

DEVELOPMENT OF AN ERGONOMICS SCREENING TOOL FOR MULTI-TASK JOB ANALYSIS

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ABSTRACT

Currently, most ergonomic analysis tools are intended for evaluation of mono-task jobs only. Also, many ergonomic analysis tools require a significant investment of time, money, and/or training to assess jobs. The field of ergonomics is in need of a tool that can quickly analyze jobs and categorize them based on assessment of risk—jobs not needing further review (probably “safe”) and those where a more detailed analysis tool would be beneficial. The University of Utah Ergonomics and Safety Laboratory developed a multi-task tool intended to analyze jobs in a relatively short period of time and sort the job into one of three categories: “safe” jobs, jobs for further review, and “hazardous” jobs. This tool is currently used by Ford Motor Company at all of its manufacturing plants. Data are currently being collected for a verification study, though no verification has yet been conducted. The tool developed in this study is heavily based on the upper extremity portion of this Ford analysis tool. The purpose of this study was to validate the Ford tool and explore new survey tools that can be useful in an efficient screening of jobs.

INTRODUCTION

Humans have been altering and manipulating tools to make them more comfortable and efficient for hundreds of years—long before the term ergonomics was created in the 1850s (Keyserling, 1993). Today, ergonomics is studied from a variety of perspectives, ranging from cognitive ergonomics to biomechanics and the physiology of work. In 1990, the Occupational Safety and Health Administration (OSHA) issued a document titled *Ergonomic Program Management Guidelines for Meat-packing Plants*, which states “The goal of any safety and health program is to prevent injuries and illnesses by removing their causes. For ergonomics, this goal is to eliminate or materially reduce worker exposure to ergonomic hazards that lead to cumulative trauma disorders and related injuries and illnesses” (Keyserling, 1993).

The National Institute of Health (NIH) estimates that 1.7 million ergonomic injuries occur each year, indicating an inherent need for progression in the field of ergonomics (Drinkaus, 2003). According to the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA), repetitive strain injuries are the nation's most common and costly occupational health problem, affecting hundreds of thousands of American workers, and costing more than \$20 billion a year in workers compensation (Drinkaus, 2003).

Ergonomists use a number of evaluation strategies to determine the “risk” of performing a given job. The terms “safe” and “hazardous” are often used to describe jobs. “Safe” does not imply that the worker is not exposed to risks, but only defines the job as one that is not hazardous (Moore, 1995). Today, the highest risk for workers in most industries is the development of cumulative trauma disorders, a term used to describe a class of soft tissue injuries and disorders that are influenced by a number of occupational activities (Keyserling, 1993). It is estimated that 75% of these injuries affect the upper extremities (Drinkaus, 2003).

Currently, ergonomists do not agree on a standard method of evaluating jobs. At this time there are four options to determine whether a job is safe or hazardous: (1) professional opinion based on subjective judgement and past experience; (2) determination of some physiological, biomechanical, or psychophysical critical threshold response; (3) epidemiological data that associates jobs, tasks, and individual variables with a manifestation of increased risk; or (4) some combination of the above three (McAtamney, 1993). Researchers in the field often spend a significant amount of time and resources evaluating job risk (Drinkaus, 2004; Drinkaus, 2003; McAtamney, 1996; Moore, 1995; Sesek, 1999; University of Michigan, 2003; Waters, 1993). Some knowledge gained from professional judgment from experienced analysts may not be able to be replaced by any single model. However, often this data is based on subjective measures and is subject to personal bias. This study is aimed at developing a more efficient method of job evaluation that will give a relatively quick risk screening. The scope of this tool is to serve as a screening mechanism. The underlying theory of this study is that many jobs lying at the far ends of the risk spectrum (high risk and low risk jobs) do not require such thorough analysis. Consequently, this tool is aimed at “screening” out the jobs at each end of the scale, thus eliminating time-consuming process of systematic job analysis for a portion of the jobs to be observed. This tool was not designed to be used as a diagnostic tool and as such does not provide recommendations for reducing ergonomic stresses in the jobs analyzed beyond indicating a broad area for improvement.

For this study, a task was defined as one cycle repeated by the subject for several minutes or more. A job was defined as the complete set of tasks performed by a given subject. Some of the jobs consisted of multiple tasks, while other jobs were mono-task in nature.

In the workforce today, most jobs involve more than one task. However, existing ergonomics tools do not adequately account for this fact (Hignett, 2000; Keyserling, 1993; McAtamney, 1993; Moore, 1995; University of Michigan, 2003; Waters, 1993). Therefore, an effective screening tool should provide an overall risk score for jobs involving more than one task. Previous research at the University of Utah suggests that the most stressful task is the best predictor of overall job risk (Drinkaus, 2004).

METHODS

Video job data were collected at three plants in Utah including light manufacturing, apparel manufacturing, and meat cutting. The sampling set included 16 mono-task jobs and 18 multi-task jobs. The onsite video collection team chose to record representative cycles based on the workers’ typical job activities and the product being produced. These video data were then “trimmed” offsite to remove unusual activities captured, such as workers stopping to talk to the

camera or stooping to pick up a dropped product. In this case, the limits associated with eliminating some aspects of the job were considered less significant than the value of having a data set that could be observed efficiently and that represented the bulk of the subjects' ergonomic risk.

The tool for data analysis was developed using ideas and analysis techniques from a number of existing methods. Each risk factor in the literature was identified and categorized according to general themes (i.e., posture, force, and repetition). Risk factors to be used in the final tool were chosen based on successful results from previous studies and their feasibility for use in a time-limited tool. The final tool was composed of a series of rating scales for speed, posture, repetition and intensity as well as an impulse load checklist. The left and right extremities were evaluated independently, but on the same basis, to provide a risk score for each side individually.

Posture, speed, and intensity were evaluated on an incremental scale. Wrist flexion and extension were evaluated on a scale of 1-5, with 5 being the most extreme (furthest from neutral) posture (Ford Motor Company, 2001). Average speed was also evaluated on a scale of 1-5. A score of 1 was defined as "moving at a slow, leisurely pace" and a score of 5 was defined as "frequent swift movements, even when seemingly unnecessary." Repetition was scored on a scale of 1-9 with a score of 1 being defined as "very slow and infrequent hand/finger motions" and a score of 9 defined as "rapid steady hand/finger motion with no rest time." At first glance, it seems that speed and repetition evaluate the same characteristic. In most cases they are correlated. However, the separation of the two allows for the distinction between jobs that work at a steady pace (in which speed and repetition are similar) and jobs that require the worker to perform a task very quickly and then rest for a period (a job with high speed but low repetition). Intensity was evaluated on scale of 1-10, based on the Borg perceived exertion scale (Borg, 2002).

Additional variables and modifiers to the variables above were evaluated on a binary scale. A yes/no checklist was created for the presence of contact stress, using the hand as a hammer, visible vibration, tool kick, grasping or manipulating greater than 4.5 kg (10 lbs), and pinching greater than 1 kg (2 lbs). Modifiers to posture, speed, repetition, and intensity were included in this binary checklist. Flexion and extension were modified to be more extreme if the worker was concurrently deviating, pronating, or supinating the wrist and also if the "worst" wrist posture occurred for greater than 25% of the cycle. Speed and repetition were modified if the highest score occurred for greater than 50% of the cycle or if the worker was idle for greater than 20% of the cycle. These variables were combined to give each task a composite risk score. Risk scores for each job, or subject, were set at the maximum risk score obtained from individual task scores.

The basis for tool validation was established by blinded health outcomes obtained from occupational medicine (OM) physicians. Each subject was evaluated monthly by these professionals to provide a dynamic set of outcome data for tool validation. Cases included in the study were blindly selected from a population that were diagnosed with carpal tunnel syndrome (CTS) and reported current pain in the upper extremities. Controls were blindly selected from a population that was asymptomatic for CTS and reported no pain in the upper extremities.

RESULTS

The average time for analyzing each individual task was approximately 6 minutes. Total analysis time for all tasks in a job ranged from 5 minutes to 40 minutes. These are acceptable times for a screening tool.

A composite tool using many of the input variables was created. The cut point of the tool was defined as the composite risk score that separates hazardous jobs from “safe” jobs. The final cut point was selected by computing the sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) corresponding to each cut point and selecting a cut point that gave the highest overall values. This is illustrated in Fig. 1. From this data, a cut point of 75 was selected. Table 1 shows the 2X2 matrix for a cut point of 75 along with the applicable statistics.

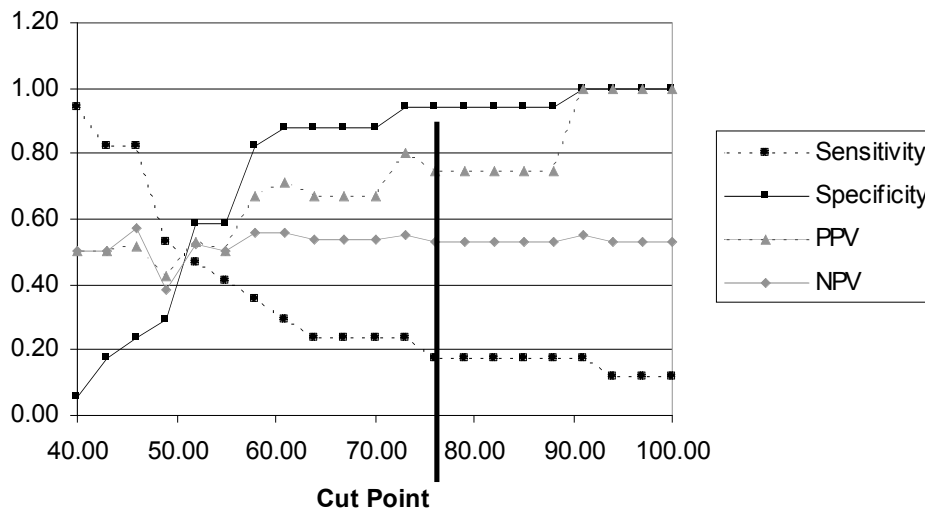


Figure 1. Variation of sensitivity, specificity, PPV, and NPV with changing cut points. The selected cut point is highlighted by the bold vertical line at 75.

Table 1. 2X2 Matrix representing risk score cut point of 75 along with accompanying outcome statistics.

Cut Point: 75		Actual	
		Case	Control
Tool	Hazardous	4	1
	“Safe”	13	16
Sensitivity: 0.24 Specificity: 0.94 Positive Predictive Value: 0.80 Negative Predictive Value: 0.55			

DISCUSSION

In this work, the idea that not all jobs require a detailed analysis by a trained professional was investigated. Jobs can be “screened” by a quick, initial analysis to give a recommendation of which jobs need further analysis. This tool has a high value of specificity and a high PPV, indicating that it can successfully screen jobs at the high end of the risk spectrum. Its values for sensitivity and NPV, however, do not indicate success in screening out jobs at the low end of the risk spectrum.

This study was limited by the sample size and lack of control over personal risk factors, such as diabetes and excessive body mass index (BMI). The study was also limited by the distribution of risk scores within the sample set. Sixteen of the 18 mono-task jobs in the sample set were taken from an apparel manufacturing plant. This sample subset included an equal number of cases and controls. Because these jobs were all very similar, they received very similar composite risk scores. These risk scores were all in the 40 to 50 range and therefore none of them were forecasted as hazardous by the tool. A more detailed analysis method would be necessary to further differentiate these jobs into accurate risk categories.

This study illustrates the value of expert ergonomic analysts in the determination of job risk. The concept of a screening tool that can be applied by an inexperienced analyst is a very attractive theory, but it is very difficult to apply.

Perhaps collection additional risk factor data would allow better differentiation between similar tasks. However, the more data that are collected, the less appeal the tool has for screening purposes.

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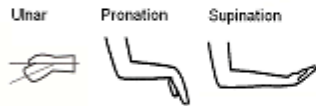
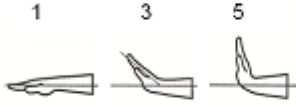
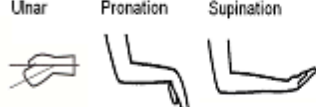
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APPENDIX

The following key was used during observation of video data in assigning values for each variable evaluated in the tool developed in this study.

Variable	Scale	Anchor
repetition	(1-9)	1- very slow and infrequent hand/finger motions; hands/fingers idle most of the time; very relaxed pace
		3- hand/finger motion at a comfortable pace; frequent and consistent pauses; taking one's own time
		5- "normal" hand/fingers speed of motion; sustainable work pace; steady hand/finger motion with possible brief pauses (e.g., waiting for next part)
		7- rapid steady hand/finger motion with little opportunity for rest; rushed, but able to keep up; little time for discretionary work
		9- rapid steady hand/finger motion; difficulty keeping up (barely or unable); nearly continuous use of the hands/fingers with no rest time
repetition > 50% cycle	y/n	Does the above repetition occur greater than 50% of the cycle?
repetition > 20% idle	y/n	Is the worker idle for greater than 20% of the cycle?
peak intensity	(1-10)	0- Nothing at all
		0.5- Very, very light
		1- Very light
		2- Light
		3- Moderate
		4- Somewhat hard
		5- Hard
		7- Very Hard
		10- Maximal
average intensity	(1-10)	Same scale as above
intensity > 25% > average intensity	y/n	Is greater than 25% of the cycle at an intensity greater than average?
contact stress	y/n	Does the subject press the upper extremity against a hard object or sharp edge?
hand as a hammer	y/n	
visible vibration	y/n	Does the subject handle or contact a tool that is vibrating?
tool kick	y/n	Does the subject handle a tool that jerks or stops abruptly?
grasp/manipulate > 10 lb	y/n	Does the worker grasp or manipulate an object with a force greater than 10 lbs?
pinch > 2lb	y/n	
		Does the subject use a pinch grip with a force greater than 2 lbs?
pinch > 2lb > 25% of cycle	y/n	Does the subject use a pinch grip for greater than 25% of the cycle?
flexion "worst"	(1-5)	1 
		3 
		5 
concurrent ulnar deviation or forearm pronation or supination with flexion?	y/n	Ulnar 
		Pronation 
		Supination 
extreme flexion posture > 25% cycle	y/n	Does the "worst" flexion posture occur for greater than 25% of the cycle?
extension "worst"	(1-5)	1 
		3 
		5 

Variable	Scale	Anchor
concurrent ulnar deviation or forearm pronation or supination with flexion?	y/n	
extreme flexion posture > 25% cycle	y/n	Does the "worst" flexion posture occur for greater than 25% of the cycle?
extension "worst"	(1-5)	
concurrent ulnar deviation or forearm pronation or supination with extension?	y/n	
extreme extension posture > 25% cycle	y/n	Does the "worst" extension posture occur for greater than 25% of the cycle?
average speed	(1-5)	1- Very Slow: extremely relaxed pace
		2- Slow: taking one's own time
		3- Fair: normal speed of motion
		4- Fast: rushed, but able to keep up
		5- Very Fast: rushed and barely/unable to keep up
speed > 50% cycle	y/n	Does the above speed occur for greater than 50% of the cycle?
impacts/min	#	How many impacts occur in one minute?