Observational Methods for Assessing Ergonomic Risks for Work-Related Musculoskeletal Disorders. A Scoping Review

Métodos observacionales para evaluar los riesgos ergonómicos de los Desórdenes Músculo esqueléticos relacionados con el trabajo: revisión del alcance

Métodos observacionais para avaliar os riscos ergonômicos das Desordens Musculoesqueléticas relacionados com o trabalho: revisão do alcance

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Received: October 10, 2017 / **Accepted:** November 24, 2017
Doi: http://dx.doi.org/10.12804/revistas.urosario.edu.co/revsalud/a.6840
To cite this article: Grooten WJA, Johanssons E. Observational Methods for Assessing Ergonomic Risks for Work-Related musculoskeletal disorders. A Scoping Review. Rev Cienc Salud. 2018; 16(especial): p. 8-38. Doi: http://dx.doi.org/10.12804/revistas.urosario.edu.co/revsalud/a.6840

Abstract

Introduction: Work-related musculoskeletal disorders (WRMSDs) are one of the most common causes of absence from work. Exposures in the work environment can cause or aggravate the impact of these musculoskeletal disorders and the identification of ergonomic exposures are essential in risk assessment. It is important to assess all three key indicators of these exposures (intensity, frequency and duration) for being able to estimate the risk level for the development of WRMSDs. *Aim:* This paper aims to give an overview of some of the observational methods that can be used for assessment of ergonomic risks at the workplace. *Methods:* This study was conducted as a scoping review of the

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medical and ergonomic literature and official governmental webpages in Sweden, U.S.A. and the Netherlands. *Results:* In total, 19 different observational methods were identified. We summarize our findings based on the body parts that were studied and what key indicators were assessed: *1)* intensity of the work load (posture and force production), *2)* frequency of the work load (e.g. repetitive movements), and *3)* the duration of the work load (e.g. static work). In an appendix we include a brief presentation of these methods together with the work sheet (if available) and the source reference of the observational method. *Conclusion:* For ergonomists that perform risk assessments, there is a large number of observational assessment tools available and it is important to understand that different methods can be used simultaneously to be able to estimate the objective risk levels for WRMSDs.

Keywords: assessment, ergonomics, musculoskeletal disorders, observational methods, risk.

Resumen

Introducción: los desórdenes músculo-esqueléticos relacionados con el trabajo (DME) son una de las causas más comunes de la ausencia laboral. Las exposiciones en el entorno de trabajo pueden causar o agravar el impacto de estos desórdenes músculo-esqueléticos y la identificación de exposiciones ergonómicas es esencial en la evaluación de riesgos. Es importante evaluar los tres indicadores clave de estas exposiciones (intensidad, frecuencia y duración) para poder estimar el nivel de riesgo para el desarrollo de DME. *Objetivo:* este artículo tiene como objetivo proporcionar una visión general de algunos de los métodos de observación que se pueden utilizar para evaluar los riesgos ergonómicos en el lugar de trabajo. *Métodos:* este estudio se realizó como una revisión del alcance de la literatura médica y ergonómica y de las páginas web gubernamentales oficiales en Suecia, EE. UU. Y los Países Bajos. *Resultados:* en total, se identificaron 19 métodos de observación diferentes. Resumimos nuestros hallazgos en función de las partes del cuerpo que se estudiaron y los indicadores clave evaluados: *1)* la intensidad de la carga de trabajo (postura y producción de fuerza), *2)* la frecuencia de la carga de trabajo (por ejemplo, movimientos repetitivos) y *3)* la duración de la carga de trabajo (por ejemplo, trabajo estático). En un apéndice incluimos una breve presentación de estos métodos junto con la hoja de trabajo (si estaba disponible) y la fuente de referencia del método de observación. *Conclusión:* para los ergónomos que realizan evaluaciones de riesgo hay una gran cantidad de herramientas de evaluación observacional disponibles y es importante comprender que se pueden usar diferentes métodos simultáneamente para poder estimar los niveles de riesgo objetivo para DME.

Palabras clave: evaluación, ergonomía, desórdenes músculo-esqueléticos, métodos de observación, riesgo.

Resumo

Introdução: as desordens musculoesqueléticas relacionadas com o trabalho (DME) são uma das causas mais comuns da ausência do trabalho. As exposições no entorno de trabalho podem causar ou agravar o impacto destas desordens musculoesqueléticas e a identificação de exposições ergonómicas são essenciais na avaliação de riscos. É importante avaliar os três indicadores chave destas exposições (intensidade, frequência e duração) para poder estimar o nível de risco para o desenvolvimento de DME. *Objetivo:* este artigo tem como objetivo proporcionar uma visão geral de alguns dos métodos de observação que se podem utilizar para avaliar os riscos ergonômicos no lugar de trabalho. *Métodos:* este estudo se realizou como uma revisão do alcance da literatura médica e ergonômica e dos sites governamentais oficiais na Suécia, nos Estados Unidos e nos Países Baixos. *Resultados:* em total, identificaram-se 19 métodos de observação diferentes. Resumimos os nossos achados em função das partes do corpo que se estudaram e os indicadores chave avaliados: 1) a intensidade da carga de trabalho (postura e produção de força), 2) a frequência da carga de trabalho (por exemplo, movimentos repetitivos) e 3) a duração da carga de trabalho (por exemplo, trabalho estático). Em um anexo incluímos uma breve apresentação destes métodos junto à folha de trabalho (se estava disponível) e a fonte de referência do método de observação. *Conclusão:* para os ergonomistas que realizam avaliações de risco, há uma grande quantidade de ferramentas de

avaliação observacional disponíveis e é importante compreender que podem-se usar diferentes métodos simultaneamente para poder estimar os níveis de risco objetivo para DME.

Palavras chave: qavaliação, ergonomia, desordens musculoesqueléticas, métodos de observação, risco.

Background Ergonomics

Ergonomics involves the interaction between human, technology and organization in the purpose of optimizing health, well-being and performance (1). Deficiencies in the working environment affect the individual, the company and the community. Therefore, well planned ergonomic working environment not only implies health benefits for the individual but also lead to increased quality and productivity gains for the company (2) and for society (3). A specific part within the field of ergonomics is, according to the international ergonomics association (IEA), the compatibility among human anatomical, anthropometric, physiological and biomechanical characteristics and the static and dynamic parameters of physical work (4). Relevant issues are thus working postures, materials handling, repetitive movements, static work, work-related disorders and safety and health (4), aiming to prevent the occurrence of injuries of the musculoskeletal system. These injuries are one of the most common causes of absence from work, leading to individual suffering and enormous costs for society. The most common body-parts that are affected are neck/shoulder and low back (5). Biomechanical exposures in the work environment can cause (6) or aggravate (7) the impact of these injuries, therefore the term work-related musculoskeletal disorders (WRMSDS) is often used to describe these injuries (4).

Prevention of WRMSDS is less costly than rehabilitation and preventive measures aim to detect the potentially harmful ergonomic work situations at an early stage, before WRMSDS occur (2). This process of identifying and classifying the risk levels for WRMSDS is called risk assessment. Risk assessment should be performed systematically by the employer, but there is often a need for an ergonomists with more extensive knowledge about work-environmental conditions. Although risk assessment often is used on an individual level, for example in the investigation if the MSD of a specific worker could be related to his/her specific workplace, risk analyses should analyze the work task rather than focusing on the individual. Moreover, risk assessments should be performed by using methods that are objective and correct, in other words, reliable and valid. It is of great importance that risk assessment is performed before the work task is taken into production, for example, during the planning stage or when reconstructing existing workplaces. By assessing the WRMSD risk in this stage, it is easier to specify the individual demands that are needed to perform the specific task. Ergonomic risk analyses can also be performed when one aims to evaluate the effect of a workplace intervention. Most studies on effects of workplace interventions

aim to evaluate the reduction of WRMSDS (8), but this approach is shadowed with a large number of methodological difficulties and it seems to be more feasible to study the effect on ergonomic exposures, rather than the occurrence of injuries.

Using an assembly line as example, workers are exposed to multiple concurrent factors that could lead to WRMSDS, such as the speed and height of the assembly line, the amount of products that are handled, the weight and shape of the products, the weight of the tools used, the duration of the working cycles and the number of pauses. The number of workers on the work site, the number of joints involved, the movement quantity and quality, the ability to alter body positions, psychological stress, time pressure, working hours, time of day, environmental factors (light, temperature, noise, vibrations), and the psychosocial work environment, etc. In a risk assessment of such a complex workplace it is important to structure the exposures into different components based on the pathophysiological mechanisms for WRMSDS. In the best of worlds, a risk assessment should cover all aspects, but often one need to focus on the two or three most important risks in order to find suitable interventions. In a multifactorial environment, one could use one specific assessment method that is perfectly constructed to assess one specific risk in one specific work task over a short time period, or use a general risk assessment method that assesses the total load over a longer time period. So the question is: which approach should be used?

Intensity, Frequency and Duration

When assessing the ergonomic risks, three key indicators of ergonomic exposure should be taken into account: **I)** the "intensity" of the work load; e.g. awkward posture of the trunk and/or extremities (posture)[3] and force production during lifting, pushing and pulling (due to lifting, pushing and pulling tasks), **F)** the "frequency" of the work load; e.g. repetitive movements, and **D)** the "duration" of the work load; e.g. static work, lack of changes in posture (9). Using these categories, many of the common ergonomic risks can be identified: manual handling (I), awkward posture (I/D), repetitive work (F), and static work (D) can be observed.

Table 1 provides examples of how these three key indicators of biomechanical exposure can be clustered against the aforementioned ergonomic risks for WRMSDS. This table also shows that many of the common WRMSDS, due to combinations of risks (6, 7), can be described by more than one key indicator. Moreover, different and similar categories could be expressed in different or similar measures, making it difficult to know which risk or key indicator is

3 It is important to understand that posture alone can cause/aggravate WRMSDS due to the weight of the body segments if they are not supported or due to end range positions of the joints involved.

observed. For example, by measuring the inclination degree of the back during a lifting task (expressed in degrees and in Newtons) in combination with the time spent in this angle (expressed in percentage of working time or in seconds), one could assess the risk level for WRMSDS for the combination of awkward postures and static work. Previous researches show that the combination of risk factors is an especially important factor to consider in a risk assessment [6]. There is in addition a need for observing concurrent risk factors for WRMSDS.

Table 1. Classification of biomechanical loading into the three key indicators (Intensity, Frequency, and Duration) of the ergonomic risks for WRMSDS, their measures and some of the common WRMSDS associated with these exposures.

Key Indicators	Risk	Measure	Common WRMSDS
I: Intensity	Manual handling	Kg or newton	Injuries in the vertebras and discs[4], Injuries in tendons[5] Injuries in muscles[6]
	Awkward posture	Degrees	
F: Frequency	Repetitive work	Cycle time	Injuries in tendons[5] Injuries in muscles[6]
	Manual handling		
D: Duration	Static work	Amount of time spent in one position, EMG-level	Injuries in tendons[5] Injuries in muscles[6]
	Awkward posture	Number of breaks Degrees	

It should be taken into account that the psychosocial (including organizational) factors, individual and environmental factors are not included in this table; these should be incorporated in the overall judgment of the level of the WRMSD risk at a later phase.

Ergonomic Risk Assessment and Intervention

Ergonomic risk assessment is part of the risk management process that will be included in a systematic analysis of potential hazards to ill-health and accidents. The purpose of making an ergonomic risk assessment is to eliminate work-related health risks by identifying existing or potential risks that may lead to MSDS. When risk factors are identified, interventions to reduce or minimize them must be carried out. Risk assessments can also be useful to evaluate an intervention performed at the workplace.

4 Arthritis/arthrosis, hernia

5 Tendinitis, tendinosis

6 (Semi-)ruptures

To successfully implement ergonomic improvements in the work environment, it is important to identify key persons who have the power and obligations to take action at the workplace at an early stage (10). It is of the outmost importance that the risk assessment is well imbedded in the organization and the key persons are employed by the organization. External consultants could be involved in the ergonomic risk assessment, but the intervention should be initiated from within the organization. Moreover, the employees should be included from the beginning. This so called participatory approach, i.e. where the employees are actively involved in the risk assessment and intervention development, has been proved successful in earlier studies (3).

Four Steps in an Ergonomic Risk Analysis

There are four steps involved in an ergonomic risk analysis. First, the physical working situation should map all performed tasks. There are several methods for this, but the hierarchical task analysis (HTA) is a recommended method for this mapping procedure [11]. The next step is to rank the tasks. This can be based on, for example, the time spent on a specific work task, or the severity of the ergonomic problems. This step is followed by an objective assessment of the three key indicators (intensity, frequency and duration) for each work task. Based on the assessment, a decision of the severity of the risk should be taken. A traffic light model —green (no obvious ergonomic problems), yellow/orange (minor/major ergonomic problems) and red (serious ergonomic problems, many workers are at risk of developing WRMSDS)— can be used for this. The fourth and final step is risk management.

In this paper, we focus on the second step, the objective assessment of the ergonomic exposures.

The methods available for the observation of risks can be divided into three categories: questionnaires, observation methods, and technical measurement methods.

1. **Questionnaires**: Here, the employee assesses the organization ergonomic risks during work using a questionnaire with pre-defined answers, e.g. the Dutch Musculoskeletal Questionnaire (12). This method is easy to use with large groups of workers and enables comparisons over time and between groups. However in workers with WRMSDS, there could be validity problems since they experience their work with a higher perception in terms of intensity, frequency and duration compared to those with no WRMSDS, thus introducing a serious form of bias, i.e. differential exposure assessment bias (13).
2. **Observational Methods:** These methods have to be based on concepts of an external observer (preferably an ergonomist) who fills in a predefined scoring sheet while watching a worker performing his/her work. These methods are more time-consuming

but their reliability and validity have been found to be satisfactory (14). Currently, there are many different observational methods for ergonomic risk assessment and no consensus exists on how to choose between them. In 2010, Takala, *et al.* provided an overview of some of the existing methods (14), but we believe there is a need for an update of this review.

3. **Technical Methods:** Lately, there has been a large development of new technical methods for observing postures, movements, and loads. For example, there are smartphones applications that can measure angles over time (15), as well as different types of accelerometers (16-18) and inclinometers (19, 20), smart clothing (21), and video-based systems (www.vidarweb.se), etc. that could be used for ergonomic risk assessment. These instruments are usually very accurate, but with some disadvantages: they are more expensive than observational methods, they need to be handled by experts and they interfere with the organization's work.

It is important to choose the most accurate and cost-effective method. We believe that weighing all the pros and cons of these three methods observational methods using pre-defined score sheets seem to be the most useful for ergonomists that work with daily ergonomic risk assessment in work environments.

Aim

The aim of this paper is to give an overview of observation methods that can be used in the assessment of ergonomic risks for WRMSDs at the workplace.

Materials and methods

Design

This study was designed as a scoping review of the literature on ergonomic risk assessment. PUBMED, ARBLINE and GOOGLE SCHOLAR databases were searched using combinations of key words such as 'ergonomic risk', 'assessment/measurement/methods', 'WRMSDs', 'intervention', together with the three biomechanical exposure categories, intensity, frequency and duration. Moreover, websites from different national institutions (Sweden) and international (the Netherlands, US) were searched as well. The two authors (WG and EJ) searched for methods using a "snowball method", which means that bibliography of papers

also were used to find methods. Special focus was put on papers published after 2008, to add methods that were developed after the systematic review of Takala, *et al.* (2010) (14).

Included were original papers that present the assessment method of the ergonomic risk exposures at work. Only papers in English, Dutch or Swedish that were available in full text were included. Moreover, only methods that use objective assessment measures were included; that is, an external assessor performs the risk assessment based on a pre-defined scoring sheet without the use of technical equipment.

Results

In total 19 methods were found that met the inclusion criteria, and for each method, the body part that is assessed together with the key indicators are presented in Table 2. In Appendix 1, the methods are described very briefly. In general, those methods had been found easy to use and provided useful information for the ergonomist to communicate the risk to the employer/employee in terms of green, yellow and red, and gave directions for ergonomic interventions.

Six methods assess risks in all body parts simultaneously (OWAS, PATH, PLIBEL, REBA, RULA, and WERA) while the other 13 methods study specific parts. One method (ALLA) focuses on the lower part of the body, only. Concerning intensity, all instruments measure this key indicator and all but one (HAL) assess the workers' posture. Fourteen of the 19 methods capture the frequency of the work task, while one instrument (KC) only partially assesses frequency, i.e., it asks the examiner with a simple one yes or no question if there were any repetitive movements. Four observation methods (ALLA, LUBA, QEC and RULA) do not include frequency in their risk assessment. Seven methods establishduration (SI, ALLA, HARM, KIM I-II, KIM III, RAMP and WERA) and two methods measure duration only partially (ART, QEC), i.e., if the work task was performed 0-2h, 2-4 h or >4 h/day.

Of the instruments, six assesses all three key indicators: SI, HARM, KIM I-II, KIM III, RAMP and WERA, while one instrument assesses all key issues partly (ART).

Table 2. Observational Methods for the Assessment of Ergonomic WRMSD Risk

Name and reference	Body Part	Intensity	Frequency	Duration
ALLA (22)	Lower limb	Yes (Posture)	No	Yes
ART (23)	Mostly hand/ fingers	Partial (Posture)	Yes	Partial
CTD RISK INDEX(24)	Upper extremity	Yes (Force and posture)	Yes	No
HAL (25)	Wrists/hands	Yes (Force)	Yes	No
HARM (26)	Neck/shoulder, Lower arm/ wrist	Yes (Force and posture)	Yes	Yes
KC (27)	Hand, lower arm	Yes (Force and posture)	Partial	No
KIM I-II (9) Lifting/Pulling/Pushing	Trunk	Yes (Force and posture)	Yes	Yes
KIM III (28) Manual work	Arm/wrist	Yes (Force and posture)	Yes	Yes
LUBA (29)	Neck, shoulders, upper back, lower back, elbows and wrists/hands	Yes (Posture)	No	No
OCRA (30)	Upper extremity	Yes (Force and posture)	Yes	No
OWAS (31)	Whole body	Yes (Posture)	Yes	No
PATH (32)	Whole body	Yes (Force and posture)	Yes	No
PLIBEL (33)	Whole body	Yes (Force and posture)	Yes	No
QEC (34)	Back, neck, arm, hand	Yes (Posture)	No	Partial
RAMP (35)	Back, upper extremity	Yes (Force and posture)	Yes	Yes
REBA (36)	Whole body	Yes (Posture)	No	No
RULA (37)	Upper extremity/Whole body	Yes (Posture)	No	No
SI (38)	Hand, lower arm	Yes (Posture)	Yes	Yes
WERA (39)	Whole body	Yes (Force and posture)	Yes	Yes

Discussion

This study maps a large number of instruments that can be used in the assessment of ergonomic WRMSD risk factors. Table 2 shows an overview of which body parts and key indicators (I, F, D) are assessed by these instruments. All of the instruments assess posture (intensity), but the other two key issues of biomechanical exposure (frequency and duration) were not included in all observational methods. Considering the instruments, only six assess all three key indicators: SI, HARM, KIM I-II and KIM III, RAMP and WERA, and among these, only WERA measures the biomechanical WRMSD risk for all body parts.

For ergonomists that perform risk assessments, there is a large number of observational assessment tools available, it is important to understand that different methods can be used simultaneously in order to estimate the objective WRMSD risk levels.

Acknowledgements

The authors wish to thank Amanda Hansson for her valuable input on the manuscript.

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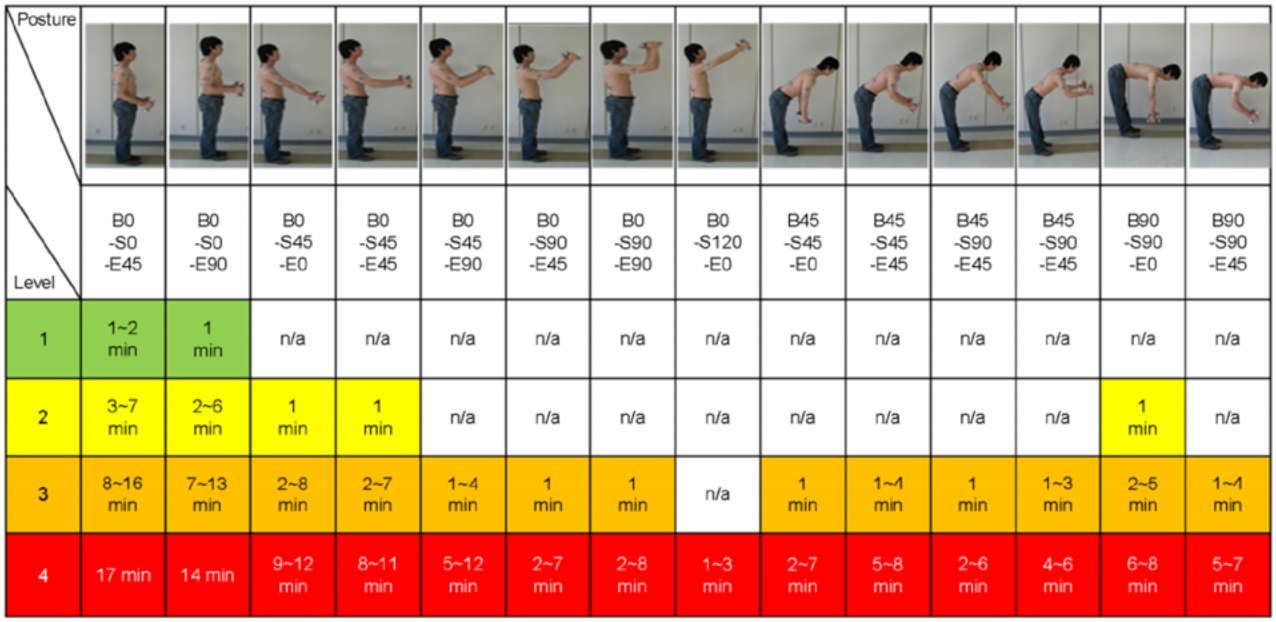
Appendix 1. Short description of the observational methods

Agricultural Lower Limb Assessment - ALLA

ALLA is a diverse and segmented ergonomic lower limb assessment tool developed for farm assessing farmers at work. ALLA is especially useful for studying lower limb burdening work [22, 40].



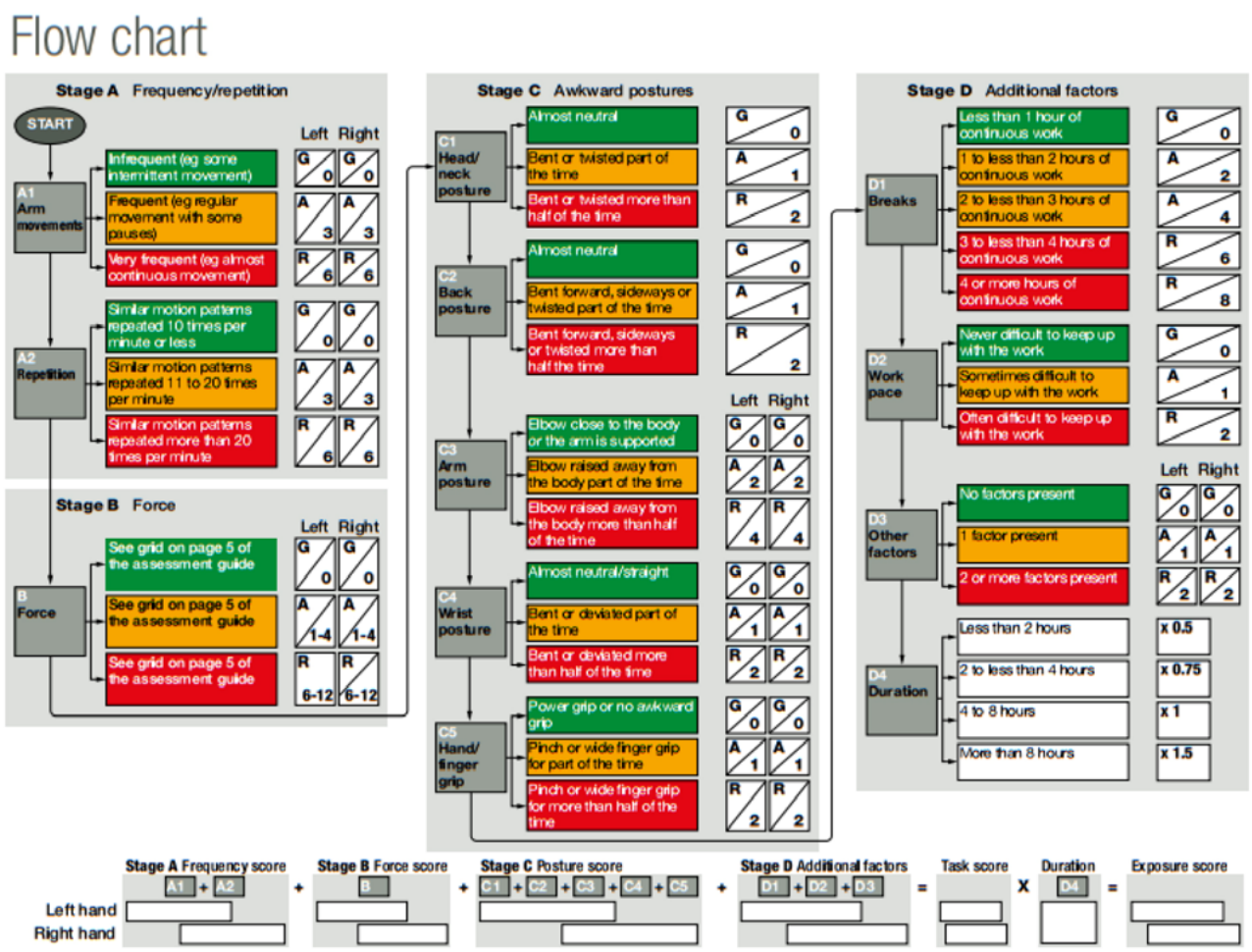
Posture / Level	B0 -S0 -E45	B0 -S0 -E90	B0 -S45 -E0	B0 -S45 -E45	B0 -S45 -E90	B0 -S90 -E45	B0 -S90 -E90	B0 -S120 -E0	B45 -S45 -E0	B45 -S45 -E45	B45 -S90 -E45	B45 -S90 -E45	B90 -S90 -E0	B90 -S90 -E45
1	1~2 min	1 min	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
2	3~7 min	2~6 min	1 min	1 min	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	1 min	n/a
3	8~16 min	7~13 min	2~8 min	2~7 min	1~4 min	1 min	1 min	n/a	1 min	1~1 min	1 min	1~3 min	2~5 min	1~1 min
4	17 min	14 min	9~12 min	8~11 min	5~12 min	2~7 min	2~8 min	1~3 min	2~7 min	5~8 min	2~6 min	4~6 min	6~8 min	5~7 min

Level	1	2	3	4
Risk level	Medium	Little High	High	Very High

Source: http://www.koreascience.or.kr/article/ArticleFullRecord.jsp?cn=OGGHBK_2010_v29n6_933

Assessment of Repetitive Task of the upper limbs - ART

ART is suited for tasks that involve actions of the upper limbs that are repeated every few minutes, or even more frequently, and occur for at least 1–2 hours per day or shift. Although ART mainly focuses on upper limbs, neck and back positions are monitored as well. The risk levels for the following factors are assessed: frequency and repetition of movements, power, work postures and influencing factors. If the predetermined risk levels do not fit, the assessment can be placed between two levels. ART can be used in assembly line, production, processing, packaging, packing and sorting work, as well as work involving the regular use of hand tools. ART is not intended for display screen equipment (DSE) assessments. ART has developed an excel sheet for analyzing several tasks that take into account the rotation frequency between different tasks (23).



Source: http://www.hse.gov.uk/pubns/indg438.pdf

Cumulative Trauma Disorder - CDT

The instrument was developed for the detection of repetitive strain injuries and includes four main factors that contribute to a sum score (based on a specific equation): the frequency, posture, force and miscellaneous factors (24).

CTD Risk Index

Job Title:	VCR Counter No.:	Date:
Job Description:	Department:	Analyst:

Cycle Time (in minutes; obtain from videotape)		ã
# Cycle/Day = $\frac{(480 \& Lunch \& Breaks)}{CycleTime}$ =	ãa	ä Larger of ãa or ãb:
# Parts / Day (if known)	ãb	
# Handmotions / Cycle		å
# Handmotions / Day (ä x å)		æ
Frequency Factor (Divide æ by 10,000) =		

(Circle appropriate condition)	Points			
	0	1	2	3
Working Posture	Sit	Stand		
Hand Posture 1: Pulp Pinch	No	Yes		
Hand Posture 2: Lateral Pinch	No	Yes		
Hand Posture 3: Palm Pinch	No	Yes		
Hand Posture 4: Finger Press	No	Yes		
Hand Posture 5: Power Grip	Yes	No		
Type of Reach	Horizontal	Up/Down		
Hand Deviation 1: Flexion	No	Yes		
Hand Deviation 2: Extension	No	Yes		
Hand Deviation 3: Radial Dev.	No	Yes		
Hand Deviation 4: Ulnar Dev.	No	Yes		
Forearm Rotation	Neutral	In/Out		
Elbow Angle	' 90E	_90E		
Shoulder Abduction	0	<45E	<90E	>90E
Shoulder Flexion	0	<90E	<180E	>180E
Back/Neck Angle	0	<45E	<90E	>90E
Balance	Yes	No		
Total the Points for the Circled Conditions				ç
Posture Factor (Divide ç by 10) =				

Grip or Pinch Force Used on Task	è	lbs.	ê Divideè byé:
Max Grip or Pinch Force	é	lbs.	
Force Factor (Divide ê by .15) =			

(Circle appropriate condition)	Points			
	0	1	2	3
Sharp Edge	No	Yes		
Glove	No	Yes		
Vibration	No	Yes		
Type of Action	Dynamic	Intermittent	Static	
Temperature	Warm	Cold		
Total the Points for the Circled Conditions				ë
Miscellaneous Factor (Divide ë by 3) =				

CTD Risk Index = .3 x (Frequency + Posture + Force Factors) + .1 x (Miscellaneous Factor)

CTD Risk Index = .3 x (+ +) + .1 x ( ) =

Source: http://home.spin.net.au/safehands/reference%20documents/CTDRisk.pdf

Hand Activity Level

This method intends to assess the MSD risk in the hand and forearm in repetitive work that is performed for at least four hours. The method is based on two variables that are judged by simple observations and estimates of the person performing the work: 1) hand activity

level (HAL), that indicates how often the movements are performed (assessed on a VAS scale), and 2) hand force, in which the produced force is estimated with a Borg CR-10 scale. These variables are placed on two axes in a chart with marked areas for red, yellow and green for identification of action and threshold limit values (TLV) (25).

ACGIH® TLV® for Hand Activity

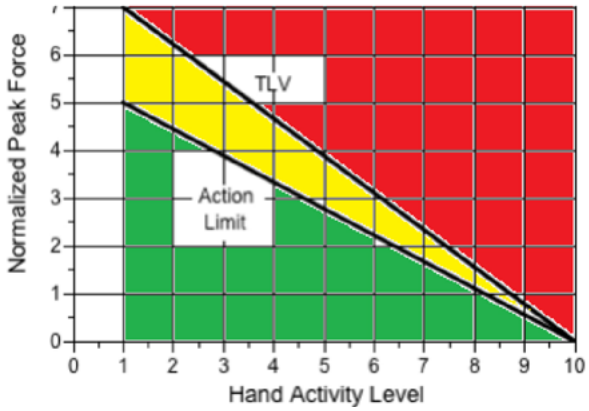
Job	Analyst	Date
	Left	Right
Hand Activity Level (HAL) (See scale below)		
Normalized Peak Force (NPF) (See table below)		
Ratio = NPF / (10-HAL)		
Determine Result TLV = 0.78 AL = 0.56	> TLV ☐ AL to TLV ☐ < AL ☐	> TLV ☐ AL to TLV ☐ < AL ☐

Hand Activity Level Rating

0	2	4	6	8	10
Hands idle most of the time; no regular exertions	Consistent conspicuous long pauses; or very slow motions	Slow steady motion/exertions; frequent brief pauses	Steady motion/ exertion; infrequent pauses	Rapid steady motion/exertions; no regular pauses	Rapid steady motion/ difficulty keeping up or continuous exertion

Estimation of Normalized Peak Force for Hand Forces

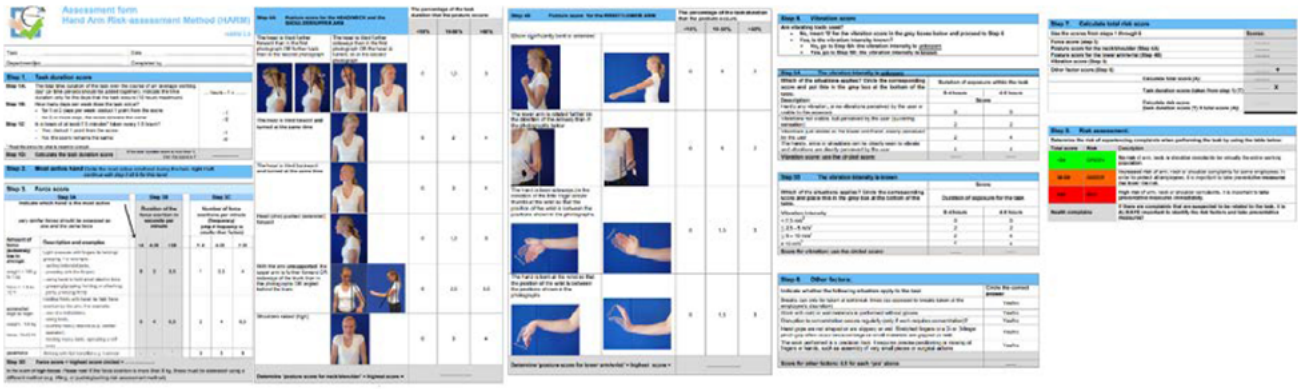
%MVC	*Subjective Scale*		*Moore-Garg Observer Scale* (Alternative Method)	*NPF*
	Score	Verbal Anchor		
0	0	Nothing at all		0
5	0.5	Extremely Weak (Just Noticeable)	Barely Noticeable or Relaxed Effort	0.5
10	1	Very Weak		1
20	2	Weak (Light)	Noticeable or Definite Effort	2
30	3	Moderate		3
40	4		Obvious Effort, But Unchanged Facial Expression	4
50	5	Strong (Heavy)		5
60	6		Substantial Effort with Changed Facial Expression	6
70	7	Very Strong		7
80	8			8
90	9		Uses Shoulder or Truck for Force	9
100	10	Extremely Strong (almost maximum)		10



Source: http://personal.health.usf.edu/tbernard/HollowHills/HALTLVM15.pdf

HARM

HARM assesses the risk of load-related injuries in the hand, arm, shoulder and neck during work tasks that last for at least one hour while the weight of what is handled is less than 6 kg. The method is intended to be used only for manual and arm-intensive work. It should not be used for assessing computer work. The assessment is conducted on one work task at the time, i.e., if there are several hand-intensive tasks within the work, they are assessed separately. HARM assesses six different areas: time, most active hand, power, work posture, vibration, and other factors. For these areas, different risk points are calculated, which are finally combined, resulting in a risk assessment. Risk levels are graded in green, yellow or red (26). The assessment form is a five-page document, alternatively it is a computerized tool.



Source: https://www.fysiekebelasting.tno.nl/en/instrumenten/welcome-to-the-hand-arm-risk-assessment-method-harm/

Keyserlings Cumulative Trauma Checklist

KC was developed to map the risk factors associated with MSDS in the upper extremities aiming to reduce accidents and inconvenience caused by poor ergonomics at the workplace in a car factory. KC assesses the occurrence of awkward posture, repetitive movements, external forces, vibration, temperature, drafts, tools, and glove use on 18 yes/no questions for both hands. For some factors, duration and frequency are also noted. A total sum score is obtained, the risks are graded into three levels (27).

Keyserlings checklista för övre extremiteterna

Företag/Arbetsplats/Arbetsmoment				
Arbetstagare			Bedömare	
Vilken är arbetstagarens dominanta hand?	Vänster	Höger	Båda	Datum för bedömningen

Besvara nedanstående frågor genom att ringa in lämpligt alternativ

		Nej	Ja			
Repetitivitet						
1.	Innehåller arbetet repetitiva handrörelser?	0	*			
	Besvara "ja" om något av följande stämmer:					
	a. arbetscykeln är kortare än 30 sek, eller					
	b. händerna repeterar samma rörelser under mer än halva arbetscykeln					
Mekanisk stress		**Vänster hand**		**Höger hand**		**Anm.**
2.	Orsakar hårda eller skarpa föremål, verktyg eller delar av arbetsytan lokalt tryck på:	**Nej**	**Ja**	**Nej**	**Ja**	
	a. fingrarnas dorsal- eller lateralsida?	0	√	0	√	
	b. handflata eller handledsbas?	0	√	0	√	
	c. underarm eller armbåge?	0	√	0	√	
	d. armhåla?	0	√	0	√	
3.	Används handflatan eller hypotenarregionen som "slagverktyg" (hammare)?	0	√	0	√	
Kraftanvändning						
4.	Lyfter, bär, skjuter/pressar eller drar arbetstagaren objekt som väger mer än 4,5 kg?	0	√	0	√	
5.	Måste arbetstagaren greppa objekt, verktyg eller redskap som har slät och hal yta (ingen ytstruktur eller fäste för att minska risken att glida)?	0	√	0	√	
6.	Används fingertoppen eller tummen för att pressa, trycka eller skjuta?	0	√	0	√	
7.	Om inga handskar används sätt kryss i rutan och gå vidare till fråga 8. ☐					
	Om arbetstagaren använder handskar, försvårar då dessa hans greppmöjlighet?	0	√	0	√	

Kommentarer:

	Vänster hand			Höger hand			
	Nej	Något	> 1/3 av cykeln	Nej	Något	> 1/3 av cykeln	Anm.
8. Greppar eller håller arbetstagaren arbetsstycken eller verktyg som väger mer än 2,7 kg per hand?	0	√	*	0	√	*	
Arbetsställning							
9. Används nypgrepp?	0	√	*	0	√	*	
10. Förekommer extension/flexion eller sidodeviation av handleden?	0	√	*	0	√	*	
11. Förekommer vridande, roterande eller skruvande underarmsrörelser?	0	√	*	0	√	*	
12. Måste arbetstagaren nå bakom kroppen?	0	√	*	0	√	*	
13. Lyfts armen i arbetet så att armbågen är i höjd med eller över maggropen (epigastriet)?	0	√	*	0	√	*	
Verktyg, handhållna objekt och annan utrustning							
14. Överförs vibrationer från verktyg eller objekt till operatörens hand?	0	√	*	0	√	*	
15. Strömmar kall utblåsningsluft över operatörens hand eller handled?	0	√	*	0	√	*	
16. Används något finger i snabba igångsättande/avfyrande tryckrörelser?	0	√	*	0	√	*	
		Nej	Ja		Nej	Ja	
17. Är verktygets eller objektets vikter obalanserade?		0	√		0	√	
18. Uppstår ryck och knyck i handen när man hanterar verktyg eller objekt?		0	√		0	√	

Lista de verktyg, objekt och utrustning som svaren på frågorna 14–18 avser:

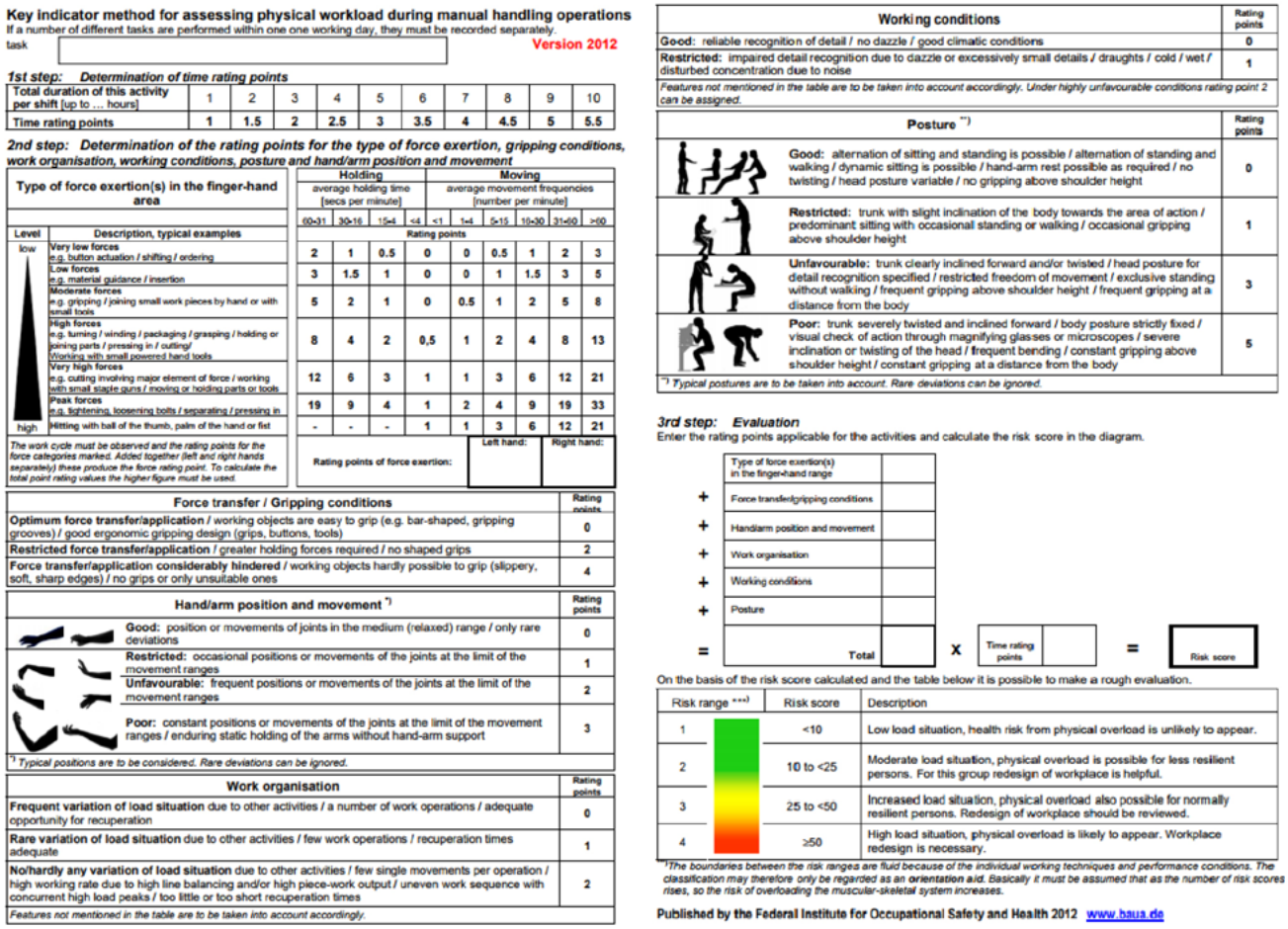
Totalsumma = _____ / _____
(Antal * /antal √)

Kommentarer:

Source: https://www.hig.se/download/18.77ab3a5b143c32193fb30af/1392299046534/Keyserlings+checklista+%C3%B6vre+extr.pdf

KIM I (Lifting) and KIM II (Push and Pull)

KIM I is designed for assessment of work tasks that require manual handling during a working day. First, it determines if manual handling primarily involves lifting/holding, holding or carrying loads. This gives a time span. Then the weight of the load is established. The most common job posture is determined as well as various aggravating factors. Finally, a risk point is calculated. Risk levels are graded in green, yellow, orange or red (9).



Key indicator method for assessing physical workload during manual handling operations

If a number of different tasks are performed within one one working day, they must be recorded separately.

task

Version 2012

1st step: Determination of time rating points

Total duration of this activity per shift [up to … hours]	1	2	3	4	5	6	7	8	9	10
Time rating points	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5

2nd step: Determination of the rating points for the type of force exertion, gripping conditions, work organisation, working conditions, posture and hand/arm position and movement

Type of force exertion(s) in the finger-hand area		Holding (average holding time [secs per minute])				Moving (average movement frequencies [number per minute])				
		60-31	30-16	15-4	<4	<1	1-4	5-15	10-30	31-60	>60
Level	Description, typical examples	Rating points									
low	Very low forces e.g. button actuation / shifting / ordering	2	1	0.5	0	0	0.5	1	2	3
	Low forces e.g. material guidance / insertion	3	1.5	1	0	0	1	1.5	3	5
	Moderate forces e.g. gripping / joining small work pieces by hand or with small tools	5	2	1	0	0.5	1	2	5	8
	High forces e.g. turning / winding / packaging / grasping / holding or joining parts / pressing in / cutting/ Working with small powered hand tools	8	4	2	0,5	1	2	4	8	13
	Very high forces e.g. cutting involving major element of force / working with small staple guns / moving or holding parts or tools	12	6	3	1	1	3	6	12	21
	Peak forces e.g. tightening, loosening bolts / separating / pressing in	19	9	4	1	2	4	9	19	33
high	Hitting with ball of the thumb, palm of the hand or fist	-	-	-	1	1	3	6	12	21

The work cycle must be observed and the rating points for the force categories marked. Added together (left and right hands separately) these produce the force rating point. To calculate the total point rating values the higher figure must be used.

Rating points of force exertion: Left hand: | Right hand:

Force transfer / Gripping conditions	Rating points
Optimum force transfer/application / working objects are easy to grip (e.g. bar-shaped, gripping grooves) / good ergonomic gripping design (grips, buttons, tools)	0
Restricted force transfer/application / greater holding forces required / no shaped grips	2
Force transfer/application considerably hindered / working objects hardly possible to grip (slippery, soft, sharp edges) / no grips or only unsuitable ones	4

Hand/arm position and movement *)		Rating points
	Good: position or movements of joints in the medium (relaxed) range / only rare deviations	0
	Restricted: occasional positions or movements of the joints at the limit of the movement ranges	1
	Unfavourable: frequent positions or movements of the joints at the limit of the movement ranges	2
	Poor: constant positions or movements of the joints at the limit of the movement ranges / enduring static holding of the arms without hand-arm support	3

*) *Typical positions are to be considered. Rare deviations can be ignored.*

Work organisation	Rating points
Frequent variation of load situation due to other activities / a number of work operations / adequate opportunity for recuperation	0
Rare variation of load situation due to other activities / few work operations / recuperation times adequate	1
No/hardly any variation of load situation due to other activities / few single movements per operation / high working rate due to high line balancing and/or high piece-work output / uneven work sequence with concurrent high load peaks / too little or too short recuperation times	2

Features not mentioned in the table are to be taken into account accordingly.

Working conditions	Rating points
Good: reliable recognition of detail / no dazzle / good climatic conditions	0
Restricted: impaired detail recognition due to dazzle or excessively small details / draughts / cold / wet / disturbed concentration due to noise	1

Features not mentioned in the table are to be taken into account accordingly. Under highly unfavourable conditions rating point 2 can be assigned.

Posture **)		Rating points
	Good: alternation of sitting and standing is possible / alternation of standing and walking / dynamic sitting is possible / hand-arm rest possible as required / no twisting / head posture variable / no gripping above shoulder height	0
	Restricted: trunk with slight inclination of the body towards the area of action / predominant sitting with occasional standing or walking / occasional gripping above shoulder height	1
	Unfavourable: trunk clearly inclined forward and/or twisted / head posture for detail recognition specified / restricted freedom of movement / exclusive standing without walking / frequent gripping above shoulder height / frequent gripping at a distance from the body	3
	Poor: trunk severely twisted and inclined forward / body posture strictly fixed / visual check of action through magnifying glasses or microscopes / severe inclination or twisting of the head / frequent bending / constant gripping above shoulder height / constant gripping at a distance from the body	5

**) *Typical postures are to be taken into account. Rare deviations can be ignored.*

3rd step: Evaluation

Enter the rating points applicable for the activities and calculate the risk score in the diagram.

	Type of force exertion(s) in the finger-hand range	
+	Force transfer/gripping conditions	
+	Hand/arm position and movement	
+	Work organisation	
+	Working conditions	
+	Posture	
=	Total	x Time rating points = Risk score

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

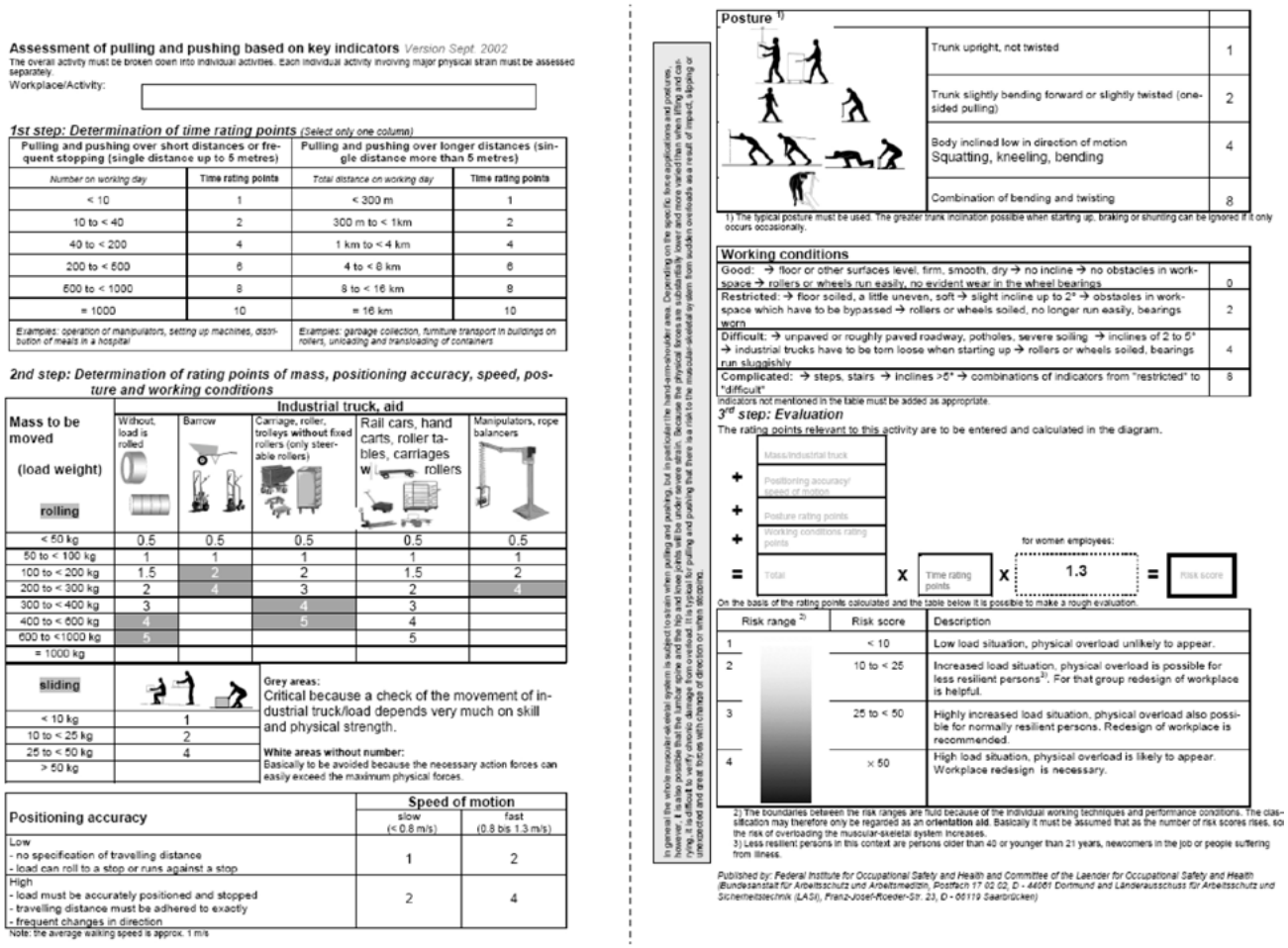
Risk range ***)	Risk score	Description
1	<10	Low load situation, health risk from physical overload is unlikely to appear.
2	10 to <25	Moderate load situation, physical overload is possible for less resilient persons. For this group redesign of workplace is helpful.
3	25 to <50	Increased load situation, physical overload also possible for normally resilient persons. Redesign of workplace should be reviewed.
4	≥50	High load situation, physical overload is likely to appear. Workplace redesign is necessary.

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

Published by the Federal Institute for Occupational Safety and Health 2012 www.baua.de

Source: https://www.baua.de/DE/Themen/Arbeitsgestaltung-im-Betrieb/Physische-Belastung/Leitmerkmalmethode/pdf/KIM-manual-handling-2.pdf?__blob=publicationFile

In a similar way, KIM II is used for assessment of work that involves pushing and pulling. The procedure is similar to KIM I. First, a time point is given, based on the distance that the load is moved (more or less than 5 m). Then, the weight of the load and how it is moved is determined. If the work involves load pushing, the body posture is assessed. Movement speed and body posture are also determined, as well as aggravating factors. Finally, a sum of risk points is calculated. Risk levels are graded in green, yellow, orange or red (9).



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

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

Workplace/Activity:

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

Pulling and pushing over short distances or frequent stopping (single distance up to 5 metres)		Pulling and pushing over longer distances (single distance more than 5 metres)	
Number on working day	Time rating points	Total distance on working day	Time rating points
< 10	1	< 300 m	1
10 to < 40	2	300 m to < 1km	2
40 to < 200	4	1 km to < 4 km	4
200 to < 600	6	4 to < 8 km	6
600 to < 1000	8	8 to < 16 km	8
= 1000	10	= 16 km	10
Examples: operation of manipulators, setting up machines, distribution of meals in a hospital		Examples: garbage collection, furniture transport in buildings on rollers, unloading and transloading of containers	

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

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

sliding	
< 10 kg	1
10 to < 25 kg	2
25 to < 50 kg	4
> 50 kg	

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

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

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

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

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

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

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

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

3rd step: Evaluation

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

Mass/industrial truck
+ Positioning accuracy/ speed of motion
+ Posture rating points
+ Working conditions rating points
= Total
x Time rating points
x for women employees: 1.3
= Risk score

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

Risk range 2)	Risk score	Description
1	< 10	Low load situation, physical overload unlikely to appear.
2	10 to < 25	Increased load situation, physical overload is possible for less resilient persons3). For that group redesign of workplace is helpful.
3	25 to < 50	Highly increased load situation, physical overload also possible for normally resilient persons. Redesign of workplace is recommended.
4	> 50	High load situation, physical overload is likely to appear. Workplace redesign is necessary.

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

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

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

Published by: Federal Institute for Occupational Safety and Health and Committee of the Laender for Occupational Safety and Health (Bundesanstalt für Arbeitsschutz und Arbeitsmedizin, Postfach 17 02 02, D - 44061 Dortmund and Länderausschuss für Arbeitsschutz und Sicherheitstechnik (LASI), Franz-Josef-Roeder-Str. 23, D - 66119 Saarbrücken)

Source: http://www.ammuppsala.se/kim-ii

KIM III (Repetitive Manual Handling for the Hand-Arm)

KIM III is developed after KIM I and II, it assesses repetitive manual handling for the hand-arm. The latest validated version was published in 2012. The analysis is based on observation of several working cycles. If the cycle time is less than 60 seconds, 5-10 cycles are observed. If the cycle time is longer than 60 seconds, 10-15 cycles are observed. The duration of the activity over a working day, the effort needed, position of hand and arm, work organization, body posture etc. are determined. Risk levels are graded in green, yellow, orange or red (28).

Loading on the Upper Body Assessment - LUBA

In LUBA, a score is calculated for the posture of each body part. The combined individual score for the neck, shoulders, upper back, lower back, elbows and wrists/hands gives a postural load index (PLI). This PLI score shows how musculoskeletal loading is associated to the worker's posture. LUBA classifys the risk of musculoskeletal disorders into four action categories (29).

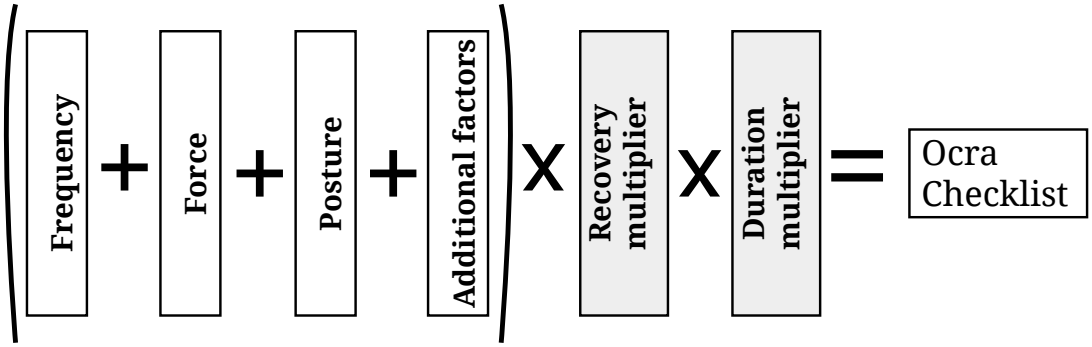
Department: Task: Operator:
Analyst name: Date:

Joint	Motion	Class	Score		Motion	Class	Score	
Wrist	Flexion	0-20°	1	___	Extension	0-20°	1	___
		20-60°	4	___		20-45°	5	___
		>60°	9	___		>45°	11	___
	Radial	0-10°	1	___	Ulnar	0-10°	1	___
	deviation	10-30°	5	___	deviation	10-20°	5	___
		>30°	10	___		>20°	9	___
Elbow	Flexion	0-45°	1	___	Supination	0-90°	3	___
		45-120°	3	___		>90°	9	___
		>120°	7	___				
	Pronation	0-70°	3	___				
	deviation	>70°	9	___				
Shoulder	Flexion	0-45°	1	___	Extension	0-20°	1	___
		45-90°	5	___		20-45°	7	___
		90-150°	9	___		45-60°	12	___
		>150°	14	___		>60°	16	___
	Adduction	0-10°	1	___	Abduction	0-30°	1	___
		10-30°	4	___		30-90°	6	___
		>30°	11	___		>90°	13	___
	Medial	0-30°	1	___	Lateral	0-10°	1	___
	rotation	30-90°	4	___	rotation	10-30°	5	___
		>90°	10	___		>30°	10	___
Neck	Flexion	0-20°	1	___	Extension	0-30°	1	___
		20-45°	5	___		30-60°	9	___
		>45°	8	___		>60°	15	___
	Lateral	0-30°	1	___	Rotation	0-30°	1	___
	bending	30-45°	5	___		30-60°	4	___
		>45°	13	___		>60°	11	___
Back	Flexion	0-20°	1	___	Extension	Not included		
		20-60°	6	___				
		>60°	13	___				
	Lateral	0-10°	1	___	Rotation	0-20°	1	___
	bending	10-20°	5	___		20-30°	3	___
		20-30°	12	___		30-45°	7	___
		>30°	16	___		>45°	14	___
Postural load =								

Source: http://2004ergonomicarticles.blogspot.com.co/2007/06/luba-assessment-technique-for-postural.html

Occupational Repetitive Actions

OCRA is a synthetic index describing risk factors related to repetitive actions at work. The total number of technical actions performed during the shift is divided by the total number of recommended technical actions. The latter is counted from observed actions multiplied by weights given for the following factors: muscle force, posture of the parts of the upper limb, lack of recovery periods, daily duration of the repetitive work, and other additional factors. The OCRA system comprise three assessment tools: *1)* The OCRA mini-checklist, which is a simplified version, as a preliminary screening tool is intended for special sectors (e.g. craftwork, small business, agriculture, etc.) in which the work is not organized according to precisely defined rates, times and cycles as it is in industry, *2)* the OCRA checklist for initial risk assessment, and *3)* the OCRA index for precise and analytical risk assessment (30).



The calculation procedure for the OCRA Checklist.

Source: http://www.epmresearch.org/index.php?fl=2&op=mcs&id_cont=837&idm=837&moi=837

OWAS - the Ovako Working Posture Analysis System

In the OWAS method the four most common work postures for the back, three postures for the arms and seven postures for the legs are identified, together with the load handled (three categories), these 252 options are then classified into four action categories (31). A portable system for coding and analyzing is currently available.

back posture

1 – upright
2 – leaning forward
3 – flexuous
4 – leaning forward and flexuous

forearms posture

1 – both below elbow joint
2 – one above elbow joint
3 – both above elbow joint

legs work

1 – sitting position
2 – standing with legs upright
3 – standing with one leg upright
4 – standing with legs bent
5 – standing with one leg bent
6 – kneeling on one or both knees
7 – walking

external load volume for men [kg]

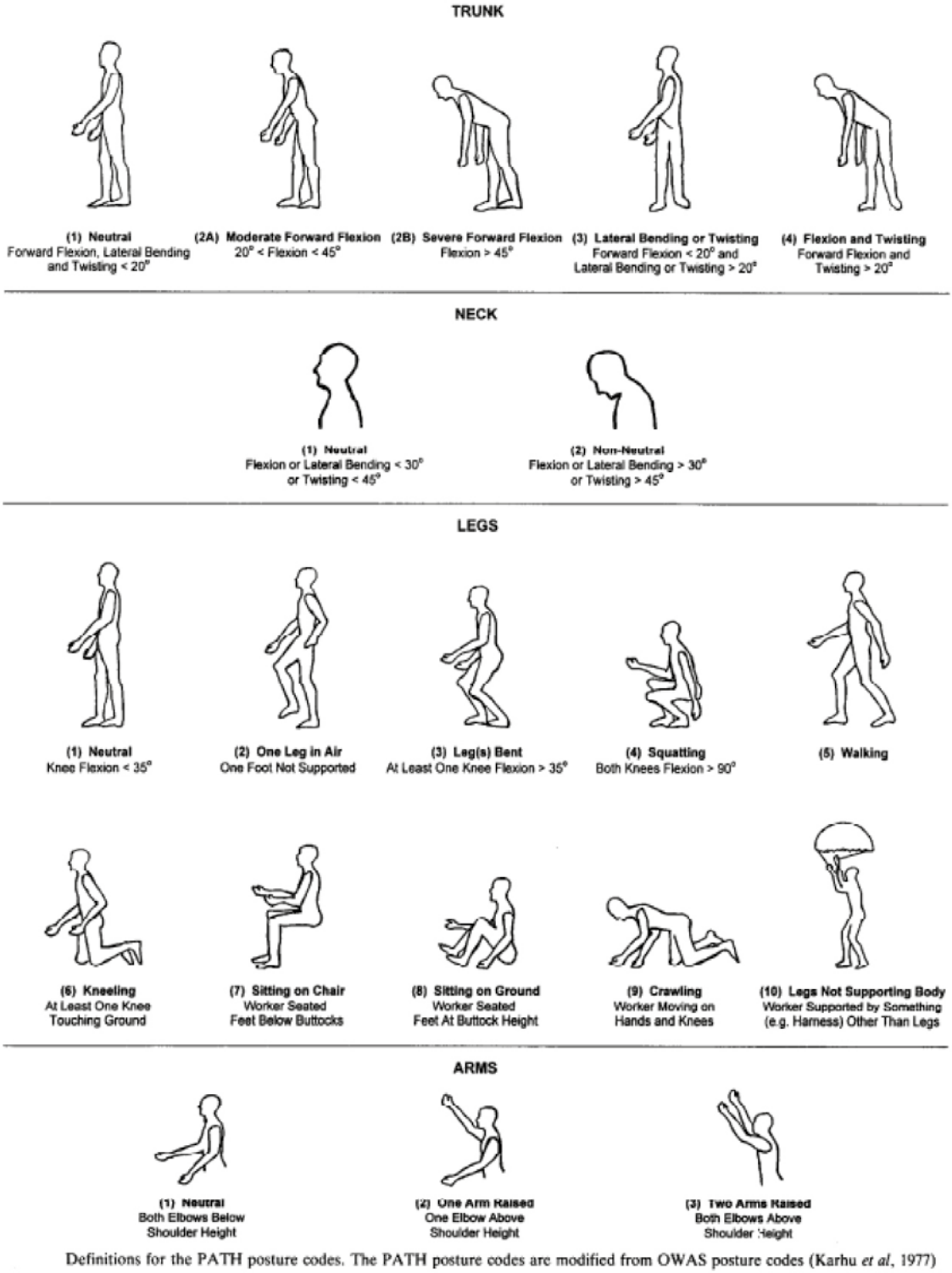
1 – below 10
2 – within the range 10-20
3 – above 20

back posture code	forearms position code	legs work code	expternal load volume code

Source: https://www.iasj.net/iasj?func=fulltext&aId=2366

Posture, Activity, Tools, and Handling - PATH

PATH has a work sampling-based approach, it was developed specifically to characterize the ergonomic hazards of heavy highway construction work. PATH is based on the OWAS definitions and uses the same risk levels [32].

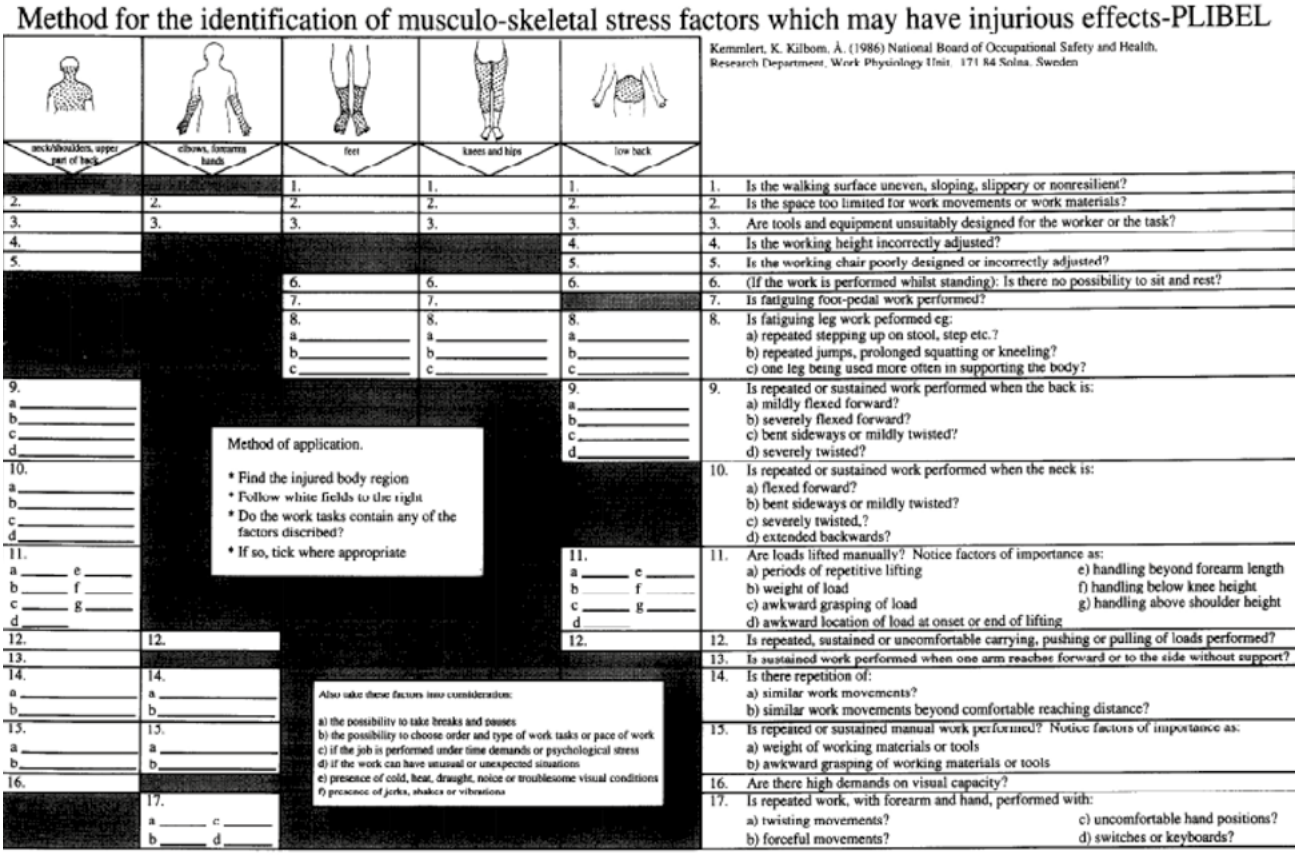


Definitions for the PATH posture codes. The PATH posture codes are modified from OWAS posture codes (Karhu *et al*, 1977)

Source: https://www.tandfonline.com/doi/abs/10.1179/oeh.1999.5.2.79

PLIBEL

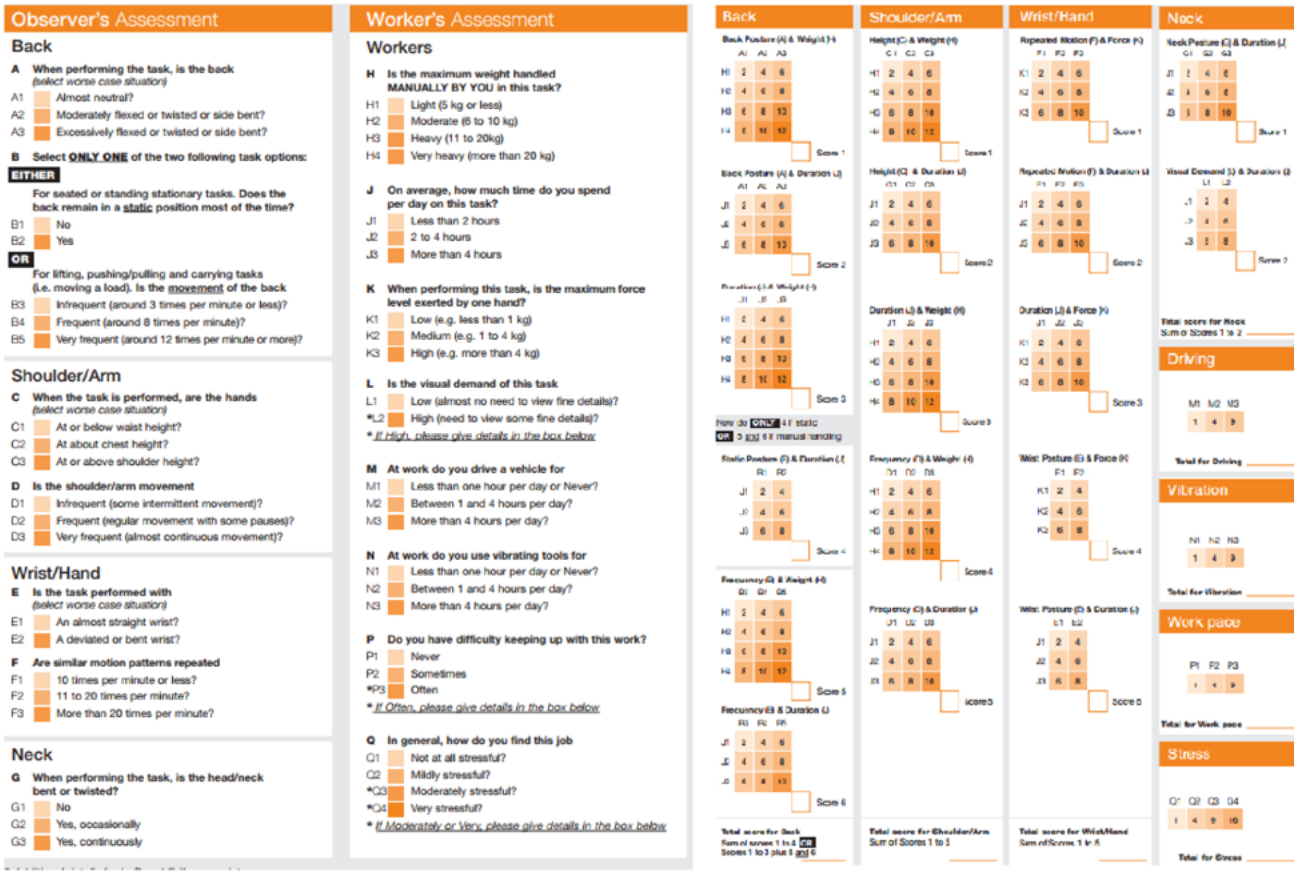
PLIBEL is a method for the identification of musculoskeletal stress factors which may have injurious effects. The checklist is designed so that items, ordinarily checked in a workplace assessment of ergonomic hazards, can be listed and linked to symbols of five body regions. The list of items consists of questions concerning awkward work postures, tiresome work movements, poor design of tools or workplace, and stressful environmental or organizational conditions. For a PLIBEL registration there is no duration criterion, excluding rare events or peak loads (33).



Source: https://www.sciencedirect.com/science/article/pii/0003687095000225?via%3Dihub

Quick Exposure Check - QEC

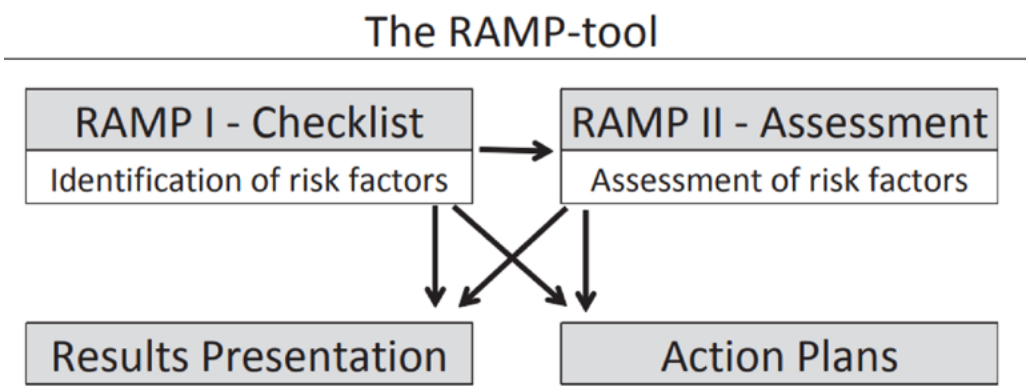
QEC is suitable for the assessment of many different types of work and work tasks, but each task should be assessed separately. The starting point for the assessment is the worst possible work positions for each body part involved in a task. The observer assesses body posture and body movements while the employee (in cooperation with the observer) estimates time, level of force, visual requirements, vehicle driving, vibrating tools, work load and stress levels. Different combinations of these parameters give points that sum up one body part at the time. Priority levels for possible interventions are proposed for the endpoints (34).



Source: http://www.hse.gov.uk/research/rrpdf/rr211.pdf

Risk Management Assessment Tool for Manual Handling Proactively - RAMP

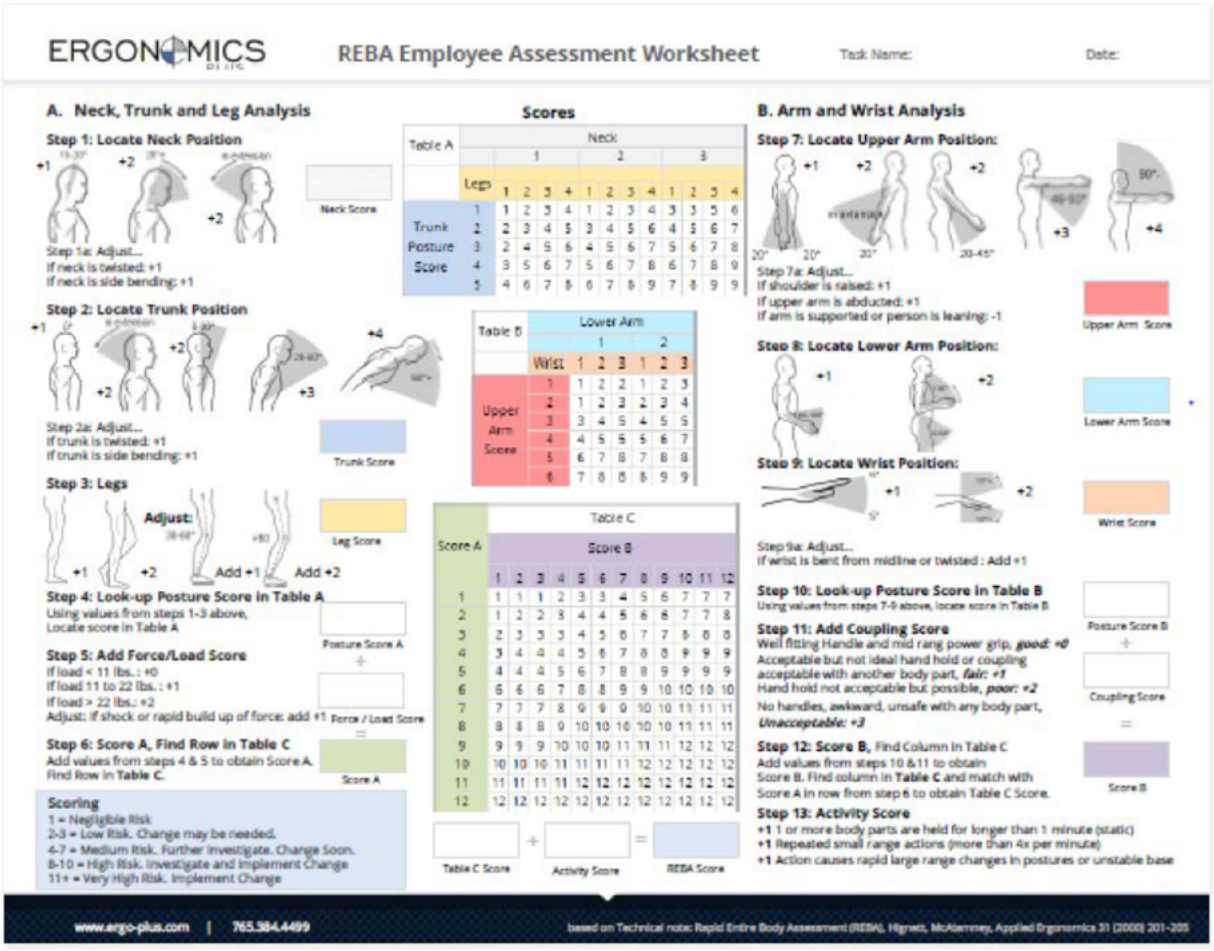
RAMP is a newly developed tool to support the assessment and management of risks of musculoskeletal disorder (MSD) in manual handling work. It consists of four modules: *1)* a checklist-based "RAMP I" for screening of MSD risks (yes/no), *2)* a "RAMP II" which enables a more in depth analysis, *3)* a "Results module" for presenting, visualizing and communicating the results, and *4)* an "Action module", for the development of risk reducing measures and systematic risk management. RAMP uses a number of equations in which multiplicative interaction of different ergonomic factors are taken into account. The tool includes two types of assessments, the worst case and the average case, intended to cover both cumulative load and peak load. Both, the initial and the sustained force can be assessed (35).



Fuente: https://www.ramp.proj.kth.se/

Rapid Entire Body Assessment Method - REBA

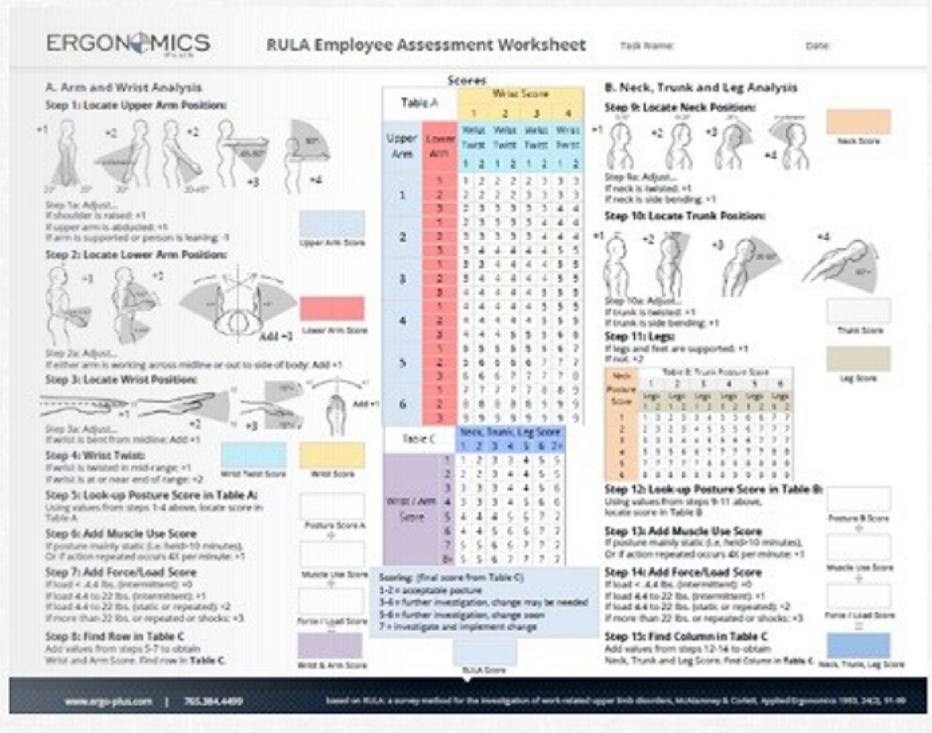
This ergonomic assessment tool uses a systematic process to evaluate the whole body postural MSD and risks associated with work tasks. A single page worksheet is used to evaluate required or selected body posture, forceful exertions, type of movement or action, repetition, and coupling (36).



Source: Hignett, S. and McAtamney, L., Rapid Entire Body Assessment(REBA), Applied Ergonomics, 31, 201-205, 2000.

Rapid Upper Limb Assessment Method - RULA

A single page worksheet is used to evaluate required body posture, force, and repetition. Based on the evaluations, scores are entered for each body region in section A) for the arm and wrist, and section B) for the neck and trunk. After the data for each region is collected and scored, tables on the form are then used to compile the risk factor variables, generating a single score that represents the level of MSD risk. The RULA was designed for easy use without the need for advanced ergonomic knowledge or expensive equipment. By using the RULA worksheet, an evaluator will assign a score for each of the following body regions: upper arm, lower arm, wrist, neck, trunk, and legs. After the data for each region is collected and scored, tables on the form are used to compile the risk factor variables, generating a single score that represents the level of MSD risk (37).



Source: http://ergo-plus.com/rula-assessment-tool-guide/

Strain Index - SI

The methodology involves the measurement or estimation of six task variables (intensity of exertion, duration of exertion per cycle, efforts per minute, wrist posture, speed of exertion, and duration of task per day), the assignment of an ordinal rating for each variable according to exposure data, and then the assignment of a multiplier value for each variable. The strain index is the product of these six multipliers (38).

TABLE I. Rating Criteria

Rating	*Intensity of Exertion*	*Duration of Exertion (% of cycle)*	*Efforts/Minute*	*Hand/Wrist Posture*	*Speed of Work*	*Duration per Day (hrs)*
1	light	<10	<4	very good	very slow	≤1
2	somewhat hard	10-29	4-8	good	slow	1-2
3	hard	30-49	9-14	fair	fair	2-4
4	very hard	50-79	15-19	bad	fast	4-8
5	near maximal	≥80	≥20	very bad	very fast	≥8

TABLE II. Rating Criteria

Rating	*Intensity of Exertion*	*Duration of Exertion (% of cycle)*	*Efforts/Minute*	*Hand/Wrist Posture*	*Speed of Work*	*Duration per Day (hrs)*
1	1	0.5	0.5	1.0	1.0	0.25
2	3	1.0	1.0	1.0	1.0	0.50
3	6	1.5	1.5	1.5	1.0	0.75
4	9	2.0	2.0	2.0	1.5	1.00
5	13	3.0[A]	3.0	3.0	2.0	1.50

$$\%\text{Duration of Exertion} = 100 * \frac{(\text{Average Duration of Exertion per Cycle})}{(\text{Average Exertional Cycle Time})}$$

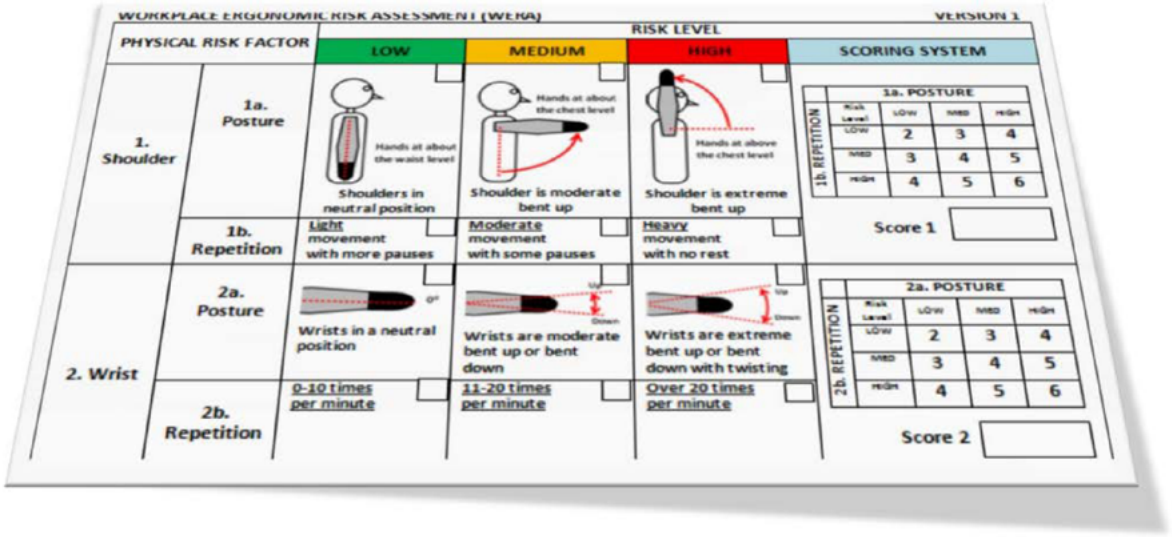
A If duration of exertion is 100%, then efforts/minute multiplier should be set to 3.0

Source: https://ergoweb.com/the-strain-index-job-analysis-method-q-a/ https://www.ergocenter.ncsu.edu/wp-content/uploads/sites/18/2018/01/Ecnc-Revised-Strain-Index-Calculator.pdf

Workplace Ergonomic Risk Assessment - WERA

WERA provides a quick method for screening the working task for assessing the physical risk factors associated with WRMSDs. The WERA tool covers six physical risk factors including posture, repetition, force, vibration, contact stress and task duration and it involves the five main body regions: shoulder, wrist, back, neck and leg. It has a scoring system and contains action levels, which provide a guide to the level of risk and the possible need for action to conduct more detailed assessments (39).

Workplace Ergonomic Risk Assessment (WERA)



Source: http://ergo.human.cornell.edu/ahWERA.html