Postural Assessments & Job Rotation

A survey of one company's assembly line supervisors

By Scott Walker, Jerry Davis and Deepesh Desai

AN UNDERLYING PRINCIPLE behind job rotation is to alleviate physical fatigue and stress by rotating employees among jobs. Job rotation differs from engineering controls in that no physical change is made to the workstation. This administrative control can be employed to rotate workers from one job to another in order to limit exposure to specific types of stressors such as heat, cold, and physically or mentally demanding tasks. Job rotation is one of the most frequently used administrative controls in manufacturing industries (OSHA, 2000; Triggs & King, 2000).

Researchers have identified various benefits of job rotation. One example is increased productivity (Miller, Dhaliwal & Magas, 1973). This early study noted that job rotation could be used to relieve boredom, stimulate better performance, reduce absenteeism and provide additional flexibility in job assignments. Error reduction (Chengalur, Rodgers & Bernard, 2004), increased employee satisfaction and reduced incidence of cumulative trauma (Putz-Anderson, 1988) are also potential benefits of implementing a job rotation program. However, Putz-Anderson cautions that poorly designed programs might actually increase worker stress levels.

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Jorgensen, Davis, Veluswamy, et al. (2004) developed a web-based questionnaire to survey job rotation practices in and around the Wichita, KS, and Cincinnati, OH, areas. A total of 169 companies were contacted and 141 completed the survey. Results indicated that 42% of the responding companies used some job rotation on a permanent basis.

Gittleman, Horrigan and Joyce (1998) analyzed alternative work organization practices in industry (e.g., worker teams, TQM, quality circles, job rotation) based on a 1993 Bureau of Labor Statistics survey and found that 12.6% of the companies surveyed with fewer than 50 employees had implemented job rotation, while 24.2% of the surveyed companies with 50 or more employees had done so. Dempsey (2002) found that 23% of jobs which required lifting and lowering involved job rotation, whereas Wellman, Davis, Punnett, et al. (2004) found that 19% of manufacturing facilities in Massachusetts used job rotation as an intervention practice for individuals with work-related carpal tunnel syndrome.

Although job rotation is being used more extensively in industry, little information is available from the perspective of assembly line supervisors. The challenges they face implementing job rotation, assigning employees, training, line balancing and maintaining productivity can greatly affect a job rotation program. This article details a survey of assembly line supervisors and their perspectives on job rotation issues. Additionally, the article introduces an approach in which postural results from Rapid Upper Limb Assessments (RULA) were adapted into an easy-to-understand color-coded matrix to aid one site's safety and health program.

Study Method

Desai, Carnahan & Davis (2005) conducted a research project that involved the development of an ergonomic job rotation schedule at the Briggs & Stratton manufacturing facility in Auburn, AL. To develop the new rotation schedule, an ergonomic assessment of all assembly line stations was conducted using RULA, a postural screening tool (McAtamney & Corlett, 1993).

Over a period of several weeks, a single knowledgeable evaluator (Desai, et al., 2005) analyzed 117 assembly line workstations, using RULA for the right and left sides of the body. The scores for each body part were based on the extreme posture observed during the work cycle. Data collected using RULA for each body segment were used as the input for the rotation schedule generation process. Scores from the right shoulder, right elbow, right wrist, left shoulder, left elbow, left wrist, neck and back were used to classify the workstations.

To complete the postural sections of RULA, the assessor observed the subjects performing the tasks, circled the diagram on the RULA form that best represented the body part position and recorded the score on the assessment form (Figure 1, p. 34). Body part scores

were transcribed onto a matrix for the corresponding body part. For example, if a subject's score for the right upper arm was a 3, then a 3 was placed in the box for "right upper arm" on the matrix (Figure 2, p. 34).

Individual scores for each body segment were then rank ordered, meaning that the scores were numerically ordered in descending order. Based on natural breaks in the mean ranks for the RULA-grouped stations, they were further grouped to form three categories—low, moderate and high ergonomic risk.

Next, the groups were color-coded. Jobs that had a score of 1, indicating that the job had a low-level risk to ergonomic stressors, were color-coded green. Jobs with a score of 2 had a moderate level of ergonomic stressors and were color-coded yellow, while jobs with a score of 3 or more were color-coded red, indicating that they had a high level of ergonomic risk. A cluster analysis was performed; it combined the severity (appropriate color-code) of each body segment on a particular station to generate the overall severity for the station. Finally, a color-coded matrix was generated (Figure 3, p. 35) that reflected the severity of each body segment and the severity of the overall job.

Guidelines were then established. It was determined that no employee should work more than one red job per shift; that every red job must be preceded by or followed by a green job; and that no employee should work more that one yellow job per shift. Permissible (ergonomic) job rotation could be comprised of green-green-green (GGG), GGY, GYG, YGG, RGY, etc. (Figure 4, p. 35).

Additionally, subjective data (body part discomfort survey, whole body fatigue and rating of perceived exertion) were collected on 117 employees, four times per day, for 5 consecutive days. Results of the study (Desai, et al., 2005) indicated that employees whose rotation schedule followed the guidelines felt better during and at the end of the shift compared to those employees whose rotation schedule did not follow the guidelines, as measured by their completion of body part discomfort surveys.

The Survey

A survey was developed and administered by the author affiliated with the Briggs & Stratton Corp. After being developed at the Auburn, AL, facility, the survey was mailed to safety engineers at each of six Briggs & Stratton manufacturing facilities, who then administered the survey to all assembly line supervisors at their specific location.

Survey Development

The survey was divided into three sections (see sample questions). The first involved obtaining information on basic supervisor demographics and manufacturing experience (e.g., amount of manufacturing experience, years in current position, number of employees supervised). This part also included a question to determine the supervisor's (self-reported) level of ergonomic-related knowledge.

- Are you aware of basic ergonomic principles? (Responses: very familiar, familiar or not at all familiar)
- Have you had any ergonomic-related injuries or complaints on your line? (Responses: yes or no)

The second part of the survey included a series of questions designed to gather the line supervisor's perspective on job rotation. The answer choices were designed to cover most possible job rotation scenarios; in addition, respondents were given an option at the end of each multiple-choice question to provide additional information.

1) Do you have a job rotation schedule currently in place on your line? Yes/No (if No skip to Question 5)

2) Why do you have a job rotation schedule in place? (Circle all that apply)

a) Management recommended implementing the job rotation schedule.

b) Safety supervisor recommended implementing the job rotation schedule.

c) It was in place when I joined the company.

d) It was my idea to implement a job rotation schedule.

e) Other reasons (Please enter the other reasons on the lines below).

3) Do you see any benefit of the job rotation schedule? (Circle all that apply)

a) Employees get a break.

b) Increased production.

c) Reduced incidence of employee injuries.

d) Not sure what the benefits might be.

e) No benefit.

4) How did you come up with the job rotation schedule? (Circle all that apply)

a) My perception of the job and worker.

b) Randomly assigning workers to the job.

c) No scientific method used to create job rotation.

d) Used a proven process of generating job rotation.

e) Don't know. Already in place when I joined the company.

5) Why don't you have a job rotation schedule in place? (Circle all that apply) *Answer Question 5 only if you answered No to Question 1.*

a) Management didn't recommend implementing a job rotation schedule.

b) Job rotation schedule was in place, but had reduced production on line, so it was discontinued.

c) Never heard of job rotation schedule.

d) Impractical to have a job rotation schedule in place.

e) Not sure if it is beneficial.

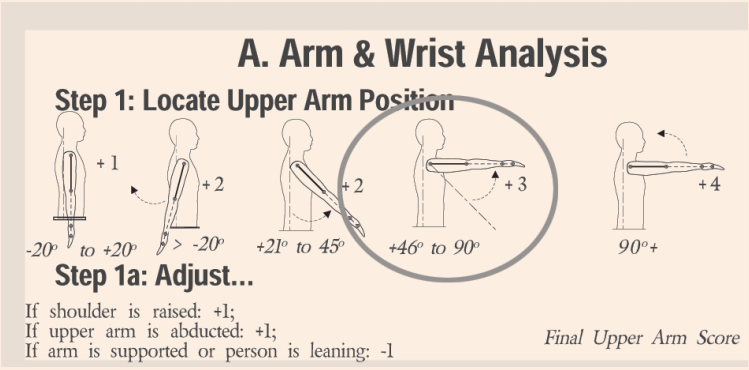
f) Other reasons (Please enter the other reasons on the lines below).

The third section of the survey consisted of multiple-choice questions that examined each supervisor's perspective on a recent project conducted at the Auburn, AL, facility, which developed a methodology for job rotation generation (Desai, et al., 2005). The respondents received a description of how workstations were assessed using RULA and how the workstations were ranked and color-coded based on their level of ergonomic risk. The survey also included an example of the color-coded job rotation matrix to provide each respondent with a better understanding of the project.

Abstract: *Job rotation is a commonly used measure to alleviate physical fatigue and stress in the workplace. While much has been written about the potential benefits of job rotation, little information is available from the perspective of assembly line supervisors, particularly with respect to the challenges they face implementing job rotation, assigning employees, balancing the line and maintaining productivity. This article details a survey of assembly line supervisors and their views on job rotation.*

Figure 1

Example of RULA Assessment for Right Upper Arm



Note. *Adapted from "RULA Employee Assessment Worksheet," by Alan Hedge, Feb. 2001, Cornell University Ergonomics Web.*

Figure 2

Example of Matrix

Station	Operation	Neck	Trunk	L. Upper Arm	L. Lower Arm	L. Wrist	R. Upper Arm	R. Lower Arm	R. Wrist
1	Remove part from basket	2	2	1	1	2	3	2	3
2	Blow off part	2	3	1	1	2	3	2	3
3	Place pin into piston	2	1	1	1	1	1	1	2

To verify their understanding of the project, respondents were asked a series of questions based on the matrix. They were asked whether, if provided a similar matrix for their assembly line, they would be able to implement a rotation schedule—especially if previous research in a similar environment indicated that employees involved in a rotation program reported that they felt better at the end of the shift.

Survey Results

The responses were totaled for all returned surveys—that is, if a respondent provided multiple answers, each was considered and descriptive statistics were calculated for all questions. Thirty-six surveys were distributed and 31 were returned—an 86% response rate. Of the 31 surveys returned, 4 were deemed incomplete and discarded before performing data analysis.

Respondents tended to be experienced in the area of manufacturing, with 4% reporting they had less than 2 years' experience; 22% reporting more than 2 years but less than 10 years' experience; and 74% reporting they had more than 10 years of manufacturing experience. Thirty-seven percent of the respondents supervised fewer than 75 assembly line employees and 63% supervised more than 75 but fewer than 150.

Responses indicated that 4% of the supervisors were not familiar with basic ergonomic principles, while 66% reported being familiar and 30% reported being very familiar with manufacturing-related ergonomic principles. When asked whether any ergonomic-related injuries or complaints had been reported on their assembly line, 74% said yes and 26% said no. Table 1 (p. 36) summarizes the results from part two of the survey.

The last question in the survey indicated that during the prior study at the Auburn facility, a significant difference in perceived exertion and fatigue was reported by workers assigned to rotations deemed to be ergonomically sound, compared to nonergonomic rotations. Based on this information, survey participants were asked whether they would apply ergonomic rotation schedules on their lines. Eighty-nine percent reported that they would attempt to implement such a rotation.

When asked how easy or difficult it would be to implement an ergonomic job rotation, the results were neutral. For those supervisors reporting that it would be difficult, the reasons included:

- It would take time for training. When this is done, it would work.
- Different level of work knowledge and mix of handwork and machines.
- Age (heavy lifting), gender (heavy lifting), body size (physical room constraints).

Discussion

Survey Results

The survey indicated that 89% of the supervisors had rotation schedules in place on their lines. Thirty-four percent reported that management recommendation was a motivating force behind these schedules; 24% stated that the rotation schedule was already in place when they joined the company; and only 12% said that it was their idea to implement job rotation.

The respondents also reported the benefits of job rotation. A high number of respondents (43%) mentioned that job rotation resulted in reduced incidence of employee injury. Twenty-four percent reported that job rotation resulted in increased production. In addition, 35% said that job rotation schedules were generated based on their perception of job and worker, while 19% reported random assignment of workers to workstations.

Potential Benefits

Basing a rotation schedule on the color-coded matrix has several positive and negative aspects. The system can be rewarding as it provides:

- a guide that the SH&E professional can use to prioritize jobs which should be investigated;
- an easy-to-understand tool that the assembly line supervisor can use for employee job rotation;
- a potential decrease in ergonomic-related injuries;
- an understanding of which jobs would best fit an employee with work restrictions (particularly useful for an occupational health nurse);
- a resource to review when an employee complains of body part discomfort.

Figure 3

Assigning Colors to the RULA Scores

Station	Operation	Neck	Trunk	L. Upper Arm	L. Lower Arm	L. Wrist	R. Upper Arm	R. Lower Arm	R. Wrist
1	Remove part from basket	2	2	1	1	2	3	2	3
2	Blow off part	2	3	1	1	2	3	2	3
3	Place pin into piston	2	1	1	1	1	1	1	2
4	Install "C" clip	1	1	1	1	2	3	2	2

Figure 4

Example of Color-Coded RULA Matrix

Sta.	Operation	Neck	Trunk	L. Upper Arm	L. Lower Arm	L. Wrist	R. Upper Arm	R. Lower Arm	R. Wrist
1	Remove part from basket								
2	Blow off part								
3	Place pin into piston								
4	Install "C" clip								

When a workstation is changed—for example, tasks are added or removed, cycle time is modified—the person responsible for the change may not consider its effect on the worker at the workstation. The color-coding feature of the matrix helps eliminate that concern. The color scheme helps the user quickly identify those jobs that need further attention. Applying the scheme to the body segments making up the RULA further helps the engineer focus on the variable affecting a given job's overall color-coded rank.

As the results indicate, if supervisors rotate their employees, the rotation schedule may be based on the supervisor's knowledge of "easy" or "difficult" jobs, or it may simply consist of having employees move to the next nearest workstation. While easy to control, this approach does not account for ergonomic stressors associated with the task. Basing a rotation schedule on the postural aspects of RULA provides the supervisor with choices that are supported by data and are less subjective than an individual's perception of easy or difficult.

The color-coded system has not been in-place long enough at the Auburn facility to demonstrate its efficacy in reducing the number of work-related musculoskeletal disorders, although the guideline of no more than one red job per shift is anticipated to have a positive effect on injury rates.

That said, assembly line supervisors have found the system helpful in placing employees who are on modified duty. At this facility, employees with a work-related injury/illness who return to work with restrictions are placed on a modified-duty program. The employee, his/her supervisor and the occupational health nurse review the work restrictions and use the RULA matrix to determine what job(s) best fit the employee's work restrictions. For example, if the restrictions limit the use of the right wrist, then any jobs where the right wrist is color-coded red or yellow are not included in a potential job rotation.

The occupational health nurse also uses the matrix as a reference when an employee visits the on-site health clinic complaining of discomfort. The nurse can refer to the matrix to verify whether the job(s) the employee is performing is coded red on the body parts where s/he is experiencing discomfort.

Limitations

Using a matrix based on aspects of RULA has some limitations:

- Applying the matrix to a large number of jobs can be difficult.
- A job will need to be reassessed each time it is redesigned.
- Aspects of RULA used to generate the matrix do not account for repetition or force.
- It takes time to become proficient at conducting a RULA.

Practitioners at the Briggs & Stratton Auburn, AL, facility found that assessing jobs, generating a color-coded matrix and establishing a rotation schedule worked best when applied to a small number (fewer than 20) workstations and when having employees rotate only within those workstations. They found that it did not take as long as expected to complete the process and get results.

For example, this site has assembly lines with more than 100 workstations per line with each line divided into zones of 15 to 20 workstations per zone. It was more efficient for a supervisor to generate a rotation schedule under which employees rotate within the zone rather than between zones. The within-zone rotation also required significantly less cross-training of employees.

The color-coded matrix is a working document. Each time a job step is added or dropped, or the cycle time is changed, the job must be reassessed and the matrix updated. This requires that those involved keep the assessor abreast of any changes to the job. As noted, it takes time to become proficient at performing RULA and many sections can be sub-

Table 1

Results from Assembly Line Supervisor Survey

Survey Questions	Multiple Choices and Responses (frequencies and percentages)			
Do you have a job rotation schedule currently in place on your line?	Yes	No		
	24 89%	3 11%		
If Yes, Why do you have a job rotation schedule in place?	Management Recommended	Safety supervisor recommended	Already in place	My idea to implement job rotation
	14 34%	8 20%	10 24%	5 12%
Do you see any benefit from the job rotation schedule?	Employee gets a break	Increased production	Reduced incidence of employee injuries	Not sure what benefits might be
	17 31%	13 24%	24 43%	1 2%
How do you come up with job rotation schedules?	My perception of the job and worker	Randomly assigning workers to jobs	No scientific methods used to create job rotation	Used a proven process of generating schedules
	13 35%	7 19%	8 22%	6 16%
If No, Why don't you have a job rotation schedule in place?	Management didn't recommend	Job rotation schedule was in place, but had reduced production, so it was discontinued	Never heard of job rotation	Impractical to have a job rotation schedule in place
	0 0%	1 34%	0 0%	1 33%

jective. For example, should a posture be assessed at its extreme position or assessed with a time-weighted average position? How many employees should be assessed performing the same work?

This was an initial attempt to use an ergonomic assessment tool to establish rotation schedules. Previous experience at the facility studied had identified posture as the significant ergonomic stressor for most of the assembly line workstations. As a result, only the postural assessment portions of RULA were used; this means the red, yellow and green color codes are not reflective of the muscle use or force required to perform the task.

Therefore, it is possible that the color-coded rank for the total job may not be entirely accurate. In addition, this project is regarded as a pilot study that the authors conducted to gain an understanding of job rotation from the assembly line supervisor's perspective. Because of the small sample size at a single corporation, readers should be cautious when drawing conclusions from this preliminary work.

Conclusion

This preliminary strategy of assigning a color that reflects the ergonomic stressors within a job and developing a rotation schedule on this basis appears to be promising. Looking to the future, additional factors need to be addressed. Force/load and muscle-use components need to be incorporated into the color-coded matrix. In addition, generating a rotation schedule manually can be time-consuming. Operations research techniques should be employed to develop a scheduling algorithm to remove much of the tediousness associated with this process.

Overall, the project has been well-received by employees and management at the facility studied, largely because the system is an easy-to-understand visual tool. Supervisors at the facility have also noted that the system provides several choices to generate a rotation schedule and reduces employee concerns regarding the perception of easy and difficult jobs. Based on the overall response, it appears this is an easy-to-use proactive measure that can positively support both production and a company's safety and health program. ■

References

Chengalur, S.N., Rodgers, S.H. & Bernard, T.E. (2004). *Kodak's ergonomic design for people at work* (2nd ed.). New York: John Wiley & Sons.

Dempsey, P.G. (2002). Usability of the revised NIOSH lifting equation. *Ergonomics, 45*(12), 817-825.

Desai, D.Y., Carnahan, B.J. & Davis, J. (2005). Development and validation of an ergonomic job rotation schedule at a manufacturing facility. *Proceedings of the Institute of Industrial Engineers, USA.*

Gittleman, M., Horrigan, M. & Joyce, M. (1998). Flexible workplace practices: Evidence from a nationally representative survey. *Industrial & Labor Relations Review, 52*(1), 99-115.

Hedge, A. (2001, Feb.). RULA employee assessment worksheet. Cornell University Ergonomics Web. Retrieved Jan. 7, 2008, from http://ergo.human.cornell.edu/Pub/AHquest/CURULA.pdf.

Jorgensen, M., Davis, K., Veluswamy, P., et al. (2004). Characteristics of job rotation in the Midwest U.S. manufacturing sector. *Proceedings of the Human Factors and Ergonomics Society, USA,* 1418-1422.

McAtamney, L. & Corlett, E.N. (1993). RULA: A survey method for the investigation of work-related upper limb disorders. *Applied Ergonomics, 24*(2), 91-99.

Miller, F.G., Dhaliwal, T.S. & Magas, L.J. (1973). Job rotation raises productivity. *Industrial Ergonomics,* 24-26.

OSHA. (2000, Nov. 14). Ergonomics program: Final rule. *Federal Register, 65*(220), 68262-68870.

Putz-Anderson, V. (1988). *Cumulative trauma disorders: A manual for musculoskeletal disease of the upper limbs.* London: Taylor and Francis.

Triggs, D.D. & King, P.M. (2000, Feb.). Job rotation: An administrative strategy for hazard control. *Professional Safety, 45*(2), 32-34.

Wellman, H., Davis, L., Punnett, L., et al. (2004). Work-related carpal tunnel syndrome in Massachusetts, 1992-1997: Source of WR-CTS, outcomes and employer intervention practices. *American Journal of Industrial Medicine, 45,* 139-152.

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