Complementing the Washington Ergonomics assessment method with the Strain Index

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Abstract

This paper explains how the Washington Ergonomics assessment method and the Strain Index can work together to provide useful information for managerial teams looking to minimize injury risks in manufacturing shops. As a base process, the Washington Ergonomics (WE) assessments were used to identify jobs/tasks with elevated ergonomic risk factors. For most of these job/tasks, the WE assessment provided enough information to generate solutions. However, some jobs required greater detail so that a solution could be identified. For hand intensive activity when greater detail was needed, the Strain Index complemented the established process. Specifically, the Strain Index added exposure time factors to the assessments that improved information to generate a job rotation program proposal for a task that involved distal upper extremity injury potential. This combined assessment methodology makes the process time efficient while providing sufficient detail when needed.

Introduction

Identifying and measuring work risk factors in an industrial environment can be complicated and time consuming tasks; especially when there are many different jobs and job tasks that workers may perform everyday. Maybe this is one reason why many companies wait to use injuries to find ergonomic issues. Only reacting to injury claims does not allow a company work toward preventing injuries.

To date, a considerable number of risk identification and injury prevention tools have been developed to help companies prevent accidents and injuries before they happen. Two of these prevention tools are the Washington Ergonomics Assessment method and the Strain Index. While they are similar in measuring job risk factors, they differ in the level or depth that the risk factors are measured. Notwithstanding they complement each other to give more information about the tasks that are under observation and help generate levels of possible solutions. The Washington Ergonomics assessment method identifies problems related with jobs that require lifting and upper extremity stress [2] while the Strain Index is designed to identify only risks for jobs that require upper extremity stress.

Assessment methods

The Washington Ergonomics assessment method is useful as a baseline tool to identify jobs with elevated ergonomic risk factors across the manufacturing facility. It is more of a general approach that provides enough information to initiate actions to resolve concerns. Simply, it provides a big picture of what is happening on the manufacturing floor and that picture helps reveal if more information is needed to generate solutions.

The Washington Ergonomics method provides information about important factors outlined below [1]:

- Movement required to perform the task; which is about counting the number of times the extremities are moved per minute.
- Hands, wrist and arms position; which is about observing the angle or the location of the extremities while performing the job.
- Force and grip requirements; which considers how many ounces or pounds the muscles are required to exert.
- Contact stress; which identifies if some part of the body is resting against some object.
- Vibration; which identifies if the muscles are being exposed to some kind of vibration
- Environment; which identifies temperature conditions under which the task is performed
- Opinion; which is an input by the person performing the task identifying how difficult the job is.

Washington Ergonomics assessments were used to assess tasks performed in an air conditioner manufacturing facility. Several higher risk activities were identified and documented to find possible solutions. The agreed upon solution was to implement a job rotation program. However, in order to generate a job rotation program, more information was needed. The Strain Index was then used as it added time factors and more specific information not attained from the Washington Ergonomics assessments.

The Strain Index is a semi-quantitative job analysis methodology that results in a numerical score. It considers six variables and multipliers that classify the tasks in hazardous or safe jobs. Hazardous jobs expose workers to musculoskeletal stressors that could result in an injury [3]. The Strain Index considers six important factors [3]:

- Intensity of exertion; which estimates the force requirements of the tasks and is measured using a subjective scale related with job difficulty. This is the most important variable for the Strain Index and it is similar to the force/grip factor that the Washington Ergonomics method considers.
- Duration of exertion; which is estimated with the percentage of time an exertion is applied per cycle. Extra information is added to the assessments when this factor is considered.
- Efforts per minute; which counts the number of exertions per minute per cycle. It is similar to the movement factor that the Washington Ergonomics method considers.
- Hand/wrist posture; which refers to the anatomical position of the wrist or hand relative to neutral position. This factor is similar to the position factor that the Washington Ergonomics method considers.
- Speed of work that estimates the pace at which the job is performed. This is another factor that adds information to the Washington Ergonomics assessments.
- Duration of Task per Day; which is the most important factor to consider when designing a job rotation scheme because this adds time factors to the information gathered before and gives an idea about how many hours the workers should perform a hazardous task to minimize the impact on their muscles. It attempts to incorporate the beneficial effects of task diversity such as job rotation and the adverse effects of prolonged activity such as overtime. This is measured in hours per shift.

From our use, it is clear that the Washington Ergonomics method and the Strain Index vary in information content; but, when they are used together to assess certain tasks, considerable additional information is collected. With each being relatively easy tools to use, the time needed to get the data is not overwhelming. Moreover, solutions like job rotation programs could be developed in a short period of time. Summarizing the information obtained from these assessments working together is:

- Movement factors / Exertions per minute factors
- Position factors / Hand-Wrist Posture factors
- Force-Grip factors / Intensity of exertion factors
- Contact stress factors
- Vibration factors
- Environment factors
- Workers opinions
- Duration of exertion factors
- Speed of work factors
- Duration per day factors

In order to outline how the process worked, the following is an explanation of how the methodology was implemented.

Methodology

The first step in order to build a job rotation pattern to minimize the impact of a hazardous task on the workers' muscles was to assess the jobs performed at the plant with the Washington Ergonomics method. It uses pair numbers, from 0 to 8, rating scale which is applied to grade arm, twist, wrist and finger movements; head, back, elbow, forearm and wrist position; force/grip, contact, vibration, environment and opinion factors. If some of these factors obtain 6 or 8, it is signal of a possible risk; moreover, if the final score that results from summing all the factors is 40 or greater the assessed job is considered a higher risk.

Once the high risk task that required a possible job rotation program is identified the next step is to find other tasks that rate lower for the high risk factors the task of interest has. This assignment can be completed using the Washington Ergonomics Scores. The task of interest scores are shown in the figure 1. This task requires hand intensive activity to be performed and involves distal upper extremity injury potential.

Task or Job Title	Date	Arm	Twist	Wrist	Finger	Head	Back	Elbow (fwd)	Elbow (side)	Forearm	Wrist	Force/Grip	Contact	Vibration	Environment	Opinion	Final Score
Task of interest	11-May	**8**	0	**8**	2	0	4	4	4	2	**8**	0	**8**	0	4	**6**	**58**

Figure 1

As we can see, the job under study is hazardous and has risk factors related with arm and wrist movements, wrist position, contact stress and the operator says it is a hard task to perform. Those factors rate 6's or 8's which means that the workers, performing that task, are being exposed to some risks and/or musculoskeletal stress. Moreover, the final score is eighteen points over the safe limit. Because of this information and several workers' concerns the managerial team decided to generate a job rotation program proposal.

It is important to count the 6's and 8's reported in the Washington Ergonomics to identify the possible risks that some tasks represent for the workers. Counting 6's and 8's and identifying what factors have them let the analysts to focus on where to change things to solve problems. Including tasks that get a lot of high rates (6's or 8's) in the job rotation program should be avoided. However, sometimes those 6's and 8's will appear on the assessments of the tasks included on the rotation pattern. In this case, the analysts should match tasks that expose different parts of the body to the musculoskeletal stress. For instance, if the task of interest gets an 8 for wrist position, it should be matched with a task that avoids bad wrist position and has a low score for this factor (4 or less).

Several tasks were looked for as candidates to be part or the job rotation program. In order to be good candidates, they would have to score lower than the task of interest for those hazardous factors. For instance, if the task of interest rates 8 for Arm movement, it is recommended, for the rotation, to include tasks rating 4 as a maximum value. Some tasks assessments are shown below (Figure 2):

Task or Job Title	Date	Arm	Twist	Wrist	Finger	Head	Back	Elbow (fwd)	Elbow (side)	Forearm	Wrist	Force/Grip	Contact	Vibration	Environment	Opinion	Final Score
Task of interest	11-May	**8**	0	**8**	2	0	4	4	4	2	**8**	0	**8**	0	4	**6**	**58**
Candidate task 1	27-Jun	0	0	0	0	0	2	4	0	2	2	2	0	0	**6**	0	18
Candidate task 2	24-May	4	0	2	4	0	0	2	0	2	2	0	0	0	4	0	20
Candidate task 3	24-May	**6**	0	2	4	0	0	2	2	0	2	4	0	0	4	0	26
Candidate task 4	24-May	4	0	0	2	0	0	2	2	0	2	4	0	0	4	0	20
Candidate task 5	25-May	2	0	2	0	0	2	**6**	4	4	2	4	4	0	4	4	38
Candidate task 6	25-May	2	0	2	0	2	**8**	4	2	4	2	4	2	2	4	4	**42**
Candidate task 7	25-May	2	0	2	0	0	2	**8**	**8**	2	4	4	0	2	4	4	**42**

Figure 2

The candidate tasks have a Washington Ergonomics score below or around 40 and, if they have factors assessed with an 8 or a 6, those factors are different from those high scored for the task of interest; except for the candidate task 3 which rates a 6 for arm movement and might keep the arms' muscles under musculoskeletal stress if it is included in the rotation program. This situation makes almost all those tasks good candidates to be included in a job rotation pattern. Considerations for the candidate task 3 are different because it seems to be not recommended to match this candidate with the task of interest on the rotation scheme. This is because the risk would stay on the workers' arms while performing both tasks.

Until now, we have examples of good candidates for the job rotation program, but we have been missing one important aspect to get the rotation done. This aspect is related to how often the workers should rotate among the selected jobs. Unfortunately the Washington Ergonomics method does not include time factors in the assessments. At this point the Strain Index is used as it contains duration per day factors in order to find out what is the amount of time recommended to spend performing one task before rotation.

Consequently; the next step is to find the Strain Index scores for all the selected jobs in order to confirm the Washington Ergonomics findings and to add exposure time factors to the analysis. The key factor is to vary the duration per day factor multiplier from the largest to the smaller and discover how the Strain Index score is modified when the workers spend different amounts of time performing the different tasks.

Before showing how the Strain Index works and gets this information; the rating criteria table and the multiplier table are presented next (Tables I and II). The first table is used to assess the job while the second table is used to get the Strain Index score by multiplying the six factors scores.

TABLE I. Rating Criteria

Rating	**Intensity of exertion**	**Duration of Exertion (% of cycle)**	**Efforts/minute**	**Hand/Wrist Posture**	**Speed of work**	**Duration per Day (hr)**
1	ligth	<10	<4	very good	very slow	<=1
2	somewhat hard	10 – 29	4 -- 8	good	slow	1 – 2
3	hard	30 -- 49	9 -- 14	fair	fair	2 – 4
4	very hard	50 -- 79	15 -- 19	bad	fast	4 – 8
5	near maximal	>= 80	>= 20	very bad	very fast	>= 8

* [3]

TABLE II. Multiplier Table

Rating	Intensity of exertion	Duration of Exertion (% of cycle)	Efforts/minute	Hand/Wrist Posture	Speed of work	Duration per Day (hr)
1	1	0.5	0.5	1.0	1.0	0.25
2	3	1.0	1.0	1.0	1.0	0.50
3	6	1.5	1.5	1.5	1.0	0.75
4	9	2.0	2.0	2.0	1.5	1.00
5	13	3.0	3.0	3.0	2.0	1.50

* [3]

If a job is described as *somewhat hard* for the intensity of exertion; is between *ten and twenty nine percent* for duration of exertion; has between *four and eight efforts per minute*; is described as *fair for hand/wrist posture*; is executed at a *slow speed pace* and the worker performs the task *eight hours a day*; the multipliers to get the Strain Index Score are *3, 1.0, 1.0, 1.5, 1.0 and 1.0,* respectively; then the Strain Index score for this task would be *(3*1.0*1.0*1.5*1.0*1.0) = 4.5.*

The value of 5 is the threshold Strain Index score to distinguish a safe from a hazardous job [3]. Consequently, it is desirable to get scores below 5 to design a job rotation program; however, if the scores are greater than 5, the closer to this value, the safer the task. By modifying the duration per day factor a high Strain Index score could get lower than 5 or closer to this threshold. Our task of interest, in figure 3, is a good example because a 54 score becomes a 9 score after changing the duration per day factor.

Task	Extensity of exertion	Duration of exertion	Efforts/Minute	Hands/Wrist Posture	Speed of Work	Duraton per Day	Strain Index Score	WE Score
Task of Interest (>= 8 hr)	3	2	3	2	1	1.5	54	58
Task of Interest (4-8 hr)	3	2	3	2	1	1	36	58
Task of Interest (2-4 hr)	3	2	3	2	1	0.75	27	58
Task of Interest (1-2 hr)	3	2	3	2	1	0.5	18	58
Task of Interest (=< 1 hr)	3	2	3	2	1	0.25	9	58

Figure 3

The Strain Index scores for the candidate tasks are given in the next figure (figure 4) where we can see different situations. The candidates 1 to 5 are safe jobs, even when they are performed eight hours (1.0 is the multiplier) and their Washington Ergonomics scores are low too; therefore, they are definitively good candidates for the job rotation program. We must not forget that the candidate task 3 is not recommended to be included in the rotation pattern because its arm movement score is 6. The risk for arm movement is confirmed by the efforts per minute factor score in the Strain Index for the same task which is 2. The candidate number 6 has a 4.5 Strain Index score but a 42 Washington Ergonomics score. This task could still be a good candidate since it was selected previously comparing the assessments factors and the Washington Ergonomics score is close to 40 which is the threshold for safe jobs. The situation for candidate task 7 is different; as we can see, if the task is performed between 4 and 8 hours the Strain Index score is higher than 5 and it is hazardous for both assessment tools; if it is performed between 2 and 4

hours, the score is practically 5 and the task is close to the safe thresholds for both assessment tools. Finally the score is lower than five if the task is performed between 1 and 2 hours.

Task	Extensity of exertion	Duration of exertion	Efforts/Minute	Hands/Wrist Posture	Speed of Work	Duraton per Day	Strain Index Score	WE Score
Candidate task 1	1	1	1	1	1	1	1.00	18
Candidate task 2	1	1	1	1	1	1	1.00	20
Candidate task 3	1	1.5	2	1	1	1	3.00	26
Candidate task 4	1	1.5	1	1	1	1	1.50	20
Candidate task 5	1	1	0.5	1	1	1	0.50	38
Candidate task 6	3	1.5	1	1	1	1	4.50	42
Candidate task 7 (4-8 hr)	3	1.5	1	1.5	1	1	6.75	42
Candidate task 7 (2-4 hr)	3	1.5	1	1.5	1	0.75	5.06	42
Candidate task 7 (1-2 hr)	3	1.5	1	1.5	1	0.5	3.38	42

Figure 4

Using the last two tables above, we can suggest a rotation to minimize the risk, where the task of interest is performed less than 1 hour; time after which, the worker could perform the candidate tasks 1, 2, 4, 5 or 6 for the rest of the shift or the candidate task 7 for a period of time between 1 and 4 hours.

Sometimes there will be administrative restrictions to build a job rotation program. For instance, it might be impossible to rotate workers every two hours, but it might be allowed to rotate every half a shift. In this case, the rotation should be done anyway for the task of interest because it is better to work 4 hours exposing the workers to an 18 Strain Index score than to work 8 hours exposing the workers to a 54 Strain Index score. To include jobs that are performed close to each other, at the same department or in different departments that are nearby is recommended too, because this minimizes the time the workers lose at the moment they rotate and the distance they have to walk in order to reach other workstations. Having medical validation is recommended too, because that confirms that the job rotation program is well designed.

Several job rotation programs can be developed using the methodology proposed above, where two important ergonomics tools complement each other and help to analyze what is the current situation in the manufacturing areas.

Conclusion

Different ergonomics assessment methods vary in information content and can complement each other under certain conditions. This was the case for the Washington Ergonomics assessment method which after generating a general approach at a manufacturing facility and identify an area needing a job rotation program proposal worked along with the Strain Index method to gather enough information to generate a good solution that minimizes the risk factors for the workers.

Some tools are useful to get general information, identify problems and generate possible solutions, but they might need to be complemented in order to design and implement the proposed solutions. Washington Ergonomics and Strain Index methods can work together to generate good job rotation programs.

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Biographical Sketch

Abraham Robledo Gallegos is a recent industrial engineering graduate of Universidad de las Americas in Puebla, Mexico. As part of his academic excellence scholarship, he studied at Clemson University. During this study, he was team lead for the senior design project for Tyco Healthcare in Seneca, South Carolina and interned at Allied Air Enterprises in Blackville, South Carolina. In Blackville, he performed ergonomic assessments for the production lines.