 kg) and low back pain (at least 1 day) in a longitudinal study with a 1-year follow-up in a cohort of 1412 participants.[50] In this study, exposure to lifting/moving weights was determined using a questionnaire and low back pain were assessed via a questionnaire and medical charts. A significantly elevated risk (OR = 2.5; 95% CI 1.5-4.1) was found for women (n=80) for the development of low back pain compared with employees who were not exposed to lifting/carrying weights (n=309).

Hoogendoorn et al (2002) examined the relationship between lifting and absenteeism due to low back pain in a longitudinal study with a 3-year follow-up in a cohort of 732 employees (75% men, 25% women).[48] In this study, exposure to lifting was determined via continuous observation during 1 working day, and absenteeism due to low back pain was assessed using a questionnaire. Absenteeism was classified into 3 categories: 1. >3 days due to low back pain; 2. brief sick leave (3-7 days); 3. long-term sick leave (>7 days). Hoogendoorn et al (2002) found both significantly and non-significantly increased risks for all 3 categories. For example, lifting ≥10kg per working day (n=112-152) was associated with an increased risk in all 3 categories of absenteeism (1. RR = 2.5; 95% CI 1.4-4.3; 2. RR = 2.7; 95% CI 1.1-6.5; 3. RR = 3.2; 95% CI 1.7-6.0) compared to employees who do not lift (n = 251-281).

Van Nieuwenhuyse et al (2006) examined the relationship between lifting and low back pain in a longitudinal study with a 1-year follow-up period in a cohort of 851 participants (39% men, 61% women).[54] In this study, exposure to lifting and low back pain (at least 7 days in the past 12 months) were self-reported by participants. After a follow-up period of 1 year, 12.6% of employees reported having low back pain. Based on their study, Van Nieuwenhuyse et al (2006) found that employees who lifted/carried >25 kg with a frequency >12 times per hour (n=13) had a significantly increased risk of low back pain (RR 3.13; 95% CI 1.18-8.33) compared to employees who did not lift/carry (n=122).

Tubach et al (2002) examined the relationship between lifting/carrying and absenteeism due to low back pain in a longitudinal study with a 2-year follow-up period in a cohort of 2,236 employees (84% men, 16% women).[53] In this study, exposure to lifting/carrying and low back pain (more than 30 days of lower back pain in the past 12 months) were self-reported by participants using questionnaires. Based on their study, Tubach et al (2002) found that employees who lift/carry >10 kg each day had an increased risk of ≥8 days of sick leave in 1 year due to low back pain (RR=4.1; 95% CI 2.2-7.5).

Nuwayhid et al (1993) examined the relationship between lifting/carrying and low back pain in a longitudinal study with an 8-month follow-up period in a cohort of 637 employees (fire-fighters).[52] In this study, exposure to lifting and low back pain (pain or complaints in the region between the bottom ribs and the tailbone, including buttocks) were self-reported by participants during a telephone interview. Based on their study, Nuwayhid et al (1993) found no statistically significantly increased risk of developing back complaints when >18 kg were lifted.

Annex **G**

Extraction table low back complaints (meta-analyses)

Author	Study population	Study design	Health effect	Exposure parameters	Degree of association
Harkness 2003[46]	N = 1029 G = 64% men; 36% women A = median 23 O = various sectors such as service organization, police, army officers, supermarket, postal distribution centre C = England	Prospective cohort study (2 years) Conf = age, sex, occupation	Low back pain (LBP) (1 year incidence = 19%) *Pain:* any pain or ache in the low back lasting for one day or longer in the past month	Lift or carry with two hands: - never N = 461 (373 no LBP; 88 LBP) - I ≤ 11 kg N = 289 (235 no LBP; 54 LBP) - I > 11 kg N = 279 (225 no LBP; 54 LBP)	 OR = 1.0 OR = 1.1 (CI 0.7-1.7) OR = 1.4 (CI 0.8-2.5)
Macfarlane 1997[50]	N = 729 G = 340 men; 389 women A = 18-75 O = construction workers, clerical workers, security/ armed forces, drivers, professionals, warehouse workers, metal workers, shop workers, machine operators, managers, domestics, food industry workers, and nursing C = UK	Prospective cohort study (1 year) Conf = age	Low back pain (LBP) (1 year incidence = 34%) *Low back pain:* any ache or pain lasting longer than 24 hours, in the area bordered at the top by the 12th rib and at the bottom by the gluteal fold.	Lifting/moving weights - no N (men) = 189 (129 no LBP; 60 LBP N (women) = 309 (226 no LBP; 83 LBP - I ≥ 11kg N (men) = 151 (101 no LBP; 50 LBP N (women) = 80 (42 no LBP; 38 LBP	 OR = 1.0 OR = 1.0 OR (men) = 1.1 (CI 0.7-1.7) OR (women) = 2.5 (CI 1.5-4.1)

Nuwayhid 1993 [52]	N = 696 G = ? A = ? O = fire fighters C = USA	Prospective cohort study (8 months) Conf = off-duty activities, work shift	Low back pain (incidence = ?) *Pain:* pain or discomfort in the region between the lowest ribs and the coccyx including the buttocks	Lifting/carrying - no N = ? - I >18kg N = ?	 OR = 1.0 OR = 1.98 (CI 0.66-5.97)
Van Nieuwenhuyse 2006 [54]	N = 637 G = 39% men; 61% women A = 26 (median) O = various C = Belgium	Prospective cohort study (1 year) Conf = ?	Low back pain (LBP) (1 year incidence = 12.6%) *Pain:* ache, pain or discomfort in the low back for seven or more consecutive days during the past 12 months	Lifting/carrying - no N = 122 (110 no LBP; 12 LBP) - I ≤ 10kg N = 83 (72 no LBP; 11 LBP) - I = 11-25kg; F ≤ 12 times per hour N = 122 (107 no LBP; 15 LBP) -I = 11-25kg; F> 12 times per hour N = 50 (43 no LBP; 7 LBP) - I > 25kg; F ≤ 12 times per hour N = 310 (271 no LBP; 39 LBP) -I > 25 kg; F> 12 times per hour N = 13 (9 no LBP; 4 LBP)	 RR = 1.0 RR = 1.35 (CI 0.62-2.91) RR = 1.25 (CI 0.61-2.56) RR = 1.42 (CI 0.60-3.40) RR = 1.28 (CI 0.69-2.36) RR = 3.13 (CI 1.18-8.33)

N, number; G, gender; A, age; O, occupation (sector); C, country; Ref, reference group; Exp, exposure; HEf, health effect; Conf = confounder taken into account; D, duration; I, intensity; F, frequency; m, mean; sd, standard deviation; %, percentage; h, hour; min, minute; s, second; OR, odds ratio; HR, hazard ratio; OR, odd ratio; PRR, prevalence rate ratio; CI, confidence interval; *,p<.05; **, p<.01; ***, p<.001

Annex H

Extraction table low back complaints (others)

Author	Study population	Study design	Health effect	Exposure parameters	Degree of association
Andersen 2007 [44]	N = 4006 G = ? A = 44 (sd=10) O = various C = Denmark	Prospective cohort study (2 years) Conf = sex, age, occupational category, intervention group	Low back pain (2 years incidence = 10.6%)	Lifting (cumulative) - never N = 684	 HR = 1.0
				- I = 1-99 kg per h N = 479	HR = 1.4 (CI 0.9-2.0)
				- I = ≥ 100 kg per h N = 290	HR = 1.9 (CI 1.3-2.8)
				Lifting at or above shoulder level - never N = 1307	 HR = 1.0
				- I = 1-49 kg per h N = 90	HR = 1.2 (CI 0.6-2.2)
				- I = ≥ 50 kg per h N = 78	HR = 1.0 (CI 0.5-2.0)

Harkness 2003 [46]	N = 788 G = 64% men; 36% women A = median 23 O = various sectors such as service organization, police, army officers, supermarket, postal distribution centre C = England	Prospective cohort study (2 years) Conf = age, sex, occupation	Low back pain (LBP) (1 year incidence = 19%) *Pain:* any pain or ache in the low back lasting for one day or longer in the past month	Lift or carry with one hand: - never N = 496 (402 no LBP; 94 LBP)	OR = 1.0
				- I ≤ 6.8 kg N = 263 (208 no LBP; 55 LBP)	OR = 1.3 (CI 0.8-1.9)
				- I > 6.8 kg N = 274 (225 no LBP; 49 LBP)	OR = 1.1 (CI 0.6-1.9)
				Lifting at or above shoulder level: - never N = 774 (630 no LBP; 144 LBP)	OR = 1.0
				- I ≤ 10.5 kg N = 128 (101 no LBP; 27 LBP)	OR = 1.3 (CI 0.8-2.2)
				- I > 10.5 kg N = 126 (100 no LBP; 26 LBP)	OR = 1.8 (CI 0.9-3.5)
Hoogendoorn 2000 [47]	N = 861 G = 70% men; 30% women A = 36 (18-59) O = blue collar jobs, white collar jobs, caring professions C = The Netherlands	Prospective cohort study (3 year) Conf = sex, age, smoking, body mass index, exercise behaviour during leisure time, coping skills, quantitative job demands, decision authority, skill discretion, supervisor support, co worker support, job security, job satisfaction, moving of heavy loads during leisure time, flexion and rotation of the upper part of body during leisure time, driving a vehicle during leisure time, and driving a vehicle at work	Low back pain (cumulative incidence = 26.6%) *Pain:* regular or prolonged in the low back in the past month	Lifting - Never N = 233 (172 no LBP; 61 LBP)	RR = 1.0
				- Never ≥ 10 kg per working day N = 142 (104 no LBP; 38 LBP)	RR (crude) = 1.01 (CI 0.66-1.53) RR = 0.92 (CI 0.60-1.42)
				- Never ≥ 25 kg per working day N = 268 (201 no LBP; 67 LBP)	RR (crude) = 0.95 (CI 0.67-1.36) RR = 0.98 (CI 0.67-1.42)
				-I ≥ 25 kg; 1-15 x per working day N = 135 (102 no LBP; 33 LBP)	RR (crude) = 0.87 (CI 0.56-1.35) RR = 0.83 (CI 0.52-1.33)
				- I ≥ 25 kg; >15 x per working day N = 57 (33 no LBP; 24 LBP)	RR (crude) = 1.58 (CI 0.98-2.60) RR = 1.57 (CI 0.90-2.75)

Hoogendoorn 2002[48]	N = 732 G = 75%, men; 25% women A = ? O = blue collar jobs, white collar jobs, caring professions C = The Netherlands	Prospective cohort study (3 year) Conf = sex, age, smoking, body mass index, exercise behaviour during leisure time, coping skills, quantitative job demands, decision authority, skill discretion, supervisor support, co worker support, job security, job satisfaction, moving of heavy loads during leisure time, flexion and rotation of the upper part of body during leisure time, driving a vehicle during leisure time, and driving a vehicle at work.	1. Sickness absence (SA) due to low back pain of 3 days or longer 2. Short absenteeism (3-7 days) 3. Long absenteeism (>7 days)	Lifting - never 1. N = 251 (219 no SA; 32 SA) 2. N = 259 (245 no SA; 14 SA) 3. N = 281 (261 no SA; 20 SA) - never ≥ 10 kg/working day 1. N = 112 (85 no SA; 27 SA) 2. N = 118 (106 no SA; 12 SA) 3. N = 152 (125 no SA; 27 SA) - never ≥ 25 kg/working day 1. N = 208 (143 no SA; 65 SA) 2. N = 232 (211 no SA; 21 SA) 3. N= 246 (192 no SA; 54 SA) - I ≥ 25 kg; 1-15 x per working day 1. N = 82 (45 no SA; 37 SA) 2. N = 92 (74 no SA; 18 SA) 3. N = 99 (69 no SA; 30 SA) - I ≥ 25 kg; >15 x per working day 1. N = 49 (26 no SA; 23 SA) 2. N = 58 (53 no SA; 5 SA) 3. N = 62 (38 no SA; 24 SA)	 1. RR = 1.0 2. RR = 1.0 3. RR = 1.0 1. RR = 2.47 (CI 1.42-4.29) 2. RR = 2.68 (CI 1.13-6.46) 3. RR = 3.19 (CI 1.72-6.01) 1. RR = 2.32 (CI 1.41-3.89) 2. RR = 1.46 (CI 0.64-3.44) 3. RR = 2.99 (CI 1.68-5.54) 1. RR = 2.27 (CI 1.25-4.14) 2. RR = 2.46 (CI 0.96-6.41) 3. RR = 2.78 (CI 1.40-5.58) 1. RR = 2.18 (CI 1.07-4.37) 2. RR = 0.89 (CI 0.24-2.89) 3. RR = 3.26 (CI 1.52-6.98)

Jansen 2004 [49]	N = 523 G = ? A = 41 (sd=10) O = various C = the Netherlands	Prospective cohort study (1 year) Conf = ?	Low back pain and disability (cumulative incidence = 26.4%) *Pain:* any pain in the lower back that lasted at least few hours in the previous year *Disability*: Von Korff disability score > 50	Lifting and carrying - never N = ?	RR = 1.0
				- I > 10 kg; D = 5 min per week N = ?	RR = 1.05 (CI 0.94-1.17)
				- I > 10 kg; D = 15 min per week N = ?	RR = 1.18 (CI 0.79-1.77)
				-I > 10 kg; D = 30 min per week N = ?	RR = 1.33 (CI 0.60-2.95)
				- I > 10 kg; D = 45 min per week N = ?	RR = 1.26 (CI 0.38-4.20)
Miranda 2008[51]	N = 2256 G = 1678 men; 578 women A = ? O = various C = Finland	Prospective cohort study (1 year) Conf = age, gender, other exposures	Low back pain (LBP) (1 year incidence = 21%) *Pain:* pain in the low back for > 7 days during the previous 12 months	Lifting > 25kg - no N (<40 years of age) = 599 (504 no LBP; 95 LBP)	OR = 1.0
				N (40-49 years of age) = 588 (464 no LBP; 124 LBP)	OR = 1.0
				N (>50 years of age) = 373 (268 no LBP; 105 LBP)	OR = 1.0
				- yes N (<40 years of age) = 311 (249 no LBP; 62 LBP)	OR (<40 years of age) = 1.4 (CI 1.0-2.1)
				N (40-49 years of age) = 211 (162 no LBP; 49 LBP)	OR (40-49 years of age) = 1.0 (CI 0.7-1.4)
				N (>50 years of age) = 85 (63 no LBP; 22 LBP)	OR (≥50 years of age) = 0.9 (CI 0.6-1.5)
Eriksen 2004[45]	N = 4266 G = 171 men; 4092 women A = ? O = nurses' aides C = Norway	Prospective cohort study (15 months) Conf = age, gender, familial characteristics, physical leisure time activities, former smoking, daily consumption of cigarettes, baseline health complaints.	Sick leave longer than 8 weeks due to low back pain (1 year incidence = 3.3%) *Low back pain:* pain in the region between the 12. rib and the gluteal folds in the past 12 months	Lifting, carrying and pushing heavy objects - 0 per average shift N = ?	OR = 1.0
				- 1-4 per average shift N = ?	OR = 0.99 (CI 0.59-1.64)
				- 5-9 per average shift N = ?	OR = 2.21 (CI 1.17-4.16)
				- ≥10 per average shift N = ?	OR = 2.20 (CI 0.94-5.10)

Tubach 2002[53]	N = 2236 G = 1854 men; 351 women A = 40-50 men; 35-50 women O = workers in French national electricity and gas company C = Switzerland	Prospective cohort study (2 years) Conf = ?	1. Low back pain with no sick leave or less than 8 days 2. Low back pain with 8 or more days sick leave *Pain:* >30 days pain in the low back in the previous 12 months	Lifting/carrying - never 1. N = 1175 (991 no LBP; 184 LBP) 2. N = 1017 (991 no LBP; 26 LBP) - I > 10kg; F <1/week 1. N = 509 (432 no LBP; 77 LBP) 2. N = 449 (432 no LBP; 17 LBP) - I > 10kg; F >1/week 1. N = 287 (236 no LBP; 51 LBP) 2. N = 248 (236 no LBP; 12 LBP) - I > 10kg; F = everyday 1. N = 164 (130 no LBP; 34 LBP) 2. N = 145 (130 no LBP; 15 LBP)	 1. RR = 1.0 2. RR = 1.0 1. RR = 1.0 (CI 0.8-1.2) 2. RR = 1.5 (CI 0.8-2.87) 1. RR = 1.1 (CI 0.9-1.5) 2. RR = 1.9 (CI 1.0-3.7) 1. RR = 1.3 (CI 1.0-1.8) 2. RR = 4.1 (CI 2.2-7.5)

N, number; G, gender; A, age; O, occupation (sector); C, country; Ref, reference group; Exp, exposure; HEf, health effect; Conf = confounder taken into account; D, duration; I, intensity; F, frequency; m, mean; sd, standard deviation; %, percentage; h, hour; min, minute; s, second; OR, odds ratio; HR, hazard ratio; OR, odd ratio; PRR, prevalence rate ratio; CI, confidence interval; *,p<.05; **, p<.01; ***, p<.001.

Annex **I**

Lower limb complaints

Two longitudinal studies examined the relationship between lifting during work and lower limb complaints.[44,55] Both studies are summarised in a table in Annex K.

Andersen et al (2007) examined the relationship between lifting and hip/knee/foot complaints in a longitudinal study with a 2-year follow-up period in a cohort of 4006 participants.[44] In this study, exposure to cumulative lifting (sub-weights unknown) and hip/knee/foot complaints in the past 12 months were self-reported. Of the participants who did not report complaints at the start of the study, 9.3% had severe pain in hips, knees or feet after 24 months. Based on their study, Andersen et al found that employees who (cumulatively) lift up to 99 kg per hour (n=479) had a statistically significantly increased risk (HR = 1.6; 95% CI 1.1-2.3) of hip/knee/foot complaints compared with employees who do not lift (n=684). This study also found that employees who (cumulatively) lift more than 99 kg per hour (n=290) had a statistically significantly increased risk (HR = 1.8; 95% CI 1.2-2.8) of hip/knee/foot complaints compared to the same reference group.

Jones et al (2007) examined the relationship between lifting and the occurrence of knee complaints in a longitudinal study with a 2-year follow-up in a cohort of over 1000 employees in various sectors.[55] In this study, both exposure to lifting and knee complaints were self-reported by participants. Of the participants who did not report any complaints at the start of the study, 10.2% experienced knee complaints after 2 years. Jones et al found that employees exposed to lifting up to 12.7 kilograms (n=83) had a statistically significantly increased risk (RR=1.8; 95% CI 1.1-2.9) of developing knee complaints compared with employees who were not exposed (n=508). Employees who were exposed to lifting more than 12.7 kilograms (n=67), however, did not have a statistically significantly increased risk (RR=0.9; 95% CI 0.5-1.7) of developing knee complaints compared to employees who were not exposed (n=508).

Annex **J**

Upper limb complaints

Four longitudinal studies examined the relationship between lifting during work and upper limb complaints.[44,56-58] These studies are summarised in a table in Annex K.

Andersen et al (2007) examined the relationship between lifting and upper limb complaints in a longitudinal study with a 2-year follow-up period in a cohort of 4006 participants.[44] In this study, exposure to cumulative lifting (sub-weights unknown) and upper limb complaints in the past 12 months were self-reported. Of the participants who did not report any complaints at the beginning of the study, 11.5% had severe neck or shoulder pain, and 6.4 had severe elbow, forearm or hand pain at 24 months. Andersen et al found that employees who (cumulatively) lift up to 99 kg per hour (n=479) did not have a statistically significantly increased risk of neck/shoulder complaints (HR = 1.4; 95% CI 0.9-1.9) or elbow/forearm/hand complaints (HR=1.3; 95% CI 0.8-2.1) compared with employees who do not lift (n=684). On the other hand, the study showed that employees who (cumulatively) lift over 99 kg per hour (n=290) did have a statistically significantly increased risk of neck/shoulder complaints (HR = 1.9; 95% CI 1.3-2.7) compared to the same reference group, but not a statistically significantly increased risk of elbow/forearm/hand complaints (HR=1.6; 95% CI 0.9-2.7).

Miranda et al (2008) examined the relationship between lifting and the occurrence of (chronic) shoulder complaints in a longitudinal study with a 20-

year follow-up in a cohort of almost 900 employees (42% men, 58% women) in various sectors.[58] In this study, exposure to lifting was self-reported by participants and chronic shoulder complaints were determined by clinicians. After 20 years of follow-up, 7% of participants had chronic shoulder complaints. Miranda et al found that employees who were exposed to lifting more than 25 kilograms (n=207) had a statistically significantly increased risk (OR=2.0; 95% CI 1.2-3.4) of chronic shoulder complaints compared with employees who were not exposed (n=597). Stratifying the entire group by sex, Miranda et al found that female employees exposed to lifting over 25 kilograms (n=107) had a statistically significantly increased risk (OR=2.3; 95% CI 1.3-5.1) of chronic shoulder complaints compared with female employees who were not exposed (n=354). On the other hand, male employees exposed to lifting more than 25 kilograms (n=100) did not have a statistically significantly increased risk (OR=1.3; 95% CI 0.6-2.9) of chronic shoulder complaints compared with male employees who were not exposed (n=243).

Feveile et al (2002) examined the relationship between lifting and neck-shoulder pain in a longitudinal study with a 5-year follow-up in a group of 3990 participants.[56] Exposure to lifting was determined using interviews and neck-shoulder pain using a questionnaire. Feveile et al (2002) found that employees exposed to lifting had a statistically significantly higher risk of developing neck-shoulder pain compared with a group of employees that was not exposed. The article does not list prevalence figures.

Harkness et al (2003) examined the relationship between lifting with 1 hand or 2 hands and lifting at or above shoulder level, and shoulder pain in a longitudinal study with a 2-year follow-up in a cohort of 803 participants (65% men, 35% women).[57] In this study, both exposure to lifting and shoulder pain were self-reported by participants. At the end of the follow-up period, 15% of participants had shoulder pain. Harkness et al (2003) found significantly increased risks for the development of shoulder pain for both lifting methods compared with the non-exposed reference group (n=209-471).

Annex

K

Extraction table other musculoskeletal complaints

Author	Study population	Study design	Health effect	Exposure parameters	Degree of association
Andersen 2007[44]	N = 4006 G = ? A = 44 (sd=10) O = various C = Denmark	Prospective cohort study (2 years) Conf = sex, age, occupational category, intervention group	1. Neck/shoulder pain (2 years incidence = 11.5%) 2. Elbow. forearm, hand pain (2 years incidence = 6.4%) 3. Hip, knee, foot pain (2 years incidence = 9.3%) 4. Any region (2 years incidence = 23.6%) *Pain:* pain in a body region in the past 12 months	Lifting (cumulative) - never N = 684 - I = 1-99 kg per h N = 479 - I = ≥ 100 kg per h N = 290 Lifting at or above shoulder level - never (N = 1307) - I = 1-49 kg per h (N = 90) - I = ≥ 50 kg per h (N = 78)	 HR = 1.0 1. HR = 1.4 (CI 0.9-1.9) 2. HR = 1.3 (CI 0.8-2.1) 3. HR = 1.6 (CI 1.1-2.3) 4. HR = 1.3 (CI 1.1-1.7) 1. HR = 1.9 (CI 1.3-2.7) 2. HR = 1.6 (CI 0.9-2.7) 3. HR = 1.8 (CI 1.2-2.8) 4. HR = 1.6 (CI 1.2-2.0) HR = 1.0 1. HR = 1.2 (CI 0.7-2.2) 2. HR = 0.9 (CI 0.4-2.2) 3. HR = 1.4 (CI 0.8-2.7) 4. HR = 1.3 (CI 0.9-1.9) 1. HR = 2.1 (CI 1.3-3.5) 2. HR = 2.2 (CI 1.1-4.3) 3. HR = 2.0 (CI 1.1-3.5) 4. HR = 1.6 (CI 1.1-2.3)

Feveile 2002 [56]	N = 3990 G = ? A = 35 men; 37 women O = various C = Denmark	Prospective cohort study (5 years) Conf = ?	Neck-shoulder pain (1 year incidence = 14%) *Pain:* pain or discomfort within the past 12 months	Lifting - I ≥ 25 kg & sedentary work: N = 339	OR = 1.0
				- I ≥ 25 kg; D ≥ 75% of workday & sedentary work for ≥ 75% of workday N = 2	OR = 2.36 (CI 0.14-39.45)
				- I ≥ 25 kg; D ≥ 75% of workday & sedentary work for 25-50% of workday N = 9	OR = 1.38 (CI 0.33-5.76)
				- I ≥ 25 kg; D ≥ 75% of workday & sedentary work for <25% of workday N = 32	OR = 2.35 (CI 1.10-5.00)
				- I ≥ 25 kg; D 25-50% of workday & sedentary work for ≥ 75% of workday N = 17	OR = 0.18 (CI 0.02-1.41)
				- I ≥ 25 kg; D 25-50% of workday & sedentary work for 25-50% of workday N = 42	OR = 1.61 (CI 0.80-3.24)
				- I ≥ 25 kg; D 25-50% of workday & sedentary work for <25% of workday N = 122	OR = 1.42 (CI 0.89-2.67)
				- I ≥ 25 kg; D <25% of workday & sedentary work for ≥ 75% of workday N = 368	OR = 1.50 (CI 1.05-2.15)
				- I ≥ 25 kg; D <25% of workday & sedentary work for 25-50% of workday N = 327	OR = 1.42 (CI 0.99-2.03)

Harkness 2003 [57]	N = 803 G = 65% men; 35% women A = median 23 O = various sectors such as service organization, police, army officers, supermarket, postal distribution centre C = England	Prospective cohort study (2 years) Conf = age, sex, occupation	Shoulder pain (SP) (1 year incidence = 15%) (2 year incidence = 15%) *Pain:* any pain or ache in the shoulder lasting for one day or longer in the past month	Lifting with one or two hands - never N = 209 (189 no SP; 20 SP)	 OR = 1.0
				- I ≤ 10 kg N = 196 (163 no SP; 33 SP)	OR = 1.9 (CI 1.2-3.1)
				- I > 10 kg N = 216 (179 no SP; 37 SP)	OR = 2.2 (CI 1.3-3.8)
				Lifting at or above shoulder level - never N = 471 (409 no SP; 62 SP)	 OR = 1.0
				- Lifting at or above shoulder level: I ≤ 9 kg N = 73 (60 no SP; 13 SP)	OR = 2.0 (CI 1.2-3.3)
				- Lifting at or above shoulder level: I > 9 kg N = 80 (63 no SP; 17 SP)	OR = 2.2 (CI 1.2-3.9)
Miranda 2008[58]	N = 909 G = 42% men; 58% women A = 64.2 (sd=9.5) O = various C = Finland	Prospective cohort study (20 years) Conf = age, gender, type of work	Chronic shoulder disorder (CSD) (20 years prevalence = 7%)	Lifting > 25kg - no N = 597 (560 no CSD; 37 CSD) N (men) = 243 (223 no CSD; 20 CSD) N (women) = 354 (337 no CSD; 17 CSD)	 OR = 1.0 OR = 1.0 OR = 1.0
				- yes N = 207 (181 no CSD; 26 CSD) N (men) = 100 (87 no CSD; 13 CSD) N (women) = 107 (94 no CSD; 13 CSD	 OR = 2.0 (CI 1.2-3.4) OR (men) = 1.3 (CI 0.6-2.9) OR (women) = 2.3 (CI 1.1-5.1)

Jones 2007 [55]	N = 1081 G = ? A = 62 men;65 women O = various C = England	Prospective cohort study (2 years) Conf = age, sex, occupational group, BMI, physical activity	Knee pain (KP) (1 year incidence = 8.2%) *Pain:* new onset of knee pain in the past 12 months	Lifting or carrying one hand - none N (1 year) = 333 (314 no KP; 19 KP)	RR = 1.0
				- I < 9 kg N (1 year) = 191 (169 no KP; 22 KP)	RR = 2.1 (CI 1.3-3.2)
				- I > 9 kg N (1 year) = 139 (125 no KP; 14 KP)	RR = 1.7 (CI 1.03-2.8)
				Lifting or carrying two hands - none N (1 year) = 306 (284 no KP; 22 KP)	RR = 1.0
				- I < 12.2 kg N (1 year) = 198 (184 no KP; 14 KP)	RR = 1.2 (CI 0.7-2.1)
				- I > 12.2 kg N (1 year) = 152 (134 no KP; 18 KP)	RR = 1.6 (CI 0.9-2.7)
				Lifting at or above shoulder level - none N (1 year) = 508 (472 no KP; 36 KP)	RR = 1.0
				- I < 12,7 kg N (1 year) = 83 (73 no KP; 10 KP)	RR = 1.8 (CI 1.1-2.9)
				- I > 12,7 kg N (1 year) = 67 (59 no KP; 8 KP)	RR = 0.9 (CI 0.5-1.7)

Karpan-salo 2002 [86]	N = 1755 G = men A = O = various C = Finland	Prospective cohort study Conf = age, education, BMI, alcohol, smoking	1. Disability pension (DP) 2. Disability pension due to musculoskeletal disorder 3. Disability pension due to cardiovascular disorder 4. Disability pension due to mental disorder *Disability:* 300 days or more on sick leave	Lifting or moving heavy loads - not at all 1. N = 802 (454 no DP; 348 DP) 2. N = 802 (701 no DP; 101 DP) 3. N = 802 (694 no DP; 108 DP) 4. N = 802 (719 no DP; 83 DP)	 1. OR = 1.0 2. OR = 1.0 3. OR = 1.0 4. OR = 1.0
				- a little 1. N = 426 (214 no DP; 212 DP) 2. N = 426 (334 no DP; 92 DP) 3. N = 426 (375 no DP; 51 DP) 4. N = 426 (364 no DP; 62 DP)	 1. OR = 1.14 (CI 0.82-1.60) 2. OR = 1.54 (CI 0.99-2.40) 3. OR = 0.82 (CI 0.50-1.35) 4. OR = 0.93 (CI 0.52-1.67)
				- a lot 1. N = 527 (226 no DP; 301 DP) 2. N = 527 (380 no DP; 147 DP) 3. N = 527 (443 no DP; 84 DP) 4. N = 527 (496 no DP; 31 DP)	 1. OR = 1.64 (CI 1.15-2.33) 2. OR = 2.46 (CI 1.57-3.86) 3. OR = 1.53 (CI 0.93-2.52) 4. OR = 1.16 (CI 0.63-2.12)

Harkness 2004 [85]	N = 896 G = 33% men; 67% women A = median 23 O = various sectors such as service organization, police, army officers, supermarket, postal distribution centre C = England	Prospective cohort study (2 years) Conf = age, sex, occupation	Widespread pain (WP; criteria for fibromyalgia) (1 year incidence = 15%) (2 year incidence = 12%) *Pain:* any pain or ache lasting for one day or longer in the past month	Lifting with one hand - never N = 216 (192 no WP; 24 WP)	OR = 1.0
				- I ≤ 6.8 kg N = 134 (116 no WP; 18 WP)	OR = 1.7 (CI 1.1-2.7)
				- I > 6.8 kg N = 120 (104 no WP; 16 WP)	OR = 1.9 (CI 1.1-3.3)
				Lifting with two hands - never N = 232 (202 no WP; 30 WP)	OR = 1.0
				- I ≤ 11 kg N = 117 (105 no WP; 12 WP)	OR = 1.3 (CI 0.8-2.1)
				- I > 11 kg N = 367 (324 no WP; 43 WP)	OR = 1.7 (CI 1.0-2.8)
				Lifting at or above shoulder level - never N = 367 (324 no WP; 43 WP)	OR = 1.0
				- I ≤ 10.5 kg N = 56 (47 no WP; 9 WP)	OR = 2.0 (CI 1.2-3.3)
				- I > 10.5 kg N = 45 (39 no WP; 6 WP)	OR = 1.7 (CI 0.9-3.2)

N, number; G, gender; A, age; O, occupation (sector); C, country; Ref, reference group; Exp, exposure; HEf, health effect; Conf = confounder taken into account; D, duration; I, intensity; F, frequency; m, mean; sd, standard deviation; %, percentage; h, hour; min, minute; s, second; OR, odds ratio; HR, hazard ratio; OR, odd ratio; PRR, prevalence rate ratio; CI, confidence interval; *,p<.05; **, p<.01; ***, p<.001

Annex **L**

Birth issues

Four longitudinal studies examined the relationship between lifting during work and birth problems, such as premature birth and miscarriage.[59-62] These studies are summarised in a table in Annex M.

In 2005, Magann et al examined the relationship between lifting and the occurrence of premature birth, premature contractions, intrauterine growth retardation and premature mortality in a cohort of 814 pregnant women in the military.[61] Within a 4-year follow-up period, exposure to lifting was self-reported by employees. Premature birth, premature contractions, growth retardation and premature mortality were determined by a doctor. The study found no significantly elevated risks (between OR=0.59; 95% CI 0.20-1.74 and OR=1.22; 95% CI 0.27-3.92) in the comparison between lifting and the above-mentioned health risks.

In the prospective cohort study by Bonzini et al (2009), the relationship between lifting and premature birth, low birth weight, small head circumference and small waist circumference of the child were examined in a group of 1327 (exclusively female) participants.[59] Exposure to lifting was determined using interviews, and exposure to the above-mentioned risks was determined based on hospital reports. Comparison of lifting ≥25 kg and the above-named factors found no significantly increased risks (premature birth (11 weeks) OR = 0.7; 95% CI 0.2-2.3; premature birth (19 weeks) OR = 1.1; 95% CI 0.3-3.6; low birth weight (11 weeks) OR = 1.1; 95% CI 0.5-2.3; low birth weight (19 weeks) OR = 1.1; 95% CI 0.4-2.6; small head circumference (11 weeks) OR = 1.6; 95% CI

1.0-2.8, small head circumference (19 weeks) OR = 1.7; 95% CI 0.9-3.2, small waist circumference (11 weeks) OR = 0.8; 95% CI 0.4-1.6 and small waist circumference (19 weeks) OR = 0.6; 95% CI 0.2-1.4) compared to the unexposed reference group.

The prospective cohort study by Florak et al (1993) examined the relationship between lifting and spontaneous abortion (<26 weeks) in a cohort of 260 working women.[60] Exposure to lifting and spontaneous abortion were reported via an interview. Florak et al (1993) found that women who were exposed to lifting for ≥1 hour per working day did not have a statistically significantly increased risk (OR=1.1; 95% CI 0.3-3.4) of spontaneous abortion compared with employees who were not exposed.

The prospective cohort study by Strand et al (1989) examined the relationship between lifting and pregnancy leave behaviour among over 2600 young women.[62] This study found that exposure to lifting between 10 and 20 kilograms was associated with a statistically significantly increased risk (OR=1.5; 95% CI 1.2-1.8) of early pregnancy leave compared with no exposure to lifting.

Annex **M**

Extraction table birth issues

Author	Study population	Study design	Health effect	Exposure parameters	Degree of association
Bonzini 2009[59]	N = 1327 G = women A = 21-38 O = various C = UK	Prospective cohort study Conf = age, BMI, smoking, education	1. Preterm delivery (11 weeks) 2. Preterm delivery (19 weeks) 3. Low birth weight (11 weeks) 4. Low birth weight (19 weeks) 5. Small head circumference (11 weeks) 6. Small head circumference (19 weeks) 7. Small abdominal circumference (11 weeks) 8. Small abdominal circumference (19 weeks)	- Lifting: I ≥ 25 kg 1. N = 121 (118 no; 3 cases) 2. N = 83 (80 no; 3 cases) 3. N = 121 (112 no; 9 cases) 4. N = 83 (77 no; 6 cases) 5. N = 120 (102 no; 18 cases) 6. N = 82 (69 no; 13 cases) 7. N = 120 (110 no; 10 cases) 8. N = 82 (77 no; 5 cases)	- Lifting: I ≥ 25 kg 1. OR = 0.69 (CI 0.21-2.26) 2. OR = 1.10 (CI 0.33-3.63) 3. OR = 1.09 (CI 0.53-2.27) 4. OR = 1.06 (CI 0.44-2.55) 5. OR = 1.64 (CI 0.96-2.81) 6. OR = 1.71 (CI 0.91-3.19) 7. OR = 0.79 (CI 0.40-1.55) 8. OR = 0.55 (CI 0.22-1.39)

Florak 1993[60]	N = 260 G = women A = O = cleaners, kitchen staff, clerical work C = the Netherlands	Prospective cohort study Conf = vibration, education, alcohol, noise	Spontaneous abortion (<26 weeks)	- Lifting: D < 1 hour per workday N = 134 - Lifting: D ≥ 1 hour per workday N = 35	 - Lifting: D ≥ 1 hour per workday OR (crude) = 1.34 (CI 0.49-3.63) OR = 1.07 (CI 0.34-3.35)
Magann 2005[61]	N = 814 G = women A = 24.4 (sd=5.1) O = military C = USA	Prospective cohort study (4 years) Conf = age, income, smoking, pre-pregnancy weight	1. Preterm birth (20-37 weeks) 2. Preterm labor (regular contractions associated with advanced cervical dilatation) 3. Intrauterine growth restriction 4. Perinatal death (death in utero)	- Lifting: ? N = 48	- Lifting: ? 1. OR = 1.14 (CI 0.32-3.18) 2. OR = 1.22 (CI 0.27-3.92) 3. OR = 0.59 (CI 0.20-1.74) 4. OR = 0.82 (CI 0.23-2.22)
Strand 1997[62]	N = 2713 G = women A = <25 = 634; 25-29 = 1077; > 29 = 1002 O = various C = Norway	Prospective cohort study Ref unexposed group (N = 2154) Conf = other occupational risks	1. Leaving work > 3 weeks before delivery by sickness certification 2. Leaving work > 8 weeks before delivery by sickness certification	- Lifting: no 1. N = 1648 (1296 no; 352 cases) 2. N = 1648 (920 no; 728 cases) - Lifting: I = 10-20kg 1. N = 1045 (689 no; 356 cases) 2. N = 1045 (397 no; 648 cases)	 - Lifting: I = 10-20kg 1. OR = 1.26 (CI 0.01-1.57) 2. OR = 1.48 (CI 1.22-1.80)

N, number; G, gender; A, age; O, occupation (sector); C, country; Ref, reference group; Exp, exposure; HEf, health effect; Conf = confounder taken into account; D, duration; I, intensity; F, frequency; m, mean; sd, standard deviation; %, percentage; h, hour; min, minute; s, second; OR, odds ratio; HR, hazard ratio; OR, odd ratio; PRR, prevalence rate ratio; CI, confidence interval; *,p<.05; **, p<.01; ***, p<.001.

Health Council of the Netherlands

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What is the optimum result of cure and care in view of the risks and opportunities?

Prevention
Which forms of prevention can help realise significant health benefits?

Healthy nutrition
Which foods promote good health and which carry certain health risks?

Environmental health
Which environmental influences could have a positive or negative effect on health?

Healthy working conditions
How can employees be protected against working conditions that could harm their health?

Innovation and the knowledge infrastructure
Before we can harvest knowledge in the field of healthcare, we first need to ensure that the right seeds are sown.

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