

Health Council of the Netherlands

Pushing, pulling and applying force in work situations



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To the Minister of Social Affairs and Employment

Subject : presentation of advisory report *Pushing, pulling and applying force in work situations*
Your reference : ARBO/A&V/2007/22676
Our reference : U 7528/AvdB/fs/832-G3
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Dear Minister,

Your predecessor requested advice on a number of working conditions-related risks by letter. I hereby present the advisory report on applying force, pushing and pulling in work situations. 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 report answers the question of whether there are possibilities for deriving occupational health-related or safety-related exposure limits for applying force, pushing and pulling. Due to the limited number of studies, the Committee was unable to determine a limit for the development of lower back and shoulder complaints. The Committee recommends the use of the Mital method to prevent the development of new complaints.

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 also forwarded the advisory report to the Minister of Health, Welfare and Sports for informational purposes today.

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

Pushing, pulling and applying force in work situations

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

to:

the Minister of Social Affairs and Employment

No. 2012/37E, The Hague, December 20, 2012

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Contents

Executive summary 9

- 1 Introduction 13
 - 1.1 Applying force, pushing, pulling: definitions 13
 - 1.2 Extent of applying force, pushing and pulling in work situations 14
 - 1.3 The request for advice 14
 - 1.4 The Committee's methods 15
 - 1.5 Reading guide 15
-

- 2 Laws and guidelines 17
 - 2.1 Working Conditions Act, Decree and Regulation 17
 - 2.2 European and international guidelines 17
 - 2.3 Other standards 19
 - 2.4 Summary 20
-

- 3 Health damage due to pushing, pulling and applying force 21
 - 3.1 Broad literature exploration 21
 - 3.2 Systematic literature review 22
 - 3.3 Health damage due to applying force, pushing and pulling in work situations 22
 - 3.4 Areas for attention in epidemiological research 25
 - 3.5 Conclusion 26
-

4	Significance of musculoskeletal complaints	27
4.1	Temporary or chronic complaints	27
4.2	Prevalence	28
4.3	Prognosis	28
4.4	Absenteeism and disease burden	29
4.5	Conclusion	30

5	Conclusions and possible limits	31
5.1	Health risks of applying force, pushing and pulling	31
5.2	Health-based occupational exposure limits	32
5.3	Committee recommendations	32

	References	35
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	Annexes	39
A	Request for advice	41
B	The Committee	45
C	Broad literature exploration	47
D	Risk analyses for pushing and pulling forces	51
E	Mital tables	55
F	Key Indicator Method (KIM)	59
G	Systematic literature review	63
H	Extraction table lower back complaints	69
I	Description of studies on lower back complaints	71
J	Extraction table shoulder complaints	73
K	Description of studies on shoulder complaints	75
L	Extraction table other complaints	77
M	Description of studies on other complaints	79
N	Comments on the draft advisory report	81

Executive summary

The request for advice

On request of the Minister of Social Affairs and Employment, the Health Council of the Netherlands examined the question of whether there are current or longer term options for deriving concrete occupational health-related or safety-related limits for applying force, pushing and pulling in work situations. This monitoring report is one of a series of advisory reports in which the Committee on the Identification of Workplace Risks examines occupational risks covered by the Dutch Working Conditions Act and its associated regulations. The Committee studied the scientific evidence on the negative health effects of applying force, pushing and pulling in work situations. The focus was mainly on the results of prospective cohort studies, as this data has the least risk of bias.

Scope

One in five employees in the Netherlands regularly performs work requiring a great deal of force, such as pushing or pulling. Over one million employees need to push or pull burdens of 25 kg. Sectors in which this is common are construction, agriculture, industry, transport and care. Key professions within this context are bricklayers, carpenters and other construction workers, (poultry) farmers, nurses and carers.

Consequences of applying force, pushing and pulling are locomotor system complaints, particularly lower back pain and shoulder complaints. Many studies have investigated the onset of low back or shoulder pain during the preceding 12 months. It is known that nearly a quarter of these people are likely to develop chronic complaints with obvious adverse health effects.

Laws and guidelines

Dutch legislation does not contain any concrete health and/or safety limits for exposure to applying force, pushing and pulling in work situations. Both European and international guidelines, as well as Inspectorate SZW guidelines refer to various risk analyses and related standards tables.

The Committee reports that the risk method used for the Mital (1997) tables is based on associations between exposure, fatigue/discomfort and health complaints. However, this method does not encompass any clear associations between maximum permissible pushing and pulling force and the health damage that may thus be prevented.

Lower back pain and shoulder complaints

Available scientific data indicates that there are signs that applying force, pushing and pulling form a health risk for lower back pain. Furthermore, there are signs that applying force, pushing and pulling form a health risk for shoulder complaints. Given the heterogeneity of exposure measures used, the Committee was unable to translate the indications from available epidemiological studies into exposure-response relationships between applying force, pushing and pulling, and the incidence of lower back and shoulder pain. Based on the small number of studies, the Committee is of the opinion that it is not possible to indicate a safe threshold level for applying force, pushing and pulling below which no adverse health effects could be expected.

Recommendations on limits

As the formulation of occupational health and safety limits is impossible, the Committee notes that the risk method associated with the Mital tables currently provides the most useable measures for estimating health risks of pushing and pulling in work situations. This method is based on extensive research into the association between pushing and pulling and the development of fatigue/discomfort, and assumes that preventing excess fatigue also prevents health complaints.

The Committee believes this association is plausible, and feels preventing undesired direct effects, such as excess fatigue, is important. However, the Committee does note that the amount of health damage prevented by applying this risk method cannot be determined. The Committee supports the approach used in the risk method related to the Mital tables to define limits for pushing and pulling in work situations.

Introduction

In 2007, almost one in five Dutch employees indicated they perform work that regularly involves a great deal of force, such as pushing or pulling.^{1,2} Sectors in which applying force, pushing and pulling are common are construction, agriculture, industry, transport and healthcare.^{1,2} Employees consider applying force, pushing and pulling to be an important risk factor for musculoskeletal complaints.^{1,2} There are also potential social costs related to rehabilitation, absenteeism and work disability. Therefore, this advisory report examines the health risks of applying force, pushing or pulling in work situations.

1.1 Applying force, pushing, pulling: definitions

The Committee defines applying force as the exertion of (muscle) strength by arms or legs from a static position.^{3,4} When force is applied, the body is in a fixed standing or seated position.^{3,4} Examples of applying force are operation of pedals or handles.

The Committee defines pushing and pulling as manually setting into motion and moving a burden over a distance, during which process the body moves in the same direction as the burden, without carrying the burden.^{3,4} For pushing and pulling, both the initial and sustained exerted force are provided by the entire body (hands and legs), with the body moving as a whole and both arms and hands only being used to transfer the force to the burden by keeping the arms in a

more or less fixed position.^{3,4} The initial exerted force is the force required to get an object in motion, and sustained exerted force is the force required to keep an object in motion. Examples of pushing and pulling are moving wheeled containers or wheelchairs.

Employees in healthcare also perform patient-related actions that require application of force (such as moving a patient in a bed). These actions fall outside the scope of this report, as this form of applying force, pushing and pulling must be seen in relation to the patient's mobility.

1.2 Extent of applying force, pushing and pulling in work situations

Applying force, pushing and pulling is a form of physical burden. Over one million employees (15.5%) are exposed to pushing and pulling burdens weighing 25 kg or more.^{1,2} These figures are higher in certain sectors, such as construction, agriculture, fisheries, trade, transport and storage. Within this context, key professions are bricklayers, carpenters and other construction workers, (poultry) farmers and warehouse employees.

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 to:

- periodically report whether there *currently* are new (international) scientific insights regarding concrete health-related and/or safety-related limits
- periodically report whether there will be new (international) scientific insights regarding concrete health-related and/or safety-related limits *in the long run*
- additionally, the minister requested *existing* scientific insights to 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 occupational health, safety and occupational disease. The chairman and members of the Committee and of the working group that prepared this advisory report are listed in Annex B.

1.4 The Committee's methods

Any existing health-based or safety-based occupational exposure limits, both in the Netherlands and abroad, 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-based or safety-based foundation.

The Committee subsequently explores the scientific literature in order to gain insight into the health-related and safety-related issues (Annex C). This initial phase is a starting point for the second phase, in which the Committee performs a systematic literature review (Annex G), and collects primary scientific publications on any negative effects of applying force, pushing and pulling on employee health and/or safety.

Once the Committee reaches a consensus on content, a draft report is published for commentary by third parties. The Committee considers the comments received in the completion of the report (Annex N).

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 into the health effects of applying force, pushing and pulling in work situations. Chapter four addresses the significance of musculoskeletal complaints: how serious are they? Finally, the Committee formulates its conclusions in Chapter five.

Laws and guidelines

This chapter provides an overview of legislation and regulations relating to the occupational risks of applying force, pushing and pulling. National rules may be found in the Working Conditions Act, the Working Conditions Decree and the Working Conditions Regulation. There are also international and European guidelines on applying force, pushing and pulling.

2.1 Working Conditions Act, Decree and Regulation

The Working Conditions Act outlines general provisions for employers and employees for the promotion of health, safety and welfare of employers and independent entrepreneurs.⁵ Sections 5.1 to 5.6 of the Working Conditions Decree and the Working Conditions Regulation relate to physical burden. However, these sections do not set legal limits for applying force, pushing and pulling.⁵

2.2 European and international guidelines

The European standard *NEN-EN 1005-3:2002+A1:2008 Safety of Machinery. Human physical burden. Part 3: Recommended maximum forces when working with machinery* and the international standard *ISO11228-2 Ergonomics - Manual handling - Part 2: Pushing and pulling* are relevant for applying force, pushing and pulling.^{6,7} Neither the NEN-EN 1005-3:2002+A1:2008 nor the ISO11228-2

have been set as legal standards in the Netherlands, but they both act as guidelines. The European and international standards propose various methods for performing a risk analysis on a pushing or pulling task (Annex D). A number of risk factors have been identified here, namely force (initial and continuous pushing/pulling force), posture (sideways tilting, bending forward and back rotation), frequency, duration, distance, object (wheels and maintenance therefore), environment (slope, steps, heat, cold and vibration), individual (age, sex, health, training and shoe friction) and organisation (rest breaks, variation or organisational options).

NEN-EN 1005-3:2002+A1:2008 includes a risk analysis method for evaluating the forces required to operate a machine (Annex D).⁶ Using three steps, this method calculates whether the health risk associated with a specific form of applying force is acceptable for most employees. The circumstances (maximum permitted static force, speed of movement, frequency and duration) of pushing or pulling tasks are taken into account.

The ISO11228-2 standard proposes two different risk analysis methods (Annex D).⁷ The first method allows estimation of the maximum permitted compression force (Newton) on the back, allowing derivation of a exposure limit and a safety limit as well as assessment of whether a specific situation is acceptable or not. The second method allows pulling and pushing forces for various activities to be determined and evaluated based on the Mital tables (1997).⁸ This method is based on psychophysical measures supplemented with physiological, energetic and biomechanical data from laboratory experiments in which people were asked to apply force, push or pull with a specific force. They were subsequently asked whether they could do so for an entire day without complaints or excessive fatigue. This allowed acceptable forces to be determined for 90% of employees for a variety of pushing and pulling activities, with a distinction between initial and sustained exerted force. These pushing and pulling forces are assessed using the Mital tables (1997).⁸ These tables (Annex E) provide limits for lifting, putting down, pulling, pushing and carrying burdens.⁸

Given their evidence base, the Mital tables currently provide the most useful data on the correlation between applying force, pushing and pulling and the development of fatigue as a direct health effect. The Mital tables also assume that the prevention of excessive fatigue also prevents health complaints. This link between excessive fatigue (insufficient recovery options) and musculoskeletal

complaints is supported by a number of scientific studies.⁹⁻¹¹ However, these studies do not allow a clear link to be made between maximum permissible pushing and pulling forces and avoiding the development of musculoskeletal complaints.

2.3 Other standards

Inspectorate SZW bases its assessments of health risks associated with applying force, pushing and pulling on the Working Conditions Decree and Regulation.⁵ These do not contain any specific requirements about how much force an employee may apply, push or pull, but require employers to identify and evaluate the risks of applying force, pushing or pulling. In its enforcement activities, the Inspectorate SZW evaluates the health and safety risks of individual activities involving manual handling based on the Key Indicator Method (KIM).^{3,12} The KIM method (score form in Annex F) may be applied to individual activities during a single day, involving manual pushing and pulling using the entire body. This method allows calculation of a risk score for physical overburdening based on various components (duration/frequency, mass, placement accuracy, speed, posture and working conditions), with no possibility for a distinction between initial and sustained exerted force.^{3,13}

The KIM method for pushing and pulling is based heavily on the NIOSH method for evaluating lifting loads.^{3,13,14} However, the KIM method can only be used if a 'quick scan' is performed, and is therefore suitable as an exploratory risk analysis for the work situation involving pushing and pulling.^{3,13} The Committee notes that the KIM method appears to lack an epidemiological evidence base, and that it does not allow the amount of health damage prevented by using the method to be determined.

Occupational diseases in the Netherlands must be registered and reported via the national reporting and registration system of the Dutch Centre for Occupational Diseases (NCvB). The NCvB promotes the quality of prevention, (early) diagnosis, treatment and support for occupational diseases and work-related conditions. In order to promote and standardise the registration of occupational diseases, the NCvB has created registration guidelines for many conditions. These provide information on the causal association between conditions and exposure (at work) to work-related 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. With regard to applying force, pushing and pulling, the NCvB guidelines indicate that there is an elevated risk of work-related conditions in the upper extremities if there is a great deal of repetitive movement and when forces of >4 kg (40 Newton) are applied for more than two hours per working day.¹⁵

2.4 Summary

The Committee notes that there are no legal Dutch sources available that allow firm conclusions to be drawn regarding occupational health-based and/or safety-based exposure limits for applying force, pushing and pulling. In its enforcement activities, the Inspectorate SZW evaluates the health and safety risks of individual activities for manual application of force, pushing and pulling using the KIM method. The Committee notes that the KIM method appears to lack an epidemiological evidence base, and that the KIM method does not allow the amount of health damage that is prevented by its use to be determined. The international guidelines refer to a risk analysis method relating to the Mital tables in order to evaluate whether pulling or pushing forces are a risk for excessive fatigue. The Mital tables also assume that the prevention of excessive fatigue also prevents health complaints. The Committee believes this association is plausible based on a number of epidemiological studies, but also notes that it is impossible to draw a direct link between the maximum permissible pushing and pulling forces and the prevention of health damage, such as musculoskeletal complaints.

Health damage due to pushing, pulling and applying force

Based on a broad literature exploration, the Committee performed a systematic literature review (Annex G). Two questions were of primary concern: 1) what health and safety issues develop due to the occupational risk applying force, pushing and pulling, and 2) to what degree is exposure to this occupational risk (in terms of duration, frequency and/or intensity) related to these issues?

3.1 Broad literature exploration

A number of review articles and reports have been published on the development of health-related issues due to applying force, pushing and pulling.¹⁶⁻²¹ There are also indications that applying force, pushing and pulling can lead to safety issues such as slipping, for example during patient-related activities.^{18,22} As the Committee identified no recent original publications on the subject and patient-related actions fall outside the scope of this advisory report, potential safety concerns due to applying force, pushing and pulling were not examined in this advisory report.

Based on the available reviews and reports, the Committee notes that exposure to applying force, pushing and pulling appears to potentially be associated with an increased risk of non-specific health complaints, particularly lower back complaints and upper extremities complaints. The positive relationship between manual handling of loads (including applying force, pushing and pulling in

combination with posture) and the development of carpal tunnel syndrome (CTS) was also suggested in one review.²⁰ However, there is one exception to this general trend: Roffey et al. concluded, based on a meta-analysis including thirteen studies, that the biological causality of the association between pushing and pulling in work situations and lower back complaints was insufficiently substantiated.²¹ Several publications criticise the Roffey et al. meta-analysis: the authors evaluate individual studies using the Bradford-Hill causality criteria, which should be applied to a combination of observational and experimental studies.²³⁻²⁵ The Committee also has its concerns regarding the scientific quality of this study. Annex C provides an overview of the reviews and reports identified.

3.2 Systematic literature review

Following the broad exploration, the Committee conducted a systematic literature review into the development of non-specific health complaints due to applying force, pushing and pulling. The Committee also chose to specifically search the literature for reference to the development of CTS due to applying force, pushing and pulling. Annex G describes the search strategy and the selection and quality criteria applied. As with other monitoring reports on the consequences of physical burdens, the Committee exclusively searched for prospective cohort studies in its systematic literature review. Prospective cohort studies determine exposure to the risk prior to the health effect, resulting in the lowest chance of bias for the correlation.

3.3 Health damage due to applying force, pushing and pulling in work situations

Based on the systematic literature review, the Committee identified eight prospective cohort studies with a focus on the development of lower back and shoulder complaints. The Committee found no studies of sufficient quality to examine the development of CTS due to applying force, pushing and pulling.

Lower back complaints

Four prospective cohort studies examined the incidence of lower back complaints due to applying force, pushing and pulling in work situations.²⁶⁻²⁹ Lower back complaints were defined as pain occurring in the lower back in the past year and persisting for more than one day. All studies on the effects of

applying force, pushing and pulling in work situations on the lower back are summarised in a table in Annex H, and described briefly in Annex I.

The review of exposure-response relationships for lower back complaints (Table 1) clearly shows that the way in which the degree of applying force, pushing and pulling was measured in these four studies was not comparable. Table 1 shows that applying force, pushing and pulling are associated with an elevated risk of lower back complaints. One of the four studies found a statistically significant elevated risk of lower back complaints; in the other three, the elevated risk was not statistically significant.

The study that found a statistically significant elevated risk for lower back complaints found that employees who cumulatively push 1-354 kg per hour are at a statistically significant increased risk of developing lower back complaints compared to employees who never push during work.²⁶ The same holds true for employees who cumulatively push more than 355 kg per hour.²⁶

Both the exposure and the effects were primarily self-reported by employees for all of the studies listed in Table 1. The results of various studies do not allow conclusions to be drawn about the level of exposure below which no back complaints develop. These studies lack clear and complete information about exposure to applying force, pushing and pulling in terms of duration, frequency and/or intensity.

Table 1 Overview of exposure-response relationships for lower back complaints due to applying force, pushing and pulling in work situations in prospective cohort studies.

Definition of exposure	Risk measure (95%CI)	Reference
Pushing/pulling/carrying ≥ 1 x per week, 1 to 20 years	1.1 (1.0-1.1)	29
Pushing/puling 135 x per day, 22.4 min per day	1.5 (0.8-3.1) ¹	28
	1.2 (0.8-1.8) ²	
Pushing/puling 741 x per day, 69 min per day	1.7 (0.8-3.7) ¹	28
	1.2 (0.8-1.9) ²	
Pulling ≤ 25 kg	1.4 (0.8-2.4)	27
Pushing ≤ 30 kg	1.1 (0.7-1.9)	27
Pulling > 25 kg	1.7 (1.0-3.1)	27
Pushing > 30 kg	0.9 (0.5-1.6)	27
Cumulatively pushing 1-354 kg/hour	1.9 (1.3-2.8)*	26
Cumulatively pushing ≥ 355 kg/hour	1.7 (1.1-2.5)*	26

CI, confidence interval; kg, kilogram; h, hour; min, minute; * statistically significant $p < 0.05$.

¹ reference group at baseline without complaints in the past 12 months.

² reference group at baseline with complaints in the past 12 months.

Shoulder complaints

Four prospective cohort studies examined the incidence of shoulder complaints due to applying force, pushing and pulling in work situations.^{26,28,30,31} Shoulder complaints were defined as pain occurring in the shoulder in the past year and persisting for more than one day. All studies on the effects of applying force, pushing and pulling in work situations on the shoulder are summarised in a table in Annex J, and described briefly in Annex K.

The overview of the exposure-response relationships for shoulder complaints (Table 2) shows that the exposure measures used in these four studies are not comparable. Table 2 shows that applying force, pushing and pulling are associated with an elevated risk of shoulder complaints. Three of the four studies found a statistically significant elevated risk of shoulder complaints; in one, the elevated risk was not statistically significant.

One of these four studies found that employees who push or pull 32 kg or more are two and a half times as likely to develop shoulder complaints than employees who do not push or pull.³⁰ A second study found that employees who push or pull 25 kg for more than half the work day are almost twice as likely to develop shoulder complaints than employees who do not or hardly push or pull.³¹ The third study showed that employees who push or pull 135 times per day (about 23 minutes of the work day) are almost three times as likely to develop shoulder complaints than employees without complaints at baseline who push or pull far less.²⁸

Table 2 Overview of exposure-response relationships for shoulder complaints due to applying force, pushing and pulling in work situations in prospective cohort studies.

Exposure	Risk measure (95%CI)	Reference
Pushing/pulling 135 x per day, 22.4 min per day	2.9 (1.2-7.2)* ¹ 0.9 (0.5-1.5) ²	28
Pushing/pulling 741 x per day, 69 min per day	4.9 (1.9-12.8)* ¹ 1.3 (0.7-2.2) ²	28
Pushing/pulling 25 g, >50% of the day	1.8 (1.1-3.0)*	31
Pushing/pulling <32 kg	1.3 (0.8-2.2)	30
Pushing/pulling ≥32 kg	2.6 (1.6-4.2)*	30
Cumulatively pushing 1-354 kg/hour	1.3 (0.9-1.9)	26
Cumulatively pushing ≥355 kg/hour	1.5 (1.0-2.2)	26

CI, confidence interval; kg, kilogram; h, hour; min, minute; * statistically significant $p < 0.05$.

¹ reference group at baseline without complaints in the past 12 months.

² reference group at baseline with complaints in the past 12 months.

Both the exposure and the effects were primarily self-reported by employees for all of the studies listed in Table 2. The results of various studies do not allow conclusions to be drawn about the safe level of exposure (the level below which no shoulder complaints develop). The studies also lack clear and complete information about exposure to applying force, pushing and pulling with distinctions based on duration, frequency and/or intensity.

Other complaints

Three prospective cohort studies examined the occurrence of other types of complaints due to applying force, pushing and pulling in work situations (Annexes L and M).^{26,32,33} These showed that applying force, pushing and pulling are associated with an elevated risk of hip, knee and foot pain, general pain and musculoskeletal injury. However, these findings were only reported once and not verified in other studies.

3.4 Areas for attention in epidemiological research

Discussion of the findings

While studying the previously described epidemiological literature, the Committee noticed a number of key problems. In particular, the diversity in the exposure measures for applying force, pushing and pulling were an obstacle to comparing the outcomes of various studies. Most studies lacked information on the duration and frequency of applying force, pushing or pulling, and exposure to this occupational risk was operationalised primarily as weight to be moved. According to the Committee, pushing or pulling a kilogram of weight does not provide much insight into the forces applied. The variation in health measures used is another problem, and the development of health complaints cannot be distinguished clearly from health complaints already present due to applying force, pushing and pulling. Finally, the Committee noted that many studies lack the statistical power required to demonstrate statistically significant associations between applying force, pushing and pulling and the occurrence of musculoskeletal complaints.

Potential biasing factors

Given the presentation of the data, the Committee notes that the studies into applying force, pushing and pulling do not present exposure in a sufficiently

distinct manner. Furthermore, the Committee cannot rule out that lower back complaints related to applying force, pushing and pulling are (in part) caused by poor trunk posture. The selected epidemiological studies do not report on this at all. Additionally, workplace exposure often encompasses multiple risk factors with a common physical point of application. For example, back complaints may not only be caused by applying force, pushing and pulling, but also by other physical risk factors such as lifting or working in a standing, kneeling or squatting position. This is often not discussed in the studies.

Self-reported exposure and complaints

In almost all epidemiological studies, exposure was reported by the study subjects themselves via questionnaires or interviews. Various studies have shown that exposure recorded via self-report is less valid than measured exposure, as self-report provides limited information on the frequency and duration of tasks and activities.^{34,35} Self-reported exposure to applying force, pushing and pulling involves a risk of overestimation or underestimation of this exposure. As there is no alternative method available that can easily be applied to large-scale epidemiological studies, the Committee still considers self-report an acceptable method for estimating exposure.

The health effects were also primarily self-reported, particularly where local (pain) complaints were concerned. According to the Committee, this is the only way to examine local, non-specific pain complaints. Physical examinations were conducted in addition to self-reports in a few prospective cohort studies.

3.5 Conclusion

The Committee concludes that available epidemiological studies provide indications that applying force, pushing and pulling pose a health risk for the development of lower back complaints. There are also signs that applying force, pushing and pulling form a health risk for shoulder complaints.

Significance of musculoskeletal complaints

Based on the ICF model (International Classification of Functioning, Disability and Health), developed by the World Health Organisation (WHO), health-related factors such as diseases or complaints (in addition to environmental and individual factors) may affect limitation of activities and participation in daily life and work (absenteeism and work resumption).³⁶ Many people occasionally experience musculoskeletal complaints. When are such complaints serious? When do these complaints negatively affect work participation (absenteeism)? In other words: how should the values measured in the epidemiological studies be valued? This chapter addresses these questions.

4.1 Temporary or chronic complaints

If back or shoulder complaints persist for more the twelve weeks without interruption, they are considered chronic. Such complaints are clearly negative health effects.³⁷ However, the prospective cohort studies into the consequences of applying force, pushing and pulling are primarily concerned with pain complaints that persisted for at least 24 hours in the past year. In order to indicate the degree to which (brief) episodes of pain complaints presage chronic complaints, and the consequences of such complaints, the Committee examined the data on the prevalence and prognosis of the complaints found, as well as data on disease burden and absenteeism.

4.2 Prevalence

In order to assess the relevance of the complaints that develop due to applying force, pushing and pulling, 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 one moment in time (point prevalence) or for a period such as a year (year prevalence).

Lower back complaints

The prevalence of lower back complaints* in a sample of the Dutch population aged 25 years and older was 44% over a twelve-month period; point prevalence was 27%. About 23% of people with lower back pain reported chronic pain, with 3% reporting it as 'continuous severe' and 20% as 'continuous mild'. About 63% indicated that pain complaints recurred (15% of whom reported as 'recurring severe' and 48% as 'recurring mild').³⁸ Only 5% indicated the pain complaints were a one-off event.

Shoulder complaints

In 2007, 26% of the Dutch population aged 25 years and older reported arm-neck-shoulder complaints in the past year.³⁹ In a sample of about 3,500 Dutch inhabitants aged 25 years and older, the following prevalence figures were found for shoulder complaints: 30% over a twelve-month period, 21% at a random moment, and 15% for chronic shoulder pain in the past twelve months.^{38,40}

4.3 Prognosis

The prognosis for the complaints that develop due to applying force, pushing and pulling can also be assessed based on scientific data on the course of such complaints.

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

Lower back complaints

In the majority of cases, back pain is short-lasting and disappears after a few weeks.³⁹ Furthermore, back complaints are known to present with multiple episodes,⁴¹ which may turn into a chronic condition.^{42,43}

In a prospective cohort study among back patients in general practice in Amsterdam and surroundings, patients were monitored for a year using monthly questionnaires.⁴⁴ The median time to recovery was seven weeks. After 12 weeks, 35% of patients still had complaints, and after one year this had dropped to 10%.⁴⁴ 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.

It is internationally accepted that back complaints persisting for over three months may be considered chronic, although the precise definition is still under debate.^{43,45} The prevalence of chronic pain* in the lower back in a sample of the Dutch population aged 25 years and older was 21%.^{38,45}

Shoulder complaints

The study by Picavet et al. (2003) in a sample of the Dutch population found that 6.3% of respondents with shoulder complaints (in addition to neck or upper back complaints) experienced an isolated pain episode.³⁸ 47% reported recurring mild pain. 26% of the respondents had continuous mild pain in the shoulders (as well as the neck or upper back). Severe pain complaints were less common: 8.3% had severe pain, and 3.1% experienced continuous severe shoulder pain (as well as neck or upper back pain).

4.4 Absenteeism and disease burden

A third measure to assess the meaning and severity of complaints due to applying force, pushing and pulling is the data on absenteeism and disease burden.

Lower back complaints

Although the prevalence of lower back pain in the general population is high, with 33% of the people stating it affected their daily life, 70% of the people with

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

back complaints had not taken sick leave in a one-year period.³⁸ Of the people with lower back complaints, 32% visit the GP per year.

In 2007, the National Institute for Public Health and the Environment (RIVM) estimated the disease burden for the entire population and the proportion thereof that is related to working conditions. As a measure for this calculation, investigators used Disability Adjusted Life Years (DALY).³⁹ 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 lower back complaints.⁴⁶ 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 burdens for the potential and actual working population were, respectively, 26,300 and 16,700 DALYs.

Shoulder complaints

Picavet et al. (2003) examined the consequences of having musculoskeletal complaints in the Dutch population.³⁸ Of the people with shoulder (or neck or upper back) complaints, 41% had visited the GP in the past year, 30% had consulted a medical specialist and 33% had seen a physiotherapist. 27% of them used medication. 72% of people with shoulder complaints (alongside neck or upper back complaints) reported they had not missed work in the past year. If work was missed, 7.7% of the people with shoulder complaints (alongside neck or upper back complaints) missed less than one week, the same percentage missed one to four weeks and 5.9% missed more than four weeks of work. 6.1% of the people with shoulder complaints (alongside neck or upper back complaints) were partially work disabled.

4.5 Conclusion

The Committee considers applying force, pushing and pulling to be a relevant occupational risk for musculoskeletal complaints, for both lower back and shoulder complaints. A significant proportion of the working population experience serious pain complaints that occur almost daily. These individuals feel limited in the workplace which can lead to absenteeism.

Conclusions and possible limits

The Minister of Social Affairs and Employment asked the Health Council whether there are any new scientific insights with regard to occupational health-based (or safety-based) exposure limits for applying force, pushing and pulling during work situations. This advisory report answers this question. The Committee's position is that, in general, a recommended exposure limit must prevent a negative health effect caused by applying force, pushing and pulling.

5.1 Health risks of applying force, pushing and pulling

The available epidemiological studies primarily examined the occurrence of lower back and shoulder pain due to applying force, pushing and pulling. Although longitudinal in design, many of these studies have limitations. Available studies recorded both the exposure to applying force, pushing and pulling and the presence of lower back and shoulder complaints via self-report. The Committee cannot rule out concurrent exposure to other physical occupational risks in many of the studies. Furthermore, the Committee notes the heterogeneity of exposure measures used for applying force, pushing and pulling, whereby the weight pushed or pulled was primarily used as a measure for exposure.

The Committee concludes that available epidemiological studies provide indications that applying force, pushing and pulling in work situations pose a

health risk for the development of lower back complaints. There are also signs that applying force, pushing and pulling form a health risk for shoulder complaints.

5.2 Health-based occupational exposure limits

In order to derive health-based occupational exposure limits, the Committee examines to what degree the available epidemiological literature provides indications for safe threshold limits, meaning a level below which exposure has no negative health effects. Although the Committee has access to a variety of prospective cohort studies examining applying force, pushing and pulling, the Committee concludes that available epidemiological data do not allow a safe occupational health-based exposure limits for this risk to be determined based on concrete scientific evidence. The data on the harmful health effects of low exposure levels are too limited to allow reliable conclusions to be drawn.

The Committee utilised a different approach for other occupational risks for which no safe limit could be determined, based on combining the results of individual, high-quality prospective cohort studies in a meta-analysis and performing a risk calculation. However, it is impossible to combine the individual studies on applying force, pushing and pulling in a meta-analysis, as the studies are not comparable enough.

5.3 Committee recommendations

As the derivation of occupational health-based or safety-based exposure limits is impossible, the Committee notes that the risk method associated with the Mital tables currently provides the most usable measures for estimating health risks of applying force, pushing and pulling in work situations. This method is based on extensive research into the relationship between pushing and pulling and the development of excessive fatigue as an undesired direct health effect. There are clear indications from epidemiological studies that excessive fatigue is associated with the occurrence of musculoskeletal complaints. The Committee believes this association is plausible, and feels preventing undesired direct effects, such as excessive fatigue, is important. However, the Committee does note that the amount of health damage prevented by applying this risk method cannot be determined. The Committee nevertheless recommends the use of the Mital tables as the best available instrument for preventing the development of as

many new complaints relating to applying force, pushing or pulling in work situations as possible.

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A	Request for advice
B	The Committee
C	Broad literature exploration
D	Risk analyses for pushing and pulling forces
E	Mital tables
F	Key Indicator Method (KIM)
G	Systematic literature review
H	Extraction table lower back complaints
I	Description of studies on lower back complaints
J	Extraction table shoulder complaints
K	Description of studies on shoulder complaints
L	Extraction table other complaints
M	Description of studies on other complaints
N	Comments on the draft advisory report

Annexes

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 adopted¹. 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.
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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

B

The Committee

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- 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
Health and Safety manager, Nederlandse Aardolie Maatschappij (NAM) BV,
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. Gouttebauge, *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 A.J. van der Beek
- Professor M.H.W. Frings-Dresen
- Professor J.H. van Dieën
Professor of Biomechanics, VU University, Amsterdam
- Dr. A.S.A.M. van der Burght, *scientific secretary*
- Dr. V. Gouttebauge, *scientific secretary*

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.

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-related and safety-related issues relating to applying force, pushing and pulling in work situations. 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. This literature exploration showed that few scientific literature reviews have been published on the development of health-related and safety-related issues due to applying force, pushing and pulling alone, or due to applying force, pushing and pulling in combination with other physical factors such as lifting and carrying (manually moving burdens).

Findings on applying force, pushing and pulling

Upon request of the Ministry of Social Affairs and Employment, TNO Prevention and Health published a report on manually pushing/pulling and health effects in 1995.¹⁶ In addition to data on exposure to manual pushing and pulling in the Dutch workplace, this report provides insights into the correlation between pushing and pulling and musculoskeletal complaints. The report found the following:

Employees who perform work characterised mainly by frequent pushing/pulling have significantly more lower back complaints than the 'unburdened' group (in terms of application of force) of employees.

Employees who perform work characterised by frequent pushing/pulling do not have fewer musculoskeletal complaints than employees whose work involves frequent lifting, carrying or combinations of frequent lifting, pushing/pulling and carrying.

Frequent pushing/pulling is particularly common in combination with frequent lifting and carrying.

This report also provides an impression of how strong the correlation is between frequent pushing/pulling and lower back complaints: employees are more than one and a half times as likely to develop lower back complaints (OR = 1.65; 95% CI 1.36-2.01) if they frequently push and pull during work.

In their review based on various epidemiological studies, Hoozemans et al. (1998) concluded that pushing and pulling was associated with the occurrence of lower back complaints.¹⁸ The authors stated that causality of this association was unclear, as a number of studies were cross-sectional in design. The authors note that studies on the relationship between pushing and pulling and upper limb complaints are scarce, but that the incidence of upper limb complaints appears to be related to this occupational risk.

Kuiper et al. published a literature review in 1999 on the incidence of lower back complaints due to manual handling operations, including pushing and pulling.¹⁹ Using a systematic search strategy, applied in six databases of epidemiological literature published from 1980 to 1997, and application of methodological criteria, just a single study that only examined pushing and pulling was included. This study found a relationship between both pushing (OR = 1.07; 95% CI 0.99-1.15) and pulling (OR = 1.08; 95% CI 1.01-1.15) and lower back complaints. Based on these findings, the authors expressed their doubts regarding what they considered inadequate exposure measures and the inclusion of potential confounders, which likely lead to overestimation or underestimation of the effect of applying force, pushing and pulling on lower back complaints in various studies. The relationship between lower back complaints and applying force, pushing and pulling was confirmed by Garg and Moore (1992).¹⁷ In their article, the authors state that the activities pushing and pulling explain nine to eighteen per cent of all back complaints, and the height (from the floor) of the hands during pushing and pulling plays a decisive role, with the apparent optimum lying between 90 and 115 centimetres.

More recently, Roffey et al. (2010) published a literature review on the association between pushing and pulling during work and the occurrence of

lower back complaints.²¹ Using a systematic search strategy in five databases, literature published between 1966 and 2008 was searched for relevant publications. The Bradford-Hill criteria were used to assess causality (strong, moderate, limited and conflicting evidence). Eventually, thirteen studies were included (four longitudinal, five cross-sectional and four case-control studies), five of low methodological quality and eight of high methodological quality. Based on these studies, the authors concluded that their systematic literature review did not provide a study of high methodological quality that fulfilled the Bradford-Hill criteria for causality between pushing and pulling during work and lower back complaints.

Findings on manual handling operations

The American National Institute for Occupational Safety and Health (NIOSH) published a report on the relationship between manual handling operations at work, including applying force, pushing and pulling, and musculoskeletal complaints.²⁰ This extensive literature review, which is based on epidemiological studies from various countries (the Netherlands, Sweden, Finland and the United States) and relates to employees in various sectors including nursing, construction or transport, identified manual handling operations – including applying force, pushing and pulling – as a risk for neck, elbow, wrist/hand and lower back complaints. Unfortunately, manual handling operations do not clearly distinguish between lifting and applying force, pushing and pulling. This report concludes that there is strong evidence in the scientific literature for the positive relationship between manual handling operations (including applying force, pushing and pulling) and the development of lower back complaints, with an odds ratio of 1.2 ($p < 0.05$) to 10.7 (95% CI 4.9-23.6). Strong evidence was also found for the positive relationship between manual handling operations (including applying force, pushing and pulling combined with posture) and the development of carpal tunnel syndrome in various studies, with risk measures (odds ratios or prevalence risk) of 1.4 (95% CI 0.9-2.1) to 15.5 (95% CI 1.7-142.0). Five studies found a statistically significant association between manual handling operations (including applying force, pushing and pulling) and neck complaints, seven found odds ratios between 1.0 (95% CI 0.2-10.9) and 3.0 (95% CI 1.2-6.3). Eight studies found that the association between manual handling operations (including applying force, pushing and pulling) and elbow complaints was strongly statistically significant, with odds ratios between 1.4 (95% CI 1.0-2.5) and 6.75 (95% CI 1.6-33.0).

Kuiper et al. published a literature review in 1999 on the incidence of lower back complaints due to manual handling operations, including pushing and pulling.¹⁹ Using a systematic search strategy, applied in six databases of epidemiological literature published from 1980 to 1997, and application of methodological criteria, only a single study found a positive relationship (OR = 1.88; 95% CI 1.31-2.86) between lifting in combination with pushing and pulling (burdens heavier than 11 kilograms) and lower back complaints. Based on these findings, the authors expressed their doubts regarding what they considered inadequate exposure measures and the inclusion of potential confounders, which likely lead to overestimation or underestimation of the effect of applying force, pushing and pulling on lower back complaints in various studies.

Conclusion of broad literature exploration

Based on the broad exploration of the literature, the conclusion may be drawn that exposure to applying force, pushing and pulling in work situations and manual handling operations may be correlated to an elevated risk of non-specific health complaints, particularly back and upper extremities complaints. Manual handling operations, including applying force, pushing and pulling, also appear to be associated with the development of carpal tunnel syndrome (CTS). The Committee found no reviews on the development of safety-related problems due to applying force, pushing and pulling during work situation. The results of the broad literature exploration do not provide consistent outcomes, therefore the Committee decided to perform a systematic literature review.

D

Risk analyses for pushing and pulling forces

NEN-EN 1005-3:2002+A1:2008⁶

This risk analysis method is based on three steps:

Step 1: maximum isometric force (F_{max})

Table 3 provides an overview of the maximum permissible static (isometric) force. For working situations, the strongest 15% of adults (men and women aged 20 to 65 years) are used as the reference group (for machines for home use, the strongest 1% is used).

Step 2: maximal isometric force (F_{max})

The maximum force is adjusted based on the circumstances. In order to determine this reduced force, or capacity (F_{cap}), the following formula is used:

$$F_{cap} = F_{max} \times V_f \times F_f \times D_f$$

whereby:

V_f = velocity during operation

F_f = frequency and duration of operation

D_f = duration of equivalent activities (pushing)

These three weighting factors lie between 0 and 1, because of which F_{cap} is reduced.

Table 3 Maximum isometric force (Newton).

Hand (1 hand)	
- power grip	250
Arms (seated, 1 arm)	
- up	50
- down	75
- outside	55
- inside	75
- pushing with back support	275
- pushing without back support	62
- pulling with back support	225
- pulling without back support	55
Whole body (standing)	
- pushing	200
- pulling	145
Foot pedal (seated with back support)	
- ankle action	250
- leg action	475

Step 3: risk assessment

In order to keep these health risks as low as possible, the exerted force must be less than 50% of the maximum force calculated in step 2. This is presented as a risk factor in one of three categories:

- < 50% Fcap = recommended; negligible risk
- 50 - 70% Fcap = not recommended; assessment of other risk factors
- 70% Fcap = to be avoided; unacceptable risk

ISO11228-2: calculating limits for compression force⁷

This method, which takes employee characteristics into account, includes a more specific and detailed risk analysis based on four steps:

Step 1 = muscle strength limits

$$F_{br} = F_b (1 - d - f)$$

whereby:

F_{br} : muscle strength limit

F_b : basic force based on working height, ratio of men:women and age

d : distance factor

f : frequency factor

Step 2 = limits for compression force

Using a table arranged by age and sex, the limit for compression forces on the back can be determined. After observing the joint angulation in the shoulder and the direction of the force vector, the corresponding limit for skeletal strength may be obtained. The required tables and graphs are available in the international standard.

Step 3 = maximum permitted forces

The strictest limit, muscle strength or general strength, is adhered to.

Step 4 = safety limits

recommended = maximum limit x 0.85

not recommended = maximum limit x 1

If the pulling/pushing distance is < 5 meters, the initial pulling/pushing force is compared with the limits. If the pulling/pushing distance is > 5 meters, the continuous pulling/pushing force is compared with the limits.

ISO11228-2: combination of a checklist and Mital⁷

In a first step, information about the task is collected using a checklist. This encompasses various risk factors applicable during pushing and pulling burdens. The next step consists of measuring pulling and pushing forces. Results are interpreted based on tables (Mital tables), ensuring the task represented an acceptable burden for 90% of employees. The tables take the following factors into account: height of the handle, displacement distance for pushing/pulling, frequency, sex, initial and continuous pushing/pulling forces.

The assessment is as follows:

not recommended = pulling/pushing forces > limits Mital tables

not recommended = pulling/pushing forces < limits Mital tables, but many risk factors have been identified on the checklist

recommended = other cases

E

Mital tables

From: Mital A, Nicholson AS, Ayoub MM. A guide to manual materials handling. London: Taylor & Francis; 1997.

Liberty Mutual Design Goals for Pulling
 mks units
 Forces in kilograms (OR = Out of Range of Tables)

Frequency	High Pull Point (hands about 140 cm)											
	2.1		7.6		15.2		30.5		45.7		61.0	
	Initial	Sustained	Initial	Sustained	Initial	Sustained	Initial	Sustained	Initial	Sustained	Initial	Sustained
1/8 h	28	20	24	18	20	15	15	20	14	20	12	18
1/30 min	25	16	22	14	19	12	18	18	10	18	9	16
1/5 min	24	15	21	13	18	11	17	17	10	17	9	15
1/2 min	21	14	19	12	16	10	16	16	9	16	8	14
1/1 min	20	13	18	11	15	10	14	14	8	14	8	14
1/30 s	20	13	18	11	14	9	14	14	8	14	8	14
1/15 s	19	12	16	9	14	9	14	14	8	14	8	14
1/12 s	19	12	16	9	14	9	14	14	8	14	8	14
1/8 s	16	8	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR

Frequency	Middle Pull Point (hands about 82 cm)											
	2.1		7.6		15.2		30.5		45.7		61.0	
	Initial	Sustained	Initial	Sustained	Initial	Sustained	Initial	Sustained	Initial	Sustained	Initial	Sustained
1/8 h	27	19	25	17	21	14	21	21	13	21	12	19
1/30 min	28	16	23	14	20	12	19	19	10	19	9	17
1/5 min	25	15	22	13	19	11	18	18	9	18	8	16
1/2 min	22	13	20	12	17	10	16	16	8	16	8	15
1/1 min	21	13	19	11	17	10	15	15	8	15	7	15
1/30 s	21	13	18	11	14	8	14	14	8	14	8	14
1/15 s	20	12	17	9	14	9	14	14	8	14	8	14
1/12 s	19	12	16	9	14	9	14	14	8	14	8	14
1/8 s	16	8	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR

Frequency	Low Pull Point (hands about 60 cm)											
	2.1		7.6		15.2		30.5		45.7		61.0	
	Initial	Sustained	Initial	Sustained	Initial	Sustained	Initial	Sustained	Initial	Sustained	Initial	Sustained
1/8 h	28	18	26	16	22	13	22	22	12	20	11	18
1/30 min	27	14	24	13	21	11	20	20	9	18	8	16
1/5 min	28	13	23	12	20	10	18	18	9	18	8	16
1/2 min	23	12	21	11	18	9	17	17	8	17	8	15
1/1 min	22	12	20	11	17	9	16	16	7	16	7	15
1/30 s	22	12	19	10	15	8	15	15	8	15	8	14
1/15 s	21	11	17	9	14	8	14	14	8	14	8	14
1/12 s	20	11	17	9	14	8	14	14	8	14	8	14
1/8 s	17	7	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR

Adaptation of the Tables published by Snook and Childs in 1991.
 The Design Goal is 75% Acceptable for Women.

Adjustment Factors
 The Design Goal for Men only may be 1.5 times higher than the table values, with variation from 1 to 2.
 The Upper Design Limit for Lifting (equivalent to 25% Acceptable for Men) is about 1.5 times the table values, with variations of 1 to 3.

Liberty Mutual Design Goals for Pushing
 mks units
 Forces in kilograms (OR = Out of Range of Tables)

High Push Point
 (hands about 140 cm)

Frequency		Push Distance [m]											
		2.1		7.6		15.2		30.5		45.7		61.0	
		Initial	Sustained	Initial	Sustained	Initial	Sustained	Initial	Sustained	Initial	Sustained	Initial	Sustained
1/8 h	1/8 h	27	21	24	16	21	13	21	12	21	11	19	9
1/30 min	2/1 h	25	17	23	13	20	11	19	9	19	8	17	6
1/5 min	12/1 h	24	16	22	12	19	10	17	9	17	8	15	6
1/2 min	30/1 h	22	14	20	11	17	9	16	8	16	8	14	6
1/1 min	1/1 min	21	14	20	11	17	9	15	7	15	7	OR	OR
1/30 s	2/1 min	20	14	19	10	17	8	OR	OR	OR	OR	OR	OR
1/15 s	4/1 min	19	12	17	9	OR	OR	OR	OR	OR	OR	OR	OR
1/12 s	5/1 min	18	12	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR
1/6 s	10/1 min	17	9	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR

Middle Push Point
 (hands about 92 cm)

Frequency		Push Distance [m]											
		2.1		7.6		15.2		30.5		45.7		61.0	
		Initial	Sustained	Initial	Sustained	Initial	Sustained	Initial	Sustained	Initial	Sustained	Initial	Sustained
1/8 h	1/8 h	27	19	25	17	21	14	21	13	21	12	19	9
1/30 min	2/1 h	25	16	23	13	20	11	19	10	19	9	17	7
1/5 min	12/1 h	24	15	22	13	19	11	18	9	18	8	16	6
1/2 min	30/1 h	22	13	20	11	17	10	16	9	16	8	15	6
1/1 min	1/1 min	21	13	20	11	17	9	15	8	15	7	OR	OR
1/30 s	2/1 min	20	13	19	10	16	8	OR	OR	OR	OR	OR	OR
1/15 s	4/1 min	19	12	17	9	OR	OR	OR	OR	OR	OR	OR	OR
1/12 s	5/1 min	18	11	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR
1/6 s	10/1 min	17	8	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR

Low Push Point
 (hands about 60 cm)

Frequency		Push Distance [m]											
		2.1		7.6		15.2		30.5		45.7		61.0	
		Initial	Sustained	Initial	Sustained	Initial	Sustained	Initial	Sustained	Initial	Sustained	Initial	Sustained
1/8 h	1/8 h	21	17	21	15	18	13	18	12	18	11	16	8
1/30 min	2/1 h	20	14	20	12	17	10	16	9	16	8	14	6
1/5 min	12/1 h	19	13	19	12	16	10	15	8	15	8	13	6
1/2 min	30/1 h	17	12	17	11	15	9	14	8	14	7	12	6
1/1 min	1/1 min	17	11	17	10	14	9	13	7	13	7	OR	OR
1/30 s	2/1 min	16	11	16	10	13	8	OR	OR	OR	OR	OR	OR
1/15 s	4/1 min	15	10	14	8	OR	OR	OR	OR	OR	OR	OR	OR
1/12 s	5/1 min	15	9	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR
1/6 s	10/1 min	14	7	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR

Adaptation of the Tables published by Snook and Ciriello in 1991.
 The Design Goal is 75% Acceptable for Women.

Adjustment Factors

The Design Goal for Men only may be 1.5 times higher than the table values, with variation from 1 to 2.
 The Upper Design Limit for Lifting (equivalent to 25% Acceptable for Men) is about 1.5 times the table value, with variations of 1 to 3.

Annex

F

Key Indicator Method (KIM)

From: Inspectie SZW. 2012. Internet: <http://www.inspectieszw.nl/>.

Assessment of pulling and pushing based on key indicators Version Sept. 2002

The overall activity must be broken down into individual activities. Each individual activity involving major physical strain must be assessed separately.







Workplace/Activity:

1st step: Determination of time rating points (Select only one column)

Pulling and pushing over short distances or frequent stopping (single distance up to 5 metres)		Pulling and pushing over longer distances (single distance more than 5 metres)	
Number on working day	Time rating points	Total distance on working day	Time rating points
< 10	1	< 300 m	1
10 to < 40	2	300 m to < 1km	2
40 to < 200	4	1 km to < 4 km	4
200 to < 600	8	4 to < 8 km	8
600 to < 1000	8	8 to < 16 km	8
= 1000	10	= 16 km	10

Examples: operation of manipulators, setting up machines, distribution of meals in a hospital *Examples: garbage collection, furniture transport in buildings on rollers, unloading and transloading of containers*

2nd step: Determination of rating points of mass, positioning accuracy, speed, posture and working conditions

Mass to be moved (load weight)	Industrial truck, aid				
	Without load is rolled	Barrow	Carrage, roller, trolleys without fixed rollers (only steerable rollers)	Rail cars, hand carts, roller tables, carrages with rollers	Manipulators, rope balancers
rolling					
< 50 kg	0.5	0.5	0.5	0.5	0.5
50 to < 100 kg	1	1	1	1	1
100 to < 200 kg	1.5	2	2	1.5	2
200 to < 300 kg	2	4	3	2	4
300 to < 400 kg	3		4	3	
400 to < 600 kg	4		5	4	
600 to < 1000 kg	5			5	
= 1000 kg					
sliding					
< 10 kg		1			
10 to < 25 kg		2			
25 to < 50 kg		4			
> 50 kg					

Grey areas:
Critical because a check of the movement of industrial truck/load depends very much on skill and physical strength.

White areas without number:
Basically to be avoided because the necessary action forces can easily exceed the maximum physical forces.

Positioning accuracy	Speed of motion	
	slow (< 0.8 m/s)	fast (0.8 bis 1.3 m/s)
Low - no specification of travelling distance - load can roll to a stop or runs against a stop	1	2
High - load must be accurately positioned and stopped - travelling distance must be adhered to exactly - frequent changes in direction	2	4

Note: the average walking speed is approx. 1 m/s

In general the whole musculoskeletal system is subject to strain when pulling and pushing, but in particular the hand-arms-shoulder area. Depending on the specific force applications and postures, however, it is also possible that the lumbar spine and the hip and knee joints will be under severe strain, because the physical processes substantially lower and more varied than when lifting and carrying. It is difficult to verify chronic damage from overload. The typical for pulling and pushing that there is a risk to the musculoskeletal system from sudden overloads also result of impact, slipping or unbalanced and great forces with change of direction or when starting.

Posture ¹⁾		
	Trunk upright, not twisted	1
	Trunk slightly bending forward or slightly twisted (one-sided pulling)	2
	Body inclined low in direction of motion Squatting, kneeling, bending	4
	Combination of bending and twisting	8

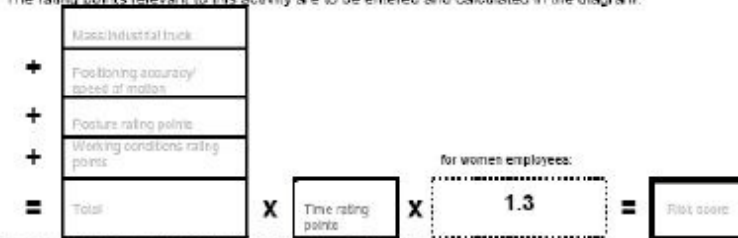
1) The typical posture must be used. The greater trunk inclination possible when starting up, braking or shunting can be ignored if it only occurs occasionally.

Working conditions	
Good: → floor or other surfaces level, firm, smooth, dry → no incline → no obstacles in work-space → rollers or wheels run easily, no evident wear in the wheel bearings	0
Restricted: → floor soiled, a little uneven, soft → slight incline up to 2° → obstacles in work-space which have to be bypassed → rollers or wheels soiled, no longer run easily, bearings worn	2
Difficult: → unpaved or roughly paved roadway, potholes, severe soiling → inclines of 2 to 5° → industrial trucks have to be torn loose when starting up → rollers or wheels soiled, bearings run sluggishly	4
Complicated: → steps, stairs → inclines >5° → combinations of indicators from "restricted" to "difficult"	8

Indicators not mentioned in the table must be added as appropriate.

3rd step: Evaluation

The rating points relevant to this activity are to be entered and calculated in the diagram.



On the basis of the rating points calculated and the table below it is possible to make a rough evaluation.

Risk range ²⁾	Risk score	Description
1	< 10	Low load situation, physical overload unlikely to appear.
2	10 to < 25	Increased load situation, physical overload is possible for less resilient persons ³⁾ . For that group redesign of workplace is helpful.
3	25 to < 50	Highly increased load situation, physical overload also possible for normally resilient persons. Redesign of workplace is recommended.
4	≥ 50	High load situation, physical overload is likely to appear. Workplace redesign is necessary.

2) The boundaries between the risk ranges are fluid because of the individual working techniques and performance conditions. The classification may therefore only be regarded as an orientation aid. Basically it must be assumed that as the number of risk scores rises, so the risk of overloading the musculoskeletal system increases.

3) Less resilient persons in this context are persons older than 40 or younger than 21 years, newcomers in the job or people suffering from illness.

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Systematic literature review

The goal of this literature review is to systematically obtain scientific data from epidemiological studies on the relationship between *applying force, pushing and pulling in work situations* and the development (both in the short term and the long term) of health-related or safety-related problems.

1 Question

The following questions were formulated for this literature review:

- a What health-related problems develop due to applying force, pushing and pulling in work situations?
- b To what degree is exposure (in terms of duration, frequency and/or intensity) to applying force, pushing and pulling during work situations related to these problems?

2 Databases

Given the limited number of systematic literature reviews identified in the broad literature exploration, this systematic literature review (with no time constraints) searched the international databases Medline (via PubMed) and Embase (via Ovid) for English-language and Dutch-language literature.

3 Search terms

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

4 Search strategy

Based on the broad literature exploration, the Committee also chose to specifically search the literature for references to the development of non-specific health complaints due to applying force, pushing and pulling.

4.1 Medline search strategy

#1= pushing[tiab] OR pulling[tiab] OR push[tiab] OR pull[tiab] OR “manual material handling”[tiab] OR “forceful work”[tiab]
#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 Embase search strategy

#1= pushing.ti,ab OR pulling.ti,ab OR push.ti,ab OR pull.ti,ab OR “manual material handling”.ti,ab OR “forceful work”.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 Search strategy

Based on the broad literature exploration, the Committee also chose to specifically search the literature for references to the development of carpal tunnel syndrome due to applying force, pushing and pulling. The following search strategy was applied:

5.1 Medline search strategy

#1 = Carpal Tunnel Syndrome"[Mesh] OR (carpal AND tunnel AND syndrome) OR (median AND neuropathy) OR CTS

#2= pushing[tiab] OR pulling[tiab] OR push[tiab] OR pull[tiab] OR "manual material handling"[tiab] OR "forceful work"[tiab]

#3= 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]

4= #1 AND #2 AND 3#

5.2 Embase search strategy

#1 = "Carpal Tunnel Syndrome"\$ OR (carpal.ti,ab AND tunnel.ti,ab AND syndrome.ti,ab) OR (median.ti,ab AND neuropathy.ti,ab) OR CTS.ti,ab

#2= pushing.ti,ab OR pulling.ti,ab OR push.ti,ab OR pull.ti,ab OR "manual material handling".ti,ab OR "forceful work".ti,ab

#3= work-related OR occupation\$ OR work\$ OR vocation\$ OR job OR industr\$ OR business OR profession\$ OR trade\$ OR enterprise\$

#4= #1 AND #2 AND 3#

6 Inclusion and exclusion criteria

The following inclusion criteria were applied for inclusion of studies identified by using the search strategy:

- 3 The study is a prospective or retrospective study (no intervention studies), or a case-control study for carpal tunnel syndrome as an outcome measure.
 - 4 The study describes the degree of exposure to applying force, pushing and pulling in a quantitative manner (duration, frequency and/or intensity).
 - 5 The study describes the short-term and/or long-term health effects of applying force, pushing and pulling in work situations.
-

- 6 The study describes a degree of association between applying force, pushing and pulling and the development of health effects in terms of relative risk, attributive risk, prevalence ratio or *odds ratio*.

Studies involving patient-related activities are not primarily included in this systematic literature review, but considered in a separate analysis.

7 Selection procedures

After the search strategy is performed in various databases, the inclusion criteria are 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 is included. The full text of the included titles and abstracts is retrieved and the inclusion criteria are again applied to the entire text by two evaluators, independently. In the event of doubt about inclusion or exclusion of a study, a third evaluator is consulted. Additionally, reference lists for all included articles and possible reviews are screened. Finally, the reference list of all included articles is submitted to four experts with the question of whether additional studies should be added.

8 Data extraction

Data extraction for included studies is 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 confounders;
- 4th column: effect of the occupational risk on health (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.

9 Quality criteria

The quality of included original longitudinal studies is 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 can be found in Table 4.

Table 4 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.
-

10 Search strategy results

The previously defined searches strategies were performed in PubMed in October 2011 and in Embase in May 2011. Based on various selection steps using titles and abstracts, a total of 126 full-text articles were assessed based on inclusion criteria. Following the final selection step, seven original cohort studies²⁶⁻³² and nine reviews^{18,21,47-53} were included. One hundred and ten publications were excluded for various reasons: no quantification of exposure to pushing or pulling, the combination of multiple risks (not only pushing or pulling), or no prospective or retrospective study design. The reference check (screening of the reference lists for all included studies and reviews and supplementation by the four experts) provided one additional original study.³³ Figure 1 shows an overview of the various selection steps in our search strategy. The additional search strategy (carpal tunnel syndrome) was performed in PubMed and Embase in early 2011. Based on various selection steps using titles and abstracts, four full-text articles were eventually assessed based on the inclusion criteria. No additional studies were selected after the final selection

step, as the publications related to exposure to repetitive activities or to the combination of multiple risks (not only pushing or pulling).

	Medline	Embase
Total hits	974	586
Duplicates	297	
Total titles	1.263	
<i>Titles/abstracts from</i>	<i>- 1.137</i>	
Total full text	126	
<i>Fulltext from</i>	<i>- 110</i>	
Reviews	9	
Total original publication	7	
<i>Reference check</i>	<i>1</i>	
Total original publication	8	

Figure 1 Search strategy results.

11 Quality assessment results

The quality of the eight original studies from the search strategy was described based on the four quality criteria. Table 5 provides an overview of the quality assessment of these prospective cohort studies.

Table 5 Quality description for the eight included studies.

Auteur	Design	Study population	Exposure	Outcome	Statistical analysis	Results
Andersen ²⁶	longitudinal	+	z	?	+	+
Harkness ²⁷	longitudinal	+	z	?	+	+
Harkness ³⁰	longitudinal	+	z	?	+	+
Harkness ³²	longitudinal	+	z	?	+	+
Hoozemans ²⁸	longitudinal	+	z/m	+	+	+
Koehoorn ³³	longitudinal	+	m	+	+	+
McBeth ³¹	longitudinal	+	z	?	+	+
Plouvier ²⁹	longitudinal	+	z	+	+	+

Exposure: z, self-reported; m, measured.

H

Extraction table lower back complaints

Author	Study population	Study design	Health effect	Exposure parameters	Degree of association
Andersen 2007 ²⁶	N = 1456 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 prevalence = 10.6%)	Pushing (cumulative): - never N = 824	HR = 1.0
			<i>Pain</i> : pain in a body region in the past 12 months	- I = 1-354 kg per hour N = 327	HR = 1.9 (CI 1.3-2.8)
				- I ≥ 355 kg per hour N = 305	HR = 1.7 (CI 1.1-2.5)
Harkness 2003 ²⁷	N = 1031 G = 64% men; 36% women A = median 23 O = various sectors such as service organization, police, army officers, supermarket, postal distribution centre	Prospective cohort study (2 years) Conf = age, sex, occupation	Low back pain (LBP) (1 year incidence = 19%) (2 years incidence = 19%) <i>Pain</i> : any pain or ache in the low back lasting for one day or longer in the past month	Pushing: - never N = 666 (539 no LBP; 127 LBP) - I ≤ 30 kg N = 182 (143 no LBP; 39 LBP) - I > 30 kg N = 183 (151 no LBP; 32 LBP)	OR = 1.00 OR = 1.3 (CI 0.8-2.1) OR (multivariate) = 1.1 (CI 0.7-1.9) OR = 1.3 (CI 0.7-2.2) OR (multivariate) = 0.9 (CI 0.5-1.6)

Harkness C = England
2003²⁷

Pulling:
- never OR = 1.0
N = 780 (637 no LBP;
143 LBP)

- I ≤ 25 kg OR = 1.5 (CI 0.9-2.6)
N = 126 (100 no LBP; 26 LBP) OR (multivariate) = 1.4 (CI 0.8-2.4)

- I > 25 kg OR = 2.1 (CI 1.2-3.4)
N = 125 (96 no LBP; 29 LBP) OR (multivariate) = 1.7 (CI 0.96-3.1)

Hoozemans
2002²⁸
N = 459
G = 262 men;
197 women
A = ?
O = various sectors
C = Netherlands

Prospective cohort study (1 year)
Conf = age, sex

Low back pain (1 year prevalence = 15%)
Pain: any pain, ache or discomfort during the last 12 months

Pushing/pulling:
- F = 16 per day; D = 131s
N = ?

- F = 135 per day; D = 1344s
N = ?
PR (self-report; reference group at baseline without complaints) = 1.53 (CI 0.76-3.09)
PR (self-report; reference group at baseline with complaints) = 1.24 (CI 0.83-1.84)

- F = 741 per day; D = 4139s
N = ?
PR (self-report; reference group at baseline without complaints) = 1.74 (CI 0.82-3.70)
PR (self-report; reference group at baseline with complaints) = 1.22 (CI 0.78-1.90)

Plouvier
2008²⁹
N = 2601
G = 2218 men;
383 women
A = 48-62
O = various sectors
C = France

Prospective cohort study (5 years)
Conf = age

Low back pain radiating below knee (LBP) (1 year incidence = 29.5%)
Pain: pain, discomfort or disability for at least one day in the low back area during the past 12 months

Pushing/pulling/carrying:
- never OR = 1.0
N = 1264

- F ≥ 1 per week; D = 1- >20 years
N = 1337
OR = 1.06 (CI 1.00-1.14)

N, number; G, gender; A, age; O, occupation (sector); C, country; Conf = confounder taken into account; D, duration; I, intensity; F, frequency; h, hour; min, minute; s, second; OR, odds ratio; HR, hazard ratio; PR, prevalence rate ratio; CI, confidence interval; *, p < .05.

I

Description of studies on lower back complaints

Based on prevalence figures, Andersen et al. (2007) examined the relationship between pushing and lower back complaints (self-reported exposure to both pushing and lower back complaints) in a cohort of 1,456 participants.²⁶ During a two-year follow-up period, 10.6 per 100 employees had a new episode of back complaints. Given this incidence, Andersen et al. found that employees who cumulatively pushed 1-354 kg per hour (partial weights and frequency unknown) had a statistically significant elevated risk of developing lower back complaints (HR 1.9; 95% CI 1.3-2.8) compared with employees who never push at work. Employees who push more than 355 kg per hour (partial weights and frequency) were also found to have a statistically significant elevated risk of developing lower back complaints (HR 1.7 (95% CI 1.1-2.5) compared with the same reference group. The Committee notes that this study examines cumulative exposure; there is no information available of partial weights and pushing frequency.

In a longitudinal study with a two-year follow-up period in a cohort of 1,031 participants (64% men, 36% women; self-reported exposure to pushing and pulling and lower back complaints), Harkness et al. (2003b) examined the relationship between pushing (≤ 30 kg & >30 kg), pulling (≤ 25 kg & >25 kg) and lower back complaints based on incidence figures.²⁷ During the two-year follow-up period, 19 per 100 employees had a new episode of back complaints. No statistically significant increased risks were found in any of the groups compared with employees who were not exposed to pushing or pulling during work.

Figures were: pushing ≤ 30 kg (OR=1.1; 95% CI 0.7-1.9), pushing >30 kg (OR=0.9; 95% CI 0.5-1.6), pulling ≤ 25 kg (OR=1.4; 95% CI 0.8-2.4) and pulling >25 kg (OR=1.7; 95% CI 0.96-3.1).

Based on prevalence figures, Hoozemans et al. (2002) examined the relationship between pushing/pulling and the incidence of lower back complaints in a cohort of 459 employees (262 men, 197 women) in various sectors.²⁸ During the two-year follow-up period, 15 in 100 employees had a new episode of back complaints. Within a one-year follow-up period, exposure to pushing/pulling and lower back complaints were self-reported by participants and objectively measured by the investigators. Hoozemans et al. found that employees with an average exposure to pushing/pulling had, for both self-reported exposure and objectively measured exposure expressed as frequency (135 times/day) and duration (1,344 sec/day), no statistically significant increased risks for the development of lower back complaints compared with employees with low exposure (frequency 16 times/day, duration 131 sec/day) to pushing/pulling. The prevalence ratios were, respectively: PR self-report = 1.5 (95% CI 0.8-3.1), PR frequency = 1.7 (95% CI 0.8-3.6) and PR duration = 1.2 (95% CI 0.6-2.6). No statistically significant elevated risks for the three exposure measures were found with employees with high exposure (frequency 741 times/day, duration 4139 sec/day) to pushing/pulling either. The prevalence ratios were: PR self-report = 1.7 (95% CI 0.8-3.7), PR frequency = 1.5 (95% CI 0.7-3.1) and PR duration = 2.0 (95% CI 0.97-4.0).

Based on incidence data, Plouvier et al. (2008) examined the relationship between pushing/pulling and the incidence of lower back complaints in a cohort of 2601 employees in various sectors.²⁸ During the five-year follow-up period, 29.5 in 100 employees had a new episode of back complaints radiating below the knee. Both the exposure to pushing/pulling/carrying and the lower back complaints were self-reported by study participants. Plouvier et al. (2008) found that employees who were exposed to pushing/pulling/carrying ≥ 1 time per week for 1 to > 20 years had a higher risk (OR=1.06; 95% CI 1.00-1.14) of lower back complaints radiating below the knee compared with employees who were not exposed.

Extraction table shoulder complaints

Author	Study population	Study design	Health effect	Exposure parameters	Degree of association
Ander- sen 2007 ²⁶	N = 1456 G = ? A = 44 (sd=10) O = various C = Denmark	Prospective cohort study (2 years)	Neck/shoulder pain (2 years prevalence = 11.5%)	Pushing (cumulative): - never N = 824	HR = 1.0
		Conf = sex, age, occupational cate- gory, intervention group	<i>Pain</i> : pain in a body region in the past 12 months	- I = 1-354 kg per hour N = 327 - I ≥ 355 kg per hour N = 305	HR = 1.3 (CI 0.9-1.9) HR = 1.5 (CI 1.0-2.2)
Harkness 2003 ³⁰	N = 626 G = 65% men; 35% women A = median 23 O = various sec- tors such as ser- vice organization, police, army offi- cers, 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%) <i>Pain</i> : any pain or ache in the shoulder lasting for one day or longer in the past month	Pushing/pulling: - never N = 380 (332 no SP; 48 SP) - I < 32 kg N = 114 (98 no SP; 16 SP) - I ≥ 32 kg N = 132 (105 no SP; 27 SP)	OR = 1.00 OR = 1.1 (CI 0.7-1.8) OR (multivariate) = 1.3 (CI 0.8-2.2) OR = 2.0 (CI 1.3-2.9) OR (multivariate) = 2.6 (CI 1.6-4.2)

Hoozemans 2002 ²⁸	N = 459 G = 262 men; 197 women A = ? O = various sectors C = Netherlands	Prospective cohort study (1 year) Conf = age, sex	Shoulder pain (1 year prevalence = 15%) <i>Pain</i> : any pain, ache or discomfort during the last 12 months	Pushing/pulling: - F = 16 per day; D = 131s N = ? - F = 135 per day; D = 1344s N = ? - F = 741 per day; D = 4139s N = ?	PR = 1.0 PR (self-report; reference group at baseline without complaints) = 2.90 (CI 1.17-7.16) PR (self-report; reference group at baseline with complaints) = 0.91 (CI 0.54-1.54) PR (self-report; reference group at baseline without complaints) = 4.86 (CI 1.85-12.79) PR (self-report; reference group at baseline with complaints) = 1.28 (CI 0.73-2.23)
	McBeth 2003 ³¹	N = 603 G = ? A = 18-65 O = various sectors C = UK	Prospective cohort study (3 years) Conf = age, sex	Chronic shoulder pain (CSP) (1 year incidence = 6%) <i>Chronic pain</i> : any pain during the previous month that had persisted for at least 24h and had lasted for more than 3 months	Pushing/pulling: - never/occasionally I = 25kg N = 525 (493 no CSP; 32 CSP) - half/most of the time I = 25kg N = 78 (71 no CSP; 7 CSP)

N, number; G, gender; A, age; O, occupation (sector); C, country; Conf = confounder taken into account; D, duration; I, intensity; F, frequency; h, hour; min, minute; s, second; OR, odds ratio; HR, hazard ratio; PR, prevalence rate ratio; CI, confidence interval; *, p<.05; **, p<.01; ***, p<.001.

K

Description of studies on shoulder complaints

Based on prevalence figures, Andersen et al. (2007) examined the relationship between pushing and neck/shoulder complaints (self-reported exposure to both pushing and neck/shoulder complaints) in a cohort of 1,456 participants.²⁶ During a two-year follow-up period, 11.5 per 100 employees had a new episode of neck/shoulder complaints. Given this incidence, Andersen et al. found that employees who pushed 1-354 kg per hour did not have a statistically significant elevated risk of developing neck/shoulder complaints (HR 1.3; 95% 0.9-1.9) compared with employees who never push during work. Employees who push more than 355 kg per hour were also not found to have a statistically significant elevated risk of developing lower back complaints (HR 1.5 (95% CI 1.0-2.2) compared with the same reference group. However, this applies to cumulative exposure, and data on partial weights and pushing frequency is lacking.

In a longitudinal study with a two-year follow-up period in a cohort of 626 participants (65% men, 35% women), Harkness et al. (2003) examined the relationship between pushing/pulling <32 kg and \geq 32 kg and shoulder complaints (self-reported exposure to both pushing and shoulder complaints) based on incidence figures.³⁰ During a two-year follow-up period, 15 per 100 employees had a new episode of shoulder complaints. Pushing/pulling <32 kg was not associated with a statistically significant risk compared with unexposed employees (OR 1.3; 95% CI 0.8-2.2). A statistically significant elevated risk was

found for pushing/pulling ≥ 32 kg (OR 2.6; 95% CI 1.6-4.2) compared with employees who were not exposed to pushing/pulling during work.

Based on prevalence figures, Hoozemans et al. (2002) examined the relationship between pushing/pulling and the occurrence of shoulder pain (self-reported and objectively measured by the investigators) in a cohort of 459 employees (262 men, 197 women) in various sectors.²⁸ During the two-year follow-up period, 15 in 100 employees had a new episode of shoulder pain. Hoozemans et al. found that employees with an average exposure to pushing/pulling had, for both self-reported exposure and objectively measured exposure expressed as frequency (135 times/day) and duration (1,344 sec/day), statistically significant increased risks for the development of shoulder pain compared with employees with low exposure (frequency 16 times/day, duration 131 sec/day) to pushing/pulling. The prevalence ratios were, respectively: PR self-report = 2.9 (95% CI 1.2-7.2), PR frequency = 4.0 (95% CI 1.6-10.0) and PR duration = 3.3 (95% CI 1.3-8.4). Statistically significant elevated risks for the two of the three exposure measures were also found with employees with high exposure (frequency 741 times/day, duration 4139 sec/day) to pushing/pulling. The prevalence ratios were: PR self-report = 4.9 (95% CI 1.9-12.8), PR frequency = 2.2 (95% CI 0.8-5.8) and PR duration = 2.7 (95% CI 1.0-7.1).

In a prospective cohort study, McBeth et al. (2003) examined the relationship between pushing/pulling and chronic shoulder pain (self-reported exposure to pushing/pulling and chronic shoulder pain) in a cohort of 603 participants.³¹ After a three-year follow-up period, 6 per 100 employees had chronic shoulder pain. Given this incidence, a significantly elevated risk of developing chronic shoulder pain was found for pushing/pulling 25 kg for half/the majority of the working hours (RR 1.8; 95% CI 1.1-3.0) compared with not or sporadically pushing/pulling 25 kg during work.

Extraction table other complaints

Author	Study population	Study design	Health effect	Exposure parameters	Degree of association
Ander- sen 2007 ²⁶	N = 1456 G = ? A = 44 (sd=10) O = various C = Denmark	Prospective cohort study (2 years) Conf = sex, age, occupational category, inter- vention group	1. Elbow, forearm, hand pain (2 years prevalence = 6.4%) 2. Hip, knee, foot pain (2 years prevalence = 9.3%) 3. Any region (2 years prevalence = 23.6%) <i>Pain:</i> pain in a body region in the past 12 months	Pushing (cumulative): - never N = 824 - I = 1-354 kg per hour N = 327 - I ≥ 355 kg per hour N = 305	HR = 1.0 1. HR = 1.6 (CI 0.9-2.7) 2. HR = 1.6 (CI 1.1-2.5) 3. HR = 1.5 (CI 1.1-1.9) 1. HR = 1.8 (CI 1.1-3.1) 2. HR = 2.0 (CI 1.4-3.0) 3. HR = 1.5 (CI 1.1-1.9)
Harkness 2004 ³²	N = 466-469 G = 33% men; 67% women A = median 23 O = various sec- tors such as ser- vice organization, police, army offi- cers, supermar- ket, postal distribution cen- tre	Prospective cohort study (2 years) Conf = age, sex, occupation	Widespread pain (WP; criteria for fibromyal- gia) (1 year incidence = 15%) (2 year incidence = 12%) <i>Pain:</i> any pain or ache lasting for one day or longer in the past month	Pushing: - never N = 320 (284 no WP; 36 WP) - I ≤ 30 kg N = 81 (70 no WP; 11 WP) - I > 30 kg N = 68 (57 no WP; 11 WP)	OR = 1.0 OR = 1.5 (CI 0.9-2.5) OR = 1.7 (CI 0.96-3.0)

Harkness C = England
2004³²

Pulling:
- never OR = 1.0
N = 363 (321 no WP;
42 WP)

- I ≤ 25 kg OR = 1.6 (CI 0.9-2.9)
N = 58 (51 no WP; 7
WP)

- I > 25 kg OR = 2.3 (CI 1.3-3.9)
N = 45 (36 no WP; 9
WP)

Koe-
hoorn
2011³³

N = 581
G = 90.5% men;
9.5% women
A = 79.4% > 45
O = building
engineer,
assistant buil-
ding engineer,
head custodian,
custodian
C = Canada

Prospective
cohort study
(3 years)

Conf = age, occu-
pation

Musculoskeletal injury
(3 year incidence =
38%)

Pain: cut, sprain/strain
or fall in any part of
the body (registration
system)

Pushing/pulling:
- D < 24% workday RR = 1.0
N = ?

- D = 24.1 - 37.2% RR = 2.7 (CI 0.9-8.2)
workday
N = ?

- D = 37.3 - 46.6% RR = 3.2 (CI 1.1-9.6)
workday
N = ?

- D > 46.7% workday RR = 5.2 (ci 1.0-26.5)
N = ?

M

Description of studies on other complaints

Based on prevalence figures, Andersen et al. (2007) examined the relationship between pushing and elbow/forearm/hand pain (self-reported exposure to pushing as well as elbow/forearm/hand pain) in a cohort of 1,456 participants.²⁶ During the two-year follow-up period, 6.4 per 100 employees experienced a new episode of elbow/forearm/hand pain. Given this incidence, Andersen et al. found that employees who pushed 1-354 kg per hour did not have a statistically significant elevated risk of developing elbow/forearm/hand pain (HR 1.6; 95% CI 0.9-2.7) compared with employees who never push during work. Employees who push more than 355 kg per hour did have a statistically significant elevated risk of developing elbow/forearm/hand pain (HR 1.8; 95% CI 1.1-3.1) compared with the same reference group. However, this applies to cumulative exposure, and data on partial weights and pushing frequency is lacking.

In the same study, Andersen et al. (2007) examined the relationship between pushing and hip/knee/foot pain (self-reported exposure to pushing and hip/knee/foot pain) in a cohort of 1,456 participants.²⁶ During a two-year follow-up period, 9.3 per 100 employees had a new episode of hip/knee/foot pain. Given this incidence, Andersen et al. (2007) found that employees who pushed 1-354 kg per hour did had a statistically significant elevated risk of developing hip/knee/foot pain (HR 1.6; 95% CI 1.1-2.5) compared with employees who never push during work. Employees who push more than 355 kg per hour also had a statistically significant elevated risk of developing hip/knee/foot pain (HR 2.0; 95% CI 1.4-3.0) compared with the same reference group. However, here too,

cumulative exposure was measured, and data on partial weights and pushing frequency is lacking.

In the same study, Andersen et al. (2007) found that employees who push 1-354 kg per hour had a statistically significant increased risk of developing pain somewhere (HR 1.5; 95% CI 1.1-1.9) compared with employees who never push during work.²⁶ Employees who push more than 355 kg per hour also have a statistically significant increased risk of developing pain somewhere (HR 1.5; 95% CI 1.1-1.9) compared with the same reference group. However, this applies to cumulative exposure, and any data on partial weights and pushing frequency is lacking. During the two-year follow-up period, 23.6 per 100 employees experienced a new episode of bodily pain.

In a longitudinal study with a two-year follow-up period in a cohort of 466-469 participants (33% men, 67% women; self-reported exposure to pushing and pulling and back complaints), Harkness et al. (2004) examined the relationship between pushing, pulling and general pain (fibromyalgia) based on incidence figures.³² During the two-year follow-up period, 12 per 100 employees had a new episode of general pain (fibromyalgia). A statistically significant elevated risk was only found for pushing/pulling >25 kg (OR 2.3; 95% CI 1.3-2.9) compared with employees who were not exposed to pushing/pulling during work. No significantly elevated risks for the development of general pain compared with the same reference group were found for pushing ≤30 kg (OR 1.5; 95% CI 0.9-2.5), pushing >30 kg (OR 1.7; 95% CI 0.96-3.0) and pulling ≤30 kg (OR 1.6; 95% CI 0.9-2.9).

Based on incidence data from a longitudinal study with a three-year follow-up period, Koehoorn et al. (2011) examined the relationship between pushing/pulling and musculoskeletal injuries in a cohort of 581 employees working as (assistant) engineers or (assistant) administrators (registration of musculoskeletal injuries and measured exposure to pushing/pulling).³³ Employees who spent between 37.3% and 46.6% of their work day pushing/pulling had a statistically elevated risk of musculoskeletal injury (RR 3.2; 95% CI 1.1-9.6) compared with employees who spent less than 24% of their work day pushing/pulling. Employees who pull/push for more than 46.7% of their working day have an increased risk of musculoskeletal injury (RR 5.2; 95% CI 1.0-26.5) compared with employees who spend less than 24% of their working day pulling/pushing.

Comments on the draft advisory report

In July 2012, the President of the Health Council released a draft of this advisory report for a round of public commentary. The following individuals and institutions responded to the draft report:

- Mrs Caspers, Arbouw, Harderwijk
- Mr van Eijk, OCÉ Technologies B.V., Venlo
- Mr Halm, FME-CWM, Zoetermeer
- Mr Houba, Dutch Centre of Expertise for Labour and Pulmonary Conditions, Utrecht
- Mr Kapias, CZ Business & Health, Koudekerke
- Mr Karsten, Occupational Physiotherapist/Labour Expert
- Mr Koppes, TNO, Hoofddorp
- Mr Pison, Dutch Association of Paving Businesses, Harderwijk

The Committee integrated the comments in the completion of its advisory report.

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

Health Council of the Netherlands

Advisory Reports

The Health Council's task is to advise ministers and parliament on issues in the field of public health. Most of the advisory opinions that the Council produces every year are prepared at the request of one of the ministers.

In addition, the Health Council issues unsolicited advice that has an 'alerting' function. In some cases, such an alerting report leads to a minister requesting further advice on the subject.

Areas of activity



Optimum healthcare

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.

