Health Council of the Netherlands

Repetitive movements at work

2013/05E

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Gezondheidsraad
Health Council of the Netherlands

To the Minister of Social Affairs and Employment

Subject : presentation of advisory report *Repetitive movements at work*
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Dear Minister,

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

Many employees in the Netherlands report they regularly perform repetitive movements. This advisory report answers the question of whether there are options for occupational health-based and/or safety-based exposure limits. Based on available scientific data, the Committee notes there are signs that repetitive movements pose a health risk for specific disorders and non-specific complaints of the upper extremity (shoulder, elbow, wrist and hand joints). However, the Committee does not see any possibilities for determining an occupational health-based exposure limit.

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

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

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

P.O.Box 16052
NL-2500 BB The Hague
The Netherlands
Telephone +31 (70) 340 70 17
E-mail: a.vd.burght@gr.nl

Visiting Address
Rijnstraat 50
NL-2515 XPThe Hague
The Netherlands
www.healthcouncil.nl

Repetitive movements at work

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

to:

the Minister of Social Affairs and Employment

No. 2013/05E, The Hague, April 19, 2013

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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Contents

Executive summary

The request for advice

On request of the Minister of Social Affairs and Employment (SZW), the Health Council of the Netherlands examined the question of whether there are current or longer term options for deriving concrete occupational health-related or safety-related exposure limits for repetitive movements at work. This advisory report is one of a series in which the Committee on the Identification of Workplace Risks examines various occupational risks covered by the Dutch Working Conditions Act and its associated regulations. The Committee has studied the scientific evidence on the negative health effects of repetitive movements.

Definition and scope of the problem

In the view of the Committee, repetitive movements occurs when the upper extremities (the shoulder, elbow, wrist and/or hand joints) make repeated movements within a short cycle. In their replies to the *Nationale Enquête Arbeidsomstandigheden 2011* (the 2011 national working conditions survey), more than one in three employees in the Netherlands reported carrying out repetitive movements on a regular basis in their work. The sectors where repetitive movements occur most are the meat-processing industry, the mechanical engineering industry, the retail trade, and the construction industry. Almost half of all employees in these sectors claim to carry out regular repetitive

movements. This primarily involves meat-processing employees, assembly workers, people who operate cash tills, hairdressers, painters and musicians.

Research has shown that employees who regularly perform repetitive movements can experience health-related complaints. This concerns specific and non-specific health conditions that affect the upper extremities. Negative health effects have an impact not just on people's well-being in daily life, but can also lead to a loss of productivity at work and sick leave.

Current laws and guidelines

There are no references in Dutch law to concrete measures regarding health-related and/or safety-related limits to exposure to repetitive movements at work. International guidelines refer to the Occupational Repetitive Action (OCRA) method as a means of evaluating what the risk of straining the upper limbs is as a result of repetitive movements involving light loads. However, this method relies primarily on an expert's consensus and its validity remains limited. In addition, it is not possible to say how much damage to health is prevented through the application of the method.

The registration guidelines of the Netherlands Center for Occupational Diseases (NCvB) are used as the criteria for reporting occupational diseases. The registration guideline that is relevant to repetitive movements also relates to work with computer use (which is outside the remit of this advisory report) and is therefore not relevant to this advisory report.

The Inspectorate SZW uses the Hand Arm Risk assessment Method (HARM) when determining the risk of arm, neck, or shoulder complaints. However, this method has only been partly validated and it is not clear how much damage to health it prevents.

Health risks due to repetitive movements at work

The Committee had various prospective cohort and patient-control studies at its disposal in which the occurrence of health-related problems resulting from repetitive movements had been investigated.

The Committee notes that the available epidemiological studies indicate that repetitive movements at work forms a health risk as far as specific disorders of the upper extremities, such as carpal tunnel syndrome and lateral epicondylitis ('tennis elbow'), are concerned. There are also indications that repetitive movements form a health risk for forms of non-specific complaints to the upper extremities.

The epidemiological literature has a number of shortcomings. There is no clear-cut definition of repetitive movements, for example. In addition, the studies use a wide range of exposure criteria and the information about exposure to repetitive movements is largely incomplete.

On the basis of the data available, it is therefore impossible to state the degree to which repetitive movements can be carried out without the occurrence of health-related problems.

Conclusion

Based on the available scientific data, there are indications that repetitive movements at work form a health risk in relation to specific disorders to the upper extremities, such as carpal tunnel syndrome and lateral epicondylitis, and non-specific complaints of the upper extremities.

In the light of the heterogeneity of the exposure criteria used, the Committee has been unable to translate the evidence from the available epidemiological literature into meaningful exposure criteria. It is therefore not possible to formulate advisory health-based occupational exposure limits that might prevent the occurrence of specific disorders and non-specific complaints to the upper extremities.

Chapter 1

Introduction

One in three Dutch employees regularly performs repetitive movements at work. This can result in health complaints of the shoulders, elbows, wrists and hands. The Committee on the Identification of Workplace Risks of the Health Council therefore examined whether occupational health-based and/or safety-based exposure limits can be determined based on current scientific evidence. This advisory report addresses this issue.

1.1 Repetitive movements: definition

Many definitions of repetitive movements are used in the literature. These definitions are focused on describing specific actions, but are not suitable for operationalising the complexity of daily exposure to repetitive movements in a variety of professions in epidemiological research.

In the opinion of the Committee, a movement is repetitive if the upper limbs (joints of the shoulders, elbow, wrists and hand) perform repeated (short, cyclical) motions.[1,2] Movements that also involve lifting or carrying a burden are only called repetitive if this burden weights less than three kilograms.[1,2] If the burden weighs three kilograms or more, the movement is considered lifting or carrying.[1,2]

In this advisory report, the Committee focuses solely on actions involving the upper limbs. For actions involving the neck, torso or lower limbs, the emphasis generally lies with posture and the repetitive nature of the activity is less prominent. Computer use, particularly data entry, is a form of repetitive work. The Committee has not addressed this form of repetitive work in this report, as a separate advisory report by the Committee has been published on this subject.[3]

1.2 Scope of repetitive movements at work

Within the context of the Nationale Enquête Arbeidsomstandigheden 2011 (2011 national working conditions survey), over one in three employees in The Netherlands indicated they regularly perform repetitive movements.[4] Repetitive movements are common in professions involving conveyer belts, cash registers and/or joysticks.[4,5] Employees who frequently perform repetitive movements include meat processing workers, assembly line workers, cashiers, hairdressers, painters and musicians.[4-6] The sectors in which repetitive movements are most common include the meat processing industry, the machining and manufacturing industry, retail, and construction. In these sectors, almost half of all employees indicate they regularly need to perform repetitive movements.[4,5] Repetitive movements are also common in subsectors of construction and industry, as well as in postal services and telecommunications.[4,5] Repetitive movements are common in the agricultural sector during harvesting, sorting and crop-related activities.

1.3 Report on Repetitive Strain Injury

In 2000, the Health Council published an advisory report on RSI (*Repetitive Strain Injury*). In this advisory report, RSI was defined as a syndrome of complaints to neck, upper back, shoulder, upper arm or forearm, elbow, wrist, hand or combinations thereof resulting in disability or participation problems.[7] The syndrome is characterised by a disruption of the balance between burden and capacity, with a variety of potential causes.[7] In addition to limited recovery time, psychological burdens and limited social support, repetitive movements are mentioned as a possible cause of RSI.[7] The Health Council concluded that greater insight into the pathophysiology of RSI complaints and the contribution of various risk factors was required before preventive measures could be recommended.[7] Scientific knowledge in the field of RSI risk factors at that time was insufficient for defining standards. Evidence for the efficacy of preventive measures was almost entirely lacking.

1.4 The request for advice

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

- Periodically report whether there are *currently* new (international) scientific insights regarding concrete occupational health-based and/or safety-based exposure limits.
- Periodically report whether *in future* new (international) scientific insights are expected regarding concrete occupational health-based and/or safety-based exposure limits.
- Additionally, the minister requested *existing* scientific insights be considered. The full request for advice has been included as Annex A to this advisory report.

On 14 March 2008, the Committee on the Identification of Workplace Risks was appointed for this task. The Committee is composed of experts in the fields of working conditions, health, safety and occupational disease. The president and members of the Committee and its working group are listed in Annex B. Upon request of the Ministry of Social Affairs and Employment, this advisory report concerns repetitive movements.

1.5 The Committee's methods

The Committee first examines whether occupational health-based and/or safety-based exposure limits are available in The Netherlands or internationally. If limits and/or legal frameworks are present, the Committee first examines whether these have a health or safety-related foundation.

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

The Committee subsequently evaluates whether the insights from the literature can be used to formulate or update occupational exposure limits for repetitive movements.

Once the Committee reaches a consensus on content, a draft report is published for commentary by third parties. Received comments are integrated in the finalisation of the advisory report (Annex L).

1.6 Reading guide

In the second chapter, the Committee provides an overview of applicable national and international laws and guidelines. In the third chapter, the Committee describes the results of the systematic literature review into the health effects of repetitive movements. Chapter four addresses the significance of specific disorders and non-specific upper limb complaints: how serious are they? Finally, Chapter 5 contains the conclusions and an answer to the request for advice.

Chapter 2

Laws and guidelines

This chapter provides and overview of legislation and regulations relating to the occupational risks of repetitive movements. The Dutch Working Conditions Act, elaborated in the Working Conditions Decree and Regulation, includes rules for employers and employees designed to protect and promote the health, safety and welfare of employees and independent entrepreneurs. There are also international guidelines on repetitive movements.

2.1 The Working Conditions Act, Decree and Regulation

The Working Conditions Act outlines general provisions for the promotion of health, safety and welfare of employees and independent entrepreneurs.[8] Sections 5.1 through 5.6 of The Working Conditions Decree and Regulation apply to physical burden. Neither these articles nor other legislation and regulations contain legal limits for repetitive movements.[8]

2.2 International guideline

The NEN-ISO 11228-3:2007 ‘Ergonomics – Manual handling – Part 3: Handling of low loads at high frequency’ standard provides ergonomic recommendations for repetitive movements, including high-frequency, manual displacement of loads lighter than 3 kg.[9] This international standard lists methods for risk

management, with a preference for the Occupational Repetitive Action (OCRA) method.

The OCRA is a method for estimating the risk of overburdening the upper limbs due to repetitive handling of light burdens (Annex E).[9] The method was developed in 1996 by Occhipinti and Colombini. Conceptually, the OCRA method is based on the procedure recommended by the National Institute for Occupational Safety and Health (NIOSH-USA) for calculating the Lifting Index, but on a content level it is based primarily on a consensus document by the technical Committee of the International Ergonomics Association (IEA) regarding musculoskeletal complaints.[10-14] In a validity study, Grieco (1998) compared exposure to repetitive movements to the prevalence of upper limb complaints. As both exposure and prevalence were measured per profession, it is impossible to derive associations at the individual level.[15] The Committee notes that the OCRA method appears to lack an epidemiological foundation, and that the method does not provide any information about the amount of health damage that it can prevent.

2.3 Other guidelines

Employers are required to include the risks of repetitive movements in their risk inventory and evaluation. In its oversight activities, Inspectorate SZW (social affairs and employment) uses the Hand Arm Risk assessment Method (HARM) to determine the risk of arm, neck or shoulder complaints in employees who regularly perform hand-arm tasks.[16,17] The method is based on knowledge of risk factors from the literature, supplemented by expert opinion. HARM may be applied to all hand-arm tasks (excluding computer use) that last for more than one hour per day and involve exertion of less than 6 kg/60 N of force using the hand.[17] HARM yields a risk assessment, expressed as a colour code according to a traffic light model. A red score means the hand-arm tasks are associated with a strongly increased risk of arm, neck or shoulder complaints; the employer must remove these hand-arm tasks. An orange score means the hand-arm tasks are associated with an increased risk of arm, neck or shoulder complaints for some employees. In this case, the employer must include these hand-arm tasks in the risk inventory and evaluation (RI&E) and take measures to reduce the risk. The Inspectorate SZW uses this gross risk assessment method because HARM is only partially validated. The relationship between the incidence of arm, neck or shoulder complaints related to use of this method is also unknown, so it remains unclear how much health damage may be prevented by using it.[16,17]

The Netherlands Center for Occupational Diseases (NCvB) adheres to registration guidelines that indicate the causal link between health conditions and (occupational) exposure to occupational factors.[18] The registration guideline Work-related musculoskeletal upper limbs conditions (RSI)[19], based among other things on the Saltsa report (2000)[20], is relevant to repetitive movements. However, this guideline was not drafted exclusively to address repetitive movements as defined by the Committee, but also encompasses computer use.

Chapter 3

Health risks due to repetitive movements at work

The Committee performed a systematic literature review (Annex D), with the following two main questions: What health and safety problems develop due to the occupational risk of repetitive movements? To what degree is exposure (in terms of duration, frequency and/or intensity) to this occupational risk related to these problems?

3.1 Broad literature exploration

A number of scientific literature reviews have been published on the development of health-related problems due to repetitive movements.[7,21-29] The Committee did not find any reviews addressing the question of the degree to which this occupational risk also results in safety-related problems. The Committee also did not identify any original studies examining the safety problems due to repetitive movements. Therefore, the potential safety-related issues relating to repetitive movements at work are not addressed in this advisory report.

Based on published reviews and reports, the Committee concludes that repetitive movements may be associated with an increased risk of specific upper limb disorders, including subacromial impingement syndrome (a condition of soft tissues in the shoulder joint), medial epicondylitis (inflammation or irritation of the attachment point of ligaments on the inside of the elbow joint), epicondylitis

laterals (inflammation or irritation of the attachment point of ligaments to the outside of the elbow) and carpal tunnel syndrome (narrowing around the middle nerve in the wrist). The Committee also notes that repetitive movements may be associated with an increased risk of non-specific upper limb complaints. Annex C provides an overview of the reviews identified.

3.2 Systematic literature review

After the broad exploration, the Committee performed a systematic literature search in various databases. The Committee also searched for recent studies performed in professions (cashiers, hairdressers, meat packers, assembly line workers, painters and musicians) where repetitive movements are common. Annex D describes the search strategy and how studies were selected and evaluated based on quality. The Committee searched for prospective cohort and patient-control studies for specific upper limb disorders. Concerning non-specific upper limb complaints, the Committee searched exclusively for prospective cohort studies. The Committee also followed this approach in other advisory reports on the consequences of physical burdens. This is because prospective cohort studies determine exposure to the risk prior to the health effect, resulting in the lowest chance of bias for the correlation. In case-control studies, minimal bias may be expected if the determination of exposure is blinded from patient status.

3.3 Health effects to due repetitive movements at work

Specific upper limb disorders

Five prospective and six patient-control studies examined the occurrence of various specific upper limb disorders due to repetitive movements. This includes the following disorders: carpal tunnel syndrome (narrowing around the middle wrist nerve), lateral epicondylitis (inflammation or irritation of the attachment of ligaments to the outer elbow joint) and wrist tendinosis (degeneration of the tendon in the wrist).[30-40] These studies were conducted in various types of employees, including administrative staff, nurses, cleaners, cashiers, packers, assembly line workers, butchers, military personnel, drivers and dentists. All studies into the consequences of repetitive movements for specific upper limb disorders are summarized in a table in Annex F, and described briefly in Annex G.

Four studies quantified the degree of exposure to repetitive movements. These studies are summarized in Table 1. This overview of exposure-response relationships for specific upper limb disorders (Table 1) clearly shows that the exposure measures used in these studies are not comparable. Repetitive movements are associated with an increased risk of specific upper limb disorders, including carpal tunnel syndrome and lateral epicondylitis. Three studies found a statistically significant increased risk of carpal syndrome and lateral epicondylitis.[33,39,40]

One of these studies found that employees who spend three quarters or more of their workday performing repeated movements are almost four times as likely to develop lateral epicondylitis than employees who do not or spend less than one quarter of their working day performing repeated arm movements.[33]

Table 1 Overview of exposure-response relationships for specific upper limb disorders due to repetitive movements, found in prospective cohort and patient-control studies.

Exposure	Disorder	Risk measure (95%CI)	Design	Reference
4.5 – 19.2 repetitions per min (> 1kgf)	Wrist tendinosis	HR 1.4 (0.5-3.6)	Prospective cohort	[34]
> 19.2 repetitions per min (> 1 kgf)	Wrist tendinosis	HR 1.3 (0.5-3.5)	Prospective cohort	[34]
38.8 – 47.2 repetitions per min	Wrist tendinosis	HR 1.4 (0.6-3.4)	Prospective cohort	[34]
> 47.2 repetitions per min	Wrist tendinosis	HR 0.9 (0.4-2.4)	Prospective cohort	[34]
25 – 50% workday repeated hand-arm movements	Lateral epicondylitis	men: OR 1.7 (0.9-3.3) women: OR 1.3 (0.7-2.5)	Patient-control	[33]
≥ 75% workday repeated hand-arm movements	Lateral epicondylitis	men: OR 2.2 (0.9-5.3) women: OR 1.9 (0.7-4.0)	Patient-control	[33]
25 – 50% workday repeated arm movements	Lateral epicondylitis	men: OR 1.8 (0.9-3.6) women: OR 1.5 (0.7-3.1)	Patient-control	[33]
≥ 75% workday repeated arm movements	Lateral epicondylitis	men: OR 1.9 (0.8-4.6) women: OR 3.7 (1.7-8.3)*	Patient-control	[33]
56 – 115 hand repetitions per 10 min	Carpal tunnel syndrome	OR 4.2 (1.8-10.1)*	Patient-control	[40]
56 – 115 dominant hand repetitions per 10 min	Carpal tunnel syndrome	OR 3.3 (1.1-9.7)*	Patient-control	[40]
56 – 115 non-dominant hand repetitions per 10 min	Carpal tunnel syndrome	OR 5.3 (1.6-17.6)*	Patient-control	[40]
1 – 20 years of repeated movements	Carpal tunnel syndrome	OR 1.5 (0.5-4.4)	Patient-control	[39]
> 20 years of repeated movements	Carpal tunnel syndrome	OR 4.6 (1.8-11.9)*	Patient-control	[39]

CI, confidence interval; min, minute; kgf, kilogram-force; HR, hazard ratio; OR, odds ratio, * statistically significant $p < 0.05$

A second study found that employees who performed between 56 and 115 repeated hand movements per 10 minutes had a three to five times higher risk of developing carpal tunnel syndrome than employees who did not or performed fewer repeated hand movements.[40] A third study found that employees who performed repeated movements for over twenty years were almost five times as likely to develop carpal tunnel syndrome as employees who did not or had performed repeated movements for less than one year.[39]

Non-specific upper limb complaints

Seven prospective cohort studies investigated the occurrence of non-specific upper limb complaints due to repetitive movements.[41-47] These studies related to different types of employees, such as administrative staff, nurses, cleaners, cashiers, packers, meat packers, assembly line and conveyer belt workers, military personnel and dentists. All studies about the effects of repetitive movements on non-specific upper limb complaints are summarized in a table in Annex H and described briefly in Annex I.

Table 2 provides an overview of the studies in which exposure to repetitive movements was quantified. This overview of exposure-response relationships for non-specific upper limb complaints clearly shows that the exposure measures used in these studies are not comparable. Table 2 shows that repetitive

Table 2 Overview of exposure-response relationships for non-specific upper limb complaints due to repetitive movements in prospective cohort studies.

Exposure	Complaints	Risk measure (95%CI)	Reference
1-15 repeated shoulder movements per min	Neck-shoulder	OR 1.1 (0.9-2.3)	41
16-40 repeated shoulder movements per min	Neck-shoulder	OR 1.5 (1.2-1.9)*	41
10-44 min of repeated movements per hour	Neck-shoulder Elbow/forearm/hand	HR 1.0 (0.7-1.5) HR 1.2 (0.7-2.1)	42
45-60 min per hour repeated movements	Neck/shoulder Elbow/forearm/hand	HR 1.5 (1.0-2.1) HR 1.9 (1.2-3.1)*	42
< 2 hours of repeated hand-arm movements per day	Shoulder	OR 1.0 (0.6-1.6)	43
≥ 2 hours of repeated hand-arm movements per day	Shoulder	OR 1.0 (0.6-1.6)	43
≥ 2 hours of repeated arm movements per day	Forearm	OR 2.9 (1.5-5.3)*	47
≥ 2 hours of repeated hand movements per day	Forearm	OR 2.9 (1.6-5.2)*	47
1-50% working day repeated arm movements	Forearm	RR 1.4 (0.4-4.2)	45
≥ 50% working day hand movements	Forearm	RR 3.4 (1.3-8.7)*	45
1-50% working day repeated arm movements	Forearm	RR 1.2 (0.4-3,7)	45
≥ 50% workday repeated arm movements	Forearm	RR 2.9 (1.2-7.3)*	45

CI, confidence interval; min, minute; HR, hazard ratio; OR, odds ratio; %, percentage; * statistically significant $p < 0.05$

movements pose a health risk for non-specific upper limb complaints, with four studies finding a statistically significant elevated risk of non-specific upper limb complaints.[41,42,45,47]

One of these studies found that employees performing between 16 and 40 repeated shoulder movements per minute were one and a half times more likely to develop neck/shoulder complaints than employees who did not perform any repeated shoulder movements.[41] A second study found that employees who performed repeated movements for between 45 and 60 minutes per hour were almost twice as likely to have elbow/forearm/hand complaints as employees who spend less than 9 minutes per hour performing repetitive movements.[42] A third study found that employees who spend two hours or more of their workday performing repeated arm or hand movements, are almost three times as likely to develop forearm complaints as employees who spend less than two hours of their workday performing repeated arm or hand movements.[47] A fourth study found that employees who spend half of their workday or more performing repeated arm or hand movements, are about three times as likely to have forearm complaints as employees who do not perform any repeated hand movements.[45]

Other complaints

Three prospective cohort studies examined the incidence of other types of complaints as a result of repeated movements (Annexes J and K).[42,48,49] Two of these three studies found that repeated movements are associated with an increased risk of hip, knee and foot and general pain.[42,49] Because these findings were only reported once, the Committee is of the opinion the scientific evidence is therefore too small to determine whether an association exists. A third prospective cohort study found that repeated movements are associated with an increased risk of stress complaints.[48] Despite further exploration of the epidemiological literature on this subject, the Committee found only the one report on this finding.

3.4 Discussion of the findings

While studying the previously described epidemiological literature, the Committee noticed a number of key problems. Given the lack of a clear definition of repeated movements, incomplete exposure information and the diversity of exposure measures and health measures used, the Committee was unable to compare various studies.

Definition of exposure to repeated movements

A clear definition of repeated movements is lacking in the epidemiological literature described. Furthermore, the studies described display great heterogeneity in exposure to repeated movements, with exposure measures often limited to the average duration of the repeated movement per working day. Information about other relevant components, such as frequency and speed of movement/precision are lacking. The exposure to repeated movements in the epidemiological literature described is very poorly described for both study and reference groups.

Variation in health and risk measures used

The variation in the definition of health measures is an additional problem. This means the development of health complaints cannot be clearly distinguished from pre-existing health complaints. Furthermore, the Committee noted that many studies lacked the power to demonstrate statistically significant associations between repeated movements and the occurrence of upper limb complaints. Additionally, the Committee notes that odds ratios were calculated in the prospective cohort studies. The Committee knows that odds ratios calculated based on prospective cohort studies somewhat overestimate risk, which was often not addressed sufficiently in the studies.

Self-reported exposure and health complaints

In almost all epidemiological studies, exposure was reported by the study subjects via questionnaires or interviews. Exposure recorded via self-report is less valid than measured exposure, as self-report sometimes provides inaccurate information about the frequency and duration of tasks and activities.[50,51] Self-reported exposure to repeated movements therefore risks overestimation or underestimation of this exposure. The Committee considers self-report of repeating movements an acceptable method, however, as no alternative method is available that can easily be deployed in large-scale epidemiological research.

The health effects were also primarily self-reported, particularly where local upper limb (pain) complaints were concerned. In the Committee's opinion, local non-specific (pain) complaints can only be mapped using self-report. In the patient-control studies, the diagnosis carpal tunnel syndrome was made based on medical charts and/or clinical examinations.

Potential biasing factors

The Committee notes that the studies into repeated movements fail present exposure in a sufficiently differentiated manner. Furthermore, the Committee cannot rule out that upper limb complaints related to repeated movements are (in part) caused by poor posture. The selected epidemiological studies do not report on this at all. Additionally, workplace exposure often encompasses multiple risk factors with a common physical point of application. For example, upper limb complaints may be caused not only by repeated movements, but also by other physical risk factors such as pushing or pulling. This is often insufficiently discussed in the studies.

3.5 Conclusion

Based on a systematic review of the literature, the Committee identified fourteen prospective cohort and six patient-control studies investigating the occurrence of upper limb health complaints due to repeated movements at work. These studies were conducted in a variety of employees, such as administrative staff, nurses, cleaners, cashiers, packers, meat packers, assembly line and conveyer belt workers, military personnel and dentists. Although repeated movements occur frequently in other professions, such as hairdressers and musicians, the Committee was unable to find good, recent, prospective cohort studies in these groups. As a definition for repeated movements is lacking, and exposure information is of poor quality, the Committee cannot compare the available studies with each other. It can be concluded that the epidemiological studies provide indications that repeated movements pose a health risk for specific upper limb disorders, such as carpal tunnel syndrome and lateral epicondylitis. There are also indications that repeated movements increase the risk of non-specific upper limb complaints.

Chapter 4

Meaning of musculoskeletal disorders and complaints

Specific upper limb disorders as well as non-specific complaints are common. At what point are these conditions serious and may they be deemed a negative health effect? In other words: what weight should be given to the specific upper limb disorders or non-specific upper limb complaints measured in the prospective cohort and patient-control studies identified in the systematic literature review? In order to answer this question, the Committee examined available data on the prevalence, incidence and prognosis of specific disorders and non-specific complaints of the upper extremities, as well as the associated disease burden and absenteeism.

4.1 Prevalence

In order to determine the relevance of the specific disorders and non-specific complaints that develop in the upper limbs due to repeated movements, the Committee evaluates the results of the epidemiological studies in the light of prevalence data for such specific disorders and non-specific complaints in the general population. Prevalence is defined as the occurrence (number) of cases of a specific health condition in a population of employees or the general population. The prevalence may be expressed for one moment in time (point prevalence) or for a period such as a year (year prevalence).

Specific upper limb disorders

Carpal tunnel syndrome is more common in women than men, particularly in the age group forty to sixty years.[52] A study conducted between 1983 and 1985 in a sample of the general population in Maastricht and surroundings examined the prevalence of carpal tunnel syndrome, with the diagnosis being based on a combination of patient complaints and abnormal nerve conduction test restuls.[53] This study showed that over 9.2% of women aged 25 to 74 years had carpal tunnel syndrome.[53] The prevalence among men ages 25 to 74 was much lower, namely 0.6%.[53] In this study, carpal tunnel syndrome was diagnosed primarily among men and women aged 55 years and older, so this prevalence estimate has little relevance to the working population.[53]

The 'Second national study into diseases and treatments in general practice', conducted in 104 general practices, the prevalence of lateral epicondylitis (self-reported using questionnaires and an interview) was 0.72%.[54] In people under the age of 20 years, this disorder is rarely diagnosed in general practice; the prevalence then increases in the age category 40 to 50 years.[54] The mentioned prevalence is practically the same for both sexes.[54] The prevalence of medial epicondylitis is estimated to be ten times lower.[54]

Non-specific upper limb complaints

In 2007, 26% of the Dutch population aged 25 and above had non-specific complaints of the arm, neck and/or shoulder in the previous year.[55] In a survey of about 3,500 Dutch people over the age of 25 years by Picavet et al. (2003) , the following prevalence figures were found for non-specific upper limb pain complaints:[56]

- over a 12-month period: neck 31%, shoulder 30%, elbow 11%, wrist-hand 18%
- at a random moment (point prevalence) neck 21%, shoulder 21%, elbow 7.5%, wrist-hand 13%
- For chronic pain in the past 12 months: neck 14%, shoulder 15%, elbow 5.3%, wrist-hand 9.3%.

4.2 Prognosis

The prognosis of the specific disorders and non-specific complaints of the upper limbs may be evaluated based on scientific data on the course of such complaints.

Specific upper limb disorders

About one quarter of patients with carpal tunnel syndrome experience a significant improvement in pain after 10 to 15 months.[52] These data also imply that three quarters of patients do not experience a significant improvement after this period.

The natural course of lateral epicondylitis appears benign. After half a year, at least 80% of patients have (practically) fully recovered, a percentage rising to over 90% at one year.[57] The prognosis appears less promising for complaints that have lasted longer or severe pain during the first visit to the GP, localisation in the dominant arm, and for people with recurring complaints.[57]

Non-specific upper limb complaints

The study by Picavet et al. (2003) in a sample of the Dutch population (including employees) found that only 6.3% of people with neck, shoulder or upper back complaints only experienced a single episode of pain. This percentage was 7.5 for elbow or wrist complaints.[56]

47% of people with neck, shoulder or upper back complaints reported recurring mild pain; this percentage was 43% for elbow or wrist complaints. 26% of respondents had continuous mild pain in neck, shoulders or upper back, 29% in the elbow or wrist. Severe pain complaints were less common: recurring severe neck, shoulder or upper back pain was reported by 8.3% of respondents, 11% complained of elbow or wrist pain. Continuous severe pain in the neck, shoulders or upper back was experienced by 3.1%; the figure was 4.0% for the elbow or wrist.

Table 3 Results from the study by Picavet et al. (2003) about pain progression.[56]

Complaints	Of the people with pain complaints			
	Percentage of persistent severe pain (%)	Percentage of persistent mild pain (%)	Percentage recurring severe pain (%)	Percentage recurring mild pain (%)
Neck/shoulder[a]	3.1	25.9	8.3	46.7
Elbow/wrist/hand[b]	4.0	29.2	11.0	43.3

[a] 6.3% non-recurring pain, 9.7% combination of persisting and recurring severe or mild pain
[b] 7.5% non-recurring pain, 5.0% combination of persisting and recurring severe or mild pain

4.3 Absenteeism and disease burden

A third measure for evaluating the meaning and significance of specific disorders and non-specific complaints due to repeated movements are data on absenteeism and disease burden.

Specific upper limb disorders

The absenteeism figures from the first half of 2003 obtained from occupational health service Maetis Arbo found that the diagnosis of carpal tunnel syndrome resulted in 0.2% of absentee days (in a six month period) among all registered employers.[52] Between 2000 and 2006, the Dutch Centre for Occupational Diseases (Nederlands Centrum voor Beroepsziekten - NCvB) received reports of 398 cases of occupational carpal tunnel syndrome (50 to 80 occupational disease reports per year).[58] In 2000, carpal tunnel syndrome was responsible for 0.8% of reported occupational diseases, for 1.2% in 2001 and 1.3% in 2003.[58] In 1999, 260 people were declared work disabled based on the diagnosis carpal tunnel syndrome (0.28%), and 366 people in 2002 (0.4%).[59]

Lateral epicondylitis is the second most commonly reported shoulder, arm or hand complaint with the NCvB, responsible for about 270 reports per year.[60] Each year there are about twenty reported cases of work-related medial epicondylitis.[60]

Non-specific upper limb complaints

Picavet et al. (2003) examined the consequences of having non-specific musculoskeletal complaints in the Dutch population.[56] Of the people neck, shoulder or upper back complaints, 41% had visited the GP in the past year, 30% had consulted a medical specialist and 33% had seen a physiotherapist. 27% of them used medication.[56] For people with elbow or wrist complaints, these percentages were 34%, 27%, 22% and 18%, respectively. 72% of people with neck, shoulder or upper back complaints and 78% of people with elbow or wrist complaints reported they had not missed work in the past year.[56] If they had missed work, this lasted for less than one week for 7.7% of people with neck, shoulder or upper back complaints, the same percentage missed one to four weeks, and 5.9% missed over four weeks of work.[56] Absenteeism figures for people with elbow or wrist complaints were: 4.8% less than one week; 5.9% one to four weeks and 5.3% more than four weeks.[56] Partial work disability was

reported by 6.1% of people with neck, shoulder or upper back complaints and by 4.0% of people with elbow or wrist complaints.[56]

4.4 Conclusion

The Committee considers repeated movements to be a relevant occupational risk for specific disorders and non-specific complaints of the upper limbs. These conditions are common and result in absenteeism and disability at work and during other daily activities.

Chapter 5

Conclusions and possible limits

The Committee examined currently available scientific data on the adverse health effects of repeated movements. In this chapter, the Committee draws its conclusion: can health-based occupational exposure limits be formulated based on these data, based on the principle that no adverse health effects may develop as a consequence of repeated movements?

5.1 Health risks of repeated movements

Specific upper limb disorders

The consequences of repeated movements for the occurrence of specific upper limb disorders were examined in five prospective cohort and six patient-control studies among administrative staff, nurses, cleaners, cashiers, packers, assembly line workers, military personnel, drivers and dentists. In these studies, exposure to repeated movements was recorded primarily through self-report, and specific upper limb disorders were diagnosed based on medical chart review and/or clinical examination. However, the studies present a highly heterogeneous collection of exposure measures that were only quantified in four studies.

The Committee concludes that these eleven epidemiological studies provide indications that repeated movements are associated with an increased risk of specific upper limb disorders such as carpal tunnel syndrome and lateral epicondylitis. Statistically significant associations were found in three studies.

Given the heterogeneity of the exposure measures used, the Committee was unable to translate the findings of available scientific epidemiological studies into useful exposure measures that could be used to recommend health-based occupational exposure limits.

Non-specific upper limb complaints

The consequences of repeated movements on the occurrence of non-specific upper limb complaints were examined in seven prospective cohort studies. These studies were conducted among, nurses, cleaners, assembly line and conveyer belt workers, cashiers, packers, military personnel and dentists. Both exposure to repeated movements and non-specific upper limb complaints were recorded primarily via self-report. Many of these studies also had multiple limitations, for example, the heterogeneity of exposure measures used.

The Committee concludes that these seven epidemiological studies provide indications that repeated movements are associated with an increased risk of non-specific upper limb complaints. Statistically significant associations were found in five studies. Due to the major differences in quantification of the exposure, the Committee is of the opinion that it is impossible to indicate how much and what duration of repeated movements may safely be performed without non-specific upper limb complaints developing.

Other complaints

The consequences of repeated movements on hip, knee and foot complaints were examined in two prospective cohort studies. One prospective cohort study examined the development of stress complaints due to repeated movements. As these findings were only reported once, the Committee is of the opinion there is too little scientific evidence available to establish a correlation.

5.2 Recommended health-based occupational exposure limits

When establishing health-based occupational exposure limits, the usual course is to determine the degree to which available epidemiological literature provides indications for a safe threshold, meaning an exposure or burden level at which there is a reasonable expectation that damaging health effects may be prevented. The Committee concludes that the epidemiological data currently available do not allow evidence-based conclusions to be drawn about the precise recommended occupational health-based exposure limit for repeated movements

at work. The data on the adverse health effects of low exposure levels are too limited to allow reliable conclusions to be drawn.

For other occupational risks where no threshold could be determined (working in a standing, kneeling or squatting position, lifting at work, computer use), the Committee used an alternative approach based on combining the results of individual, high-quality prospective cohort studies in meta-analysis and performing a risk calculation.[3,61,62] However, this approach is not viable for repeated movements. It is impossible to combine the individual studies in meta-analyses, as the studies are not sufficiently comparable in terms of definitions for exposure to repeated movements.

5.3 Answering the request for advice

Based on available scientific data, the Committee concludes there are indications that repeated movements at work pose an adverse health risk for the occurrence of specific upper limb disorders such as carpal tunnel syndrome and lateral epicondylitis. The Committee also found indications that repeated movements at work pose a health risk for non-specific upper limb complaints. Based on available data, however, it is impossible to define health-based occupational exposure limits that would allow prevention of specific disorders and non-specific complaints of the upper limbs.

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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 limit values (regulations comprising concrete figures), to which end advice is to be requested of the government's social partners.

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

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

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

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

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

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

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

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

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

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

Annex **B**

The Committee

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

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

The Health Council and interests

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

The Committee established the Working Group *Physical occupational risks* for the purpose of preparing the advisory report. The Working Group was composed of the following experts:
- Professor A. Burdorf, *chairman*
- Professor A.J. van der Beek
- Professor M.H.W. Frings-Dresen
- Professor J.H. van Dieën
  Professor of Biomechanics, VU University, Amsterdam
- Dr. A.S.A.M. van der Burght, *scientific secretary*
- Dr. V. Gouttebarge, *scientific secretary*

Annex C

Broad literature exploration

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

Findings on repeated movements

In 1994, Kilbom investigated the relationship between repetitive labour using the upper limbs (repetitive movements) and the occurrence of health problems.[22] Based on a search strategy in three databases, literature was identified on the association between repetitive movements and work-related complaints. 17 epidemiological studies were processed, which showed that repetitive movements of the shoulders (from 2.5 movements per minute), wrists (from 10 movements per minute) and hands were associated with tendonous conditions/ tendinopathy of the upper limbs (including carpal tunnel syndrome [CTS], tendinitis, tenosynovitis).. Measures for associations in these studies varied from 1.5 to 6.0.

In a systematic literature review, Windt et al. (2000) searched for relevant, original studies on the association between a number of occupational risks and the occurrence of shoulder complaints.[24] Using a search strategy applied in four

databases (Medline, Embase, Psychlit and Cinahl), after applying selection and quality criteria, eight original studies (six cross-sectional and two case-control) were identified that examined repeated movements as an occupational risk. With the exception of one of the cross-sectional studies, in which employees exposed to repeated movements had an increased risk of shoulder complaints (1.5 [95% CI 1.1-1.9]), no clear evidence for the association between repeated movements and shoulder complaints was found in any study (risk measures varying between 0.4 and 4.6). That same year, the Health Council published an advisory report on RSI (repetitive strain injury) on the request of the Minister of Social Affairs and Employment at the time.[7] In this advisory report, the Committee stated that repetitive movements are a risk factor for RSI, i.e. complaints of the arm-neck-shoulder (CANS). These findings on the relationships between repeated movements and CANS was confirmed in a review article by Aptel et al.[21]

In their systematic review, Palmer and Smedley (2007) searched for relevant studies on the association between physical occupational risks and work-related neck-shoulder complaints.[23] Using a systematic search strategy in four database, after application of inclusion and quality criteria, 21 original studies were finally included (four prospective cohort studies), including 14 focussed on repeated movements. 11 of these 14 studies found risk estimates of 17 or more for the relationship between repeated movements and neck-shoulder complaints. This literature review found that repeated movements of the shoulder and shoulder/neck joints are more strongly related to neck/shoulder complaints than repeated wrist/hand joint movements.

The same authors recently published three systematic literature reviews on the association between occupational factors (including repetitive movements) and the occurrence of specific disorders or non-specific complaints of the upper extremities.[25-27] In 2009, van Rijn et al., using a search strategy in three databases (Medline, Embase and the Cochrane Central Register of Controlled Trials) looked for relevant studies investigating the association between a number of occupational factors (including repetitive movements) and CTS.[25] After application of a number of inclusion criteria by two reviewers, 44 studies were evaluated for methodological quality and processed. Eight studies were found that examined the association between repeated movements and CTS, which showed that employees exposed to repeated movements had a higher risk of CTS, with risk estimates of 4.6 (95% CI 1.8-11.9) to 9.4 (95% CI 2.3-37.1). In 2009, van Rijn et al., using a search strategy in three databases (Medline, Embase and the Cochrane Central Register of Controlled Trials), also looked for relevant studies investigating the association between a number of occupational factors (including repetitive movements) and specific elbow complaints (including

lateral and medial epicondylitis).[26] After application of a number of inclusion criteria by two reviewers, 13 studies were evaluated for methodological quality and included. Four studies examining the association between repeated movements and these specific disorders were identified. One prospective cohort study found that employees exposed to repeated movements had an increased risk of lateral epicondylitis (risk estimate of 4.7 [95% CI 2.2-9.7]). In 2010, van Rijn et al. searched for relevant, original studies on the association between a number of occupational risk factors (including repetitive movements) and specific shoulder complaints (including subacromial impingement syndrome).[27] Using a search strategy in three databases (Medline, Embase and the Cochrane Central Register of Controlled Trials) and following application of selection and quality criteria, two original studies of good methodological quality were identified that examined repetitive movement as an occupational risk. Based on these two studies, it was found that employees exposed to repetitive movements were at increased risk for subacromial impingement syndrome (risk estimate of 2.4 [95% CI 1.3-4.3] to 3.3 [95% CI 1.3-8.1]).

Two systematic literature reviews were published very recently. One is a meta-analysis on the association between repeated movements and CTS performed by Barcenilla et al. (2012).[28] After application of inclusion criteria, 11 studies were ultimately included and used to calculate a pooled risk (OR). This showed that employees exposed to repetitive movements at work had an increased risk of CTS (risk estimate of 2.3 [95% CI 1.7-2.9]) compared with unexposed employees. The second literature review by Mayer et al. (2012) only included prospective cohort studies in order to evaluate the association between repetitive movements and neck/shoulder complaints.[29] Based on 10 included studies, the authors concluded that there is moderate to strong evidence in the scientific literature for the association between repetitive movements and neck/ shoulder complaints.

Conclusion of broad literature exploration

Based on the broad exploration of the literature, the conclusion may be drawn that exposure to repetitive movements at work may be correlated to an elevated risk of non-specific uppers limb complaints. Exposure to repeated movements at work may also be associated with an increased risk of specific upper limb disorders, primarily subacromial impingement syndrome (a condition of soft tissues in the shoulder joint), medial epicondylitis (inflammation or irritation of the attachment point of ligaments on the inside of the elbow joint), epicondylitis laterals (inflammation or irritation of the attachment point of ligaments to the

outside of the elbow) and carpal tunnel syndrome (narrowing around the middle nerve in the wrist).

Annex **D**

Systematic literature review

The objective of this literature study is to gather scientific data in a systematic manner from epidemiological studies regarding the relationship between *repetitive movements during work* and the occurrence (both for the short term and the long term) of health problems.

1 Question

The following questions have been formulated for this systematic literature review:

a Which health problems arise as a result of repetitive movements during work?

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

2 Databases

In view of the small number of systematic literature reviews found in the broad literature exploration, this systematic literature review (without a time limit) in the international search files Medline (via Pubmed) and Embase (via Ovid) searched the English and Dutch literature.

3 Search terms

Terms were searched in the international databases that are associated with concepts such as *repetitive movement*, *work-related* and *health effects*.

4 Search strategy

Medline search strategy:
#1= repetitive movement*[tiab] OR cumulative movement*[tiab] OR repetitive motion*[tiab] OR cumulative motion*[tiab] OR repetitive task*[tiab] OR cumulative task*[tiab] OR repetitive work*[tiab] OR cumulative work*[tiab]

#2= work-related[tw] OR occupations[MeSH] OR occupational exposure[MeSH] OR occupation*[tw] OR work[MeSH] OR workplace[MeSH] OR work*[tw] OR vocation*[tw] OR job[tw] OR employment[MeSH] OR industr*[tw] OR business[tw] OR profession*[tw] OR trade*[tw] OR enterprise*[tw]

#3= "health effects"[tw] OR occupational health[MeSH] OR occupational diseases[MeSH] OR musculoskeletal diseases[MeSH] OR "occupational risk factor"[tw] OR safety[MeSH] OR safet*[tw] OR safety management[MeSH] OR risk management[MeSH] OR sprains and strains[MeSH] OR wounds and injuries[MeSH] OR health[tw] OR disorder[tw] OR disorders[tw] OR syndrome[tw] OR disease[tw] OR diseases[tw] OR wounds[tw] OR injuries[tw] OR injury[tw] OR sprains[tw] OR strains[tw] OR pain[tw] OR discomfort[tw] OR risk[MeSH]

4= #1 AND #2 AND 3#

Embase search strategy:
#1= "repetitive movement$".ti,ab OR "cumulative movement$".ti,ab OR "repetitive motion$".ti,ab OR "cumulative motion$".ti,ab OR "repetitive task$".ti,ab OR "cumulative task$".ti,ab OR "repetitive work$".ti,ab OR "cumulative work$".ti,ab

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

#3= "health effects" OR "occupational risk factor" OR safet$ OR health OR disorder OR disorders OR syndrome OR disease OR diseases OR wounds OR injuries OR injury OR sprains OR strains OR pain OR discomfort

#4= #1 AND #2 AND 3#

5 Inclusion and exclusion criteria

The following inclusion criteria are applied to include studies from the results of the search strategy:

1 The study is either a prospective or a retrospective study (not an intervention study) in the case of aspecific symptoms of the upper extremities as the outcome measure or a case control study in the case of Subacromial Impingement Syndrome, lateral epicondylitis, medial epicondylitis and carpal tunnel syndrome as outcome measure.
2 The study describes the degree of exposure to repetitive movements in a quantitative manner (duration, frequency and/or intensity).
3 The study describes short-term and /or long-term effects on health as a result of repetitive movements during work.
4 And the study describes a degree of association between repetitive movements and the occurrence of health problems in terms of relative risk, attributive risk, prevalence ratio or odds ratio.

6 Selection procedures

Two reviewers (independent of each other) applied the inclusion criteria to the titles and summaries of the various studies after the search strategy was applied to the different databases. A study was included when there was some doubt about inclusion or exclusion of the study on the basis of the title and summary. The complete text of the included titles and summaries were retrieved and two reviewers (independent of each other) re-applied the inclusion criteria to the complete text. A third reviewer was consulted in case of doubt regarding the inclusion or exclusion of a study. In addition, the list of references of all included articles and possible reviews were screened. The included studies in the four recent literature reviews ((Van Rijn et al.; Barcenilla et al.) were also included in the Committee's exercise provided that the inclusion criteria were satisfied and these were subsequently examined for more recent studies about the specific disorders of Subacromial Impingement Syndrome, lateral epicondylitis, medial epicondylitis and carpal tunnel syndrome.[25-28] A search was also carried out for recent studies (past five years) about occupations that often involve repetitive actions such as cashiers, hair dressers, meat packers, assembly workers, painters and musicians. The final list of references of included articles was submitted to four experts with the question whether additional studies should be included.

7 Data extraction

The data extraction of the included studies was arranged according to the type of effects in a standardised table that shows the following information:

- 1st column : first author and year of publication
- 2nd column: study population (number, age, gender, occupation, country)
- 3rd column: study design and possible interfering factors
- 4th column: effect of the occupational risk on health (prevalence or incidence data)
- 5th column: exposure parameters (definition of the particular exposure group and reference group)
- 6th column: degree of association between the occupational risk and the effect on health

8 Search strategy results

The previously defined search strategy was carried out in March 2012 in Pubmed and Embase. In the end, a total of 166 full texts were assessed on the basis of the inclusion criteria. After this last selection step on the original studies and after the reference check carried out on the included literature reviews (including Van Rijn et al.; Barcenilla et al.) by the four experts and on the occupations of cashiers, hair dressers, meat packers, assembly workers and painters, 14 original prospective cohort studies [32,34-37,41-49] (specific disorders and aspecific symptoms of the upper extremities and sundry symptoms) and six case control studies [30,31,33,38-40] (specific disorders of the upper extremities) were included. These studies have been incorporated in different extraction tables (Annex F for specific disorders of the upper limb; Annex G for nonspecific complaints of the upper limb; Annex H for other complaints).

Annex **E**

OCRA method

See following pages.[9,12-15]

CHECKLIST OCRA

A SHORTENED PROCEDURE FOR THE IDENTIFICATION OF UPPER LIMB OVERLOAD IN REPETITIVE TASKS

COMPILED BY/I ..... DAY.....

PAGE 1

DENOMINATION OF THE WORKPLACE AND BRIEF DESCRIPTION OF THE TASK.....
.....

-how many woorkplaces are identical or very similar.....
-how many shifts are present in a day .....
-how many workers work in these workplaces during a day and considering all the identical workplaces.....

	DESCRIPTION	MINUTES
SHIFT DURATION	official	
	real	
OFFICIAL PAUSES	contractual	
OTHER PAUSES (other than the official ones)		
LUNCH BREAK	official	
	real	
NON REPETITIVE TASKS (eg: cleaning, supplies, etc)	official	
	real	
NET DURATION OF REPETITIVE TASK/S		
No. Of UNITS (or cycles)	planned	
	real	
NET CYCLE TIME (secs.)		
OBSERVED CYCLE TIME		

TYPE OF WORK INTERRUPTION (WITH PAUSES OR OTHER VISUAL CONTROL TASKS) (max. score allowed = 10).
Choose one answer. It is possible to choose intermediate values.

[0] - there is an interruption of at least 8/10 minutes every hour in the repetitive work (also count the lunch break) or the recovery period in included in the cycle.
[2] - there are 2 interruptions in the morning and 2 in the afternoon (plus the lunch break), lasting at least 8-10 minutes on the 7-8 hour shift, or at least 4 interruptions per shift (plus the lunch break), or four 8/10 minute interruptions in the 6-hour shift.
[3] - there are 2 pauses, lasting at least 8-10 minutes each in the 6-hour shift (without lunch break); or, 3 pauses, plus the lunch break, in a 7-8-hour shift.
[4] - there are 2 pauses, plus the lunch break, lasting at least 8—10 minutes each over a 7-8 hour shift (or 3 pauses without the lunch break), or 1 pause of at least 8-10 minutes over a 6-hour shift;
[6] - there is a single pause, lasting at least 10 minutes, in a 7-hour shift without lunch break; or, in an 8-hour shift there only is a lunch break (the lunch break is not counted among the working hours).
[10] - there are no real pauses except for a few minutes (less than 5) in a 7 to 8-hour shift..

The first hour | the last hour

Shif duration in min..... draw the breaks in the shift.

[ ] RECOVERY

ARM ACTIVITY AND WORKING FREQUENCY WITH WHICH THE CYCLES ARE PERFORMED (max. score possible= 10)

Choose one answer for each upper limbs. It is possible to use intermediate scores. If both static and dynamic actions are present:
•CONSIDER both static and dynamic actions •As most representative of the task CHOOSE the one with the highest risk value.

DYNAMIC TECHNICAL ACTIONS

- [0] -arm movements are slow. frequent short interruptions are possible (20 actions per minute).
- [1] -arm movements are not too fast. short interruptions are possible (30 actions per minute).
- [3] -arm movements are quite fast (about 40) but short interruptions are possible
- [4] -arm movements are quite fast. only occasional and irregular short pauses are possible (about 40 actions per minute).
- [6] -arm movements are fast. only occasional and irregular short pauses are possible (about 50 actions per minute).
- [8] -arm movements are very fast. the lack of interruptions makes it difficult to keep the pace, which is about 60 actions per minute
- [10] -very high frequencies: 70 actions per minute, or more. absolutely no interruptions are possible

STATIC TECHNICAL ACTIONS

- [2,5] - an object is held for at least 5 consecutive seconds secs., incurring one or more static actions for 2/3 of the cycle (or observation) time
- [4,5] - an object is held for at least 5 consecutive seconds secs., incurring one or more static actions for 3/3 of the cycle (or observation) time .

	R	L
Number of actions in the cycle		
Frequency of actions per minute		
Possibility of short interruptions		

R L

☐ ☐

FREQUENCY

PRESENCE OF WORKING ACTIVITIES INVOLVING THE REPEATED USE OF FORCE IN THE HANDS-ARMS (AT LEAST ONCE EVERY FEW CYCLES DURING ALL THE TASK ANALYSED: ☐ YES ☐ NO

Can be signed more than one score and sum them for obtaining the final score

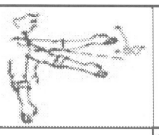
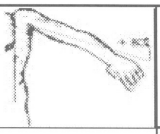
IF YES:

THE WORKING ACTIVITY REQUIRES THE USE OF ALMOST MAXIMUM FORCE FOR: (8 points or more on the Borg scale) ☐ pulling or pushing levers ☐ pushing buttons ☐ closing or opening ☐ pressing or handling components ☐ using tools ☐ Lifting or handling objects	[6] - 2 seconds every 10 min [12] - 1 % of the time [24] - 5 %of the time [32] -over 10% of the time (*)
THE WORKING ACTIVITY REQUIRES THE USE OF STRONG FORCE FOR: (5-6-7 points on the Borg scale) ☐ pulling or pushing levers ☐ pushing buttons ☐ closing or opening ☐ pressing or handling components ☐ using tools ☐ Lifting or handling objects	[4] - 2 seconds every 10 min [8] - 1 % of the time [16] -- 5 %of the time [24] - over 10% of the time (*)
THE WORKING ACTIVITY REQUIRES THE USE OF MODERATE FORCE FOR: (3-4 points on the Borg scale) ☐ pulling or pushing levers ☐ pushing buttons ☐ closing or opening ☐ pressing or handling components ☐ using tools ☐ Lifting or handling objects	[2] - 1/3 of the time [4] - about half the time [6] - over half the time [8] - nearly all the time

(*)THIS CONDITION IS ABSOLUTELY NOT ACCEPTABLE

FORCE R ☐ L ☐

PRESENCE OF AWKWARD POSTURES IN THE UPPER LIMBS DURING A REPETITIVE TASK ; ☐ RIGHT; ☐ LEFT; ☐ BOTH

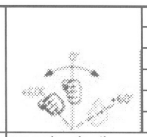

flexion	abduction	extension

R L

1	the arm/arms are not leaning on the workbench but are a little uplifted for a little over half the time
2	the arms are kept at about shoulder height, without support, (or in other extreme postures) for about 10% of the time
6	the arms are kept at about shoulder height, without support, (or in other extreme postures) for about 1/3 of the time
12	the arms are kept at about shoulder height, without support, (or in other extreme postures) for over half the time
24	the arms are kept at about shoulder height, without support, (or in other extreme postures) all the time

NB = DOUBLE THE VALUES IF THE HANDS ARE WORKING ABOVE HEAD HEIGHT.

B-elbow

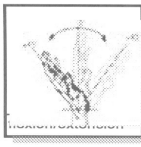
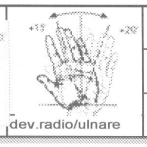



flexion/extension | prono/supination

R L

2	the elbow executes sudden movements (wide flexion-extension or prono-supination, jerking movements, striking movements) for about 1/3 of the time
4	the elbow executes sudden movements (wide flexion-extension or prono-supination,. jerking movements, striking movements) for over half the time
8	the elbow executes sudden movements (wide flexion-extension or prono-supination, jerking movements, striking movements) nearly all the time

C-wrist

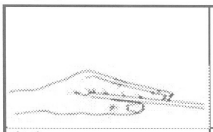
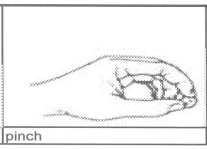
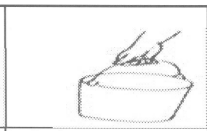
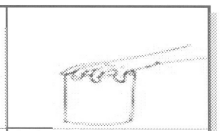



flexion/extension | dev.radio/ulnare

R L

2	the wrist must bent in a extreme position, or must keep awkward postures (such as wide flexion/extensio, or wide lateral deviation) for at least 1/3 of the time
4	the wrist must bent in a extreme position, or must keep awkward postures (such as wide flexion/extensio, or wide lateral deviation) for over half the timeof the time
8	the wrist must bent in a extreme position, or must keep awkward postures (such as wide flexion/extensio, or wide lateral deviation) fall the time

D-hand

pinch | pinch | hook grip | pinch

R L

The hand take objects or tools in:

pinch
hook grip
pinch
other different kinds of grasp

2	for about 1/3 of the time.
4	for over half the time
8	nearly all the time

E-stereotypy or repetitiveness

PERFOMS WORKING GESTURES OF THE SAME TYPE INVOLVING SHOULDERS AND/OR ELBOW AND/OR WRIST AND/OR FINGERS FOR 2/3 OF TIME
(or cycle time between 8 and 15 seconds, full of technical actions performed by the upper limbs. These actions can be different from each other)

1.5

PERFOMS WORKING GESTURES OF THE SAME TYPE INVOLVING SHOULDERS AND/OR ELBOW AND/OR WRIST AND/OR FINGERS NEARLY ALL THE TIME
(or cycle time less than 8 seconds, full of technical actions performed by the upper limbs. These actions can be different from each other)

3

R L

POSTURE R L

N. B. : use the highest scores between the 4 sections (A,B,C,D) and add it to E

▪PRESENCE OF ADDITIONAL RISK FACTORS: only choose one answer per group of questions

2	-.Gloves inadequate (which interfere with the handling ability required by the task) are used for over half the time
2	- the working gestures required imply a countershock (such as e.g., hammering, or hitting with a pick over hard surfaces, etc.) with frequency of 2 time per minute or more
2	- the working gestures imply a countershock (using the hand as a tool) with frequency of 10 time per hour or more
2	- exposure to cold or refrigeration (less than 0 degree) for over half the time
2	- vibrating tools are used for 1/3 of the time o more. For tools with high level of vibrations use score 4.
2	- the tools employed cause compressions of the skin (reddering, callosities, blisters, etc..)
2	- precision tasks are carried out for over half the time (tasks over areas smaller than 2-3 mm)
2	- more than one additional factor is present at the same time and , overall, they occupy over half the time
3	- more than one additional factor is present at the same time and , overall, the occupy the whole of the time

1	working pace set by the machine, but there are "breathing spaces" in which the working rhythm can either be slowed down or accelerated.
2	- working pace completely determined by the machine

ADDITIONAL ☐ R ☐ L

EVALUATION OF FINAL CHECKLIST SCORE FOR TASK / WORK

(Recovery+Frequency+Force+Posture+Additional) x "net duration of repetitive task multiplier"

MULTIPLIERS FOR THE TOTAL DURATION OF REPETITVE TASK / TASKS IN THE SHIFT

60-120 min = 0,5	241-300 min = 0,85	421-480 min = 1
121-180 min = 0,65	301-360 min = 0,925	sup.480 min = 1,5
181-240 min = 0,75	361-420 min = 0,95	

Checklis OCRA score R ☐ L ☐

LINK BETWEEN OCRA INDEX AND CHECKLIST OCRA FINAL SCORE

CHECK LIST	OCRA	AREA	RISK
UP TO 7,5	2,2	GREEN	ACCEPTABLE
7,6 – 11	2,3 – 3,5	YELLOW	BORDERLINE O VERY LOW
11,1 - 14.0 14,1 – 22,5	3,6 - 4,5 4,6 – 9	LOW RED AVERAGE RED	LOW AVERAGE
≥ 22,6	≥ 9,1	VERY RED OR VIOLET	HIGH

Annex **F**

Extraction table specific upper limb disorders

Author	Study population	Study design	Health effect	Exposure parameters	Degree of association
Garg 2012 [32]	N = 429 G = 36.6% male; 63.4% female A = 41.2(sd=11.7) O = poultry process assembly worker, manufacturing and assembly of animal laboratory equipment worker, engine manufacturing and assembly worker, electronic motor manufacturing and assembly worker C = USA	Prospective cohort study (38 months) Conf = age, body mass	Carpal tunnel syndrome (CTS) *CTS:* symptoms (numbness, tingling) in at least two median nerve served digits, symptoms occurring on ≥25% of days during the preceding month, symptoms occurring for at least two or more consecutive follow-iup periods and an abnormal nerve conduction study	Threshold Limit Value for Hand Activity Level: - per unit score ≤ 1.25 N = 160 (153 no CTS; 7 CTS) - per unit score > 1.25 N = 171 (155 no CTS; 16 CTS)	HR = 3.8 (CI 1.0-14.9) HR = 0.1 (CI 0.0-3.4)
Nathan 2002 [36]	N = 256 G = 145 male; 111 female A = 34.9 (sd=10.0) O = steel mill, meat/food packaging, electronics and plastics industrial worker C = USA	Prospective cohort study (11 year) Conf = gender, age, occupational factors	Carpal tunnel syndrome (CTS) *CTS:* abnormal median nerve conduction established during electrophysiologic testing and 2 or more hand/wrist symptoms specific to CTS.	Repetition hand use: - Not at all - Consistently	OR = 1.0 OR = 1.14 (CI 0.59-2.20)

Nathan 2005 [37]	N = 148 G = 60% male; 40% female A = 35.1 (sd=9.7) O = steel mill, meat/ food packaging, electronics and plastics industrial worker C = USA	Prospective cohort study (17 year) Conf = ?	Carpal tunnel syndrome (CTS) *CTS:* numbness, tingling and noctural awakening at least twice a month (at least two symptoms) or at least once a month (one symptom) in combination with pain, tightness and clumsiness at least twice a month AND maximum latency difference of .40 ms or more.	Repetition hand use: - Very light duration - Very heavy use	 OR = 1.0 OR = 0.56
Cannon 1981 [30]	N = 30 patients G = 3 male; 27 female A = 43.2 (sd=11) O = various within plant factory C = VS	Case control study Control = 90 controls (age=44.8) matched for sex	Carpal Tunnel Syndrome *Carpal Tunnel Syndrome*: identified through medical records	Repetitive work: - No N = 78 no CTS; 25 CTS - Yes N = 12 no CTS; 5 CTS	 OR = 1.3
Frost 1998 [40]	N = 743 cases G = 83.2% male; 16.8% female A = 37.7% <35; 39.8% 35-49; 22.5≥50 O = slaughterhouse worker C = Denmark	Nested case control study Control = 398 repair or chemical workers Conf = non occupational risk factors	Carpal tunnel syndrome (CTS) *CTS:* combination of symptoms, occurring at least 1 night a week, indicating entrapment of the median nerve, and current symptoms involving at least 1 of the 3 radial fingers in a physical examination and positive neurophysiological criteria of CTS	Repetition hand use: - No slaughterhouse worker N = 392 no CTS; 6 CTS - Slaughterhouse worker (56-115 wrist exertion per 10 min) N = 699 no CTS; 44 CTS	 OR = 1.0 OR (either hand) = 4.24 (CI 1.77-10.13) OR (dominant hand) = 3.26 (CI 1.09-9.71) OR (nondominant hand) = 5.31 (CI 1.60-17.61)
Fung 2007 [31]	N = 166 G = 12 male; 154 female A = 48 (sd=7) O = service industry (waiter, drivers, health care) worker C = China	Case control study Control = 111 controls (age=43.8; sd=11; 31 male, 80 female) Conf = sex, age, body mass index, stress, smokingy	Carpal tunnel syndrome (CTS) CTS: presence of paraesthesia over the radial side of the palm, with positive Tinel sign and/of Phalen's test, sometimes with tenar atrophy.	Repetitive motion of the wrist: - Never - Seldom - Sometimes - Frequent	 OR = 1.0 OR = 1.1 (CI 0.4-3.2) OR = 0.7 (CI 0.2-1.9) OR = 0.9 (CI 0.4-2.4)

Roquelaure 1997 [38]	N = 65 G = 10 male; 55 female A = 41.1 (sd=7.5) O = blue collar worker C = France	Case control study Control = 65 controls (age=41.2; sd=7.2; 10 male, 55 female) Conf = sex, age	Carpal tunnel syndrome (CTS) CTS: at least 3 of the following conditions: (i) tingling, pain or numbness in the median nerve distribution of the hand with noctural exabertion with more than 20 occurences or lasting more than 3 weeks in the previous year; (ii) positive Tinel's sign and positive Phalen's test or hypoesthesia in the territory of the median the wrist level; (iv) surgical release of the transverse carpal ligament.	Repetitive movements without job rotation: - No - Yes Repetitive movements with changes in activity/ breaks < 15% daily worktime: - No - Yes	 OR = 1.0 OR = 6.3 (CI 2.1-19.3) OR = 1.0 OR = 6.0 (CI 1.8-20.2)
Wieslander 1989 [39]	N = 34 G = ? A = 20-66 O = ? C = Sweden	Case control study Control = 143 controls Conf = sex, age	Carpal tunnel syndrome (CTS) *CTS:* diagnosed by hand surgeon confirmed electroneurographically by measurement of the conduction velocities in the median nerve at wrist level.	Repetitive movement of the wrists: - < 1 year N = 113 no CTS; 20 CTS - 1-20 years N = 19 no CTS; 5 CTS - >20 years N = 11 no CTS; 9 CTS	OR = 1.0 OR = 1.5 (CI 0.5-4.4) OR = 4.6 (CI 1.8-11.9)
Harris 2011 [34]	N = 413 G = 262 male; 151 female A = 38.6 (sd=11.2) O = dairy, chair, mushroom and stone manufacturing worker C = USA	Prospective cohort study (28 months) Conf = gender, age	Wrist tendinosis (WT) *WT:* included wrist flexor and wrist extensor tendinosis, diagnosis based on pain scale, muscle test and core sign.	Repetition heavy or power pinch: - ≤4.52 per min N = 134 (9 no WT; 125 CTS) - 4.52-19.2 per min N = 96 (9 no WT; 87 CTS) - >19.2 per min N = 159 (8 no WT; 151 CTS) Repetition all wrist postures: - ≤38.88 per min N = 117 (9 no WT; 108 CTS) - 38.88-47.24 per min N = 97 (9 no WT; 88 CTS) - >47.24 per min N = 175 (8 no WT; 167 CTS)	HR = 1.0 HR = 1.4 (CI 0.5-3.6) HR = 1.3 (CI 0.5-3.5) HR = 1.0 HR = 1.4 (CI 0.6-3.4) HR = 0.9 (CI 0.4-2.4)

Leclerc 2001 [35]	N = 598 G = ? A = ? O = assembly worker, clothing worker, food worker, packaging worker, cashier C = France	Prospective cohort study (1 year) Conf = occupational group	1. Lateral epicondylitis (3 years incidence = 12.2%) 2. Wrist tendinosis (3 years incidence = 5.7%)	Turn and screw: - No - Yes Repetitive hitting: - No - Yes	 OR = 1.0 1. OR = 2.1 (CI 1.2-3.7) OR = 1.0 2. OR = 2.7 (CI 0.8-5.6)
Haarh 2003 [33]	N = 209 G = 100 male; 109 female A = 18-66 O = various C = Denmark	Case control study Control = 388 controls (age=18-66) matched for age and sex	Lateral epicondylitis Lateral epicondylitis: pain and tenderness at the lateral humeral epicondyle, with or without concomitant pain in the adjacent extensor muscles of the forearm	Same repetitive movements of fingers or hands: - Never or almost never N (men) = 85 N (women) = 93 - 25-50% of the time N (men) = 77 N (women) = 95 - ≥75% of the time N (men) = 35 N (women) = 56 Same repetitive movements of arms: - Never or almost never N (men) = 106 N (women) = 153 - 25-50% of the time N (men) = 54 N (women) = 47 - ≥75% of the time N (men) = 37 N (women) = 44	 OR = 1.0 OR (men) = 1.7 (CI 0.9-3.3) OR (women) = 1.3 (CI 0.7-2.5) OR (men) = 2.2 (CI 0.9-5.3) OR (women) = 1.9 (CI 0.9-4.0) OR = 1.0 OR (men) = 1.8 (CI 0.9-3.6) OR (women) = 1.5 (CI 0.7-3.1) OR (men) = 1.9 (CI 0.8-4.6) OR (women) = 3.7 (CI 1.7-8.3)

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

Annex **G**

Description of the studies on specific upper limb disorders

Three prospective cohort and five patient-control studies examined the occurrence of carpal tunnel syndrome due to repetitive movements.[30-32,36-40] These studies found that repeated movements are associated with an elevated risk of carpal tunnel syndrome. Only two patient-control studies present quantified exposure to repetitive movements (Table 1).[39,40] The six other studies used an exposure measure that did not provide any information about duration, frequency and/or movement speed/precision. For example, the study by Garg (2012) operationalised repetitive movements using the US *Threshold Limit Value for Hand Activity Level* method.[32] This TLV-HAL is a composite measure for overall burden related to repeated movements and does not provide a possibility for distinguishing the separate contribution of each underlying risk factor. Four of the eight studies (all four patient-control studies) found a statistically significant elevated risk of carpal tunnel syndrome.[30,38,39]

The first study found that over 20 years of exposure to repetitive movements of the wrist was associated with a statistically significant increased risk (4.6; 95% CI 1.8-11.9) of developing this disorder.[39] A second study found that performing 56 to 115 wrist movements per ten minutes (among butchers) resulted in a statistically significant increased risk of 3.3 (95% CI 1.1-9.7) to 5.3 (95% CI 1.6-17.6).[40] The two other patient-control studies showed that repetitive movements (in administrative staff) were associated with a statistically significant increased risk of 1.3 to 6.3 for the development of carpal tunnel syndrome.[30,38]

One prospective cohort and one patient-control study examined the incidence of lateral epicondylitis due to repetitive movements (packers, assembly line workers, butchers, cashiers).[33,35] These studies found that repetitive movements are associated with a statistically significant increased risk of lateral epicondylitis. The prospective cohort study showed that repetitive movements (without quantified exposure) were associated with a statistically significant increased risk of 2.1 (95% CI 1.2-3.7) for the development of this disorder.[35] The patient-control study showed that women who spent three quarters or more of their workday performing repetitive movements had a statistically significant elevated risk (3.7; 95% CI 1.7-8.3) of developing lateral epidcondylitis.[33]

Two prospective cohort studies examined the incidence of wrist tendinosis due to repetitive movements (in packers, assembly line workers, butchers and cashiers).[34,35]Only one of these studies quantified the exposure to repetitive movements.[34] These studies found that repetitive movements are associated with an increased risk of wrist tendinosis. Neither study found a statistically significant association, however.

Annex **H**

Extraction table non-specific upper limb complaints

Author	Study population	Study design	Health effect	Exposure parameters	Degree of association
Andersen 2003 [41]	N = 3123 G = ? A = ?	Prospective cohort study (4 years)	Nek/shoulder pain (NSP) (4 years prevalence = 6.3%)	Repetitive shoulder movements: - Never N = 1357 no NSP; 179 NSP	OR = 1.0
	O = food processing workers, textile workers, service workers C = Denmark	Conf = sex, age, body mass index, physical time activity, psychosocial factros	(4 years incidence = 14.1%) *Pain:* pain in a body region in the past 12 months	- F = 1-15 movements per min N = 1564 no NSP; 239 NSP	OR = 1.1 (CI 0.9-2.3)
				- F = 16-40 movements per min N = 928 no NSP; 204 NSP	OR = 1.5 (CI 1.2-1.9)
Andersen 2007 [42]	N = 1456 G = ? A = 44 (sd=10)	Prospective cohort study (2 years)	1. Nek, shoulder pain (2 years prevalence = 11.5%)	Repetitive work: - D = 0-9 min per hour N = 893	HR = 1.0
	O = nurses, administrative worker, nurse assistant, cleaning and kitchen worker, technical staff C = Denmark	Conf = sex, age, occupational category	2. Elbow, forearm, hand pain (2 years prevalence = 6.4%) *Pain:* pain in a body region in the past 12 months	- D = 10-44 min per hour N = 256	1. HR = 1.0 (CI 0.7-1.5) 2. HR = 1.2 (CI 0.7-2.1)
				- D = 45-60 min per hour N = 260	1. HR = 1.5 (CI 1.0-2.1) 2. HR = 1.9 (CI 1.2-3.1)

Harkness 2003 [43]	N = 803 G = 65% men; 35% women A = median 23 O = various sectors such as service organization, police, army officers, supermarket, postal distribution centre C = England	Prospective cohort study (2 years) Conf = age, sex, occupation	Shoulder pain (SP) (1 year incidence = 15%) *Pain:* any pain or ache in the shoulder lasting for one day or longer in the past month	Repetitive arm/wrist movements: - never N = 107 no SP; 23 SP) - D < 2 hours N = 136 no SP; 22 SP) - D ≥ 2 hours N = 152 no SP; 27 SP)	 OR = 1.0 OR = 1.0 (CI 0.6-1.6) OR = 1.0 (CI 0.6-1.6)
Leclerc 2004 [44]	N = 498 G = 178 male; 420 female A = ? O = meat cutting worker, clothing and shoe industry worker, assembly line worker, supermarket cashier, C = France	Prospective cohort study (1 year) Conf = occupational group	Shoulder pain (SP) (3 years incidence = 21-29%) *Pain:* at least one day of pain in the shoulder during the past six months	Repetitive use of tool (man): - No N = 53 (44 no SP; 9 SP) - Yes N = 59 (36 no SP; 23 SP) Hit (woman): - Never or not repetitively N = 183 (149 no SP; 34 SP) - Repetitively N = 31 (21 no SP; 10 SP)	 OR = 1.0 OR = 4.3 (CI 1.6-11.9) OR = 1.0 OR = 1.5 (CI 0.6-3.7)
Macfarlane 2000 [45]	N = 1260 G = ? A = 18-65 O = various C = UK	Prospective cohort study (2 years) Conf = sex, age	Forearm pain (FP) (2 years prevalence = 8.3%) *Pain:* pain experienced during the previous month and lasting at least one day.	Repetitive movement of the wrists: - Never N = 203 (198 no FP; 5 FP) - Occasionally N = 230 (222 no FP; 8 FP) - Half / most of the time N = 348 (319 no FP;29 FP) Repetitive movement of the arms: - Never N = 266 (260 no FP; 6 FP) - Occasionally N = 221 (212 no FP; 9 FP) - Half / most of the time N = 292 (265 no FP;27 FP)	 RR = 1.0 RR = 1.4 (CI 0.4-4.2) RR = 3.4 (CI 1.3-8.7) RR = 1.0 RR = 1.2 (CI 0.4-3.7) RR = 2.9 (CI 1.2-7.3)

Miranda 2008 [46]	N = 7217 (baseline); 883 (follow-up) G = 42% male; 58% female)A = 64.2 (sd=9.5) O = various C = Finland	Prospective cohort study (20 years) Conf = sex, age, and occupational factors	Chronic Shoulder disorder (CSD) (prevalence at follow-up = 7%) *Pain:* minimum of 3 months of symptoms preceding the clinical examination	Repetitive movements: - No N = 691 (650 no CSD; 41 CSD) N (men) = 312 (292 no CSD; 20 CSD) N (women) = 64 (51 no CSD; 13 CSD)	OR = 1.0
				- Yes N = 176 (154 no CSD;22 CSD) N (men) = 379 (358 no CSD; 21 CSD) N (women) = 112 (103 no CSD; 9 CSD)	OR = 2.3 (CI 1.3-4.0) OR (men) = 4.1 (CI 1.9-9.0) OR (women) = 1.4 (CI 0.6-3.3)
Nahit 2003 [47]	N = 782 G = 66% male; 34% female A = 24 (median) O = firefighters, shipbuilder, dentist, nurse, retail worker, postal worker, podiatrists, police, forestry worker, army C = UK	Prospective cohort study (1 year) Conf = sex, age, occupational group	Forearm pain (FP) (1 year incidence = 8.3%) *Pain:* pain in the shaded area lasting at least 24 hours during the past month	Repetitive movement of the wrists: - D = < 2 hour N = 448 (424 no FP; 24 FP)	OR = 1.0
				- D = ≥ 2 hour N = 209 (178 no FP; 31 FP)	OR = 2.9 (CI 1.5-5.3)
				Repetitive movement of the arms: - D = < 2 hour N = 508 (477 no FP; 31 FP)	OR = 1.0
				- D = ≥ 2 hour N = 145 (123 no FP; 22 FP)	OR = 2.9 (CI 1.6-5.2)

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

Annex I

Description of the studies on non-specific upper limb complaints

Seven prospective cohort studies investigated the occurrence of non-specific upper limb complaints due to repetitive movements.[41-47] These studies related to different types of employees, such as administrative staff, nurses, cleaners, cashiers, packers, meat packers, assembly line and conveyer belt workers, military personnel and dentists. The studies show that repetitive movements are associated with an increased risk of non-specific upper limb complaints. Five of the seven studies quantified exposure to repetitive movements in terms of duration.[41-43,45,47] These studies did not clearly describe the exposure to repetitive movements in both study and reference groups, so it remains unknown how many repetitive movements these groups performed. This means exposure of less than two hours per day (in the reference group) may indicate no repetitive movements or exposure of an hour on average.

Five of the seven studies found a statistically significant increased risk of upper limb complaints.[41,42,44,45,47] The first study found that employees (administrative staff, meat packers) who performed between 16 and 40 shoulder movements per minute are at statistically significant increased risk (1.5; 95% CI 1.2-1.9) of developing neck/shoulder complaints compared with employees who never perform shoulder movements at work.[41] A second study found that employees (administrative staff, nurses, cleaners) who perform repetitive movements for between 45 and 60 minutes per hour had a statistically significant elevated risk (1.9; 95% CI 1.2-3.1) of developing elbow/forearm/hand complaints compared with employees who almost never performed repetitive

movements.[42] A third study found that male employees (cashiers, meat packers, assembly line and conveyer belt workers) who performed repetitive movements had a statistically significant higher risk (4.3; 95% CI 1.6-11.9) of developing shoulder complaints compared with male employees who did not perform repetitive movements at work.[44] A fourth study found that employees (nurses, military personnel, dentists) who spend two hours per day or more performing repetitive wrist and hand movements have a statistically significant elevated risk (2.9; 95% CI 1.5-5.3) of developing forearm complaints compared with employees who spend less than two hours per day performing such movements.[47] A fifth study found that employees (various sectors) who spend up to 50% of a workday or more performing repetitive hand movements have a statistically significant elevated risk (3.4; 95% CI 1.3-8.7/2.9; 95% CI 1.2-7.3) of developing forearm complaints compared with employees who did not make these movements.[45]

Annex **J**

Extraction table other complaints

Author	Study population	Study design	Health effect	Exposure parameters	Degree of association
Andersen 2007 42	N = 1456 G = ? A = 44 (sd=10)	Prospective cohort study (2 years)	1. low back pain (2 years prevalence = 10.6%)	Repetitive work: - D = 0-9 min per hour N = 893	HR = 1.0
	O = nurses, administrative workers, nurse assistants, cleaning and kitchen workers, technical staff C = Denmark	Conf = sex, age, occupational category	2. Hip, knee, foot pain (2 years prevalence = 9.3%) 3. Any region (2 years prevalence = 23.6%) *Pain:* pain in a body region in the past 12 months	- D = 10-44 min per hour N = 256 - D = 45-60 min per hour N = 260	1. HR = 1.3 (CI 0.8-1.9) 2. HR = 1.4 (CI 0.9-2.1) 3. HR = 1.1 (CI 0.8-1.4) 1. HR = 1.7 (CI 1.2-2.6) 2. HR = 1.1 (CI 0.7-1.8) 3. HR = 1.4 (CI 1.1-1.8)

Bonde 2005 [48]	N = 2846 G = ? A = 38-39	Prospective cohort study (3 years)	Stress symptoms (SS) (3 years incidence = 1.5%)	Repetitive work: - No N = 813 (779 no SS; 24 SS)	OR = 1.0
	O = textile plants worker, electronic plant worker, cardboard industrial worker, service (postal sorting, supermarket) worker C = Denmark	Conf = sex, age, body mass index, physical leisure time activity	*Symptom:* somatic, emotional and cognitive symptoms in the past four weeks	- Yes N = 2033 (1957 no SS; 76 SS)	OR = 1.3 (0.6-2.2)
				- F = 1-15 per min N = 1288 (1235 no SS; 53 SS)	OR = 1.3 (0.5-1.9)
				- F = 16-60 per min N = 745 (722 no SS; 23 SS)	OR = 1.2 (0.8-3.7)
Mc Beth 2003 [49]	N = 1403 G = ? A = 18-65 O = various C = UK	Prospective cohort study (3 years) Conf = sex, age	Chronic widespread pain (CWP) (3 years prevalence = 9%)	Repetitive movement of the wrists: - Never / occasionally N = 344 (319 no CWP; 25 CWP)	RR = 1.0 RR = 1.8 (CI 1.2-2.7)
			Pain: any pain during the previous month that had persisted for at least 24h and if so, whether the pain lasted for more than 3 months	- Half / most of the time N = 333 (203 no CWP;30 CWP)	RR = 1.0 RR = 1.4 (CI 0.9-2.0)
				Repetitive movement of the arms: - Never / occasionally N = 382 (350 no CWP; 32 CWP)	
				- Half / most of the time N = 194 (171 no CWP;23 CWP)	

Annex **K**

Description of studies on other complaints

Three prospective cohort studies examined the incidence of other complaints due to repetitive movements (Annex H).[42,48,49] These studies were performed in various groups of employees, including administrative staff, nurses, cleaners, cashiers and assembly line workers. One of these studies found that exposure to repetitive movements is associated with an increased risk (OR = 1.4; 95% CI 0.9-2.1) of pain in the hip, knee and foot and general pain.[42] A second study found a statistically significant elevated risk (OR = 1.8; 95% CI 1.2-2.7) for general pain.[49] A third study found that employees who perform between 16 and 60 movements per minute are at elevated risk (OR - 1.2; 95% CI 0.8-3.7) of developing stress complaints compared with employees who do not perform repetitive movements.[48]

Annex **L**

Comments on the draft report

In November 2012, the President of the Health Council released a draft of this monitoring report for a round of public commentary. The following individual responded to the draft report:

- Mrs. M. Linders.

The Committee integrated the comments in completing its advisory report.

Health Council of the Netherlands

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