How to design rotating tasks within jobs?

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Abstract

Although rotating tasks is generally advocated by ergonomists, few cases or effect studies really exist in literature. Few ergonomics techniques for task analysis exist, concentrating on both physical and mental workload. No convenient technique aims at a comparison of tasks. Instead techniques focus on an extensive, absolute assessment of workload. However, provided that excesses in workload do not occur, hard work every now and then should not necessarily be prevented, as long as recovery afterwards is granted. The goal of rotating tasks should thus not be to lower workload as such, but to divide physically and demanding work equally among the employees.

This field of interest is illustrated with a study on implementing rotating tasks within jobs. Dutch mail sorting centres, wanted to reduce sick leave. An instrument was developed providing scheduling rules as to a maximum of hours an employee could safely perform a task. Moreover the instrument indicates which combinations of tasks might be considered sufficiently different, in terms of physical or mental load, in order to provide recovery.

Keywords: methods, work organization, work rotation, work task design, manual materials handling ,mental workload

1. Introduction

1.1. Background

Having engineered the workstations, tools, aids and the like, any ergonomist will ever have studied work-rest schedules or recommended some kind of job rotation in addition. Job rotation can be defined as systemic alternating tasks, in order to improve mental workload and to stimulate variation of physical workload. However: to what extent do we know about how to rotate in order to obtain the adequate effects? If so, how should we measure workload or evaluate the expected improvements?

This field of interest is illustrated with a study on Sorting Centres (SC) for distribution of mail .The tasks in the SC's are mainly organised according to Tayloristic principles: sorting machines requiring specific human input and output. As a result jobs consist of one or more monotonous or physically demanding tasks with job characteristics like manual materials handling, uncomfortable working postures, repetitive tasks, machine operating, or VDU work. Tayloristic design of jobs is not only characteristic in sorting centres. These risks also arise in manufacturing areas or food industries.

In this paper the applied techniques are discussed for carrying out a task analysis and developing the instrument for rotating tasks within jobs as well as the lessons learnt during implementation of the rotation.

1.2. Object of the study

The SC's where the postal items are sorted all suffered from a high percentage of sick leave (>10 %), comparing to for example 5% in the mail delivery service. Wanting to reduce the amount of sick leave the SC's considered rotating tasks within jobs in order to improve physical and mental recovery and thus improve the work situation. The prerequisite was not to change other work aspects like work organization or sorting techniques. Rotation should take place within departments in order to provide a basis and colleagues during the shift.

To implement rotation tasks within jobs the SC's needed an instrument to provide their planners with scheduling rules as to a maximum number of hours per day a worker could safely perform a task. Moreover, it should indicate which combinations of tasks might be considered sufficiently different in terms of physical or mental load. The instrument should also provide both guidance and flexibility when developing schedules, taking into account unforeseen circumstances in operations or personnel staffing.

2. Rotating tasks & recovery according to literature

Although rotating tasks is generally advocated by ergonomists to optimise work situations, few cases or effect studies on physical and mental aspects really exist in literature.

Rotating tasks is believed to enhance skills, to improve quality, reduce monotony and to generate flexibility in employment. Jonsson [1] revealed that rotation between tasks with dynamic movement characteristics, including differences in levels/ zones of muscular activity, results in alternation of high and low energetic loads and thus facilitates recovery. Henderson [2] found that in poultry processing alternating highly strenuous or stressing jobs with jobs with less impact within the day resulted in a decrease of the number of musculoskeletal complaints. Likewise Hinnen [3] revealed in a study on cashier work that job rotation with other tasks in the shop had beneficial effects on prevalence of musculoskeletal disorders.

These success stories are in contrast to studies with less definite results. Frazer e.a. [4] estimated risks of reporting low back pain during job rotation. The increase of risk appeared to be greater for those who rotated into the demanding job compared to the reduction experienced by those who rotated out of a demanding job. Kuijer [5] evaluated job rotation schemes for refuse collecting, street sweeping and driving at a refuse collecting department in order to prevent low back, shoulder and fatigue complaints. Job rotation resulted in a total reduction of physical and mental workload. However no effects were found on recovery needed at the end of the day, nor were there any differences between job rotation within a day or job rotation every other day. However refuse collectors who rotated with driving tasks had a more than two times higher risk of low back pain complaints. Kuijer suggested that probably job rotation might have no effect on the peak mechanical load but only on the cumulative mechanical load. He cited that if peak load is believed to have more adverse effects on back complaints than cumulative mechanical load, job rotation may not unanimously be that effective.

Rotating tasks concentrates on recovery, by altering the amount and the kind of work load and/or varying the affected body regions. After all repeated insufficient recovery may lead to a faster onset of health complaints. However recovery does not necessarily refer to breaks. By integrating variation in the job, as in rotating tasks, the work flow will not be disrupted and production secured (Henning [6], Dababneh,[7]).

De Looze [8] recently confirmed that clear guidelines are still missing about quantitative aspects on time on the job and discomfort, pain and injuries. In addition to optimal job design, including rich and varying tasks, work rest schedules are necessary to guarantee recovery. Lipscomb e.a. [9] studied the influence of work-schedule characteristics on reported musculoskeletal disorders for about 1100 nurses. They confirmed that demanding jobs, with high physical and mental workload, in combination with long working hours lead to an increase of musculoskeletal disorders of about 50-170%, depending on the body region. A reduction of the duration of exposure to demanding work conditions and implementation of healthy work-rest schedules contributed to prevention of musculoskeletal disorders.

In short: the goal of rotating tasks should not be to lower overall workload, but to prevent from overloading the same structures by facilitating recovery through alternating/ combining tasks. Physically and mentally demanding work thus should be equally divided among the employees. In addition the additional effect of possible reduction of individual physical and mental workload would of course be favoured. The effects of job rotation cannot easily be

estimated because of the complex effects of altering tasks.

3. Setting of the study

The study was conducted in three out of six SC's. The population included male and female employees, about 60% being older than 45 years, working mostly full time (8 h/ day) or some times part time (> 4h/ day).

3.1. The process and its work environment

The goal of a SC is to handle supplied post items for its own region. Sorting activities take 24 h, mostly during evening and night hours. Daily about 17 million postal items are sorted and distributed in six Dutch sorting centres (SC) with 900-1600 employees each. Main task groups concern in-house lorry transport of containers, administrating of incoming and out going delivering trucks, franking post items, operating sorting machines for small, large and thick post items, manually sorting of all kinds of rejected or unsuitable machine post items, repair of damaged post items and VDU work for manually coding post items that cannot be automatically detected by the sorting machines.

Most jobs in the SC are highly repetitive and monotonous jobs. As confirmed during the task analysis, the ergonomic quality of the work environment is moderate to good. This is the result of consistent ergonomics support during design of many years.

3.2. Phasing of the study

The study incorporated three phases.

a) Preparing the instrument by performing a task analysis, in order to compare all tasks considering physical and mental workload. Moreover future changes in work situations, resulting in change of workload, should be easily processed (section 4).

b) Developing the instrument indicating when tasks had to be alternated and with which other tasks (section 5).

c) Testing the instrument in one of the SC's in order to improve usability and to learn lessons on the practical consequences of implementating rotating tasks within jobs (section 6).

Unfortunately no formal evaluation or measurement of effects could take place. In the meantime other organisational and technical measures had also been taken to get reliable data concerning the effects of job rotation.

4. Task analysis - Risk assessment comparing tasks

4.1. Looking for appropriate task analysis techniques

In order to develop an adequate instrument for job rotation in any case a task analysis had to be carried out. The task analysis should focus on classification of tasks on physical and mental aspects in order to assess tasks on their combination/ alteration. However: which instrument could evaluate the combination of physical and mental workload? So called complete techniques, like LEST by Guélaud [10], PLIBEL by Kemmlert [11] or AET by Rohmert & Landau [12] were disapproved of. LEST could cover the whole range of loads. However it would have led into too detailed results, considering the objective of the study: 'comparing tasks' Therefore LEST comparatively would be too time consuming. PLIBEL on the other hand would have resulted in poor insight in tasks that are very similar. Moreover PLIBEL pays little attention to mental workload. Although appropriate AET finally also would be relatively time consuming for 55 tasks, besides depending on statistical analysis by a dedicated laboratory abroad.

Carnahan [13] studied several rotation schedules, while quantifying effects with the Job Severity Index (JSI). Discussing the for a matter of fact ambiguous results of the intervention he also concludes that the JSI is only a single fitness measure, not covering all effects of job rotation.

4.2. Classification of tasks

As existing techniques were of no true help, a convenient technique was developed in order to estimate physical and mental workload. On the one hand the work load estimating techniques for physical aspects derived from Hettinger & Spitzer [14] and on the other hand techniques to assess task attributes by Turner & Lawrence [15] for mental workload made their contribution.

Every task was ranked on physical workload, indicating posture (sit, kneel, stand, walk, bend, etc.) and specification of the load (only affecting hands, one or two arms or whole body), provided with a classification of intensity like light, medium, or heavy. Intensity classification was based on basic assumptions derived from common guidelines like OCRA, NIOSH and other standards. Additionally the type of physical workload was added (lifting, pulling/ pushing, working

posture, repetitive movements).

Likewise four task attributes were considered:
- diversity (e.g. tools, postures, work speed, activities);
- autonomy (e.g. working techniques, order, workpace);

- necessary or social contacts;
- importance (e.g difficulty of activities, kind of arising difficulties).

Table 1 presents a part of the task analysis for three exemplary tasks in the SC. Each of the fifty-five tasks in the SC was classified comparably. Taking peaks and dips into account, an ordinary work load was considered. If excessive changes in peak loads were foreseen two variances of the task were distinguished.

Table 1
Part of the task analysis for area Sorting machine 'small post items' (Post = posture, Specs load = specification type of workload and intensity)

Sorting machine 'small post items'				
Tasks	Statistics	Physical load		Task content
		Post.	Specs load	
1. Operate machine & item entry	95 boxes pp/ h (4-7 kg)	Stand Walk	2 arms, medium load (lifting, pulling, repetitive)	Diversity + Autonomy – Contact +/- Importance -
2. Sort machine output	60 boxes pp/ h (4-7 kg)	Walk	2 arms, medium load (lifting, repetitive)	Diversity - Autonomy – Contact -/- Importance -
3. Sort reject by hand	1055 items pp/h (30 g)	Sit	2 arms, medium (repetitive)	Diversity - Autonomy - - Contact +/- Importance -

4.3. User participation

Task analysis results were based on an expert based review of tasks. The expert review was based on results of observations and interviews in three SC's with employees, while performing their tasks. These findings were added to twenty years of human factors experience with studying and designing work and workload in the SC's.

In order to assure participation, the preliminary results of the task analysis were presented to a representative group of experienced, all round workers from 6 SC's. Although all SC's are identical to a high degree, some slight differences in working techniques or machinery appeared. The preliminary results were adjusted by discussing and comparing rankings of the tasks. The final results of the tasks analysis were thus established with cooperation of the end users.

5. Instrument for task allocation

5.1. When to rotate – 'endurance time' versus 'limits'

In order to provide guidance when to rotate, two types of boundaries were set for every task: 'endurance time' and 'limit'. If tasks will be performed too long workers will not feel healthy any more. Discomfort or complaints will occur, mistakes and errors will arise

'Endurance time' refers to a time period that suits optimal physical and mental performance. The basis for establishing the 'endurance time' refers to a normal working day, pauses included, taking shifts of > 4 hours into account. In practice the 'endurance time' should be aimed at. Exceeding the 'endurance time' will not result in immediate damage. If exceeded often and more extensively, the risk of damage will increase.

In order to prevent risk of damage and injuries the so-called 'limit' has to be maintained. The 'limit' equals twice the 'endurance time'. On reaching the limit, tasks should immediately be alternated with suitable other tasks to provide recovery. If not available, rest pauses could be an adequate alternative.

For example: 'endurance time' for sorting mail by hand is two hours. This means that preferably after two hours sorting by hand should be alternated with another task. Ultimately after four hours rotation should have taken place ('limit').

These boundaries have not been scientifically established. They are estimates based on two aspects:
1) the relative classification of intensity of a certain task (light/ medium/ heavy), as was established in the task analysis, with help of employees (section 4.2);
2) demarcations derived from international standards and guidelines for performing a task like OCRA, or NIOSH. For example in an optimum situation one should not: perform repetitive moments more often than 30x/ minute, plan fewer recovery periods for repetitive work than 1:5, handle objects of more than 23 kg.

The boundaries only serve as to compare tasks in order to attain rotation of tasks. This is why the instrument would better serve as an indication instead

of a directive. Besides rotating tasks should at least be aimed for at ‘natural moments’ during operations.

5.3. What to rotate with – the rotation table

The rotation table, presented in table 2, consists of a cross-tabulation in which all fifty-five tasks have been combined.

5.3.1. Classification of combinations of tasks

Any combination of tasks received a score, ranging from 0 upto and including 3, as to indicate the opportunities for recovery:
0 = both tasks are higly similar. The same body parts and cognitive skills are affected. No recovery possible
1 = both tasks are considered as being almost the same, with some slight differences. If no alternatives are present, this rotation provides a variance, but no real recovery.
2 = good opportunity for mental and physical recovery.
3 = excellent recovery.

Table 2
Part of the rotation table for area Sorting machine 'large post items' containing tasks A-D (cross tabulation). For each task endurance time and limits are presented (2nd column/ row). All possible combinations of tasks are scored from 0 (no recovery) upto 3 and included (excellent recovery).

Sorting machine 'large post items' Tasks A - D		A	B	C	D
	Endurance time - Limit (hours)	1-2	2-4	2-4	4-8
A.Operate machine & item entry	1-2	X	1	3	2
B.Sort machine output	2-4	1	X	3	2
C.Sort reject by hand	2-4	3	3	X	3
D.Clean machine	4-8	2	2	3	X

5.3.2. Rules of rotation

Preferably tasks will be performed just once a day. If necessary a task can be performed more often, for example twice a day: at the beginning and at the end of the day.

In this model it makes no difference whether task A will be followed by B, or - the reverse- task B followed by A. Any how a new task should at least be performed for at least 25% of the endurance time (not exceeding the endurance time of the new task).

In case of suboptimal rotation, task X followed by task Y, having a combination score of 0 or 1, 'time on the job' adds up until rotation occurs with a task combining score of at least 2. In this case the over all time period for tasks X and Y shall not exceed the limit for task X (or Y). In case of such suboptimal alternation of tasks (X-Y), still rotation with another task Z is necessary providing a combination score of at least 2.

Example: a job at the sorting machine for 'large post items' consist of tasks A-D (see table 2). The employee starts with task A, and continues for 1 hour, meeting the endurance time. Rotation with task B for 2 hours (combination score of 1) would not result in – so to say – a time 'reset' of performing a task (recovery). Performance time thus adds up to 1 (task A) + 2 (task B) = 3 hours. Accordingly the limit of task A is violated. Now rotation with task C or D is needed for at most 4 hours (limit task C) or 8 hours (limit task D). Task C should be performed for at least 1 hour (25% of 3 hours performance of task A-B). Then again task A could be performed for 1-2 hours or task B for 2-4 hours.

Boundaries and combination codes apply to all employees: young or old, male or female, full time or part time. Hard work every now and then should not necessarily be prevented, as long as recovery afterwards is granted.

6. Implementation in a pilot study

In one of the SC's the instrument for rotating tasks was tested. Points of interest of the pilot study referred to the usability of the instrument and to the consequences of rotation in the SC.

6.1. Usability

In workshops every department put the instrument to the test. Direct management, making the schedules, applied the instrument to make a virtual planning. A few rather machine oriented SC departments had to conclude there were no suitable tasks available. Recovery could not be provided within the existing organisational frame work. Other departments discovered bottlenecks concerning the organisation of letting impaired and injured employees performing the light tasks continuously and therefore inhibiting rotation of tasks for other employees.

In conclusion direct management thought the instrument to be usable. However they met difficulties explaining employees why and how to rotate tasks. As a result an additional instruction was developed.

6.2 Lessons learned

Although changes in work organization were out of scope, nevertheless some departments restructured their boundaries in order to provide both departments more opportunities in rotating tasks. Ignoring this need would have led to frustration and to sabotage of rotating tasks.

Furthermore later there appeared to be slight, but important differences in tasks over the SC's. As a result for every SC the basic task analysis had to be specified for its characteristics.

At the pilot SC a human resources deputy accompanied the implementation, being responsible for keeping the rotating of tasks alive. Later this commitment appeared to be of utmost importance when other sc's started implementing rotating tasks.

7. Rotating tasks integrated in daily life

After the pilot the SC's perfected the instrument, by linking this table to manpower requirement. Thus our rotation schedules were incorporated in personal planning on a day to day basis.

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