

## New tools in Germany: development and appliance of the first two KIM ("lifting, holding and carrying" and "pulling and pushing") and practical use of these methods

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**Abstract.** The Key Indicator Methods (KIM) assess the risk of manual handling of loads on a screening level. Their purpose is the recognition and removal of job design deficits. The risk assessment is carried out in two stages. The first stage is the ordinal scaled description of workload items. The second stage is the evaluation of the degree of probability of physical overload. The intended user population are both practitioners in enterprises such as safety engineers, industrial engineers, and inspectors. The first two KIM were developed and tested from 1996 to 2001 in connection with the implementation of the EU directives into German national legislation. They consist of two independent, but formally adaptable methods for lifting, holding, and carrying and for pulling, and pushing. The KIM were drafted in the German Federal Institute for Occupational Safety and Health (BAuA) in close collaboration with the German Labour Inspectors. Numerous companies, scientists, statutory accident insurances, institutions, employer associations, and trade unions were involved. Since their first publication in 2000 and 2001, these methods are widely accepted among possible users with a corresponding broad application in Germany. They are recommended by the EU Labour Inspector Conference for application. In 2007 a third KIM for manual handling operating tasks KIM MHO were developed, tested, and validated in the last four years.

Keywords: physical workload, risk assessment, manual handling of loads, Key Indicator Methods

### 1. Introduction

The first Key Indicator Method (KIM) was the KIM for lifting, holding, and carrying (KIM-LHC). The blueprint was developed in 1996 [3, 6], tested and validated until 1999. In 2000 the revised version was published [8]. The first purpose was to develop a method in order to support the risk assessment for manual handling of loads on the National level. Thus the method was adjusted to the working conditions in German enterprises. Important parts in the development process were the analysis of the kind and range of physical workload in practice as well as the ability and the requirements of the users. This activity

was carried out in close collaboration with enterprises and inspectors and resulted in a specification sheet for the development of the risk assessment method.

Another important part of the process was the critical review of other comparable risk assessment methods available [7]. Starting with the experience gained from many years of practical work in the field of ergonomic and the critical methodological review of the published scientific literature, a large number of methods were tested in a research project with the aim of making a specific application recommendation. The result of this analysis revealed that these methods only tentatively satisfied the requirements that arise in German practice. The principal problems that occurred time and again were the following: i. the methodological models were not comprehensible enough for the practical user, and ii. the methods were

often not practicable because of limitations of application area, and iii. the methods were too laborious and possible application errors were not defined. Apart from the high and, in practice, hardly achievable effort required, this gives rise to critical application situations. The users who are normally well practised at their specific worksite, have no clear view of the normally complicated overall system and apply the methods purely schematically. This can lead to false judgements with severe consequences for the employees and/or the economic situation of the enterprise. The rejection of these methods by many of those involved users is correspondingly high. [7]

That was the reason for the development of KIM-LHC as a new additional method. However this KIM was not totally new. The biomechanical, physiological and psychophysiological approach of the NIOSH-equation was applied, extended and operationalized. Because it only covers the major activity indicators, it was called Key Item Method. Later it was redefined as Key Indicator Method.

In the same way the second KIM for pushing and pulling (KIM-PP) were developed from 1998 until 2001 [4] and the third KIM for manual handling operations (KIM-MHO) until 2011 (see paper from André Klusmann). The application of these methods is not mandatory in law in Germany. But there is an application recommendation of the Occupational Safety and Health (OSH) authorities [3, 4].

## 2. The model of the Key Indicator Methods

Physical strain is affected by many factors. For risk assessment on a screening level the most important factors were selected and called as key indicators. The key indicators for lifting, holding, and carrying are duration/frequency, load mass, posture, and working conditions. The key indicators for pushing, and pulling are duration/frequency, mass to be moved, transport vehicle, positioning accuracy, speed of motion, posture, and working conditions. All key indicators are ordinal scaled ranging from null to the maximum. At this stage the workload is described objectively without any evaluation.

The target variable of the method is the assessment of the risk from the manual handling of loads in the form of a risk score. This is determined by allocating a rating point to the individual key indicators according to their intensity and then linking them in a simple computation (Fig. 1).

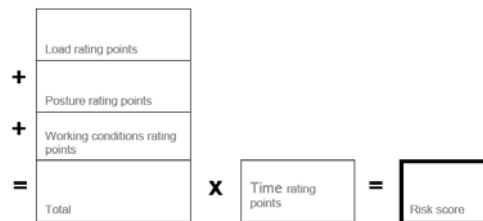


Figure 1 - Calculation of the risk score

The possible risk score (from 2 up to appr. 70) is divided in four risk ranges (Fig. 2).

For the evaluation of workload four components are taken into account: biomechanical modelling, muscular-metabolic effects, dose relation, and constitution. This approach only takes account chronic damage and not accident-like events.

The factor biomechanics particularly takes into account the mechanical load on bones and joints from the postural and action forces applied. The forces to be transferred into the skeletal system are a measure of the internal strain and possible overstrain on individual structural elements. The biomechanical components are taken into consideration through the indicators load mass, positioning accuracy, speed of motion, and posture.

The muscular-metabolic component relates to the activity of the muscles. Direct hazards are only possible with major events of overload (sprains, torn muscle fibre). Otherwise the muscles react under load situations with reversible fatigue. The muscular-metabolic component is taken into consideration mainly via the duration/frequency and load mass, positioning accuracy, speed of motion, and postures.

The dose relation is obtained by considering the duration of the action of the biomechanical load or the muscular-metabolic.

The dose component relates to the duration of impact. It is taken into consideration mainly in terms of the duration.

Whereas the three components mentioned relate to activity, the constitutional prerequisite is considered in relation to individuals. The relationship of work strain and physical resilience has to be taken into account. Muscular strength, endurance, physical type and skill vary considerably. Healthy employees with sturdy bone structure and

well-trained muscles are less at risk under the same load situations [2].

Risk range	Risk score	Description
1	< 10	Low load situation, physical overload unlikely to appear.
2	10 bis < 25	Increased load situation, physical overload is possible for less resilient persons <sup>4)</sup> . For that group redesign of workplace is helpful.
3	25 bis < 50	Highly increased load situation, physical overload also possible for normal persons. Redesign of the workplace is recommended.
4	≥ 50	High load situation, physical overload is likely to appear. Workplace redesign is necessary <sup>5)</sup> .

3) Basically it must be assumed that as the number of point rating rises, so the risk of overloading the muscular-skeletal system increases. 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. More exact analyses require specialist ergonomic knowledge.

4) 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.

5) Design requirements can be determined with reference to the number of point in the table. By reducing the weight, improving the execution conditions or shortening the strain time, elevated stress can be avoided.

Figure 2 - Evaluation table

### 3. The Key Indicator Methods

Both KIM-LHC and KIM-PP are designed in their original form as single-paged worksheets (Fig. 3 and 4). For reasons of practicality the complete overview is important. The worksheet can be filled in directly and filed for documentation. The rear page contains important instructions for use.

The worksheets and the instructions for use can be downloaded from the Website of the European Agency for Safety and Health at Work [12] in several European languages. Supplementary to the paper & pencil version interactive computer aided worksheets are available in German from the BAuA-website [13, 14]. In addition there is an abundance of modifications of the Key Indicator Methods integrated into the health management system of enterprises.

**ASSESSMENT OF MANUAL HANDLING TASKS BASED ON KEY INDICATORS** Version: 2001  
Where there are a number of individual activities with considerable physical strain, they must be estimated separately.

Workplace/Activity: \_\_\_\_\_

**1<sup>st</sup> step: Determination of time rating points** (Select only one column!)

Lifting or displacement operations (< 5 s)		Holding (> 5 s)		Carrying (> 5 m)	
Number on working day	Time rating points	Total duration on working day	Time rating points	Overall length on working day	Time rating points
< 10	1	< 5 min	1	< 300 m	1
10 to < 40	2	5 to 15 min	2	300 m to < 1 km	2
40 to < 200	4	15 min to < 1 hr	4	1 km to < 4 km	4
200 to < 500	6	1 hrs to < 2 hrs	6	4 to < 8 km	6
500 to < 1000	8	2 hrs to < 4 hrs	8	8 to < 16 km	8
≥ 1000	10	≥ 4 hrs	10	≥ 16 km	10

**Examples:** - laying bricks, picking workpieces into a machine, taking boxes out of a container and putting them onto a conveyor belt. **Examples:** - holding and guiding a cast iron slug while working on a wheel stand, operating a hand grinding machine, operating a weed-water. **Examples:** - furniture removal, delivering scaffolding parts to a building site.

**2<sup>nd</sup> step: Determination of rating points of load, posture and working conditions**

Effective load <sup>1)</sup> for men	Load rating point	Effective load <sup>1)</sup> for women	Load rating point
< 10 kg	1	< 5 kg	1
10 to < 20 kg	2	5 to < 10 kg	2
20 to < 30 kg	4	10 to < 15 kg	4
30 to < 40 kg	7	15 to < 25 kg	7
≥ 40 kg	25	≥ 25 kg	25

1) Effective load means in this context the real action force which is necessary for moving load. This action force does not correspond to the load mass in each case. When lifting a carton, only 50 % of the load mass will have an effect on worker and when using a cart only 10 %.

Typical posture, position of load <sup>2)</sup>	Posture, position of load	Posture rating point
	+ Upper body upright, not twisted + When lifting, holding, carrying and lowering the load is close to body	1
	+ Slightly bending forward or twisting the trunk + When lifting, holding, carrying and lowering load is near to medium to body	2
	+ Low bending or far bending forward + Slightly bending forward with simultaneous twisting of trunk + Load far from the body or above shoulder height	4
	+ Bending far forward with simultaneous twisting of trunk + Load far from body + Restricted stability of posture when standing + Crouching or kneeling	8

2) To determine the posture rating points the typical posture during manual handling must be used. For example when there are different postures with load a mean value must be used – not occasional extreme values.

**Working conditions**

Working conditions	Working conditions rating point
Good ergonomic conditions, e.g. sufficient space, no physical obstacles within the workspace, even level and solid flooring, sufficient lighting, good gripping conditions	0
Space for movement restricted and unfavourable ergonomic conditions (e.g. 1: space for movement restricted by too low high or working area less than 1,5 m <sup>2</sup> or 2: posture stability impaired by uneven floor or soft ground)	1
Strongly restricted space of movement and/or instability of centre of gravity of load (e.g. transfer of patients)	2

**3<sup>rd</sup> step: Evaluation**  
 The rating points relevant to this activity are to be entered and calculated in the diagram.

+	Load rating points		+ Posture rating points		+ Working conditions rating points		= Total	X	Time rating points	=	Risk score
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On the basis of the rating calculated and the table below it is possible to make a rough evaluation.<sup>3)</sup> Regardless of this provisions of the Maternity Leave Act apply:

Risk range	Risk score	Description
1	< 10	Low load situation, physical overload unlikely to appear.
2	10 bis < 25	Increased load situation, physical overload is possible for less resilient persons <sup>4)</sup> . For that group redesign of workplace is helpful.
3	25 bis < 50	Highly increased load situation, physical overload also possible for normal persons. Redesign of the workplace is recommended.
4	≥ 50	High load situation, physical overload is likely to appear. Workplace redesign is necessary <sup>5)</sup> .

3) Basically it must be assumed that as the number of point rating rises, so the risk of overloading the musculoskeletal system increases. 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. More exact analyses require specialist ergonomic knowledge.

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

5) Design requirements can be determined with reference to the number of point in the table. By reducing the weight, improving the execution conditions or shortening the strain time, elevated stress can be avoided.

Check of the workplace necessary for other reasons:

Reasons: \_\_\_\_\_

Date of assessment: \_\_\_\_\_ Assessed by: \_\_\_\_\_

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Figure 3 - Worksheet KIM lifting, carrying and weighting

**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 < 1 km	2
40 to < 200	4	1 km to < 4 km	4
200 to < 500	6	4 to < 8 km	6
500 to < 1000	8	8 to < 16 km	8
= 1000	10	= 16 km	10

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

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

Mass to be moved (load weight)	Industrial truck, aid				
	Without load is rolled	Barrow	Carriage, roller, trolleys without fixed rollers (only steerable rollers)	Rail cars, hand carts, roller tables, carriages with rollers	Manipulators, rope balancers
rolling					
< 50 kg	0,5	0,5	0,5	0,5	0,5
50 to < 100 kg	1	1	1	1	1
100 to < 200 kg	1,5	2	2	1,5	2
200 to < 300 kg	2	4	3	2	4
300 to < 400 kg	3		4	3	
400 to < 500 kg	4		5	4	
500 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 shutting can be ignored if it only occurs occasionally.

**Working conditions**

Good: → floor or other surfaces level, firm, smooth, dry → no incline → no obstacles in work-space → rollers or wheels run easily, no evident wear in the wheel bearings	0
Restricted: → floor soiled, a little uneven, soft → slight incline up to 2° → obstacles in work-space which have to be bypassed → rollers or wheels soiled, no longer run easily, bearings worn	2
Difficult: → unpaved or roughly paved roadway, potholes, severe soiling → inclines of 2 to 6° → industrial trucks have to be torn loose when starting up → rollers or wheels soiled, bearings run sluggishly	4
Complicated: → steps, stairs → inclines > 6° → combinations of indicators from "restricted" to "difficult"	8

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

**3<sup>rd</sup> 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				

**Risk score:** Total × Time rating points × 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 persons <sup>3)</sup> . 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 situation may therefore only be regarded as an orientation aid. Basically it must be assumed that as the number of risk scores rises, so the risk of overloading the musculoskeletal system increases.  
 3) Less resilient persons in this context are persons older than 40 or younger than 21 years, newcomers in the job or people suffering from illness.

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Figure 4 - Worksheet pushing and pulling

#### 4. Application areas

In the beginning, the intended application area was the support for risk assessment at the National level. The intended users were practitioners in companies, particularly in small and medium-size enterprises. Therefore the methods had to fulfil the following goals in practical terms:

- Value-neutral description of the most important activity indicators
- Reliable coverage of these indicators with the lowest possible effort
- Revelation and rough quantification of relevant health risks
- Indication of job design deficits
- Comprehensibility and retraceability of the judgement by the user
- Low effort for documentation
- Calculability of assessment errors.

After 12 years experience with the application it can be said that the Key Indicator

Methods have fulfilled this demands. It is widely-used in Germany and seen by many practitioners as a source of support for their professional expertise. An analysis of users experiences and frequently asked questions shows, that approximately three-quarter of tasks can be assessed finally with this method. The assessment results are nearly always accepted and enable one to conclude the need for action in a short time.

Since the mid 00s an extend application is observable. Additional to the risk assessment the Key Indicator Methods are used for industrial engineering and company surveys. For this purpose, the Key Indicator Methods were integrated into several tools and systems.

However in several cases the method has been applied far beyond its use limits for complex work designs and for appraisal purposes in legal disputes. The method is unsuitable for these purposes.

#### 5. Embedding in methods inventory

The proportion of relevant misapplications and misjudgements is small [7]. The most frequent errors are

assessments based on inadequate knowledge of the activity, computation errors, application complicated work sequences, uncritical applications and failure to pay attention to the instructions.

Uncertainty and assessment errors can basically never be discounted. One simple way out of this problem is to combine a number of methods that complement one another or to check the results of another method. For the on-site work of ergonomists and German company physicians a four-part methods inventory has been developed [1]. It involves an average time input of less than two hours per workplace or employee in order to record the objective physical strain with KIM, the perceived stress, the existing health complaints and orthopaedic findings. The value for the corporate occupational safety and health practitioners is not in the precise calculation and comparative evaluation of risk, but in the highlighting of relationships between objective work load, perceived strain, and health complaints and the influencing factors to be considered.

## 6. Projects

Further Key Indicator Methods are projected. The revision of KIM lifting, holding and carrying and KIM pushing and pulling are in process. Projected novel Key Indicator Methods are restricted working posture, high physical strain, and mixed physical workload. All KIM will be developed as a method package with interfaces to higher level ergonomic and scientific methods.

One focus of further development is the justification of limit values. The risk assessment for physical workload is different to the risk assessment of mechanical and chemical exposition. Whereas these hazards have to be avoided, the physical workload has to be optimized because physical strain is an essential part of human life. In consideration of the widespread individual physical capacities regarding muscle forces, endurance and resilience the KIM assessment approach has proved suitable. A further development is necessary for assessment of risks due to

physical underloading, particularly for sedentary work without any physical demands.

## 7. Conclusion

The system KIM proved to be qualified for risk assessment of physical workload in manual handling of loads on the screening level. From the mid 00s it was discussed more and more on international context [5, 9, 10, 11]. The outlined projects will complete and improve this system.

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