Requirements to assess physical work-ability of production workers in the manufacturing industry

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Musculoskeletal disorders (MSD) are a major reason for the absence due to illness of workers in the manufacturing industry. There is a need to evaluate the capabilities of workers as well as to systemize the data. With this data, on the one hand, a suitable workplace for workers with MSD’s can be developed, on the other hand, this data can be used by workplace designers to create preventive, capability-appropriate workplaces.

The requirements for functional capacity evaluation in the context of the manufacturing industry are discussed as well as the benefit of such a procedure. Furthermore, the important capabilities which are relevant for assembly work and therefore need to be assessed are presented and described in detail. Derived from the description of the capabilities and guidelines for the occupational physicians, the capabilities specific to musculoskeletal complains and related functional limitations need to be assessed.

Practitioner Summary: In order to evaluate work-related physical capabilities efficiently, a one-hour test procedure has been developed and assigned to specific MSD or functional limitations. It consists of two stages. One is a method for comprising limitation-oriented estimation of capabilities and the other one is a method for precise evaluations of performance. Overall it includes medical examinations, a questionnaire and a test procedure with work-specific trials.

Keywords: physical capabilities, musculoskeletal disorders, preventive ergonomics, assembly work

1. Introduction

Musculoskeletal disorders are common in assembly work and a major reason for the absence due to illness of workers in the manufacturing industry (OSHA 2014, Landau et al. 2008). Assembly work is characterized by a variety of stressful activities such as manual material handling of loads, awkward static postures, action forces and repetitive movements of the upper extremities. In addition, the average age of the working population in western countries will rise in the near future and also absence is increasing with age. The group of workers from 50 to 65 years of age proportionately thereby causes the largest part of the work loss (Meyer et al., 2011). Moreover, capabilities diminish and the range of performance levels between individuals grow wider with higher age (Rademacher et al. 2014). It should be mentioned that not all capabilities decrease with age and that positive changes have to be recognized as well.

The Institute of Ergonomics and Human Factors (IAD) is carrying out a three-year research project funded by the German Research Foundation (DFG) in cooperation with a German car manufacturer. The expected result of this project is an assistance system to design capability-appropriate workplaces that include the assessment of physical capabilities of production workers. Therefore it is necessary to assess the physical work-ability of workers in a very objective way, specific to particular MSD’s and according to job demands, so that the received data can be systemized and provided to workplace designers. On the one hand, a suitable workplace for workers with MSDs can be developed, while on the other hand, this data can be used by workplace designers to develop preventive ergonomics where capability data can be used for creating capability appropriate workplaces. To achieve a healthy and workable workforce, companies need to react at an early stage in order to adjust workplaces to the needs and capabilities of workers as well as to the change of the workforce. In summary it is a contribution to prevent work-related musculoskeletal disorders, to reduce early-retirement rates as well as to improve motivation and output of employees.

In this paper we deal with the question of how to evaluate the work-ability of production workers in a very objective, specific and efficient way.
2. Method

First we ascertained how capabilities of workers are assessed in German car manufacturing industry. The capacity level is rated by occupational physicians after a medical examination. From our field study we can state that there is no standard procedure used. After a literature review we found that a very common method in the field of functional capacity evaluation (FCE) is the assessment from Isernhagen (1988), which was developed for the assessment of work-ability of rehabilitation patients. In this regard, similar assessment methods like Ergos Work Simulator, Valpar Component Work Samples (VCWS), Arcon FCE System etc. must be mentioned. All these assessment methods have one thing in common: they are not practical for occupational physicians working in the manufacturing industry in Germany. The reasons are that they are too complex, too time consuming as well as too expensive.

Rademacher et al. (2009) developed a three-hour assessment which consists of a medical examination, an interview with several questionnaires and a test procedure with numerous work-specific trials according to assembly work. The testing procedure is a good approach for a work-related assessment, but is difficult to include the complete assessment into a daily routine of occupational physicians. Some work-specific trails are however proper to integrate into our procedure.

Another valuable tool is the so called Ergo-Kit FCE method of Gouttebarge et al. (2010). They assess the physical work-ability in a three step procedure. Within a full FCE method functional tests are selected particular to musculoskeletal complains.

The considerations to assess work-related capabilities of Gebauer et al. (2006) seem to be a comprehensible approach. This advance includes a standard medical examination as well as a standard testing procedure.

Here, requirements for a new assessment method are derived. In addition all physical capabilities which should be assessed are declared and described in detail.

2.1 Requirements of capability rating

The aim is to propose a procedure for occupational physicians to assess the physical work-ability in the field of the manufacturing industry. The clients who will be assessed are production workers, who perform physical work on cycle dependent workplaces. Therefore they often have musculoskeletal complaints and related functional diseases which limit them to work on these workplaces (Landau et al. 2008). The method should efficiently evaluate physical work-ability of production workers according to particular MSDs and appropriate to high physical workplace demands.

These requirements provide the basis for the further development of the assessment method. After analysis of the context of use and identification of user needs the requirements of the assessment are set as follows:

- Consideration of all assembly-specific capabilities
  - Clear definition of these capabilities
- Standardized approach for testing of all abilities
  - Work related testing
  - Kenesio-physical assessment
- High level of objectivity, reliability and validity of the method
- Practical classification of capabilities into categories
- Testing only of those capabilities which, after medical diagnosis and anamnesis, are suspected of being limited
- Required time < 1 hour
- Easily integrated into everyday work of occupational physicians
- Compatibility to workplace demands

2.2 Capabilities needed for assembly work
Human capabilities can be separated into mental, physical, sensory, and social capabilities (Tittor et al. 2004). Capabilities in ergonomics are defined as the potential to perform an action or to produce a physical or mental work outcome (WIAD, 2013).

Due to the fact that assembly work requires a physical outcome, physical capabilities are in the focus of the assessment. The physical capabilities needed in production systems, are derived from job demands in assembly work (Rademacher et al. 2009) as well as criteria in ergonomic assessment methods (e.g. Ergonomic Assessment Worksheet (EAWS), Schaub et al. 2012) and existing work-related assessments (Isernhagen, 2001, Tittor et al. 2004). The classification was made also with regard to the common activity items described in the dictionary of occupational titles (DOT, 2003). The most important physical capabilities in the manufacturing industry could be identified and broken down into the main categories of manual material handling, locomotion, body postures, action forces and use of shoulder/arm/hands.

In detail the capabilities presented in figure 1 should be assessed.

![Physical work-related capabilities diagram]

Figure 1. Physical work-related capabilities

3. Results
Based on the determined requirements we present a procedure to efficiently test all the physical work-related capabilities declared above. We used the considerations of Gebauer et al. (2006) as well as the approaches of the other described FCE methods. As a result a detailed description of each capability is given in order to test and rate those capabilities assigned by the limited body function. Furthermore a standard testing procedure can be presented.

3.1 Detailed description of capabilities

In order to have a clear understanding of the workers’ capabilities and to facilitate the communication between occupational physicians and workplace designers, all capabilities are described in detail. Also the main body parts related for each capability are named. Limitations of different body parts can be assigned to specific capabilities that may be reduced. All other capabilities are set with a 100% workers’ capacity. For example only the activities such as locomotion, constrained postures of the lower limb and standing need to be assessed if there are knee complaints and accordingly a lower extremity MSD. This reduces the amount of work for the occupational physician.

This general description contains a differentiated description of the standard body posture, which is required for the tasks to be performed. The description of the capabilities is consolidated from different work-related assessments which are derived from the different literature of Anneken (2006), Landau et al. (2001, WHO 2001). The tolerability for a healthy worker is described in relation to an 8 hour shift. The tolerability is deduced from the EAWS (Schaub et al. 2012), ISO 11226 and EN 1005-4 risk models. A level of 25 risk points on this assessment is considered as a tolerable limit (as described in EAWS and EN 614-2). Hence, the tolerability for a healthy worker concerning the duration and frequency of a load situation is 25 points. The information about the performance duration for a healthy worker may help the occupational physician assess the final rating of the workers’ capability.

Furthermore guidelines for the examining physician are given. This includes indications of limitations of physical functions, which can lead to a reduced ability to perform this capability as well as the required range of motion of the relative joints. Further requirements will be stated e.g. neurological examinations, if there is a need to assess it for particular capability.

An example for the capability “hands above head level” is given:

1. Description of standard body posture
   The distinctive feature of this position is that the hands are above eye level. Therefore the head is in a state of slight to strong extension. Working with one’s hands above the head describes an elevation in the shoulder joint of >90° to a max. of 180° in the frontal or sagittal plane as well as a bending in the elbow joint to a max. of 90°.

2. Duration and frequency for a healthy worker
   Duration of execution: up to 30% of an 8-hour-shift, frequency ≤ 2x/minute

3. Functional limitations
   Functional limitations of the upper extremities (mobility and strength) as well as lumbar spine (mobility), thoracic spine (stability) and cervical spine (mobility) can lead to a reduced ability to perform this function.

4. Required mobility of the joints involved
   A prerequisite for working with one’s hands above head level is the movement of the following joints:
   - Spine: Extension of lumbar and thoracic spine
   - Cervical Spine: free manoeuvrability in complete extension of at least 40°
   - Shoulder joint (Glenero-Humeral-Joint): flexion and abduction at least 90° up to 180°
   - Sterno-Clavicular-Joint: free internal and external rotation as well as pro- and retraction, elevation and depression
   - Acromio-Clavicular-Joint: free movement in all directions
   - Elbow joint: 0° extension to 90° flexion

   In addition organisational as well as design advices for each capability are available. Beyond the possible combinations of this posture with other body parts is explained. For example the activity “hands
above head level” can be done either sitting or standing. Often a strong bending back position is combined with this position. A further requirement regarding movements of the shoulder-arm-system is habitually a combination of head and neck movement, especially in the neck extension, with hand-eye-coordination and fine motor skills.

3.2 Testing procedure

The test procedure for these capabilities includes a medical examination, a questionnaire and selected functional tests. The health status or medical condition itself does not establish the work-ability of a worker. Hence, the additional testing with functional tests and a questionnaire i.e. subjective statement of the worker, seems to be the most reliable way to assess capabilities in the context of work (Wind et al. 2005).

The procedure is based on Gebauer et al. (2006), but modified and adapted to the need of occupational physicians working in the manufacturing industry in Germany. The test procedure for these capabilities consists of two stages (A and B) (see figure 2). Both ways (A and B) should lead to the same result.

The capability level will be classified into four expansion levels (no limitation, light limitation, medium limitation or severe limitation).

Figure 2. Procedure of a standard capability evaluation (Gebauer et al. 2006)

A) Methods for comprising limitation-oriented, estimated capability:
First of all in order to obtain the medical condition of the client an orthopaedic examination and an anamnesis (history of disease/ complaints) are used in addition to the consideration of preliminary medical findings. Afterwards the following procedure should be completed to rate the expected capability of the worker. A possible presence of pain should be evaluated by using a visual analogue scale (VAS). The subjective complaints of clients (often pain) are documented in accordance with the American Medical Association (Cocchiarella & Andersson 2005) with the pain classification VAS of 0-10. In this classification, pain intensity, duration and frequency are combined to a clinical picture. Furthermore the range of motion is examined through neutral-zero-method (Cave & Roberts 1936) and functional testing after Ott and Shober (Williams et al. 1993). Additionally the level of irritation should be considered. A diagnosis of irritation can be based on a relieving posture, positive trigger points, muscle tension etc. Short-term irritation often occurs after physical exertion, for performance diagnostics only irritation of the duration of at least a week is considered. The categorisation depends on the frequency of occurrence within a year. Finally the muscle function of strength according to Janda is tested (Janda 2000). The assessment conducts a division of muscle strength into steps from 0 to 5. The level 5 corresponds to 100% muscles strength and level 1 to 10% muscles strength. No recognizable or palpable muscle contraction is described at level of 0. Also the loss of stability of joints should be included in this professional examination.

As a conclusion the following criteria are combined into a set of rules, of which the level of capability can be determined:
• Pain status through visual analogy scale (VAS)
• Irritation level through professional examination
• Deficit of range of motion through neutral-zero-method
• Loss of strength through examination according to Janda
• Loss of stability through professional examination

B) Methods for precise evaluations of performance:
The second stage includes selected work-related assessments, a questionnaire and a medical testing of sensory capabilities.

One very important basis for the capability ratings are work-specific physical trials which are with respect to relevance of work tasks and the related physical stresses. The maximum performance capacity within an ergonomic test run will be assessed through different kinesio-physical tests. The tests are selected from a wide test battery. For example to evaluate the capacity of manual material lifting, the test method “Progressive Isoinertial Lifting Evaluation (PILE)” (Mayer et al. 1988) shall be used. Capabilities that might be reduced are at first assigned through the medical examination and then rated with a standard functional test. Each test also includes a subjective, structural performance observation of the test instructor, which completes the rating of the particular capability.

In order to get a subjective statement of the health condition of the worker a survey is integrated in this procedure. We recommend the Oswestry Disability Index (Fairbank & Pynsent 2000), which is examines the subjective limitations, e.g. in the capacity standing, through back pain. This questionnaire has a high level of reliability and validity (Wind et al. 2005). Furthermore other work-related questionnaires exist e.g. the short version of the Work Ability Index (WAI) in order to get a self rating of the overall work-ability which can be used instead (Tuomi et al., 1998).

In addition sensory capabilities are important in assembly work which namely are seeing, hearing and tactile sensing. These capabilities can be tested through standard medical assessments, for example seeing can be tested with the visual acuity test.

4. Discussion
The described procedure is focused on physical work-related performance. The approach is simular to the ICF model because activity/duration of performance of an 8 hour work shift of a worker is deduced from complaints.

The model of Gebauer et al. (2004) is a solid basis for the assessment of work-related capabilities, but it is necessary to adapt the procedure to the special needs in the automotive industry. The characteristic of the assessment of physical work-ability in German manufacturing industry is that capabilities are rated by occupational physicians, who examine a lot of clients during a day and are therefore very limited in time. As a result only capabilities with related functional limitations of body parts are assessed. The assessment presents a standard procedure for occupational physicians that can be easily integrated into their daily routine, it is time efficient (max. 1 hour) and it concentrates on relevant capabilities of assembly work and therefore matches job demands.

A computer based testing system could also improve the usability of the assessment for occupational physicians. The system could apply the rules of the capability rating and support the tester to find the right capability level. Later the data could be processed by a database and provided easily to the workplace designers.

We recommend a combination of a standard medical examination, a performance assessment and use of questionnaires, which make the outcome of the assessment more objective. The problem of cooperation of the client cannot be solved for sure, but it can be minimized with this procedure. Also the performance outcome depends on the daily form and fitness level of the worker. In any case predicting the real workplace performance is still challenging. Hence there is a need to reevaluate and acquire feedback from the worker and his foreman. Finally it must be stated that this procedure is a conceptual framework and needs to be evaluated in practical field work.

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References


