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State of scientific knowledge about the need of recovery time at specific workplaces and recomendations for further research

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Abstract. Research activities to determine the need of recovery time at work were mainly performed in the 1970s and 1980s. Previous studies were largely based on expert opinions or were generated within small and non-representative groups. Often, laboratory experiments were carried out with a low number of subjects. Especially during the last decade, only little additional scientific knowledge was generated on this topic. The very resource intensive development of more detailed results based on the existing level of scientific knowledge is assumed as one reason for this. In general, it seems to be reasonable to continue further research on the knowledge generated in previous studies, but implement larger samples and more representative groups. Besides, according to monotonous manual work, more research is especially needed regarding relative operating forces and operation frequencies taken grip conditions and hand/body position into account.

Keywords: muscle-work, monotonous tasks, cognitive demands, fatigue, recovery time

1. Introduction

Recovery time at specific work places could be necessary to prevent work-related symptoms of fatigue.

A key factor to estimate the work related strain is the assessment of the human "steady state limit". This is defined as the height of human performance that can be executed permanently without an overload of the employee. Below the human "steady state limit", stress (exposition to workload) and strain (individual reaction of exposition to workload) are in a balanced state.

If working conditions require efforts above the human "steady state limit", strain increases and work-related fatigue occurs. In this case, recovery time is an organizational solution to reduce employees' strain level. To counteract work-related fatigue effectively, the recovery phase(s) usually should follow as closely as possible to the exposition phase(s): This means, several short recovery phases are physiologically more effective than one longer recovery period with the same sum in time.

The aim of this study was to determine the state of scientific knowledge about two kinds of work operations requiring efforts above the steady state limit:

- monotonous manual work within short cycle times and
- work tasks with high cognitive demands within short cycle times.

At this, knowledge about the recommended amount of recovery time as well as the duration and frequency of resting periods should be generated.

Further aims were to analyze, how monotonous tasks are characterized in scientific literature and to identify existing practical methods to determine the needed recovery time as well.

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2. Method

A literature study was performed (MÜHLEMEYER et al., 2010) with the focus on monotonous manual work within short cycle times and work tasks with high cognitive demands within short cycle times. For this purpose, the typical stress situations of these tasks have been identified first. This knowledge is needed to determine the type of work-related fatigue and based on this to set duration and arrangement of recovery phases.

Monotonous manual work often occurs during working at assembly lines. Due to frequent and rapid movements of employees fingers and hand(s) and handling low weights, usually low variable muscle work should have the greatest impact on the overall strain level (see table 1). An alternative definition of low variable muscle work is that in this case less than 1/7 of the total muscle mass is used.

Table 1

Distinction between low variable dynamic muscle work and heavy dynamic muscle work in case of activities of individual limbs (LAURIG, 1974)

dynamic work of	one limb/limbs	both limb/limbs	activities together with dynamic work of other limbs: hand	foot	leg
finger	low variable muscle work				
hand			without shoulder		
arm		with shoulder		heavy dynamic muscle work	
foot					
leg					

Testing activities, for example, can be tasks with high cognitive demands within short cycle times. Often, this occurs if testing activities have a low level of complexity. These tasks can also lead to employees' mental underload. A simple functional test like "lamp on - lamp off" of a switch is a typical example.

On the other hand, a complex audit on different test objects including error determination an error recovery is a task with the need of sustained attention and concentration that can lead to employees' mental overload (see table 2).

Table 2

Examples of structuring testing activities with different levels of complexity (EISSING & SCHMITZ, 1991)

way of processing in the brain		automated	hidden controlled	accessed controlled
examples	complexity	low	medium	high
simple functional test of a switch (lamp off/on)		X		
quality testing of solder joints			X	
complex audit work on different test objects including error determination and error recovery depending on various conditions				X

3. Results

Research activities to determine recovery time at work were mainly performed in the 1970s and 1980s. Previous studies about recovery time at work are largely based on expert opinions or were generated within small and non-representative groups (e.g. students). Often, laboratory experiments were carried out with a low number of subjects.

Especially during the last decade, only little additional scientific knowledge was generated on this topic. The very resource intensive development of more detailed results based on the existing level of scientific knowledge is assumed as one reason.

In the 1970s, laboratory tests have been done to generate descriptions and formulas/data about the needed recovery time in case of low variable dynamic muscle work. In order to determine the needed recovery time, for example the results of LAURIG, 1976 can be used. But, as also shown in table 3, the focus of most research projects was on heavy dynamic muscle work. For this subject, only one field study was carried out (see table 3).

Table 3

References providing statements about the needed recovery time depending different types of human strain (BRUDER, 1993)

laboratory tests		field studies	
description	**formulas/data**	**description**	**formulas/data**
Type of human strain: low variable dynamic muscle work			
SCHNAUBER/MÜLLER, 1970 ASMUSSEN/MAZIN, 1978	SCHMIDTKE et al., 1971 LAURIG, 1976	Ø	Ø
Type of human strain: heavy dynamic muscle work			
MÜLLER/KARRASCH, 1995 BRODAN/KUHN, 1966 ENGEL et al., 1969	ROHMERT, 1960 MILLAHN/HELKE, 1968 SCHMIDTKE et al., 1971 PODLESAK, 1977 NESPER-KLUMPP/ HETTINGER, 1986 KAMEL et al., 1989	SEMMER, 1976	Ø

As mentioned in the introduction, another important question of the literature study was how monotonous tasks are characterized in scientific literature. Different authors defined different cycle times to be a short (high repetitive) or a long (low repetitive) cycle time. Predominantly, activities whose cycles are shorter than 30 seconds are defined as tasks within short cycles. This definition was also used by SILVERSTEIN et al., 1987 and is placed in the standard DIN EN 1005-5 (see table 4).

Table 4

References providing statements about definitions of repetitive work
(KILBOM, 1994 modified by HOEHNE-HÜCKSTÄDT et al., 2007 and MÜHLEMEYER et al., 2010)

author(s)	cycle time	notes
SILVERSTEIN et al., 1987	< 30 s > 30 s	high repetitive low repetitive
HUPPES, 1992	< 30 s	very short cycle
KONZ, 1990	< 30 s	fundamental cycle
KUORINKA/KOSKINEN, 1979	2 to 9 s 10 to 26 s	short cycle long cycle
LAURIG, 1983	< 4 s	low variable dynamic muscle work
RODGERS, 1986	< 30 s < 120 s	very repetitive repetitive

4. Discussion

In general, it seems to be reasonable to continue further research on the existing knowledge generated in previous studies, but implement larger samples and more representative groups (include e.g. elderly employees, males and females). Besides, according to monotonous manual work within short cycle times, more research is especially needed regarding relative operating forces and operation frequencies taken grip conditions and hand/body position into account.

According to work tasks with high cognitive demands within short cycle times, further research should concentrate on studies focusing on fatigue in work tasks causing mental under- and overload.

Doing this, it would be important to summarize, which activities performed in short cycle times in the working environment occur particular frequently at the moment and – if assessable – might be prominent in the upcoming years. In these activities, the workload situations should be analyzed in line with actual practice. Needed but not yet existing knowledge should be generated by new measurements. These findings consolidated with existing knowledge should be used to update an existing – or to develop a new method – to determine the needed recovery time, taken into account also age, gender of the employees and other relevant factors like grip conditions and hand/body positions as well.

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