Health Council of the Netherlands

Working while standing, kneeling or squatting

Gezondheidsraad
Health Council of the Netherlands

To the State Secretary of Social Affairs and Employment

Subject : presentation of advisory report
Working while standing, kneeling or squatting
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Dear State Secretary ,

Your predecessor requested advice by letter on a number of occupational risks. I am pleased to present to you the advisory report on working in a standing, kneeling or squatting position. The advisory report was drafted by the Committee on the Identification of Workplace Risks.

Physical burden is one of the largest health risks for workers in The Netherlands. This advisory report answers the question as to whether there are options for health-based or safety-based occupational exposure limits for working in a standing, kneeling or squatting position. Although the Committee was unable to determine a threshold level below which there are no health risks, it did manage to map the extent of the risks of low back pain. These risks may be used as a starting point for further discussion on occupational exposure limits.

The Committee has made use of the comments received in response to a public draft of this report. Subsequently, the advisory report has been reviewed by the Standing Committee on Health and the environment of the Health Council.

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

Yours sincerely,
(signed)
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to:

the State Secretary of Social Affairs and Employment

No. 2011/41E, The Hague, December 23, 2011

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

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

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

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INAHTA

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Executive summary

The request for an advisory report

At the request of the Minister of Social Affairs and Employment, the Health Council of the Netherlands has investigated whether at the present time there are any new scientific insights concerning health-based or safety-based occupational exposure limits (OELs) for work performed in a standing, kneeling or squatting position. This 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 Working Conditions Act and its associated regulations. To answer the Minister's questions, the Committee studied the scientific data on adverse health effects of working in a standing, kneeling or squatting position, and considered the results of longitudinal studies to be particularly important, as they involve the least likelihood of bias.

Scope

In the Netherlands, nearly 2.5 million people say that they 'regularly' or 'very often' perform their work in standing position. More than 900,000 people perform work in kneeling or squatting position. Examples of sectors in which these occupational risks frequently occur include the agricultural, construction, installation and cleaning sectors.

Lower back complaints are one of the consequences of performing work in standing, kneeling or squatting position. Many studies have investigated the onset of low back pain during the preceding 12 months. It is known that nearly a quarter of these people with lower back complaints are likely to develop chronic complaints with obvious adverse effects on their health.

More than a third of the people who had suffered lower back complaints in recent months said that they felt limited in their daily life; 30% of them had visited their general practitioner and 30% had been on sick leave because of these health problems.

Working in a standing position

The available scientific data show that working in a standing position can result in pain in the lower back, legs, knees and feet. Working in a standing position can also lead to varicose veins in the legs. Pregnant women who sustainably stand at work have a higher risk of preterm birth. On the basis of the small number of studies, the Committee is of the opinion that it is not possible to indicate a safe threshold level below which no adverse health effects could be expected for people who work in a standing position. However, by combining the results of the available longitudinal studies in a meta-analysis, it is possible to obtain information on the extent of the risk of lower back complaints having occurred in the past 12 months.

Working in a kneeling position

Scientific studies show that working in a kneeling position can lead to lower back pain complaints as well. Another adverse effect of working in this position is osteoarthritis of the knee joint. The Committee is of the opinion, on the basis of the small number of studies and their results, that it is not possible to indicate a safe threshold level below which no adverse health effects could be expected for people who work in a kneeling position. It is also not possible to further estimate the risks on the basis of the available data,

Working in a squatting position

The available scientific data indicate that working in squatting position can cause lower back pain and pain in the knees. The Committee is of the opinion, on the basis of the small number of studies and their results, that it is not possible to indicate a safe threshold level below which no adverse health effects could be

Low back pain complaints	Working in a standing position (*hours* per day)					
	no	0.5 hour	1 hour	2 hour	3 hour	4 hour
Percentage (%) onset of low back pain in working population per year	13.0[a]	14.1	15.2	17.1	20.5	23.7
Extra incidence per year (%)		1.1	2.2	4.7	7.5	10.7
	Working in a squatting position (*minutes* per day)					
	no	10 min	20 min	30 min	40 min	
Percentage (%) onset of low back pain in working population per year	13.0	13.7	14.5	15.3	16.2	
Extra incidence per year (%)		0.7	1.5	2.3	3.2	

[a] Incidence of low back pain complaints in general population without exposure to physical load: 13.0 %.

expected for people who work in a squatting position. However, by combining the results of the available longitudinal studies in a meta-analysis, it is possible to obtain information on the extent of the risk of lower back complaints having occurred in the past 12 months.

Working in kneeling position

Scientific studies show that working in kneeling position can lead to lower-back pain complaints as well. Another adverse impact of working in this position is osteoarthritis of the knee joint. The Committee is of the opinion on the basis of the small number of studies and their results that it is not possible to indicate a safe threshold level below which no adverse health effects could be expected for people who work in a kneeling position. It is also not possible to further estimate the risks on the basis of the available data.

Possibilities for health-based occupational limit-values

On the basis of the available scientific data, the Committee concluded that it is not possible to indicate a safe level below which no adverse health effects would be expected for people who work in standing, kneeling or squatting position. However, it was possible to obtain information on the extent of the risks of lower-back complaints arising from either working in standing position or working squatting position. The Committee is of the opinion that these substantiated health-based risks can serve as a starting point for determining occupational limit values.

To this end, it will be necessary to hold at different levels discussions on what risk is still acceptable. This will require the establishment of a prescriptive

framework. An important choice here involves deciding what extra risk of a given adverse effect on health is deemed acceptable, taking into account aspects such as the prevalence and incidence of the health effect within the general population. As the prevalence and incidence of lower-back complaints in the general population are high and most episodes of lower-back complaints are of short duration and end spontaneously, it will be necessary to reach agreement on the level of severity and duration of back complaints that will not be considered acceptable. However, policy and social considerations will also play a role in the ultimate decision.

Chapter 1

Introduction

The advisory report before you is one of a series addressing health risks resulting from working while standing, kneeling or squatting. In the Netherlands, more than one in ten workers regularly works in an uncomfortable position (including standing, kneeling or squatting). There are indications that working in a standing, kneeling or squatting position leads to musculoskeletal disorders. This results in these positions being considered a health risk in a number of sectors. The consequences for society in terms of rehabilitation, sick leave and work disability may be costly.

1.1 The request for advice

This report answers a request for advice submitted to the Health Council of the Netherlands on 10 July 2007 by the Minister of Social Affairs and Employment. The request which is given in full in Annex A of this report, specified:

- periodical reports on the existence *at the moment* of new (international) scientific insights with regard to concrete health-based and / or safety-based occupational exposure limits
- periodical reports on the expected existence *in the longer term* of new (international) scientific insights with regard to concrete health-based and / or safety-based occupational exposure limits
- consideration of *current* scientific insights.

On 14 March 2008, the Committee on the *Identification of Workplace Risks* was set up to deal with this task. The Committee is composed of experts in the fields of occupational health, safety and disease. The chairman and members of the Committee and its working group are listed in Annex B of this report.

1.2 The Committee's approach

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

Subsequently, the Committee explores the scientific literature using review publications. This allows the Committee to gain insight in the health and safety problems resulting from working in a standing, kneeling or squatting position (Annex D). This initial phase is a starting point for the second phase, in which the Committee performs a systematic literature review (Annex E), and collects primary scientific publications on the potential adverse effects of working in a standing, kneeling or squatting position on health and/or safety.

Once the Committee has reached consensus, a draft of its report is made public for comment from third parties. The comments received are taken into consideration in framing the final report (Annex C).

1.3 Chapter contents

In the second chapter, the Committee provides a general introduction to the occupational risk; the definition for working while standing, kneeling or squatting, which Dutch workers face working in a standing, kneeling or squatting position. The Committee also provides insights into the scope of the health problems resulting from working in a standing, kneeling or squatting position. Chapter three provides an overview of existing national and international laws and guidelines. In the fourth chapter, the Committee describes the results of the systematic literature review of the health effects of working in a standing, kneeling or squatting position. Chapter five outlines the possibilities for health-based or safety-based OELs based on available data. The results of the meta-analyses are presented in Chapter six. The Committee subsequently discusses the risks of the three occupational risk factors in Chapter seven. Finally, the main conclusions regarding working in a standing, kneeling or squatting position are summarized in Chapter eight.

Chapter 2

The occupational risks of working in a standing, kneeling, or squatting position

This chapter provides a brief introduction to the topic of working in a standing, kneeling or squatting position. It explains how working in a standing, kneeling and squatting position should be defined and which workers are exposed to it. Additionally, a broad literature search (Annex D) is used to provide an initial impression of the health problems resulting from working in a standing, kneeling or squatting position.

2.1 Definition of standing, kneeling and squatting

Standing is a posture in which the body rests upon the legs and the legs are not moved beyond a circle of one meter relative to their initial position.

Kneeling is a posture in which the worker rests on the floor with one or two knees.

Squatting is a posture in which the worker supports the body with the feet and the upper and lower legs form an angle of less than 90^{o} relative to each other.[1,2,3]

2.2 Scope of working while standing, kneeling or squatting in The Netherlands

43 percent of workers in The Netherlands work in 'the same' posture for long periods of time (including standing, kneeling or squatting), and more than one in ten workers often or regularly works in an 'uncomfortable' working posture.[4] In The Netherlands, slightly fewer than 2.5 million workers 'regularly' or '(very) often' perform work while standing, representing 34% of the Dutch labour force.[5,6] Over 900,000 workers 'regularly' or '(very) often' work in kneeling or squatting positions*, which corresponds to 13.2 percent of the Dutch labour force.[5-7]

There are sectors in which standing, kneeling or squatting work is common, such as agriculture, the construction, installation, furniture and cleaning industry, and automobile trade and repair. Hairdressers, fire fighters, beauticians, security personnel, teachers and shop workers also have to deal with these postures. With the exception of the construction industry, little is known about specific professions within sectors with regard to working while standing, kneeling and squatting. In construction, among others plumbers, bricklayers, carpenters, road workers, roofers, facade insulators, decorators, scaffolding builders, tilers and floor layers (very) often work in a standing, kneeling or squatting position.

2.3 Review publications on health problems

The literature exploration revealed that few recent scientific review articles are available concerning the development of health and safety problems due to working in a standing, kneeling or squatting position. The literature on working in a kneeling or squatting position primarily shows that this occupational risk is associated with the development of knee osteoarthritis.[8] A single review is available on working in a standing position. This publication reports no causal relationship between working in a standing position and the occurrence of low back pain.[9]

These findings prompted the Committee to conduct a systematic literature review covering the past twenty years, with the aim of discovering to what degree working in a standing, kneeling or squatting position results in specific health problems.

* These data have almost all been obtained via self-reporting.

Chapter 3

Laws and guidelines

This chapter provides an overview of legislation and regulations relating to the occupational risk of working in a standing, kneeling or squatting position.

The Working Conditions Act includes rules for employers and employees designed to protect and promote the health, safety and welfare of employees and independent entrepreneurs. International and European standards on working in a standing, kneeling or squatting position are subsequently presented, and the chapter concludes with other guidelines.

3.1 The Working Conditions Decree

Articles 5.1 to 5.6 of the Working Conditions Decree relate to physical burden, but these articles contain no legal OELs for working in a standing, kneeling or squatting position.[10]

The principle is the working conditions policy that an employer must implement, in accordance with article 3 of the Working Conditions Act, namely:

1 The employer ensures the safety and health of employees with regard to all work-related aspects and implements a policy focused on the best feasible working conditions, taking the following into account, while considering the current state of science and professional service provision:
   a unless this cannot reasonably be demanded, the employer organizes work such that its performance has no adverse effects on the safety and health of the employee;

b unless this cannot reasonably be demanded, the dangers and risks to the employee's safety or health are, wherever possible, prevented or limited at the source; insofar as such dangers and risks cannot be prevented or limited at the source, other effective measures will be taken, with measures focused on collective protection superseding measures focused on individual protection; only if it cannot reasonably be demanded that measures focused on individual protection will be taken, will effective and suitable personal protection devices be made available to the employee;

c the organization of workplaces, working procedures and equipment employed during work, as well as the contents of work will be adjusted to suit the personal abilities of the employees, insofar as may reasonably be demanded;

d monotonous and tempo-sensitive labour will, insofar as may reasonably be demanded, be avoided or, if this is impossible, be limited;

e effective measures will be taken in the area of first aid, fire control and evacuation of employees and other individuals present, and effective contacts with applicable external emergency services will be maintained;

f every employee must, in the event of serious and immediate danger to his own safety or the safety of others, taking his technological knowledge and resources into account, be able to take the required appropriate measures in order to prevent the consequences of such a danger, whereby article 29, first paragraph, third sentence of this document applies;

2 The employer implements, within general working conditions policy, a policy focused on the prevention and, if this is impossible, limitation of psychosocial work burden.

3 In implementing the first paragraph, the employer ensures equitable distribution of authorizations and responsibilities between persons working for the employer, taking into account employee competencies.

4 The employer regularly reviews the working conditions policy based on experiences with said policy, and adjusts measures as often as experiences gathered indicate is necessary.

Article 5.4 of the Working Conditions Decree '*Ergonomic workplace furnishing*' also applies, which states: *'Unless this cannot reasonably be demanded, workplaces will be furnished in accordance with ergonomic principles.'* (http://wetten.overheid.nl)

For pregnant women, children and employees in child care centres, policy guideline 1.42 '*Organisation of work by pregnant employees and employees during lactation*', under d, applies until 2012:

the requirement to bend down, squat or kneel as part of the pregnant employee's work should be avoided wherever possible. During the last term, pregnant employees should not be obligated to

squat, kneel, bend down, or operate foot pedals while standing more than once per hour.' (http://wetten.overheid.nl)

The Committee was unable to find any health-based evidence for the figures in the policy guideline.

3.2 International OELs and standards

The European Working Conditions guidelines do not list any figures for OELs and standards for physical burden. An internal market guideline provides a foundation for a quantitative norm in the field of physical burden. For example, the European Committee has, within the context of a machines directive setting requirements for machine design, issued a mandate, i.e. providing machine designers with guidance with regard to maximum and minimum forces required to operate a machine. In addition to the ergonomic principles machine designers need to take into account, the NEN-EN 1005-4 standard '*Safety of machinery. Human physical performance. Part 4: Evaluation of working postures in relation to machinery*' contains indications on how certain postures are acceptable, and which postures should be avoided.[11] Postures and movements are evaluated on the drawing board/CAD monitor or using actual people in an experimental model during the design process. As with the ISO 11226 standard for static work postures, analysis is performed per joint. In addition to postures relating to torso, shoulders, head and neck, the European standard also provides indications on how much of a burden postures are for other body parts. However, this standard provides no information on working in a standing, kneeling or squatting position.

The international ISO 11226 standard '*Ergonomics - Evaluation of static working postures*' provides a method for evaluating the burden of static working postures.[12] In a first step, a check is performed to verify whether the angle of the joint is acceptable for almost all healthy adults, and in a second step, the duration for which said posture can be maintained is examined. This standard is primarily focused on postures relating to the torso (angle between the vertical line and a line drawn through the *trochanter major* and the seventh cervical vertebrae), head (angle between the vertical line and a line through the corner of the eye and earlobe), neck (angle between head and torso), shoulders (angle between the vertical line and the line through the *acromion-clavicle* and *humerus-radius* joints), lower arms and hands, but not on working postures such as standing, kneeling or squatting.

3.3 Other guidelines

When assessing sustained standing, the Labour Inspectorate bases its decisions on article 5.4 of the Working Conditions Decree '*Ergonomic workplace furnishing*'. In practice, this means that location-specific work should preferably be performed while seated, unless this is impossible. In such cases, working while standing is permitted for at most one hour at a time, and four times per day at most (Arbo information sheet 8). For kneeling and squatting working postures, the inspectorate guideline states employees may bend through their knees and/or kneel a maximum of 40 times per hour or for 8 minutes per hour at most.[4] Additionally, the Labour Inspectorate enforces the regulations applicable to pregnant women, children and child care workers. According to the inspectorate, the standards for child care workers have been drafted on the initiative of the social partners and reflect the current state of the technology. Although the guideline appears to be health-based, the Committee has insufficient references to evaluate this.

Occupational diseases in The Netherlands must be registered and reported via the national reporting and registration system of the Netherlands Center for Occupational Diseases (NCvB). In order to stimulate and standardize the reporting of occupational diseases, the NCvB has issued registration guidelines for a number of disorders.[13] These registration guidelines were developed based on recent scientific literature from various databases. The NCvB's expert network was also asked to provide relevant publications.

For standing working postures, the NCvB indicates there is a risk of *plantar fasciitis* ('heel spur') if an employee stands for more than four hours per day. Other guidelines are available from the NCvB for kneeling and squatting while working. In the '*Osteoarthritis of the knee*' registration guideline, it states employees run an elevated risk of knee osteoarthritis if they spend more than 60 minutes per day performing work in a kneeling or squatting position for at least one year. Additionally, the NCvB indicates that working in a kneeling, squatting position leads to an increased risk of meniscus injury. Finally, the '*Pressure induced bursitis*' registration guideline states that employees run an elevated risk of acute and chronic bursitis in the pressure area of the knees if they spend at least eight hours within a three-day period for at least one month, exposed to pressure on the knee or working while in a kneeling position, respectively.

Finally, a Manual for pre-employment medical examinations was published in 2005 to aid occupational physicians and occupational health services perform pre-employment medical examinations. A pre-employment medical examination is only permitted if a job has specific health requirements. The Manual is a consensus document agreed to between stakeholders, and recommends a pre-employment medical examination to be performed for specific job requirements due to the potential health risks. The Manual indicates that for a specific job, a pre-employment medical examination should be considered if per day 15 minutes or more of working in a kneeling or squatting position may be required. Although this value may not be considered as a health-based OEL, it does indicate a limit for which stakeholders feel action is required.[14]

3.4 Summary

Based on the Working Conditions Act and international and European standards, the Committee notes there are no legal sources available that provide concrete pronouncements (in terms of duration, frequency and/or intensity) on health-based or safety-based OELs for working in a standing, kneeling or squatting position. The NCvB registration guidelines are designed to promote the quality of prevention, (early) diagnosis, treatment and support for occupational diseases, and act as guidelines for reporting occupational diseases. The scientific underpinning has not always been systematic. The Labour Inspectorate guidelines for working in a standing, kneeling or squatting position are designed for enforcement. The Committee has too little information on the scientific evidence of the inspectorate's guidelines to be able to judge them.

Chapter 4

Health effects of working in a standing, kneeling or squatting position: description

The Committee performed a systematic literature review, focusing on the following two questions: 1) What are the health and safety problems related to working in a standing, kneeling or squatting position, and 2) to what degree is exposure (in terms of duration, frequency and/or intensity) to working in a standing, kneeling or squatting position related to these problems?

4.1 Considerations

Longitudinal studies determine exposure to the risk prior to the health effect, resulting in the lowest chance of bias for the association. Therefore, the Committee values the results of longitudinal studies over those of case-control and cross-sectional studies. In this chapter, the Committee describes the results of the systematic literature review. Annex E describes the search strategy and how studies were selected and their quality evaluated.

4.2 Working in a standing position

Of the three working postures included in the systematic literature review, the most information is available on the 'standing working postures'.[15-40] Working in this posture is associated with lower back complaints and complaints of the lower limbs (hips, legs, knees, feet). All studies relating to health effects due to working in a standing position are summarized in a table in Annex F.

Lower back complaints

There are ten studies available examining the association between working in a standing posture and lower back complaints.[15-19,22,24,26,31,38] Most of these studies define lower back complaints as ‘pain occurring in the low back in the last year that lasted for more than one day’. Although not all studies present statistical degrees of association, the Committee is of the opinion that working in a standing posture appears to present an increased risk of low back pain.

Of the ten available studies into lower back complaints as a result of working in a standing position, three have a longitudinal design.[15,22,26]

Harkness et al. (2003) examined the association between working in a standing position and the occurrence of low back pain in a cohort of almost 1200 new workers in various sectors in Great Britain.[22] At the start of the study and after 12 and 24 months, exposure and complaints were self-reported using questionnaires. The authors defined low back pain as ‘pain persisting for more than 24 hours in the past month’ 64% of the cohort was male, with a median age of 23 years (range 21 to 28 years). Investigators found that workers who performed work while standing for between 15 minutes and two hours per working day did not have a statistically significant elevated risk of low back pain (OR = 1.6, 95% CI 0.8-2.9) compared with workers who perform less than 15 minutes of work while standing per day. Workers who work while standing for more than two hours per day also had no statistically significant elevated risk of low back pain (OR = 1.8; 95% CI 0.9-3.4). Workers who already had lower back complaints at the start of the study (25%) were excluded from follow-up. Of the workers without lower back complaints, 19% developed low back pain within 12 months; after another 12 months of exposure, the incidence* of low back pain was again 19%.

In a longitudinal study with a follow-up period of two years in a cohort of 4,006 individuals, Andersen et al. (2007) found that workers who spent more than 30 minutes per hour (this is over four hours per eight hour working day) working while in a standing position had over twice (HR = 2.1; 95% CI 1.3-3.3) the risk of developing low back pain than workers who worked less time in this posture.[15] Data on both the degree of working in a standing position and low back pain were obtained through self-reporting at the start of the study and after 24 months. Low back pain was defined as 'moderate to severe pain in the past 12 months'. 64% of the cohort was female, with a median age of 45 years (SD 10

* Incidence: new cases of workers with low back pain.

years). At the start of the study, 8% of participants reported no pain complaints (neck/shoulder, elbow/forearm/hand, lower back, hip/knee/foot) in the past year; 46% had mild complaints. After 24 months, 10.6% of workers had low back pain, with individual pain varying from moderate to severe.

Based on incidence data, Macfarlane et al. (1997) investigated the association between a number of occupational aspects, including alternating standing/walking and the incidence of low back pain in a cohort of almost 1500 workers in various sectors.[26] In a one year follow-up period, both exposure to alternating standing/walking and low back pain were self-reported by participants. Macfarlane et al. found that male workers who spent more than two hours per working day alternating standing and walking ran no statistically significant elevated risk (OR = 2.1; 95% CI 0.7-3.4) of low back pain compared with male workers with less exposure. However, female workers alternating standing and walking for more than two hours per working day did have a statistically significant elevated risk (OR = 3.5; 95% CI 1.4-8.8) of low back pain compared with female workers with less exposure. However, this study made no distinction between standing and walking. The Committee therefore did not include this study in its further evaluation. Figure 1 provides an overview of the associations found between working in a standing position and low back pain in longitudinal studies.

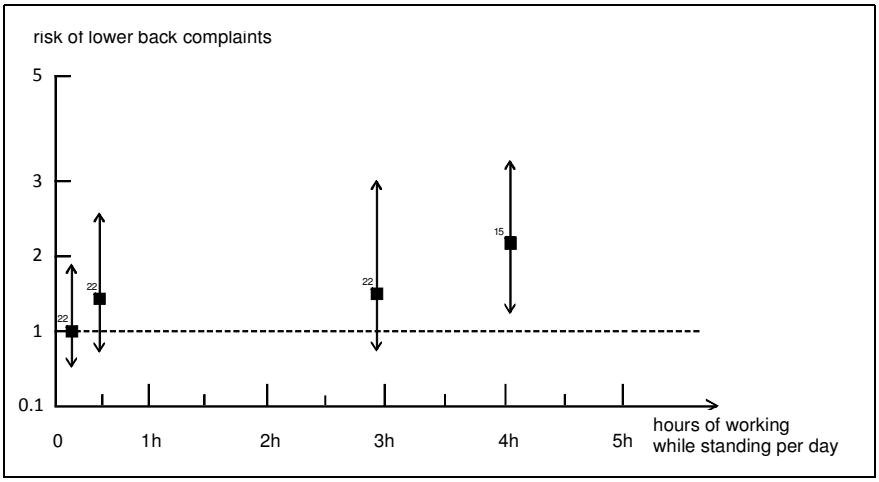

Figure 1 Association between working in a standing position and low back pain based on two longitudinal studies[15,22]. (Only the studies included in the meta analyses are displayed [see Chapter 6].)

The systematic literature review also located seven cross-sectional studies examining lower back complaints resulting from working in a standing position.[16-19,24,31,38] In the cross-sectional study by Bener (2004), workers with various jobs who performed sustained work in a standing position were six times (OR = 6.2; 95% CI 4.0-9.6) as likely to have low back pain as workers who almost never work in said posture.[16] In another cross-sectional study, Hou and Shiao (2006) found a smaller association, namely that nurses who spent between four and six hours per day working in a standing position have about one and a half times as many low back pain as colleagues who spent less than four hours working in a standing position.[24] The other five cross-sectional studies found no statistically significant increases in the occurrence of lower back complaints due to working in a standing position.[17-19,31,38]

Lower limb complaints

Working in a standing position is also associated with various types of lower limb complaints.[15,18-21,24,28,29,32,33,37,39] A few studies describe an association between working in a standing position and hip or knee osteoarthritis.[20,21,28,33,37,39] The majority of these studies describes general lower limb complaints, defined as pain in the knees, ankles, feet, upper or lower legs.[15,18,19,24,29,32]

The systematic literature review only identified one longitudinal study examining various types of hip, knee or foot pain resulting from working in a standing position.[15] This study (2 year follow-up in a cohort of 4006 participants; self-reported exposure to working in a standing position and complaints) found that working in a standing position for more than 30 minutes per hour was only just short of a statistically significant association (incidence 9.3%; HR = 1.7; 95% CI 1.0-2.9) with moderate to severe lower limb pain.

Seven case-control studies were found in which various types of lower limb complaints resulting from working in a standing position were examined.[20,21,28,32,33,37,39] Complaints were primarily knee or hip related. None of these case-control studies found a statistically significant association between working in a standing position and lower limb complaints. The study by Pope (2003), for example, found no statistically significant association (OR = 1.2; 95% CI 0.8-1.8) between working in a standing position and lower limb pain.[32] The case-control study by Yoshimura et al. (2004) also found that workers who work in a standing position for more than two hours per day did not have a

statistically significant increased risk (OR = 1.1; 95% CI 0.5-2.5) of lower limb complaints compared with less exposed workers.[39]

The systematic literature review found four cross-sectional studies examining various types of lower limb complaints resulting from working in a standing position.[18,19,24,29] Chandrasakaran et al. (2003), Chee et al. (2004), Hou et al. (2006) and Messing et al. (2008) studied the association between working in a standing position and the incidence of lower limb complaints.[18,19,24,29] All studies used self-reporting of pain complaints over the past year or since starting the job. The studies found that workers* who worked in a standing position for more than four hours per day, were two to six times as likely to have pain complaints in upper and lower legs, ankles or feet as workers who spent less than four hours per day working in a standing position.

Varicose veins

In addition to lower back and lower limb complaints, studies were also found that examined the incidence of varicose veins in the lower legs due to working in a standing position. In the studies by Sisto et al. (cross-sectional study) and Tuchsen et al. (longitudinal study), it was found that workers with various professions who often (about 50% of a working day) worked in a standing position had an elevated risk (OR = 1.25-2.29) of varicose veins in the lower limbs.[35,36]

4.3 Working in a kneeling position

Various scientific studies identified in the systematic literature review describe the effect of working in a kneeling position on low back pain, knee osteoarthritis and knee complaints.[20-22,28,31,39,41-47] Knee osteoarthritis has been studied the most. All studies relating to health effects due to working in a kneeling position are summarized in a table in Annex G.

Lower back complaints

The association between working in a kneeling position and lower back complaints was only examined in one longitudinal study (2 year follow-up) by Harkness et al. (2003).[22] Based on incidence figures (exposure to working in a

* The workers studied were assembly line workers, nurses and employees in other professions.

kneeling position and new cases of low back pain were self-reported), workers who spent up to 15 minutes per working day working in a kneeling position did not have a statistically significant elevated risk (OR = 1.2; 95% CI 0.8-2.0) of low back pain compared with workers who never worked in a kneeling position. For workers who performed more than 15 minutes of work in a kneeling position per working day, it was only just short of a statistically significant increased risk (OR = 1.7; 95% CI 1.0-2.9).

The systematic literature review identified two cross-sectional studies in which lower back complaints due to working in a kneeling position were studied.[45,47] In 1992, Holmstrom et al. (1992) found that the incidence of severe low back pain was associated with working in a kneeling position (in construction), with a prevalence ratio between 2.6 (95% CI 1.9-3.5; exposure of 1-4 hours per day) and 3.5 (95% CI 2.4-4.9; exposure >4 hours per day).[45] The cross-sectional study by Van Vuuren et al. (2005) found that workers (in a steel factory) working in a kneeling position (50% of a working day or longer) had a statistically significant increase in (OR = 4.6; 95% CI 1.2-16.6) low back pain compared with workers who did not work in a kneeling position.[47]

Knee osteoarthritis

Knee osteoarthritis as a consequence of working in a kneeling position is described in numerous studies.[20,28,39,41-44,46] Most studies define knee osteoarthritis according to the Kellgren/Lawrence scale (grade 3 or 4) or the WORMS criteria using radiography.[48,49] The systematic literature review found no longitudinal studies into the association between working in a kneeling position and knee osteoarthritis.

The systematic literature review found five case-control studies in which knee osteoarthritis due to working in a kneeling position was examined.[20,28,39,44,46] According to Cooper et al. (1994), workers with a variety of professions who spend more than half an hour per day working in a kneeling position have an increased risk of knee osteoarthritis.[20] These findings were confirmed by a study by Dawson et al.[44] However, other case-control studies found no association between the incidence of knee osteoarthritis and working in a kneeling position.[28,39,46]

Three cross-sectional studies examined knee osteoarthritis as a consequence of working in a kneeling position.[41-43] Studies by Baker et al. (2002) and Coggon et

al. (2000) found that workers* who work in a kneeling position for more than one hour per working day were about twice as likely to have knee osteoarthritis as workers who hardly ever work in a kneeling position.[42,43] On the other hand, the cross-sectional study by Amin et al. (2008) found a non-statistically significant incidence (OR = 1.6; 95% CI 0.9-3.0) of knee osteoarthritis among workers who worked in kneeling/squatting positions combined with heavy lifting.[41]

Knee complaints

In a cross-sectional study, Nahit (2001) examined the relationship between working in a kneeling position and knee complaints in general: workers (with different professions) who spent 15 minutes or more in a kneeling position during their working day were found to have more knee pain than workers who did not perform any kneeling work (OR = 1.8; 95% CI 1.2-2.6).[31]

4.4 Working in a squatting position

As for working in a kneeling position, various scientific studies describe low back pain, knee osteoarthritis and lower limb complaints in relation with working in a squatting position.[15,17-22,31,37,39,41-43,46,50-52] Of these types of complaints, knee osteoarthritis has been studied the most.[20,39,41-43,46,50] All studies on the health effects of working in a squatting position are summarized in a table in Annex H.

Lower back complaints

Four studies examine the association between working in a squatting position and lower back complaints.[15,22,31,52] As for working in a kneeling position, lower back complaints were defined as pain in the lower back lasting for more than one day.

The systematic literature review identified two longitudinal studies that examined lower back complaints due to working in a squatting position.[15,22] The study by Harkness et al. (2 year follow-up in almost 1,200 new workers; self-reported exposure to working in a squatting position and low back pain) found that workers who performed work in a squatting position for up to 15 minutes per

* Baker et al. studied workers in various professions, Coggon et al. focused primarily on workers in agricultural and construction sectors.

working day had no statistically significant risk increase (OR = 1.1; 95% CI 0.7-1.7) for the incidence of developing low back pain compared with workers who were not exposed.[22] On the other hand, workers who spent more than 15 minutes per working day performing work in a squatting position did show a statistically significant increase in the risk (OR = 1.8; 95% CI 1.1-3.1) of low back pain compared to unexposed workers.

In a longitudinal study with a follow-up period of two years, Andersen et al. (2007) found that workers who spent more than 5 minutes per hour (so over 40 minutes per day) working in a squatting position were only just short of a statistically significant increased risk (HR = 1.5; 95% CI 1.0-2.1) of moderate and severe low back pain compared with workers who spent less time working in this posture.[15]

Figure 2 displays an overview of the associations found in the longitudinal studies that are included in the meta-analyses between a squatting working posture and low back pain in the next chapter.

The systematic literature review found one case-control study examining the association between a squatting working posture and lower back complaints.[52] This study by Yip et al. (2004) found that sustained work in a squatting position significantly increased the risk of low back pain (OR = 1.7; 95% CI 1.1-2.7).[52] This finding was not confirmed by the cross-sectional study by Nahit et al. (2001).[31]

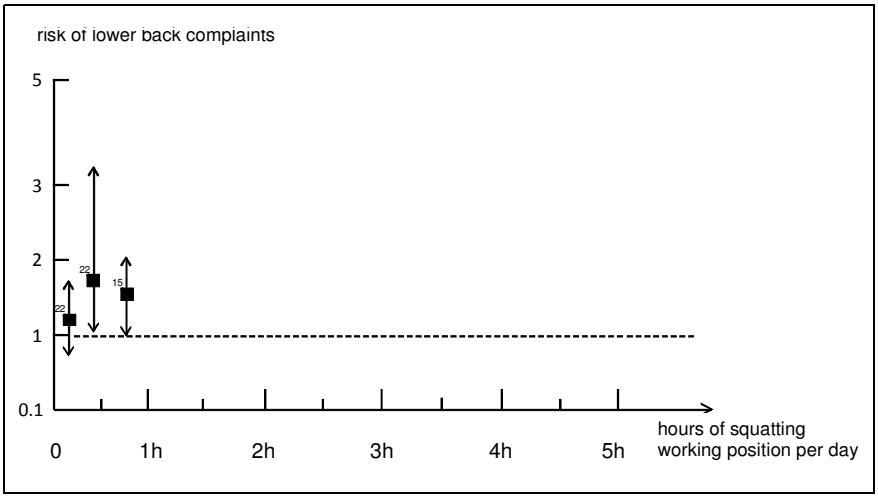

Figure 2 Associations between working in a squatting position and low back pain based on two longitudinal studies[15,22]. (Only the studies included in the meta analyses are displayed [see Chapter 6]).

Knee osteoarthritis

Seven studies examined the association between working in a squatting position and knee osteoarthritis.[20,39,41-43,46,50] As for working in a kneeling position, knee osteoarthritis was defined according to the Kellgren/Lawrence scale (grade 3 or 4) or the WORMS criteria using radiography.[48,49]

The association between working in a squatting position and knee osteoarthritis was only examined in one longitudinal study (40 year follow-up) by Felson et al. (1991).[50] This study found that male workers performing work in a squatting position (self-reported exposure to working in a squatting position) combined with light physical activity did not have a statistically significant elevated risk (OR = 1.1; 95% CI 0.5-2.1) of knee osteoarthritis compared with male workers who never worked in a squatting position. Female workers performing work in a squatting position (self-reporting) combined with light physical activity also did not have a statistically significant elevated risk (OR = 1.6; 95% CI 0.8-3.0) of knee osteoarthritis compared with female workers who never worked in a squatting position.

The systematic literature review identified three case-control studies in which knee osteoarthritis as a result of working in a kneeling position was studied.[20,39,46] The study by Cooper et al. (1994) found that workers who spent more than 30 minutes per working day working in a squatting position were almost seven times as likely to have knee complaints as workers who were less or not exposed to this risk.[20] A marginal note is that this case-control study had a small number of participants (eleven and four, respectively). The two other case-control studies found no statistically significant association between a squatting working posture and knee osteoarthritis.[39,46]

Three cross-sectional studies examined knee osteoarthritis as a consequence of working in a squatting position.[41-43] Studies by Baker et al. (2002) and Coggon et al. (2000)* found that workers who work in a squatting position for more than one hour per working day were about twice as likely to have knee osteoarthritis as workers who hardly ever work in a squatting position.[42,43] On the other hand, the cross-sectional study by Amin et al. (2008) found that workers who work in a squatting/kneeling position, in combination with heavy lifting, did not have a

* Baker et al. studied workers in various professions, Coggon et al. focused primarily on workers in agricultural and construction sectors.

statistically significant increase (OR = 1.6; 95% CI 0.9-3.0) of knee osteoarthritis compared with workers who were less exposed.[41]

Lower limb complaints

A squatting working posture is also associated with lower limb complaints other than osteoarthritis.[15,21,31,46,51] Andersen et al. (2007), in a longitudinal study based on incidence figures (2-year follow-up period, self-reported exposure to a squatting working posture and moderate and severe lower limb pain), found that workers who spent more than 5 minutes per hour (so more than 40 minutes per day) working in a squatting position had a statistically significant elevated risk (HR = 1.6; 95% CI 1.1-2.3) of lower limb pain (hips, knees, feet) compared with workers who spent less time working in this posture.[15]

These findings were not confirmed by Tuchsen et al. (2003).[51] In this longitudinal study based on self-reported complaints in the past 12 months (5-year follow-up period, self-reported exposure to a squatting working posture and lower limb complaints), the authors found that workers who spent more than 25% of a working day (over 2 hours) working in a squatting position had a lower risk (OR = 0.6; 95% CI 0.4-0.9) of hip complaints compared to less exposed workers. Although selection processes in certain professions could not be excluded, the investigators stated that squatting regularly stretches leg and hip muscles, which may have preventive effects.

The systematic literature review yielded two case-control studies in which hip osteoarthritis as a result of working in a squatting position was studied.[21,46] Croft et al. (1992) found that workers who spent over 30 minutes per working day working in a squatting position did not have an increased risk of hip osteoarthritis (OR = 0.7; 95% CI 0.4-1.4). Lau et al. (2000) also found that workers exposed to more than one hour per day of working in a squatting position were (just) short of having a statistically significant increased risk (OR = 1.3; 95% CI 0.5-3.2 for men; OR = 1.6; 95% CI 1.0-2.8 for women) of hip osteoarthritis compared with less exposed workers.

One cross-sectional study examined the incidence of knee complaints due to working in a squatting position.[31] Nahit et al. (2001) found that workers who spent longer than 15 minutes per working day performing work in a squatting position had no statistically significant higher prevalence (OR = 1.3; 95% CI 0.8-1.9) of knee pain compared with workers who spent fewer than 15 minutes in a squatting working posture.

4.5 Other findings

Six studies in the literature review examined the association between working while standing and the risk of preterm birth in pregnant women.[23,25,27,30,34,40] In general, these studies defined the birth of a child between week 20 and 37 of pregnancy as preterm.

One of these studies was a meta-analysis of 29 studies identified in a systematic literature search in Medline (from 1966 to 1998).[30] Based on a pooled risk estimate, the authors found that pregnant women who worked in a standing position for more than 3 hours per working day had a higher risk (OR = 1.3; 95% CI 1.1-1.4) of preterm birth compared with pregnant women who performed less or no work in a standing position. The five other studies also found a statistically significant association: pregnant workers who performed work in a standing position for 4 hours or more, combined with walking or not, were about three times as likely to have a preterm birth as pregnant colleagues less exposed to this risk.

The systematic literature review found three longitudinal studies examining the risk of preterm births due to working in a standing position.[23,27,40] Based on incidence figures, the longitudinal study (2-year follow-up) by Henriksen et al. (1995) found that women who worked in a standing position for two or more hours per working day did not have a statistically significant increase in the risk (OR = 1.1; 95% CI 0.7-1.5) of preterm birth compared with women who spent less than 2 hours per working day working in a standing position.[23]

A statistically significant risk of preterm birth as a consequence of working in a standing position was also absent in the longitudinal study by Magann et al. (2005).[27] In a cohort of 814 women, followed for the duration of their pregnancy it was found that female workers who worked in a standing position for more than 4 hours per working day did not have a statistically significant increase in the risk (OR = 1.2; 95% CI 0.8-3.0) of preterm birth compared with women who were exposed for less than 4 hours per working day.

The longitudinal study by Fortier et al. (1995), in a cohort of over 4000 women (nine-month follow-up) found that workers who worked in a standing position for three or more hours per working day did not have an increased risk of preterm birth compared with female workers who spent fewer than three hours per day working in a standing position.[40]

The systematic literature review found two case-control studies in which preterm birth as a result of working in a standing position was studied.[25,34] The study by Luke et al. (1994) found that women who spent between four and six hours per working day working in a standing position did not have a statistically significant higher risk of preterm birth (OR = 1.8), and women who were exposed for more than six hours per working day had a statistically significant increase in the risk of preterm birth (OR = 2.9, $p<0.001$).[25]. These findings were confirmed in the case-control study by Saurel-Cubizolle et al. (2004), which found that pregnant women who spent over six hours per working day working in a standing position had a significantly higher risk of preterm births (OR = 1.3; 95% CI 1.1-1.5).[34]

4.6 Subjects for discussion in epidemiological research

Importance of study design

Longitudinal research in which exposure is determined prior to the health effect has the lowest risk of bias for the association between exposure and effect. Such research provides the most reliable picture. In case-control studies, minimal bias may be expected if the determination of exposure is blinded from patient status. Case-control studies in which exposure is based on questionnaires or interviews has similar problems to cross-sectional research, in which self-reported exposure may be affected by health status.

Therefore, the Committee places a greater value on the results of longitudinal studies. If unavailable, it then turns to case-control studies, as long as exposure is not self-reported. The Committee only views cross-sectional research as indicative of an association.

Self-reported exposure and complaints

Non-specific lower back complaints can only be determined by asking individuals themselves. All epidemiological studies had self-reported measures for exposure, obtained through questionnaires or interviews; no independent measures or registrations were performed. The health effects were also self-reported where local (pain) complaints were concerned. Only for knee osteoarthritis was independent registration used. Comparative research into self-reporting and measurements for working postures such as sitting and standing/ walking showed the validity of self-reporting for mapping the duration of exposure.[53,54] The Committee therefore views self-reported exposure to working

in a standing, kneeling or squatting position and of pain complaints as a sufficiently reliable method.

Potential confounding factors

Given the reporting, the Committee notes that the studies into kneeling and squatting working postures insufficiently differentiate exposure; information on whether exposure was continuous or encompassed multiple episodes is lacking.

Additionally, the Committee cannot rule out that lower back complaints associated with kneeling or squatting are (partially) caused by a bent-over torso posture occurring in said working postures. The selected epidemiological studies do not report on this at all. Also, work floor exposure often encompasses multiple risk factors with a common physical point of impact. For example, back complaints may not only be caused by working in a standing, kneeling or squatting position, but also by other physical risk factors such as manual lifting. This is often not discussed in the studies, in part because in practice these activities occur side by side.

The longitudinal and other epidemiological studies found clear associations between psychosocial factors (e.g. control over work, monotonous work and stress index) and lower back complaints.[15,22,45,55] There are various theories about the relationship between psychosocial factors and musculoskeletal disorders.[56] The Committee cannot indicate to what degree such factors contribute to the relationships identified between working in a standing, kneeling or squatting position and musculoskeletal complaints.

Working in a standing, kneeling or squatting position and specific groups

The Committee did not systematically review whether specific groups of workers are at greater risk of health effects due to working in a standing, kneeling or squatting position. However, the literature review was structured so broadly that data on specific groups was obtained. For example, multiple studies examining the consequences of sustained standing for pregnant women were found. They showed that sustained standing (more than 3-4 hours per working day) led to an increased risk of preterm birth.

Based on available epidemiological studies, the Committee cannot determine whether the risks of working in a standing, kneeling or squatting position differ for men and women. In incidental cases, studies found differences, but the results were inconsistent. On the other hand, studies among the Dutch general population have shown that the prevalence of hip and knee osteoarthritis in

particular is higher among women than men. Women are also more affected by lower back complaints.[57]

The Committee was also unable to determine whether there is an age-dependent risk. The available studies did not look at the effects of age in relation to health effects of working in a standing, kneeling or squatting position.[57]

4.7 Summary of longitudinal study results

The systematic literature review showed that working in a standing, kneeling and squatting position can pose a risk for the development of lower back and lower limb complaints. There are three longitudinal studies that examined these complaints .[15,22,26] One of these three studies investigated the occurrence of lower back complaints due to a combination of two risk factors, namely (alternating) standing and walking, so the Committee did not use this study. This left two longitudinal studies examining the occurrence of lower back and lower limb pain due to working in a standing, kneeling or squatting position.[15,22] An overview of the findings and exposure-response relationships from these two longitudinal studies is presented in Table 1.

Table 1 Exposure-response relationships from two longitudinal studies.

	Lower back pain		Lower limbs pain		Reference
	exposure	risk measure (95%CI)	exposure	risk measure (95%CI)	
Standing working posture	<15 min/day	1.1 (0.6-2.1)a 1.0 (0.5-1.9)b			22
	15 min-<2h/day	1.6 (0.8-2.9)a 1.4 (0.7-2.7)b			
	≥2h/day	1.8 (0.9-3.4)a 1.5 (0.8-3.0)b			
	>30min/h	2.1 (1.3-3.3)c 1.9 (1.2-3.0)d	>30min/h	1.7 (1.0-2.9)c	15
Kneeling working posture	<15 min/day	1.,4 (0.9-2.2)a 1.2 (0.8-2.0)b			22
	≥15 min/day	2.1 (1.3-3.3)a 1.7 (1.0-2.9)b			
Squatting working posture	<15 min/day	1.1 (0.7-1.7)a			22
	≥15 min/day	1.8 (1.1-3.1)a			
	>5 min/h	1.5 (1.0-2.1)c	>5 min/h	1.6 (1.1-2.3)c 1.2(0.8-1.8)d	15

CI, confidence interval; min, minutes; h, hours

a corrected for age, gender and profession
b corrected for a and other postures
c corrected for gender, age, profession and intervention group
d corrected for c and other pain complaints

Working in a standing position

The systematic literature review identified two longitudinal studies that investigated the occurrence of lower back and lower limb pain due to working in a standing position.[15,22] One of the two studies found that working in a standing position for more than 30 minutes per hour (this is four hours per eight hour working day) resulted in a significantly increased incidence of low back pain over the past year.[15] The second study found no statistically significant risk increase for the three defined levels of exposure compared with workers who did not have to stand.[22] There was a consistent increase in the risk of low back pain in the past month associated with an increase in duration of working in a standing position, but the trend was not statistically significant. Little is known about the shape of the exposure-response relationship. It is also not possible to identify a level of exposure below which there is a degree of certainty that no back complaints will occur. The available data is too limited for this.

Working in a kneeling position

The systematic literature review found one longitudinal study that examined the occurrence of lower back complaints due to working in a kneeling position.[22] The study showed indications that working in a kneeling position for more than 15 minutes per day is associated with a two time higher risk of low back pain. The Committee cannot comment on the shape of the exposure-response relationship based on available data. It is also not possible to define a safe threshold limit based on the data. This is because health complaints were only examined for two different exposure levels. Additionally, insight is lacking into the average exposure duration of workers in the group exposed more than 15 minutes per day.

Working in a squatting position

The systematic literature review into the incidence of lower back and lower limb complaints due to working in a squatting position found two longitudinal studies.[15,22] One of the two studies found that spending 15 minutes per day or longer working in a squatting position increased the risk of low back pain. In the second longitudinal study, the association between working in a squatting position and low back pain was only just short of significance, but a significantly increased risk of hip, knee and foot pain was found. Given the limited data and lack of insight into the average exposure of workers who were exposed for more

than 15 minutes, the Committee is of the opinion that it is impossible to determine a safe threshold limit.

Chapter 5

Possibilities for health-based or safety-based OELs

As described in Chapter 1, the Committee was asked to investigate the possibilities for setting health-based or safety-based OELs for the occupational risks of working in a standing, kneeling or squatting position. A great deal has been published on deriving health-based OELs for substances.[58-60] For many substances, based on an understanding of their mechanisms of action, it should be possible to define an exposure level in the air at which adverse health effects may reasonably be expected to be prevented.

5.1 Health-based recommended OEL

For the risks of working in a standing, kneeling or squatting position, the Committee expects that it should in theory be possible to identify an exposure level below which the risk of adverse health effects is zero. To derive a health-based recommended OEL, standard procedure is to determine to what degree epidemiological literature contains indications for the height of the threshold limit.

For working in a standing position, the two longitudinal studies indicate an exposure-response relationship, where working in a standing position for over 30 minutes per hour results in a statistically significant increase in the risk of low back pain. Only one study was available on working in a kneeling position in relation to low back pain, which found that 15 minutes or more of working in a kneeling position per working day significantly increased the risk of complaints.

The same result was found for the relationship between working in a squatting position and low back pain. However, these findings were not confirmed in the second longitudinal study, which found that exposure for 5 minutes per hour did not lead to a significantly increased risk.

The Committee concluded in Chapter 4 that the epidemiological data currently available do not allow evidence-based conclusions to be drawn about the precise level of a health-based recommended OEL for these risks.

5.2 Risks

The Committee views working in a standing, kneeling or squatting position as a relevant occupational risk. The Committee is also worried by the fact that no firm point of view appears to be possible on the degree of risk faced by workers who work in a standing, kneeling or squatting position. The Committee therefore suggests an alternative approach. This approach is derived from the approach applied for genotoxic carcinogenic substances.[61,62] Risk values are calculated for these substances. Risk values are exposure levels for predefined additional risks (or reference values). For carcinogens, the levels of exposure are determined at which 4 additional cancer deaths per 1,000 or 100,000 deaths occur following 40 years of occupational exposure. The above reference values are specific to carcinogenic substances and are only given as an example here. A similar approach is sometimes used for airway allergens.

The Committee ascertains that the principles for determining reference values are explicitly associated with the (type of) occupational risk. Health considerations are not the only ones that play a role. Policy and social considerations must also be taken into account.

Health-based recommended occupational exposure limit	*Exposure or burden level* at which adverse health effects may reasonably be expected to be prevented.
Risk value or risk level	*Exposure or burden level* that may reasonably be related to a certain (predefined) additional risk of adverse health effects
Reference value	An accepted *additional risk* of an effect due to exposure or burden, compared with the risk of an effect in the general population

5.3 Meaning of lower back and lower limb complaints

Many people occasionally experience back and knee trouble. Where chronic complaints and knee osteoarthritis are concerned, it is clear these are adverse

health effects. The longitudinal studies into the effects of working in a standing, kneeling or squatting position, however, are primarily focused on low back pain and pain in the lower limbs in the past 12 months that persisted for at least 24 hours. The question arises to what degree (brief) episodes of pain symptoms herald chronic complaints, and what the consequences of having such complaints are. In order to answer this question, the Committee checked what is known about the prevalence and prognosis of the complaints found, along with disease burden and sick leave.

It is internationally accepted that back complaints persisting for longer than three months may be considered chronic, although debate on the exact definition continues.[63,64] The NHG standard* for non-specific back pain indicates that back complaints are chronic if they are present continuously for more than 12 weeks.[25]

5.3.1 *Prevalence*

In order to assess the relevance of the complaints that develop due to working in a standing, kneeling or squatting position, the results of the epidemiological studies were compared with the prevalence of such complaints among the general population.

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 12 month period; point prevalence was 27%. About 23% of people with low back pain reported chronic pain, with 3% reporting it as 'continuous severe' and 20% as 'continuous mild'. About 63% (15% of whom reported as 'recurring severe' and 48% as 'recurring mild') indicated that pain complaints recurred.[65] Only 5% indicated the pain complaints were a one-off event.

Lower limb complaints

In the sample of the Dutch population, the prevalence over a 12 month period was 13% for hip complaints, 22% for knee complaints, 9% for ankle complaints and 9% for foot complaints. Point prevalence was 9% (hip), 15% (knee), 5%

* A guideline from the Dutch College of General Practitioners.
** Self-reporting via questionnaire: 'Have you had pain during the past 12 months'.

(ankle) and 7% (feet), respectively. For chronic complaints, prevalence was: 7%, 12%, 4% and 5%.[65] Of the people with hip or knee complaints, 5% described the pain as 'continuous severe', 28% as 'continuous mild', 10% as 'recurring severe' and 46% as 'recurring mild'. Percentages for ankle and foot complaints were 6%, 30%, 12% and 35%, respectively. In another publication, the investigators reported prevalence figures of 10% for knee osteoarthritis and 4% for hip osteoarthritis.[57]

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

5.3.2 *Prognosis*

Also the course of the complaints that develop as a consequence of working in a standing, kneeling or squatting position may be assessed on the basis of scientific data.

Lower back complaints

In the majority of cases, back pain is short-lasting and disappears after a few weeks.[66] Furthermore, back complaints are known to present with multiple episodes,[67] which may turn into a chronic condition.[64,68]

In a longitudinal study, patients in general practice in Amsterdam and surroundings with both chronic and beginning back pain were studied. Patients were monitored for one year using a monthly questionnaire. Patients with milder back complaints were less well represented in the patient population than those with more severe back pain. The median time to recovery was 7 weeks. After 12 weeks, 35% of patients still had complaints, and after one year this dropped to 10%.[69] Furthermore, the study showed that 75% of patients had to deal with recurring complaints, and that on average, they had two episodes of relapsing symptoms, the first after about seven weeks.

The prevalence of chronic pain* in the lower back in a sample of the Dutch population over the age of 25 years was 21%.[65]

A recent Dutch study found that stable pain intensity in particular as well as the degree of disability during the first three months were relatively good predictors

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

for the development of chronic lower back complaints (37% of explained variance). In this study, chronic lower back complaints were defined as 'persistent pain with an intensity of ≥ 4 on the Numerical Rating Scale at baseline and >3 at 3 and 6 months follow-up'[63]

Lower limb complaints

A longitudinal study among patients with knee complaints in Dutch general practice found that after three months, 25% of patients had recovered, with the percentage rising to 44% after 12 months. The average pain score (WOMAC*) had improved by 36% after three months, and by 46% after 12 months. Scores for physical functions (WOMAC) improved by comparable percentages.[70] Recovery from knee complaints after three months was primarily dependent on gender (male), shorter duration of symptoms, lower (WOMAC) score for stiffness, and menopause. Predictive factors for recovery after 12 months were: no previous episodes of knee complaints and a lower pain score (WOMAC).

5.3.3 Sick leave and disease burden

A third measure to assess the meaning and severity of complaints due to working in a standing, kneeling or squatting position are data on sick leave and disease burden.

Lower back complaints

Although the prevalence of low back pain in the general population is high, with 33% of people stating it inhibited their daily life, 70% of people with back complaints had not taken sick leave in a one year period.[65] Of the people with lower back complaints, 32% visit the GP each year.

In 2007, the National Institute for Public Health and the Environment (RIVM) estimated disease burden relating to working conditions in the total Dutch population. As a measure for this calculation, investigators used Disability Adjusted Life Years (DALY).[66] 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.[71] 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

* WOMAC: Western Ontario and McMaster Universities Arthritis Index.

burden in The Netherlands. The estimated disease burden for the potential and active labour force were, respectively, 26,300 and 16,700 DALYs. For back complaints as a result of sustained bending forward with the upper body, the calculated disease burden was 1,720 DALYs for the active labour force.

Lower limb complaints

Prevalence figures for hip and knee complaints in the general population were more positive: 30% of people felt inhibited in daily life due to the complaints, while for 80%, they were not a reason for absenteeism, 5% missed less than one week of work and 4% one to four weeks.[65] 33% of people with hip or knee complaints visit the GP each year. This percentage is 40% for ankle and foot complaints. Five percent of interviewed people were (partially) on work disability due to hip or knee complaints.

For knee osteoarthritis due to frequent kneeling and squatting, disease burden in the active labour force is estimated at 600 DALYs, and 2,700 DALYs in the active and formerly active labour force.[66] The disease burden due to knee osteoarthritis (multiple causes) in the general population was 56,400 DALYs.

5.4 Summary

The Committee concludes that, based on available data on the risks of working in a standing, kneeling or squatting position, it is not possible to set a health-based OEL. The Committee therefore proposes a different approach. What health risks are the result of exposure, to what degree do they occur and what impact do they have? The challenge is to define a prescriptive framework, as has been done for other risks (carcinogenic substances and allergens). Such a framework may be helpful in deciding which risks are still acceptable.

Chapter 6

Meta-analyses

After describing the primary studies from the systematic literature review, the Committee presents the combined results in this chapter. By analysing the results of previous studies jointly (meta analysis), perhaps conclusions may be drawn and insights be generated that were not possible based on each individual study. A meta- analysis is performed in this chapter in order to evaluate the effect of working in a standing, kneeling or squatting position on lower back complaints.

6.1 Background

As the results from most longitudinal studies showed barely or barely not significant associations between standing, kneeling or squatting working postures and lower back complaints, the Committee decided to perform a number of meta analyses. Combining the results of individual studies in one meta-analysis increases statistical power.

The Committee's choice to only use data from longitudinal studies is based on the fact that exposure is measured prior to the health effect in these studies, thus minimizing the chances of bias for the association and therefore providing the most valid picture. The Committee realizes both meta-analyses are based on only two longitudinal studies. Of course, this affects how generally applicable the outcomes of the meta-analyses are.

6.2 Conditions and assumptions

Studies must meet a number of conditions for meta-analyses to be conducted. For example, it is necessary for exposure and health effects in various studies to be comparable. In the selected longitudinal studies, the influence of exposure duration was the primary measure. Minor differences in definition for exposure as well as health effects were accepted.[72]

In summary, the Committee sets the following requirements for the epidemiological studies:

- a longitudinal study design
- a comparable reference group (i.e.: not or minimally exposed)
- a comparable method for measuring the degree of working in a standing or squatting posture (self-reported)
- a comparable definition of a health effect
- a comparable method for measuring the health effect (self-reported).

The Committee also made two assumptions in order to perform the analyses.

The Committee is of the opinion that, based on the results in Table 1, it is reasonable to assume that the risk of health complaints increases with increasing exposure duration. Data regarding the shape of the exposure-response relationship are scarce, however. For physical occupational risks, a linear relationship is not necessarily expected, as postures, movement and burdens are part of normal human movement. It is likely that both the lack of any physical burden as well as excessive burden may yield health risks.[73]

For working in a standing position, longitudinal studies only provide indications of a linear relationship (Table 1). For working in a kneeling and squatting position, on the other hand, a linear relationship appears more likely as there is already an increased risk following brief exposure (15 minutes). Given the limited available data, the Committee currently assumes a (log) linear relationship between exposure to working in a standing, kneeling or squatting position and the complaints observed. This linear relationship appears to hold true for at least part of the exposure-response relationship.

The second assumption is that the reference group has not been exposed to the studied working posture (i.e. prevalence or incidence of musculoskeletal complaints equal those in the general population).[65,74]

6.3 Execution

Given the differences between exposure cut-offs in the longitudinal studies, in this case for working in standing and squatting positions, the Committee decided to convert the exposure-response relationships from these studies into a comparable risk measure of two hours of standing working posture per day and 30 minutes of squatting working posture per day. This conversion was performed for each study using SPSS 16.0.*

The meta-analyses were performed using the calculated slope of the exposure-response curve and expressed as a regression coefficient with standard error. In the meta-analyses, these regression coefficients were weighted for variance in order to account for discriminating power (based, among other things, on the size of the study population and the number of incident cases) of the original studies. Pooled risks were calculated in order to evaluate the effect of a 30 minute (squatting) and two hour (standing) increase in exposure per day on lower back complaints.

6.4 Results

Working in a standing position

The systematic literature review found that three longitudinal studies with lower back complaints as outcome measures qualified for meta-analysis.[15,22,26] One longitudinal study proved unusable because the health complaints were not related to working in a standing position, but rather to the combination of standing and walking.[26] The other two longitudinal studies used comparable reference groups, with comparable definitions for low back pain, namely *'any pain, ache, symptom or discomfort in the (lower) back region for at least one day in the past month[22] or in the past 12 months[15]'*.

* *If different risk measures were used for sequential exposure categories within one study:* the slope of the exposure-response curve was calculated using a log linear regression model [$y = e^{\alpha+\beta X+\log(N)}$ in which: Y = number of people with new complaints (incidence), X = exposure measure for working in a standing or squatting position, N = number of people in study population. The exposure measure was expressed as an odds ratio [exp (X)].] In each study, the middle value per broad exposure category was used as a point estimate for exposure (e.g. 2 hours for exposure category 0-4 hours). *In cases where a single risk measure was presented within a study:* this risk measure is converted to the risk for 30 minutes (squatting) or two hour (standing) per day increase in exposure, with the middle value in a broad exposure category again being used as a point estimate for exposure.

Using the meta-analysis (based on two longitudinal studies), the Committee calculated the size of the risk measure for working in a standing position per two hour per day increase in exposure. The pooled risk estimate is 1.44 (95% CI 1.14-1.82) per two hours of working in a standing position per day.

Working in a kneeling position

The systematic literature review yielded a single longitudinal study for working in a kneeling position.[22] It was therefore impossible for the Committee to conduct a meta analysis.

Working in a squatting position

The systematic literature review identified two longitudinal studies with lower back complaints as outcome measures that qualified for meta analysis.[15,22] These studies used comparable reference groups and comparable definitions for low back pain, namely: *'any pain, ache, symptom or discomfort in the back region for at least one day in the past month[22] or in the past 12 months[15]'*.

Using the meta-analysis (based on two longitudinal studies), the Committee calculated the size of the risk measure for working in a squatting position per 30 minute per day increase in exposure. The pooled risk estimate is 1.21 (95% CI 1.02-1.43) per 30 minutes of working in a squatting position per day.

6.5 Summary table

Table 2 provides an overview of the results of the meta-analyses performed for further assessing the effect of working in a standing or squatting position on health outcomes. The table displays various exposure-response relationships from selected studies converted to comparable risk estimates for two hours per day of working in a standing position and 30 minutes per day of working in a squatting position.

The meta-analyses assumed that the estimated risk is applicable to both the incidence of new episodes of lower back complaints in the past 12 months and in the past month.

Table 2 Results of the meta-analysis per two hour increase in exposure per day to working in a standing position and 30 minute increase in exposure per day to working in a squatting position.

Risk	Health effect	Study design	Number of studies	Pooled risk (95% CI)
Working in a standing position	Lower back pain[a]	Longitudinal	2 [15,22]	1.44 (1.14 - 1.82) per 2 hours
Working in a squatting position	Lower back pain	Longitudinal	2 [15,22]	1.21 (1.02 - 1.43) per 30 minutes

CI, confidence interval

[a] Self-reported non-specific lower back complaints in the past 12 months.

Chapter 7

Health risks of working in a standing, kneeling or squatting position

In this chapter, the Committee describes to what degree working in a standing, kneeling or squatting position are risk factors for the development of physical complaints, and the severity of the complaints found. The Committee indicates the possibilities regarding health-based recommended OELs and potential alternative approaches. Uncertainties in available scientific literature are also addressed.

The available scientific data demonstrates relationships between the duration of working in a standing, kneeling or squatting position and musculoskeletal complaints.

7.1 Working in a standing position

The Committee concludes, based on two longitudinal studies into the effects of working in a standing position on health (see Chapter 4) that this occupational risk may result in health complaints. Working in a standing position is associated with lower back complaints, hip, leg, knee, foot and ankle complaints and the occurrence of varicose veins.

7.1.1 *Lower back complaints*

The longitudinal study by Harkness et al. shows a steady increase in risk of low back pain in the past month for an increased duration of working in a standing position, but the risk of these complaints was not statistically significant in any of the exposed groups, including among employees who spent more than two hours per day working in a standing position [22]. In another longitudinal study, however, Andersen et al. found a statistically significant increased risk of low back pain with moderate to severe pain in the past 12 months if work was performed while standing for more than 30 minutes per hour.[15]

Combining the results of both longitudinal studies in a meta-analysis resulted in a statistically significant risk increase (about 45%) for the incidence of episodes of lower back complaints in the past 12 months for each two hour increase in working in a standing position.

To subsequently provide an impression of the degree to which working in a standing position affects the incidence of lower back complaints in The Netherlands, the Committee used the results of the meta-analysis to calculate the additional cases of lower back complaints that would develop following 1, 2, 3 and 4 hours of exposure (Table 3). The calculations are based on: the pooled risk estimate from the meta-analysis (see Section 6.5) and the data from the longitudinal studies on the incidence of low back pain after one year of exposure. The durations of exposure used in these calculations fall within the observed exposure range for both studies.

In order to gain insight into the consequences of the risks found for the situation in The Netherlands, the Committee sought out data on the incidence of lower back complaints among the Dutch labour force who had no relevant exposure (in the past 12 months) to physical burden. However, these data were not available. Based on registrations from General Practice, the estimated incidence of lower back complaints requiring medical care is 6.75%. The number of back complaints in the labour force is underestimated based on these figures, as the severity of back complaints increases the odds of visiting the GP, creating selection bias for more serious complaints. The best estimates for the number of back complaints without physical burden are provided by a large study by Hoogendoorn et al. The annual incidence of new cases of lower back complaints in the average labour force in this study is 13%. This is the incidence of lower back complaints in a working population not specifically selected for physically demanding jobs.[75]

Table 3 Calculated incidence of low back pain in The Netherlands in 12 months for working in a standing position based on two longitudinal studies [15,22]

Low back pain	Working in a standing position					
	Without exposure to physical burden	30 minutes per day	1 hour per day	2 hours per day	3 hour per day	4 hour per day
Pooled incidence per year (%)	13.0	14.1	15.2	17.7	20.5	23.7
Additional incidence per year (%)		1.1	2.2	4.7	7.5	10.7

Calculations show that one hour of work in a standing position per day leads to a 2.2% rise in the incidence of low back pain in the past year in The Netherlands (on a group level). For four hours of working in a standing position per day, incidence after a year is doubled compared with a population of workers that do not perform work in a standing position.

7.1.2 Lower limb complaints

The Committee did not calculate any incidence increases for lower limb complaints, as the relationship was only examined in one of the longitudinal studies. In the study by Andersen et al., an only just short of statistically significant increased risk of hip, knee and foot complaints was found for working in a standing position for longer than 30 minutes per hour.[15] It is noteworthy that all available cross-sectional studies into the relationship between standing and leg, ankle and foot complaints pointed towards a significantly increased incidence of complaints if more than four hours per day were spent in a standing working posture (see Annex F).

7.2 Working in a kneeling position

The available epidemiological studies (chapter 4) showed that working in a kneeling position has health risks and is associated with lower back and knee complaints, including osteoarthritis.

7.2.1 Lower back complaints

The relationship between working in a kneeling position and low back pain was only examined in the longitudinal study by Harkness et al., which found an exposure-response relationship.[22] This means the longer a kneeling working

posture is assumed, the greater the risk of low back pain. When the investigators corrected for gender, age and profession, they found a significantly increased risk of low back pain in the past month for 15 minutes of working in a kneeling position or more. After correction for other working postures, the relationship was only just short of being statistically significant. Exposure to less than 15 minutes per day did not result in an increased risk of low back pain. Furthermore, investigators noted there was a strong correlation between kneeling and squatting (r=0.61) and that kneeling was more strongly associated with complaints than squatting.

7.2.2 Lower limb complaints

The other epidemiological studies indicated a relationship between knee osteoarthritis and working in a kneeling position. The cross-sectional studies in particular showed that more than one hour of working in a kneeling position per day is associated with a significantly higher incidence of knee osteoarthritis (see Annex G).

7.3 Working in a squatting position

The available epidemiological studies (Chapter 4) and the results of the meta-analysis (Chapter 6) show that working in a squatting position entails health risks and is associated with lower back and knee complaints, including osteoarthritis.

7.3.1 Lower back complaints

Working in a squatting position and the relationship with low back pain was examined in the longitudinal study by Harkness et al. in which an exposure-response relationship was found.[22] When investigators corrected for gender, age and profession, they found a statistically significant increase in the risk of low back pain over the past month for working in a squatting position for 15 minutes or more per day. After correction for other working postures, the relationship was no longer statistically significant. Exposure of less than 15 minutes per day did not result in an increased risk of low back pain. Andersen et al. found a just short of statistically significant increased risk of low back pain in the past 12 months for more than 5 minutes of squatting per hour.[15]

Table 4 Calculated incidence of low back pain in The Netherlands in the past 12 months for working in a squatting position based on two longitudinal studies.[15,22]

Low back pain	Working in a squatting position				
	Without exposure to physical burden	10 min. per day	20 min. per day	30 min. per day	40 min. per day
Pooled incidence per year (%)	13.0	13.7	14.5	15.3	16.2
Additional incidence per year (%)		0.7	1.5	2.3	3.2

Combining the results of the two studies in a meta-analysis resulted in a statistically significant increased risk (20%) of lower back complaints for 30 minutes of working in a squatting position. To provide an impression of the degree to which working in a squatting position affects the incidence of lower back complaints in The Netherlands, the Committee used the results of the meta analysis to calculate the additional cases of lower back complaints that would develop following 10, 20, 30 and 40 minutes of exposure (Table 4). Starting points are comparable to the calculations for risks of working in a standing position. These calculations show that after 20 minutes of working in a squatting position per day for one year, the incidence of lower back complaints increases by 1.5%.

7.3.2 *Lower limb complaints*

The longitudinal study by Andersen et al. found a statistically significant increase in the risk of hip, knee or foot pain following more than 5 minutes of working in a squatting position per hour[15] The longitudinal study by Tuchsen et al. found a statistically significant lower risk of hip pain for 25% or more of the working day spent in a squatting working posture.[51] In the longitudinal study by Felson et al. no statistically significant association was found between working in a squatting position and knee osteoarthirtis.[50] In short, the longitudinal studies did not show a clear picture with regard to a relationship between working in a squatting position and lower limb complaints.

Of the other epidemiological studies, the cross-sectional studies in particular showed indications for a relationship between knee osteoarthritis and working in a squatting position: more than one hour per day of squatting resulted in a statistically significant increase in the incidence of knee osteoarthritis (see Annex H).

7.4 OELs based on risk calculation

The Committee is of the opinion that in principle, the results of the meta-analysis allow derivation of a OEL based on a risk calculation. This method entails calculating corresponding exposure based on a predefined risk (reference value).

What accepted additional risk

When calculating risk, choices must be made regarding adverse health effects and the accepted additional risk. For working in a standing, kneeling or squatting position, the health effects are low back or lower limb pain and knee osteoarthritis. There is no 'fixed recipe' for what additional risk of complaints is acceptable. For comparable occupational health risks of which the Committee is aware, the choice was made following extensive discussion. The Committee believes such discussion falls outside the scope of the current assignment. The degree to which the health effect occurs in the labour force without being exposed to working in a standing, kneeling or squatting position plays a role in choosing the additional risk. The Committee believes there is a role for consensus documents here, such as the Manual for pre-employment medical examinations mentioned in Chapter three.

In this paragraph, the Committee provides a starting point for debate, and provides an elaboration of a risk calculation for low back pain due to working in a standing position for illustrative purposes.

Example of a risk calculation for working in a standing position

The Committee has calculated that, should a worker perform four hours of work in a standing position, there is an additional risk of low back pain of 10.7%. This means that if 1,000 workers in The Netherlands work in a standing position for more than 4 hours per day, 107 additional workers may develop lower back complaints.

A shorter duration of working in a standing position results in a proportionately lower incidence of additional cases with lower back complaints. If the Committee converts this to an accepted risk of one additional worker with back complaints (reported over a 12 month period) among 100 workers, this roughly corresponds to a maximum duration of 22 minutes of working in a standing position per 8-hour working day;

The study by Picavet et al. shows that about one quarter of people with lower back complaints (reported as occasional complaints during the past year) indicate that complaints are chronic.[65] This means that of the 107 extra cases of back complaints, about 27 develop chronic back complaints that persist for more than 3 months.[76] The severity of such chronic back complaints is described in NHG guideline M54 Non-specific low back pain (first revision). For chronic back complaints, pain may be present every day, but a strongly variable course may also be possible. The prognosis for chronic back complaints is moderate, and the emphasis of treatment lies on dealing with complaints and daily functioning rather than the pain disappearing.

Based on the data above, various health-based risk levels may be determined:

- an accepted risk of one additional worker with chronic back complaints among 100 workers roughly corresponds with a maximum duration of 88 minutes (almost one and a half hours) of standing per 8 hour working day
- an accepted risk of one extra worker with chronic back complaints among 1,000 workers roughly corresponds with a maximum duration of 9 minutes of standing per 8 hour working day.

Chapter 8

Conclusions

The Minister of Social Affairs and Employment requested the Health Council to report on whether *at the present* time or *in due* course new (international) scientific insights exist or might be expected to arise with regard to concrete health-based and safety-based OELs for working in a standing, kneeling or squatting position. To answer the Minister's questions, the Committee studied data on the adverse health effects of these working postures. In this chapter, the Committee formulates its conclusions on the health risks of working in a standing, kneeling or squatting position and the possibilities it sees for health-based recommended OELs.

8.1 Working in a standing position

The consequences of working in a standing position are described in detail in the scientific literature. However, many of these studies have their limitations. Study designs vary, for example. Additionally, both exposure and health complaints in available research are mapped out using self-reporting. Also in a large number of studies concurrent exposure to other physical occupational risks has occurred. Therefore, the Committee decided to give the most weight to the results of longitudinal studies. There are two longitudinal studies that show that the longer work in a standing position is performed, the greater the risk of low back pain. These studies have been conducted among workers in various sectors. The Committee is of the opinion that, based on available data, it is not possible to

Table 5

Low back pain	Working in a standing position				
	Without exposure to physical burden	1 hour per day	2 hours per day	3 hour per day	4 hour per day
Pooled incidence per year (%)	13.0	15.2	17.7	20.5	23.7
Additional incidence per year (%)		2.2	4.7	7.5	10.7

indicate how long it is possible to work in a standing position without lower back complaints developing. By combining the results of both longitudinal studies in a meta-analysis, the Committee was able to gain insight into the size of the risk.

Four hours of working in a standing position per day results in an additional incidence (per year) of workers with low back pain (over the past 12 months) of 10.7%. Per 1000 workers in The Netherlands, this means that in addition to the 130 workers who develop back pain due to other causes, 107 additional workers develop low back pain each year due to four hours of working in a standing position. This is almost a doubling of the number of workers with complaints. These findings are supported by results from cross-sectional research. The study by Brener et al. shows that standing for more than 30 minutes per day is associated with low back pain in workers in various sectors.[16] A study among nurses also found that the odds of low back pain are increased while working in a standing position for more than 6 hours .[24]

What is the significance of the above risk of low back pain for determining an OEL? In Chapter 5 of this advisory report, the Committee determined to what degree (brief) episodes of low back pain predict chronic back complaints. After all, in such cases there is a clear adverse health effect. It is known that about one quarter of people who indicate they occasionally have low back pain may eventually develop chronic back complaints.

Working in a standing position may also result in other complaints. Although this has not been investigated in as much detail, cross-sectional research shows that working in a standing position may lead to lower limb complaints. The incidence of varicose veins has also been described as one of the consequences of working in a standing position. Additionally, pregnant women have an increased risk of preterm birth in case of protracted standing working postures. Quantitative data on the size of said risks are not available, however.

8.2 Working in a kneeling position

Even a brief period of working in a kneeling position may lead to health complaints. Cross-sectional research has shown that people who work in a kneeling position for a long time have an increased risk of (serious) low back pain. However, this correlation was not found in the only longitudinal study. In addition to low back pain, knee osteoarthritis and other knee complaints may occur. The Committee also found no longitudinal studies for these complaints. Therefore, it is not possible to better map out the risks, and the Committee cannot draw any conclusions regarding a health-based or safety-based OEL.

8.3 Working in a squatting position

The consequences of working in a squatting position for health have been mapped out in two longitudinal studies. Both longitudinal studies show that the longer work in a squatting position is performed, the greater the risk of low back pain. In the view of the Committee, a threshold limit at which these complaints do not occur cannot be identified. These studies have been conducted among workers in various sectors. By combining the results of both longitudinal studies in a meta-analysis, the Committee was able to gain insight into the size of the risk.

Thirty minutes per day of working in a squatting position results in an additional incidence (per year) of workers with low back pain of 2.3%. Per 1000 workers in The Netherlands, this means that in addition to the 130 workers who develop back pain due to other causes, 23 additional workers develop low back pain each year due to 30 minutes of working in a squatting position. This finding is confirmed by case-control studies. The consequences of working in a squatting position for a longer period cannot be calculated, as this lies outside the measurement range for the study.

Table 6

Low back pain	Working in a squatting position				
	Without exposure to physical burden	10 min. per day	20 min. per day	30 min. per day	40 min. per day
Pooled incidence per year (%)	13.0	13.7	14.5	15.3	16.2
Additional incidence per year (%)		0.7	1.5	2.3	3.2

In addition to back pain, cross-sectional and case-control studies also show that the risk of knee osteoarthritis increases due to working in a squatting position. However, this is not confirmed by longitudinal research.

The consequences of working in a squatting position for the lower limbs are also unclear. Longitudinal studies show both an increased risk of lower limb complaints as well as a protective effect due to working in a squatting position. Based on these data, the Committee cannot draw any conclusions regarding a health-based or safety-based OEL or the risks involved.

8.4 Developing a prescriptive framework

Based on available scientific data, the Committee sees options for OELs based on health-based risk calculations for working in a standing or squatting position. However, a risk calculation involves selection of an adverse health effect and an accepted additional risk; in other words, a prescriptive framework is required. Particularly the decision of what additional risk of a specific adverse health effect is acceptable, taking into account prevalence and incidence of this health effect in the general population, requires social considerations. By way of illustration, the Committee performed a number of calculations in Chapter 7 for acute and chronic low back pain due to working in a standing position, in order to provide insight into the additional risks that must be considered for various exposure durations.

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Annexes

Annex **A**

Request for advice

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

On 26 September 2006, during deliberation in the Dutch House of Representatives of a bill to modify the Working Conditions Act, a motion by House members Koopmans and Stuurman was adopted[1]. This motion requests the government to promptly set up a work programme yielding health-based and safety-based occupational exposure limits (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 occupational exposure limits 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 occupational exposure limits;
- 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 occupational exposure limits;
- the Ministry of Social Affairs and Employment will then assess the need for and desirability of including an occupational exposure limit (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 occupational exposure limits 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 occupational exposure limit 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 occupational exposure limit 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 occupational exposure limits;

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 occupational exposure limits.

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

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

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

Yours sincerely,

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

Annex **B**

The Committee

- Professor T. Smid, *chairman*
  Endowed Professor of Working Conditions, VU University 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 University Medical Center, Amsterdam
- Professor A. Burdorf
  Professor of Occupational Epidemiology, Erasmus Medical Center, Rotterdam
- H.J. van der Brugge, *observer*
  Ministry of Social Affairs and Employment, Den Haag
- Professor M.H.W. Frings-Dresen
  Professor of Occupational Health, Coronel Institute for Work and Health, Academic Medical Center, 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, UUniversity Medical Center Groningen

- Dr. P.C. Noordam, *observer*
  senior advisor, Labour inspectorate, Den Haag
- Professor W.R.F. Notten (until May 2011)
  Professor of Knowledge Management and Innovation in Healthcare, Erasmus Medical Center, Rotterdam
- Dr. T. Spee
  Occupational Hygiene policy advisor, the Arbouw Foundation, Amsterdam
- J. van der Wal
  Head of Safety, Shell Europa Exploration and Production, Nederlandse Aardolie Maatschappij (NAM), Assen
- Dr. C.A. Bouwman, *secretary* (until January 2011)
  Health Council, Den Haag
- Dr. A.S.A.M. van der Burght, *secretary*
  Health Council, Den Haag
- Dr. V. Gouttebarge, *secretary*
  Health Council, Den Haag

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

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

The Health Council and interests

Members of Health Council Committees are appointed in a personal capacity because of their special expertise in the matters to be addressed. Nonetheless, it is precisely because of this expertise that they may also have interests. This in itself does not necessarily present an obstacle for membership of a Health Council Committee. Transparency regarding possible conflicts of interest is nonetheless important, both for the chairperson and members of a Committee and for the President of the Health Council. On being invited to join a Committee, members are asked to submit a form detailing the functions they hold and any other material and immaterial interests which could be relevant for the Committee's work. It is the responsibility of the President of the Health Council to assess whether the interests indicated constitute grounds for non-appointment. An advisorship will then sometimes make it possible to exploit the expertise of the specialist involved. During the inaugural meeting the declarations issued are discussed, so that all members of the Committee are aware of each other's possible interests.

Annex **C**

Comments on draft report

In July 2011 the President of the Health Council published a draft of this report and invited a round of comments. The following persons and organisations submitted their reactions to the draft report:

- F. van Eijk, OCÉ, Venlo
- W. van Veelen, FNV Trade Union Federation, Amsterdam
- W.M.J.M. van Mierlo, VNO-NCW, MKB-Nederland, Den Haag
- K. Peerenboom, VHP-ergonomie, Den Haag
- Mrs N. Gras, Ministry of Social Affairs and Employment, Den Haag.

The Committee considered this commentary in finalizing its report.

Annex **D**

Broad literature exploration

The goal of this literature exploration is to obtain an overview of and insight into recent developments regarding the origin of health and safety problems relating to working in a standing, kneeling or squatting position. To this end, recent review articles were consulted exclusively, preferably published in peer-reviewed journals. Where possible, the working group also made use of reports from renowned national and international institutes or organizations.

Findings

In 2008, Jensen published a systematic literature review in which the influence of a number of work-related activities on knee osteoarthritis was mapped out.[8] Using a systematic search strategy deployed in four databases, epidemiological literature between 1966 and 2007 was searched for relevant studies. After applying a number of inclusion and quality criteria, 20 studies were included, 12 on knee osteoarthritis and kneeling and/or squatting. Eight of these 12 studies found a positive association between kneeling and knee osteoarthritis, with an odds ratio from 2.2 (95% CI 1.4-3.6) to 6.9 (95% CI 1.8-26.4). Three patient-control studies also found that kneeling and/or squatting led to an increased risk of knee osteoarthritis, with odds ratios from 1.2 (95% CI 0.7-2.0) to 3.0 (95% CI 1.4-6.1) for men, and from 0.8 (95% CI 0.3-2.0) to 3.2 (95% CI 0.8-13.0) for women. In these three studies, exposure to kneeling and/or squatting was measured retrospectively and defined as working in a kneeling or squatting

position for more than 1 or 2 hours per day. In this review, kneeling or squatting working postures combined with (heavy) lifting were found to be a risk factor for knee osteoarthritis, with odds ratios from 2.2 (95% CI 1.4-3.6) to 5.4 (95% CI 1.4-21.0). Jensen does admit that many studies use different methods for measuring exposure to working in a kneeling or squatting posture, and that exposure itself is not always quantified. The small number of participants is also listed as a limitation for some of the studies.

For working in a standing position, one recent review article was found in which the association with low back pain was studied.[9] Using a systematic search strategy in three databases, the scientific literature starting from 1966 was searched for relevant studies. After applying five inclusion and nine exclusion criteria, five studies of high methodological quality were included. Based on the Bradford-Hill criteria for relevance, the authors concluded that working in a standing position had no causal relationship with the incidence of low back pain.

Annex **E**

Systematic literature review

The goal of this literature review is to obtain in a systematic manner scientific data from epidemiological studies on the relationship between *working in a standing, kneeling or squatting position* and the development (both short-term and long-term) of health or safety problems.

1 Question

The following questions were formulated for this systematic literature review:

a What health and safety problems develop due to working in a standing, kneeling or squatting position?

b To what degree is exposure (in terms of duration, frequency and/or intensity) to working in a standing, kneeling or squatting position related to these problems?

2 Databases

Using various key words in this literature review, the international databases Medline (via PubMed) and Embase (via Ovid) were searched for English and Dutch language literature.

3 Key words

For the occupational risk of working in a standing, kneeling or squatting position, key words were used that corresponded to the following terms: *standing / kneeling / squatting*, *work-related* and *health effect*.

4 Search strategy

3.4a Medline search strategy

#1= standing[tiab] OR kneeling[tiab] OR squatting[tiab] OR crouching[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#

3.4b Embase search strategy

#1= standing.ti,ab. OR kneeling.ti,ab. OR crouching.ti,ab. OR squatting.ti,ab.

#2= work-related.ti,ab. OR occupation$.ti,ab. OR work$.ti,ab. OR vocation$.ti,ab. OR job.ti,ab. OR industr$.ti,ab. OR business.ti,ab. OR profession$.ti,ab. OR trade$.ti,ab. OR enterprise$.ti,ab.

#3 = 'health effects'.ti,ab. OR 'occupational risk factor'.ti,ab. OR safet$.ti,ab. OR health.ti,ab. OR disorder.ti,ab. OR disorders.ti,ab. OR syndrome.ti,ab. OR disease.ti,ab. OR diseases.ti,ab. OR wounds.ti,ab. OR injuries.ti,ab. OR injury.ti,ab. OR sprains.ti,ab. OR strains.ti,ab. OR pain.ti,ab. OR discomfort.ti,ab.

#4= #1 AND #2 AND 3#.

5 Inclusion and exclusion criteria

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

- the study describes, within the context of work, the degree of exposure to the risk of working in a standing, kneeling or squatting position,
- and the study describes health and/or safety effects on the back, lower limbs and preterm birth as a result of the occupational risk of working in a standing, kneeling or squatting position,
- and the study describes a degree of association between the occupational risk of working in a standing, kneeling or squatting position and the development of health effects in terms of relative risk, attributive risk, prevalence ratio or odds ratio.

Studies that only describe a degree of association between a combination of risks and the development of health complaints were excluded.

6 Selection procedures

After the search strategy was performed on various databases, the inclusion criteria were applied to titles and abstracts of the obtained studies by a single evaluator. If there were doubts about the inclusion or exclusion of a study based on title and abstract it was included. The full text of the included titles and abstracts was requested and the inclusion criteria were again applied to the full text by a single evaluator. Additionally, reference lists of all included studies and possible reviews were screened. Finally, the reference list of all included studies was submitted to the working group with the question whether additional studies should be added.

7 Data extraction

Data extraction for included studies was classified per risk (standing, kneeling or squatting working postures) and per type of effect in three standardized tables 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, definition of reference group used and any confounding factors;

- 4th column: method used to measure exposure of occupational risk and health effects;
- 5th column: occupational risk's effect on health or safety;
- 6th column: degree of association between occupational risk and effect on health or safety.

8 Quality description

The quality of included studies (among employees) was described based on four criteria drafted from existing and accepted sources (IJmker et al. 2007; Von Elm et al. 2007; Dutch Cochrane Centre 2008). These four criteria were applied to the included studies *independently* by two researchers, with consensus being sought out in case of doubt or disagreement between the two. The quality criteria may be found in Table 7.

Table 7 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, adjusted for age and gender, and their precision are reported.
-	Risk estimates, adjusted for age and gender, and their precision are not reported.
?	Unclear information.

9 Search strategy results

The previously defined search strategies were performed on 26 August 2009 in PubMed and on 1 October 2009 in Embase. After application of the selection steps on titles and abstracts, a total of 104 full-text articles were assessed using

the inclusion criteria. After the final selection step, 26 primary studies and six reviews were included. Based on the reference check of included articles (primary studies and reviews) and among the working group experts, nine more primary studies were included. In total, 35 primary studies were processed in three extraction tables.

10 Results of quality description

The quality of 35 primary studies from the search strategy was described based on five quality criteria. Table 8 only provides an overview of quality assessment of 28 studies describing low back pain, knee osteoarthritis and/or lower limb complaints as outcome measures (and were therefore included in the meta analyses). Table 8 also lists the design of each study.

Table 8 Quality description of included studies with low back pain, knee osteoarthritis and/or lower limb complaints as outcome measures.

Author	Design	Study population	Exposure	Outcome	Statistical analysis	Results
Amin[41]	cross-sectional	+	s	+	+	+
Andersen[15]	longitudinal	+	s	?	+	+
Baker[42]	cross-sectional	+	s	+	+	-
Bener[16]	cross-sectional	+	s	+	+	?
Brulin[17]	cross-sectional	?	s	+	+	+
Chandrasakaran[18]	cross-sectional	+	s	+	+	?
Chee[19]	cross-sectional	+	s	+	+	+
Coggon[43]	cross-sectional	+	s	+	-	+
Cooper[20]	case-control	+	s	+	+	?
Croft[21]	case-control	?	s	+	+	?
Dawson[44]	case-control	+	s	+	+	+
Felson[50]	longitudinal	?	s	+	+	+
Harkness[22]	longitudinal	+	s	?	+	+
Holmstrom[45]	cross-sectional	+	s	+	+	-
Hou[24]	cross-sectional	?	s	+	+	+
Lau[46]	case-control	+	s	+	+	?
Macfarlane[26]	longitudinal	+	s	?	+	+
Manninen[28]	case-control	+	s	+	+	?
Messing[29]	cross-sectional	?	s	+	+	+
Nahit[31]	cross-sectional	+	s	?	+	+
Pope[32]	case-control	+	s	?	+	+
Sandmark[33]	case-control	+	s	+	+	+
Tuchsen[51]	longitudinal	?	s	?	+	-
Vingard[37]	case-control	?	s	+	+	+
Van Vuuren[47]	cross-sectional	-	s	+	+	?

Xu[38]	cross-sectional	+	s	?	+	?
Yip[52]	case-control	+	s	+	+	+
Yoshimura[39]	case-control	+	s	+	+	-

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

Annex **F**

Extraction table working in a standing position

Author	Study population	Study design	Measurement methods	Health effect	Degree of association
Andersen 2007[15]	N = 114 G = ? A = 44 (sd=10) O = various C = Denmark	Prospective cohort study (2years) Ref = less exposed group (N = 1.384) Conf = sex, age, occupational category, intervention group	Exp = self-administrated questionnaire (estimation of amount of time spent in a posture) HEf = self-administrated questionnaire (7 categories scale, from not at all to very much)	Low back pain *Pain:* pain in a body region in the past 12 months (prevalence)	- Standing: D > 30 min per h HR = 2.1 (CI 1.3-3.3)
Bener 2004[16]	N = 473 G = 219 men;254 women A = 25-70 O = various C = United Arab Emirates	Cross-sectional study Ref = less exposed group matched for age and sex (N = 240) Conf = ?	Exp = self- interview (postural exposure; dichotomous, 30 min or more) HEf = self-administrated questionnaire adapted from the Rolland-Morris questionnaire	Low back pain *Pain:* any pain or ache in the back lasting for one day or longer in the past 6 months	- Standing: D > 30min per day RR = 6.22 (CI 4.01-9.67)
Brulin 1998 [17]	N = 217 G = women A = 48.6 (sd=11.8) O = home care service C = Sweden	Cross-sectional study Ref = unexposed group (N = 144) Conf = age, worktime per week, workplace	Exp = self-administrated questionnaire (postural exposure; 3-4 categories scale) HEf = self-administrated questionnaire derived from the Nordic questionnaire	Low back complaints *Complaint:* symptom in a body region at any point in time during the last seven days	- Standing in awkward position: OR = 1.7 (CI 1.0-2.7)
Chandrasakaran 2003[18]	N = 323 G = women A = 31.2 (sd=7.4;18-54) O = assembly worker	Cross-sectional study Ref = less exposed group (<4h per day; N = 206)	Exp = self-administrated questionnaire (postural exposure; 4 categories scale, from not at all to four or more hours)	Back pain *Pain:* pain in a body region in the past 12 months	- Standing: D >4h per day OR(crude) = 1.1 (CI 0.7-1.5)

	C = Malaysia	Conf = age, pregnancy, work history	HEf = self-administrated questionnaire derived from the Nordic questionnaire		
Chee 2004[19]	N = 499 G = women A = 30.6 (sd=8.1) O = assembly operator C = Malaysia	Cross-sectional study Ref = less exposed group (<4h per day; N = 407) Conf = work history	Exp = self-administrated questionnaire (postural exposure; 4 categories scale, from not at all to four or more hours) HEf = self-administrated questionnaire derived from the Nordic questionnaire	1. Upper back pain 2. Low back pain *Pain:* pain in a body region in the past 12 months	- Standing: D >4h per day 1. OR(crude) = 1.0 (CI 0.7-1.3) 2. OR(crude) = 1.2 (CI 0.9-1.6)
Harkness 2003[22]	N = 234-275 G = 64% men, 36% women A = median 23 O = various sectors such as service organization, police, army officers, supermarket, postal distribution centre C = England	Cohort study (2 years) Ref = unexposed group (N = 76) Conf = age, sex, occupation	Exp = valid self-administrated questionnaire (postural exposure during the last working day) HEf = self-administrated questionnaire	Low back pain *Pain:* any pain or ache in the low back lasting for one day or longer in the past month (prevalence)	- Standing: D <15min per day OR = 1.1 (CI 0.6-2.1) OR (multivariate) = 1.0 (CI 0.5-1.9) - Standing: D ≥15min-<2h per day OR = 1.6 (CI 0.8-2.9) OR (multivariate) = 1.4 (CI 0.7-2.7) - Standing: D ≥2h per day OR = 1.8 (CI 0.9-3.4) OR (multivariate) = 1.5 (CI 0.8-3.0)
Hou 2006[24]	N = 3.950 G = women A = 50% within 25-34 O = nurse C = China	Cross-sectional study Ref = low exposed group (<4h per day) Conf = age, tenure, weekly working hours	Exp = self-administrated valid questionnaire (duration and frequency of postural exposure) HEf = self-administrated questionnaire derived from the Nordic questionnaire	Low back pain *Pain:* pain, discomfort, soreness, numbness, limited motion since entering your current job	- Standing: D 4-6h per day OR = 1.31 (CI 1.10-1.55) - Standing: D >6h per day OR = 1.51 (CI 1.24-1.85)
Macfarlane 1997[26]	N = 310 G = ? A = median 38 (18-75) O = various C = England	Prospective cohort study (1 year) Ref = healthy group (N=537) Conf = age, sex	Exp = self-administrated questionnaire (postural exposure; dichotomous, more than 2 hours or not) HEf = self-administrated questionnaire	Low back pain *Pain:* any ache or pain lasting longer than 24 hours, in the area bordered at the top by the 12th rib and at the bottom by the gluteal fold (incidence) [a]*:* not consulting a general practitioner [b]*:* consulting a general practitioner	- Standing/walking: D >2h per work day OR (men[a]) = 0.9 (CI 0.6-1.5) OR (men[b]) = 2.1 (CI 0.7-3.4) OR (women[a]) = 1.8 (CI 1.1-2.8) OR (women[b]) = 3.5 (CI 1.4-8.8) - Standing/walking: D >2h per work day & 1-7 exposure years OR (men) = 2.0 (CI 1.1-2.7) OR (women) = 1.6 (CI 0.9-2.9) - Standing/walking: D >2h per work day & 8-18 exposure years OR (men) = 1.4 (CI 0.7-3.0) OR (women) = 2.2 (CI 1.2-4.1)

					- Standing/walking: D >2h per work day & >18 exposure years OR (men) = 1.3 (CI 0.6-2.9) OR (women) = 2.0 (CI 1.0-4.2)
Nahit 2001[31]	N = 151-192 G = 68% men;32% women A = median 23 O = various C = England	Cross-sectional study Ref = unexposed group (N = 880-916) Conf = age, sex	Exp = self-administrated questionnaire (duration of postural exposure during the last working day; 4 categories, from less than 15 minutes to 4 hours or more) HEf = self-administrated questionnaire	Low back pain *Pain:* pain in the lower back lasting longer than one day during the past month)	- Standing: D ≥4h OR = 1.4 (CI 0.97-2.0)
Xu 1997[38]	N = 532-1.225 G = ? A = 19-59 O = various C = Denmark	Cross-sectional study Ref = seldom or never exposed group (N = 1.363) Conf = sex, age, education, employment	Exp = interview by telephone with questionnaire (daily time of postural exposure; 6 categories, from never to all of the time) HEf = interview by telephone with questionnaire	Low back pain *Pain:* pain, ache or discomfort of low back at any time during the past 12 months	- Standing: D ¼ of the time OR = 1.31 PPR = 1.17 - Standing: D ½ of the time OR = 1.40 PPR = 1.21 - Standing: D ¾ of the time OR = 1.61 PPR = 1.30 - Standing: D all of the time OR = 1.55 PPR = 1.29
Andersen 2007[15]	N = 114 G = ? A = 44 (sd=10) O = various C = Denmark	Prospective cohort study (2years) Ref = less exposed group (N = 1.384) Conf = sex, age, occupational category, intervention group	Exp = self-administrated questionnaire (estimation of amount of time spent in a posture) HEf = self-administrated questionnaire (7 categories scale, from not at all to very much)	Hip, knee, foot pain *Pain:* pain in a body region in the past 12 months (prevalence)	- Standing: D > 30 min per h HR = 1.7 (CI 1.0-2.9)
Chandrasakaran 2003[18]	N = 323 G = women A = 31.2 (sd=7.4;18-54) O = assembly worker C = Malaysia	Cross-sectional study Ref = less exposed group (<4h per day; N = 206) Conf = age, pregnancy, work history	Exp = self-administrated questionnaire (postural exposure; 4 categories scale, from not at all to four or more hours) HEf = self-administrated questionnaire derived from the Nordic questionnaire	1. Upper leg pain 2. Lower leg pain *Pain:* pain in a body region in the past 12 months	- Standing: D >4h per day 1. OR(crude) = 3.1* (CI 2.1-4.5) 1. OR = 1.8* (CI 1.1-2.9) 2. OR(crude) = 4.8* (CI 3.3-7.1) 2. OR = 3.3* (CI 2.1-5.3)
Chee 2004[19]	N = 499 G = women A = 30.6 (sd=8.1) O = assembly operator C = Malaysia	Cross-sectional study Ref = less exposed group (<4h per day; N = 407) Conf = work history	Exp = self-administrated questionnaire (postural exposure; 4 categories scale, from not at all to four or more hours) HEf = self-administrated questionnaire derived from the Nordic questionnaire	Lower-limb pain *Pain:* pain in a body region in the past 12 months	- Standing: D >4h per day OR(crude) = 4.1 (CI 3.1-5.4) OR = 2.7 (CI 1.9-3.9)

Cooper 1994 20	N = 50 G = ? A = >55 O = various such as nurse, teacher, electrical maintenance, construction worker C = England	Case-control study Ref = less exposed group (N = 99) Conf = body mass index	Exp = interview (postural exposure) HEf = radiography	Knee osteoarthritis (according Kellgren/Lawrence scale)	- Standing: D >2h per day OR = 0.8 (CI 0.4-1.4)
Croft 1992[21]	N = 245 hip patients G = men A = >55 O = agricultural and construction sectors C = England	Case-control study Ref = group with minimal joint space of both hips ≥3.5 mm Conf = age	Exp = interview postural exposure history) HEf = radiography	Hip osteoarthritis *Osteoarthritis:* minimal joint space of one of the hips ≤2.5 mm (≤1.5 mm = severe)	- Standing: D >2h per day & 20-39 exposure years OR = 1.8 (CI 1.0-3.1) OR (severe)= 1.5 (CI 0.5-4.8) - Standing: D >2h per day & ≥40 exposure years OR = 1.7 (CI 1.0-2.8) OR (severe)= 2.7 (CI 1.0-7.3)
Hou 2006[24]	N = 3.950 G = women A = 50% within 25-34 O = nurse C = China	Cross-sectional study Ref = low exposed group (<4h per day) Conf = age, tenure, weekly working hours	Exp = self-administrated valid questionnaire (duration and frequency of postural exposure) HEf = self-administrated questionnaire derived from the Nordic questionnaire	Lower leg pain *Pain:* pain, discomfort, soreness, numbness, limited motion since entering your current job	- Standing: D 4-6h per day OR = 1.59 (CI 1.30-1.95) - Standing: D >6h per day OR = 1.73 (CI 1.38-2.18)
Manninen 2002[28]	N = 281 G = 55 men;226 women A = 67.5 (sd=5.7) men; 69.2 (sd=5.4) women O = various C = Finland	Case-control study Ref = low exposed group (<50% of work day) matched for age and sex (N = 524) Conf = body mass index, leisure-time physical exercise	Exp = interview by telephone (postural exposure history before 49 years of age; 3 categories, from less than half of the day to almost all the time) HEf = arthroplasty operation	Knee osteoarthritis (before 49 years of age)	- Standing: D >50% of work day OR = 0.57 (CI 0.33-0.99) OR (crude) = 0.68 (CI 0.42-1.09) OR (men) = 0.57 (CI 0.18-1.73) OR (men;crude) = 0.52 (CI 0.20-1.33) OR (women) = 0.55 (CI 0.29-1.04) OR (women;crude) = 0.78 (CI 0.45-1.35) - Standing: D nearly all work day OR = 0.62 (CI 0.40-0.95) OR (crude) = 0.74 (CI 0.50-1.07) OR (men) = 0.36 (CI 0.15-0.90) OR (men;crude) = 0.46 (CI 0.22-0.95) OR (women) = 0.70 (CI 0.42-1.16) OR (women;crude) = 0.88 (CI 0.56-1.37)

Messing 2008[29]	N = 512 G = 4.534 men;3223 women A = 18-65 O = various C = Canada	Cross-sectional study Ref = low exposed (never or occasionally; N = 7.245) Conf = sampling design	Exp = self-administrated questionnaire (postural exposure) HEf = self-administrated questionnaire derived from the Nordic questionnaire	1. Lower-leg or calf pain 2. Ankle or foot pain *Pain:* pain interfering with usual activities fairly often or all the time over the past 12 months	- Standing most of the time during work day 1. OR = 3.60*** (CI 2.12-6.19) 1. OR (men) = 3.46*** (CI 1.52-7.89) 1. OR (women) = 3.64*** (CI 1.84-7.20) 2. OR = 3.95*** (CI 2.56-6.10) 2. OR (men) = 6.29*** (CI 3.46-11.50) 2. OR (women) = 2.78*** (CI 1.49-5.21)
Pope 2003[32]	N = 52-71 G = 36.4% men;63.6% women A = 13.1% 18-39;45.7% 40-59;41.2% >60 O = various C = England	Case-control study Ref = unexposed group matched for sex and age (N = 692) Conf = age , sex	Exp = valid self-administrated questionnaire (posture exposure) HEf = self-administrated questionnaire	Hip pain *Pain:* pain in the hip area lasting longer than one day during the past month	- Standing: D >2h per day & 1-15 exposure years OR = 1.19 (CI 0.80-1.78) - Standing: D >2h per day & ≥16 exposure years OR = 1.46 (CI 1.00-2.14)
Sandmark 2000[33]	N = 625 G = 325 men;300 women A = 49 men; 48 women O = various C = Sweden	Population-based case-control study Ref = no or low exposed group (2-51h lifelong sum standing) Conf = age, body mass index, smoking	Exp = self-administrated questionnaire (posture exposure) HEf = self-administrated questionnaire	Knee osteoarthritis	- Standing: D 51-96h (lifelong sum) OR (men) = 1.5 (CI 0.9-2.4) OR (women) = 1.2 (CI 0.7-1.9) - Standing: D 96-213h (lifelong sum) OR (men) = 1.7 (CI 1.0-2.9) OR (women) = 1.6 (CI 1.0-2.8)
Sisto 1995[35]	N = 7.217 G = 3.322 men;3.895 women A = 30-64 O = various C = Finland	Cross-sectional study Ref = unexposed group Conf = age	Exp = self-administrated questionnaire (postural exposure; dichotomous) HEf = self-administrated questionnaire (medical history checked by physician)	Varicose vein of the lower extremity	- Standing OR (men;diagnosis) = 1.3 (CI 0.9-1.7) OR (men;surgery) = 1.7 (CI 1.0-2.8) OR (women;diagnosis) = 1.4 (CI 1.2-1.6) OR (women;surgery) = 1.5 (CI 1.2-1.8)
Tuchsen 2000[36]	N = 77 G = 44 men;33 women A = 18-59 O = various C = Denmark	Cohort study Ref = low exposed group (1st quartile standing prevalence) Conf = age, smoking	Exp = interview by telephone (postural exposure) HEf = data from Occupational Hospitalization Register	Varicose vein of the lower extremity (hospital admission)	- Standing: medium exposure (2nd & 3rd quartile standing prevalence) OR (men) = 1.25 (CI 1.08-1.44) OR (women) = 1.97 (CI 1.75-2.21) - Standing: medium exposure (4th quartile standing prevalence) OR (men) = 1.58 (CI 1.30-1.91) OR (women) = 2.29 (CI 2.02-2.60)

Vingard 1997[37]	N = 230 G = women A = 63 O = nurse C = Sweden	Case-control study Ref = less exposed group (<2h per day) (N=273) Conf = age	Exp = self-administrated questionnaire (postural exposure; 6 categories, from <1h per day to >8h per day) HEf = medical operation	Total hip replacement	- Standing: D 2-<6h per work day RR = 1.4 (CI 0.8-2.2) - Standing: D ≥6h per work day RR = 1.6 (CI 0.9-2.8)
Yoshimura 2004[39]	N = 93 G = women A = 73 (sd=9.8) O = none C = Japan	Case-control study Ref = less exposed group (N = 73 standing; 27 kneeling; 30 squatting) Conf = ?	Exp = self-reported questionnaire (postural exposure history) HEf = clinical diagnostic	Knee osteoarthritis *Osteoarthritis:* grade 3 or 4 according to Kellgren/ Lawrence scale	- Standing: D ≥2h day OR = 1.17 (CI 0.54-2.52)
Fortier 1995[40]	N = 4.390 G = women A = ? O = various C = Canada	Prospective cohort study (9 months) Ref = less exposed group (3h per day; N = 2.160) Conf = age, education, medical history	Exp = interview by telephone (postural exposure; 3 categories, from <3h per day to ≥6h per day) HEf = medical registration and interview	1. Small-for-gestational-age infant 2. Preterm birth (<37 weeks)	- Standing: D 3-5h per day 1. OR = 1.13 (CI 0.83-1.55) 1. OR (crude)= 1.09 2. OR = 0.78 (CI 0.52-1.19) 2. OR (crude)= 0.78 - Standing: D ≥6h per day 1. OR = 1.42 (CI 1.02-1.95) 1. OR (crude)= 1.50 2. OR = 0.88 (CI 0.59-1.33) 2. OR (crude)= 1.02
Henriksen 1995[23]	N = 197-1071 G = woman A = ? O = ? C = Denmark	Cohort study (2 years) Ref = minimal exposed group (≤2h per day; N = 2.799) Conf = parity, maternal height, smoking, leisure time activities, social class partner	Exp = self-administrated Q_{16} questionnaire (daily postural exposure in hours) HEf = self-administrated questionnaire (medical and obstetrical history)	Preterm birth	- Standing: D >2-5h per day RR = 1.1 (CI 0.7-1.5) - Standing: D >5h per day RR = 1.2 (CI 0.6-2.4) - Standing and/or walking: D >2-5h per day RR = 1.2 (CI 0.8-1.8) - Standing and/or walking: D >5h per day RR = 3.3 (CI 1.4-8.0)
Luke 1994[25]	N = 210 G = women A = 92.4% >24 O = nurse C = USA	Case-control study Ref = no preterm birth group (standing 0-4 hours, >37 weeks pregnancy; N = 1.260) Conf = none	Exp = self-administrated structured questionnaire (postural exposure; 4 categories, from <2h per shift to >6h per shift) HEf = self-administrated structured questionnaire	Preterm birth (<37 weeks)	- Standing: D 4-6h per shift OR = 1.8 - Standing: D >6h per shift OR = 2.9***
Magann 2005[27]	N = 215 G = women A = 24.4 (sd=5.1) O = military C = USA	Prospective observational study (4 years) Ref = group standing 0-4 hours, <21 weeks during pregnancy (N = 270) Conf = age, birth weight	Exp = self-administrated questionnaire (postural exposure; 3 categories scale, from 0-4 to >8 hours) HEf = self-administrated questionnaire (medical and obstetrical status)	1. Preterm birth (>20 weeks) 2. Preterm labor(regular uterine contractions between 20 and 36+6 weeks) 3. Intrauterine growth restriction 4. Perinatal death (fetal death in utero)	- Standing: D >4h per day 1. OR = 1.64 (CI 0.88-3.06) 2. OR = 2.18 (CI 1.11-4.44) 3. OR = 0.81 (CI 0.47-1.41) 4. OR = 0.72 (CI 0.37-1.36)

Mozurkewich 2000[30]	N = 9.011 G = ? A = ? O = various C = various	Meta-analysis involving 3 case-control, 3 cross-sectional and 8 prospective cohort studies Ref = unexposed or less exposed group (N=15.848) Conf = ?	Exp = - HEf = -	Preterm birth (20-36 weeks 'gestation)	- Standing D >3h per work day Pooled OR = 1.26 (CI 1.13-1.40)
Saurel-Cubizolles 2004[34]	N = 2.329 G = women A = ? O = various C = 16 European countries	Case-control study Ref = full term singleton birth (>36 weeks; N = 4.049) Conf = maternal age, education, marital status	Exp = questionnaire (postural exposure; 3 categories, from less than 2 hours to more than 6 hours) HEf = questionnaire (medical and obstetrical status)	Preterm birth (22-36 weeks)	- Standing: D 2-6h OR (all countries) = 1.06 (CI 0.9-1.2) OR (frequent prenatal leaves & infant mortality rate <8 per thousand) = 0.98 (CI 0.8-1.2) OR (non-frequent prenatal leaves) = 1.09 (CI 0.9-1.4) OR (non prenatal leaves & infant mortality rate >10 per thousand) = 1.15 (CI 0.8-1.6) - Standing: D >6h OR (all countries) = 1.26 (CI 1.1-1.5) OR (frequent prenatal leaves & infant mortality rate <8 per thousand) = 1.06 (CI 0.8-1.3) OR (non-frequent prenatal leaves) = 1.38 (CI 1.1-1.7) OR (non prenatal leaves & infant mortality rate >10 per thousand) = 1.55 (CI 1.1-2.3)

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

Annex **G**

Extraction table working in a kneeling position

Author	Study population	Study design	Measurement methods	Health effect	Degree of association
Harkness 2003[22])	N = 234-275 G = 64% men, 36% women A = median 23 O = various sectors such as service organization, police, army officers, supermarket, postal distribution centre C = England	Cohort study (2 years) Ref = unexposed group (N = 76) Conf = age, sex, occupation	Exp = valid self-administrated questionnaire (postural exposure during the last working day) HEf = self-administrated questionnaire	Low back pain *Pain:* any pain or ache in the low back lasting for one day or longer in the past month	- Kneeling: D <15min per day OR = 1.4 (CI 0.9-2.2) OR (multivariate) = 1.2 (CI 0.8-2.0) - Kneeling: D ≥15min per day OR = 2.1 (CI 1.3-3.3) OR (multivariate) = 1.7 (CI 1.0-2.9)
Holmstrom 1992[45]	N = 1.632 G = 1.772 men;1 woman A = 39.5 (sd=12.5;18-65) O = construction sector C = Sweden	Cross-sectional study Ref = never or seldom pain subjects (N = 141) Conf = age	Exp = self-administrated questionnaire (postural exposure; 4 categories scale, from never/seldom to more than 4 hours a day) HEf = self-administrated questionnaire derived from the Nordic questionnaire	1. Low back pain 2. Severe low back pain *Pain:* pain, ache or discomfort in the lower back, including the gluteus regions, with or without radiating pain in one or both legs, experienced often or very often in the past 12 months, at least for 1-7 days (8-30 days = severe) and any degree of functional impairment (very severe impairment = severe)	- Kneeling: D <1h per day 1. PRR = 1.13 (CI 1.0-1.3) 2. PRR = 2.4 (CI 1.7-3.3) - Kneeling: D 1-4h per day 1. PRR = 1.23 (CI 1.1-1.4) 2. PRR = 2.6 (CI 1.9-3.5) - Kneeling: D >4h per day 1. PRR = 1.24 (CI 1.1-1.4) 2. PRR = 3.5 (CI 2.4-4.9)

van Vuuren 2005[47]	N = 366 G = ? A = 31.76 (sd=7.80) O = steel plant worker C = South Africa	Cross-sectional study Ref = <50% exposed group Conf = psychosocial and biomechanical demands	Exp = valid Occupational Risk Factor Questionnaire (postural exposure; dichotomous) HEf = valid Functional Rating Index (FRI)	Low back pain *Pain:* any back problems at the time (FRI ≥30% = stringent definition)	- Kneeling and squatting: D ≥50% of work day OR = 1.95 (CI 0.58-6.49) OR (stringent) = 4.62* (CI 1.28-16.6)
Croft 1992[21]	N = 245 hip patients G = men A = >55 O = agricultural and construction sectors C = England	Case-control study Ref = group with minimal joint space of both hips ≥3.5 mm Conf = age	Exp = interview postural exposure history) HEf = radiography	Hip osteoarthritis *Osteoarthritis:* minimal joint space of one of the hips ≤2.5 mm (≤1.5 mm = severe)	- Kneeling: D >30min per day & 1-19 exposure years OR = 0.6 (CI 0.4-1.0) OR (severe)= 0.5 (CI 0.2-1.4) - Kneeling: D >30min per day & ≥20 exposure years OR = 0.7 (CI 0.4-1.3) OR (severe)= 1.0 (CI 0.3-3.2)
Lau 2000[46]	N = 796 G = 196 men; 600 women A = ? O = ? C = China	Case-control study Ref = less exposed group Conf = none	Exp = self-administrated structured questionnaire (postural exposure; dichotomous, an hour or more each day) HEf = medical diagnosis	1. Hip osteoarthritis 2. Knee osteoarthritis *Osteoarthritis:* grade 3 or 4 according to Kellgren/ Lawrence scale	- Kneeling 1. OR (men) = 3.9 (CI 1.1-14.2) 1. OR (women) = 1.3 (CI 0.7-2.5) 2. OR (men) = 1.4 (CI 0.7-3.0) 2. OR (women) = 0.9 (CI 0.6-1.3)
Amin 2008[41]	N = 47 G = men A = 64 (sd=9) O = various C = USA	Cross-sectional study Ref = unexposed group (N = 98) Conf = age, body mass index, injury history	Exp = self-administrated validated questionnaire (postural exposure; dichotomous, 30 min or more) HEf = MRI imaging	Knee osteoarthritis (WORMS cartilage morphology ≥ 2)	- Squatting/kneeling in combination with heavy lifting: D ≥ 30 min per day OR = 1.6 (CI 0.9-3.0) OR (crude) = 1.2 (CI 0.7-2.2)
Baker 2002[42]	N = 68 G = 196 men;47 women A = 20-59 O = various C = England	Cross-sectional study Ref = less exposed group matched for age and sex (N = 67) Conf = sex, age, occupational category, body mass index	Exp = interview based on structured questionnaire (postural history) HEf = arthroscopy	Knee cartilage injury	- Kneeling: D >1h per day OR = 2.6 (CI 1.6-4.3)
Coggon 2000[43]	N = 333 G = 96 men;237 women A = 47-93 O = mostly construction and agricultural sector C = England	Cross-sectional study Ref = control group matched for age and sex (N = 396) Conf = body mass index	Exp = interview (weekly frequency of postural exposure) HEf = radiography	Knee osteoarthritis (according Kellgren/Lawrence scale)	- Kneeling: D >1h per day OR = 1.8 (CI 1.2-2.6) OR (men) = 1.7 (CI 1.0-3.0) OR (women) = 2.0 (CI 1.1-3.5)
Cooper 1994[20]	N = 13 G = ? A = >55 O = various such as nurse, teacher, electrical maintenance, construction worker C = England	Case-control study Ref = less exposed group (N = 9) Conf = body mass index	Exp = interview (postural exposure) HEf = radiography	Knee osteoarthritis (according Kellgren/Lawrence scale)	- Kneeling: D >30min per day OR = 3.4 (CI 1.3-9.1) OR (not adjusted) = 1.8 (CI 0.6-5.7)

Dawson 2003[44]	N = 29 G = women A = 50-70 O = various C = UK	Case-control study Ref = less exposed group (N = 82) Conf = age, body mass index	Exp = interview (posture exposure in years during working life) HEf = radiography; physician diagnostic	Knee osteoarthritis (moderate knee pain on most days in the past month and being placed on list for surgery)	- Kneeling: 15-<26 exposure years OR = 2.70 (0.76-9.58) - Kneeling: ≥26 exposure years OR = 4.18 (1.26-13.8)
Manninen 2002[28]	N = 212 G = 55 men;226 women A = 67.5 (sd=5.7) men; 69.2 (sd=5.4) women O = various C = Finland	Case-control study Ref = low exposed group (<50% of work day) matched for age and sex (N = 63) Conf = body mass index, leisure-time physical exercise	Exp = interview by telephone (postural exposure history before 49 years of age; 3 categories, from less than half of the day to almost all the time) HEf = arthroplasty operation	Knee osteoarthritis (before 49 years of age)	- Kneeling or squatting: D <2h per day OR = 0.85 (CI 0.55-1.32) OR (crude) = 0.95 (CI 0.65-1.39) OR (men) = 0.58 (CI 0.21-1.64) OR (men;crude) = 0.81 (CI 0.34-1.91) OR (women) = 0.97 (CI 0.59-1.59) OR (women;crude) = 0.98 (CI 0.64-1.51) - Kneeling or squatting: D ≥2h day OR = 1.73 (CI 1.13-2.66) OR (crude) = 1.69 (CI 1.17-2.44) OR (men) = 1.68 (CI 0.66-4.28) OR (men;crude) = 1.58 (CI 0.72-3.46) OR (women) = 1.81 (CI 1.11-2.95) OR (women;crude) = 1.71 (CI 1.13-2.60)
Nahit 2001[31]	N = 151-192 G = 68% men;32% women A = median 23 O = various C = England	Cross-sectional study Ref = unexposed group (N = 880-916) Conf = age, sex	Exp = self-administrated questionnaire (duration of postural exposure during the last working day; 4 categories, from less than 15 minutes to 4 hours or more) HEf = self-administrated questionnaire	Knee pain *Pain:* pain around the knee lasting longer than one day during the past month)	- Kneeling: D ≥15min OR = 1.8 (CI 1.2-2.6)
Yoshimura 2004[39]	N = 93 G = women A = 73 (sd=9.8) O = none C = Japan	Case-control study Ref = less exposed group (N = 73 standing; 27 kneeling; 30 squatting) Conf = ?	Exp = self-reported questionnaire (postural exposure history) HEf = clinical diagnostic	Knee osteoarthritis *Osteoarthritis:* grade 3 or 4 according to Kellgren/ Lawrence scale	- Kneeling: D ≥1h day OR = 0.75 (CI 0.52-1.76)

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

Annex **H**

Extraction table working in a squatting position

Author	Study population	Study design	Measurement methods	Health effect	Degree of association
Andersen 2007[15]	N = 283 G = ? A = 44 (sd=10) O = various C = Denmark	Prospective cohort study (2years) Ref = less exposed group (N = 1.082) Conf = sex, age, occupational category, intervention group	Exp = self-administrated questionnaire (estimation of amount of time spent in a posture) HEf = self-administrated questionnaire (7 categories scale, from not at all to very much)	Low back pain *Pain:* pain in a body region in the past 12 months	- Squatting: D >5min per h HR = 1.5 (CI 1.0-2.1)
Harkness 2003[22]	N = 234-275 G = 64% men, 36% women A = median 23 O = various sectors such as service organization, police, army officers, supermarket, postal distribution centre C = England	Cohort study (2 years) Ref = unexposed group (N = 76) Conf = age, sex, occupation	Exp = valid self-administrated questionnaire (postural exposure during the last working day) HEf = self-administrated questionnaire	Low back pain *Pain:* any pain or ache in the low back lasting for one day or longer in the past month	- Squatting: D <15min per day OR = 1.1 (CI 0.7-1.7) - Squatting: D ≥15min per day OR = 1.8 (CI 1.1-3.1)
Nahit 2001[31]	N = 151-192 G = 68% men;32% women A = median 23 O = various C = England	Cross-sectional study Ref = unexposed group (N = 880-916) Conf = age, sex	Exp = self-administrated questionnaire (duration of postural exposure during the last working day; 4 categories, from less than 15 minutes to 4 hours or more) HEf = self-administrated questionnaire	Low back pain *Pain:* pain in the lower back lasting longer than one day during the past month)	- Squatting: D ≥15min OR = 1.5 (CI 0.98-2.2)

Yip 2004[52]	N = 182 G = women A = 48-51 O = various (59% housewives) C = China	Case-control study Ref = less exposed group (less tertile of daily time) matched for age (N = 235) Conf = working status	Exp = self-reported questionnaire (daily time of postural exposure) HEf = interview with use of diagram for pain site indication	Low back pain *Pain:* pain of low back that last for more than a day during the past 12 months (for at least 14 days = severe)	- Squatting: D middle and highest tertile of daily time OR = 1.77 (CI 1.15-2.73) OR (severe) = 1.51 (CI 0.86-2.53)
Croft 1992[21]	N = 245 hip patients G = men A = >55 O = agricultural and construction sectors C = England	Case-control study Ref = group with minimal joint space of both hips ≥3.5 mm Conf = age	Exp = interview postural exposure history) HEf = radiography	Hip osteoarthritis *Osteoarthritis:* minimal joint space of one of the hips ≤2.5 mm (≤1.5 mm = severe)	- Squatting: D >30min per day & ≥1 exposure year OR = 0.7 (CI 0.4-1.4) OR (severe)= 1.3 (CI 0.4-3.6)
Lau 2000[46]	N = 796 G = 196 men; 600 women A = ? O = ? C = China	Case-control study Ref = less exposed group Conf = none	Exp = self-administrated structured questionnaire (postural exposure; dichotomous, an hour or more each day) HEf = medical diagnosis	Hip osteoarthritis *Osteoarthritis:* grade 3 or 4 according to Kellgren/ Lawrence scale	- Squatting OR (men) = 1.3 (CI 0.5-3.2) OR (women) = 1.6 (CI 1.0-2.8)
Tuchsen 2003[51]	N = 617 G = 2030 men;1684 women A = 18-65 O = various C = Denmark	Cohort study (5 years) Ref = seldom or never exposed group (N = 3.097) Conf = demographic and anthropometric variables	Exp = interview by telephone (postural exposure; dichotomous) HEf = interview by telephone five years later	Hip pain *Pain:* trouble, pain or malaise in one or both hips at any point in time within the last 12 months	- Squatting: D ≥25% of work day OR = 0.64 (CI 0.42-0.98)
Andersen 2007[15]	N = 283 G = ? A = 44 (sd=10) O = various C = Denmark	Prospective cohort study (2years) Ref = less exposed group (N = 1.082) Conf = sex, age, occupational category, intervention group	Exp = self-administrated questionnaire (estimation of amount of time spent in a posture) HEf = self-administrated questionnaire (7 categories scale, from not at all to very much)	Hip, knee, foot pain *Pain:* pain in a body region in the past 12 months	- Squatting: D >5min per h HR = 1.6 (CI 1.1-2.3)
Amin 2008[41]	N = 47 G = men A = 64 (sd=9) O = various C = USA	Cross-sectional study Ref = unexposed group (N = 98) Conf = age, body mass index, injury history	Exp = self-administrated validated questionnaire (postural exposure; dichotomous, 30 min or more) HEf = MRI imaging	Knee osteoarthritis (WORMS cartilage morphology ≥ 2)	- Squatting/kneeling in combination with heavy lifting: D ≥ 30 min per day OR = 1.6 (CI 0.9-3.0) OR (crude) = 1.2 (CI 0.7-2.2)
Baker 2002[42]	N = 61 G = 196 men;47 women A = 20-59 O = various C = England	Cross-sectional study Ref = less exposed group matched for age and sex (N = 62) Conf = sex, age, occupational category, body mass index	Exp = interview based on structured questionnaire (postural history) HEf = arthroscopy	Knee cartilage injury	- Squatting: D > 1h per day OR = 2.2 (CI 1.4-3.6)

Coggon 2000[43]	N = 333 G = 96 men;237 women A = 47-93 O = mostly construction and agricultural sector C = England	Cross-sectional study Ref = control group matched for age and sex (N = 396) Conf = body mass index	Exp = interview (weekly frequency of postural exposure) HEf = radiography	Knee osteoarthritis (according Kellgren/Lawrence scale)	- Squatting: D >1h per day OR = 2.3 (CI 1.3-4.1) OR (men) = 2.2 (CI 1.0-4.9) OR (women) = 2.8 (CI 1.1-7.2) - Squatting: D >1h per day or kneeling: D >1h per day OR = 1.9 (CI 1.3-2.8) OR (men) = 2.0 (CI 1.1-3.6) OR (women) = 2.1 (CI 1.2-3.6) - Squatting: D >1h per day or kneeling: D >1h per day for >1year OR = 1.7 (CI 1.1-2.7) OR (men) = 2.0 (CI 0.9-4.4) OR (women) = 1.6 (CI 0.9-3.0) - Squatting: D >1h per day or kneeling: D >1h per day for 1-9.9years OR = 2.6 (CI 1.6-4.2) OR (men) = 3.0 (CI 1.4-6.1) OR (women) = 2.8 (CI 1.4-5.5) - Squatting: D >1h per day or kneeling: D >1h per day for 10-19.9years OR = 1.1 (CI 0.6-2.1) OR (men) = 1.3 (CI 0.5-3.2) OR (women) = 0.8 (CI 0.3-2.0) - Squatting: D >1h per day or kneeling: D >1h per day for >20years OR = 1.7 (CI 0.9-3.4) OR (men) = 1.7 (CI 0.7-4.0) OR (women) = 3.2 (CI 0.8-13.0)
Cooper 1994[20]	N = 11 G = ? A = >55 O = various such as nurse, teacher, electrical maintenance, construction worker C = England	Case-control study Ref = less exposed group (N = 4) Conf = body mass index	Exp = interview (postural exposure) HEf = radiography	Knee osteoarthritis (according Kellgren/Lawrence scale)	- Squatting: D >30min per day OR = 6.9 (CI 1.8-26.4) OR (not adjusted) = 3.7 (CI 0.8-16.6)

Felson 1991[50]	N = 1.376 G = 569 men;807 women A = ? O = various C = USA	Prospective cohort study (40 years) Ref = sedentary or light demands and no squatting (N = 54) Conf = age, height, body mass index	Exp = self-administrated questionnaire (postural exposure; dichotomous, squatting needed or not) HEf = radiography	1. Radiographic knee osteoarthritis 2. Severe knee osteoarthritis 3. Bilateral knee osteoarthritis *Radiographic:* ≥ grade 2 radiographic change at least in one knee. *Severe:* ≥ grade 3 radiographic change at least in one knee. *Bilateral:* ≥ grade 2 radiographic change in both knee and symptomatic osteoarthritis diagnosed.	- Squatting 1. OR (men) = 1.07 (CI 0.53-2.17) 1. OR (women) = 1.56 (CI 0.80-3.03) 2. OR (men) = 0.94 (CI 0.40-2.22) 2. OR (women) = 2.05 (CI 0.95-4.43) 3. OR (men) = 1.12 (CI 0.49-2.57) 3. OR (women) = 1.77 (CI 0.80-3.92)
Lau 2000[46]	N = 796 G = 196 men; 600 women A = ? O = ? C = China	Case-control study Ref = less exposed group Conf = none	Exp = self-administrated structured questionnaire (postural exposure; dichotomous, an hour or more each day) HEf = medical diagnosis	Knee osteoarthritis *Osteoarthritis:* grade 3 or 4 according to Kellgren/ Lawrence scale	- Squatting OR (men) = 1.2 (CI 0.7-2.0) OR (women) = 1.1 (CI 0.8-1.5)
Nahit 2001[31]	N = 151-192 G = 68% men;32% women A = median 23 O = various C = England	Cross-sectional study Ref = unexposed group (N = 880-916) Conf = age, sex	Exp = self-administrated questionnaire (duration of postural exposure during the last working day; 4 categories, from less than 15 minutes to 4 hours or more) HEf = self-administrated questionnaire	Knee pain *Pain:* pain around the knee lasting longer than one day during the past month)	- Squatting: D ≥15min OR = 1.3 (CI 0.8-1.9)
Yoshimura 2004[39]	N = 93 G = women A = 73 (sd=9.8) O = none C = Japan	Case-control study Ref = less exposed group (N = 73 standing; 27 kneeling; 30 squatting) Conf = ?	Exp = self-reported questionnaire (postural exposure history) HEf = clinical diagnostic	Knee osteoarthritis *Osteoarthritis:* grade 3 or 4 according to Kellgren/ Lawrence scale	- Squatting: D ≥1h day OR = 1.05 (CI 0.57-1.94)

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