#### Abstract

The Cumulative Trauma Disorder (CTD) risks for three different tasks using McCauley-Bell and Badiru's (1993) formula based on task, personal, and organizational factors were examined. For the Multi-Layer Insulation (MLI) blanket task, the results showed that the task, personal, and organizational risks were at about the same level. The personal risk factors for this task were evaluated using a hypothetical female employee age 52. For the pizza dough task, it was shown that the organizational risk was particularly high, with task related factors also at quite dangerous levels. On the other hand, there was a very low level of personal risk factors, based on a female age 17. The flow cytometer task was assessed with three different participants, all of whom had quite disparate levels of personal risk, which slightly affected the overall CTD risk. This reveals how individual difference variables certainly need to be considered. The task and organizational risks for this task were rated at about the same moderate level. The overall CTD risk averaged across the three participants was .335, indicating some risk. Comparing across the tasks revealed that the pizza dough task created the greatest overall CTD risk by far (.568), with the MLI (.325) and flow cytometer task (.335) having some risk associated with them. Future research should look into different tasks for more of a comparison.

# CTD Risk Assessment Lab

#### **Overall Introduction**

Organizations lose a lot of money when employees end up with injuries created on the job. These injuries very often fall under work related musculoskeletal disorders (WMSD), which include repetitive strain injuries (RSI) and cumulative trauma disorders (CTD), among others. Common CTDs occur in the areas of the back, neck, shoulders, wrists and hands, as well as other joints of the body. For office-type work where there is a lot of writing, typing, etc. there is a certain amount of strain put on the wrist and fingers, which can lead to common disorders such as carpal tunnel syndrome. Several occupations that have a higher risk of CTDs include carpenters, small parts assemblers, and grocery store clerks. These disorders can be very painful and lower work efficiency and productivity. Eventually it can lead to the employee having to leave the job which results in the company loosing an experienced worker and suffer the cost of a workman's compensation claim. Of reported CTD cases, 48% of the victims were not well enough to return to work. Furthermore, the average rate of CTDs in high risk occupations can be alarmingly high, with as much as 15 to 20%. In addition to the costs the organization must face when employees develop CTDs, the employee must also face the costs of diagnosis and treatment

# Purpose of lab

Fortunately, employing ergonomic interventions can mitigate most of these CTDs, as there are several guidelines that can be followed to minimize the risks. In attempting to prevent the costly CTDs on everyone, the first step is to identify the risk factors and analyze how to mitigate those risks. The risk factors are typically thought of

as multidimensional, meaning that there are several different factors that could affect the outcome of whether an individual develops a CTD. Several of these risk factors were assessed in this lab, including task-related, personal, and organizational risks in three different work settings. These risk factors themselves are multidimensional; for instance, personal risk factors include age, health, etc. The three risk factors were quantified using McCauley-Bell and Badiru's (1993) formula for assessing CTD risk. With this very convenient formula, the overall risk can be calculated with the aggregation of the three types of risk factors. With this analysis, one can determine which areas to concentrate on to reduce the risk if it is high enough to be a concern. An ergonomic evaluation can then determine what interventions would be appropriate to decrease the risk of developing a CTD and improve task comfort and efficiency. This lab, however, only took the first step of the process, that of determining what the risks are and how much of a risk is present.

# Task A: Fabrication of Multilayer Insulation Blankets

The work environment was located at the Kennedy Space Center in the Space Station Processing Facility. The environment was a sewing shop which is responsible for fabricating and repairing Multi-Layer Insulation (MLI) blankets. The MLI blankets are used externally to insulate the International Space Station elements. For the pressurized elements, the blankets are attached external to the pressure shell and underneath the Micrometeoroid Object Debris (MMOD) shields. *Figure 1* shows Node 1 with some of the MMOD shields (grey aluminum panels) missing and the MLI blankets (white) shown around the radial hatches.

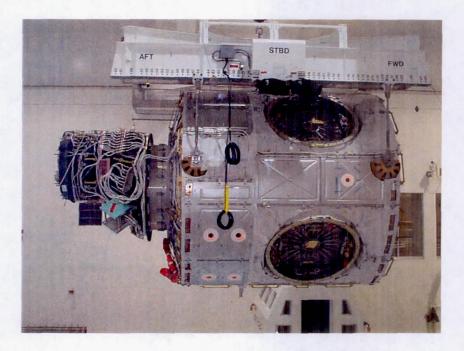


Figure 1. Node 1 with MLI Blankets shown around the radial hatches.

The MLI blankets are composed of layers of different materials including aluminized glass fabric, polymide films and polyester mesh. The raw materials are laid out on the tables in the sewing shop shown in *Figure 2*, and cut and trimmed per

engineering drawings. The multiple layers of materials are stitched together using the sewing machines shown in *Figure 3*.



Figure 2. Tables



Figure 3. Sewing Machines

### Methodology

The sewing shop located in the SSPF was visited and the shop foreman was interviewed to determine the ratings for the task-related risk factors and the organizational-related risk factors. A still camera was used to record images of the sewing shop. For purposes of this lab exercise, a hypothetical employee was also interviewed to complete the personal risk factors.

## Effective use of tools and techniques

The technique that was used to determine the risk of Cumulative Trauma Disorder (CTD) was to apply the McCauley-Bell Fuzzy Rating Scale for Evaluation of Cumulative Trauma Disorder Risk. The three modules: task; personal and organizational were evaluated for relative significance.

Task Related Risk Factors

The task related risk factors were: Awkward Joint Posture; repetition; Hand Tool Use; Force; Task Duration; and Vibration. Each of the factors was evaluated as high, medium, low or none (no risk associated with the factor).

Awkward Joint Posture: Medium - Most of the sewing performed in the sew shop is done on a sewing machine. The shop recently purchased new ergonomic chairs that are fully adjustable and well cushioned. Machine sewing does involve awkward joint postures at times, but because the operator is sitting in front of the machine and the material is automatically fed through the machine awkward joint postures are rare. The thread is cut automatically at the end of the stitch so the operator does not have to use scissors frequently. However, on very rare occasions, hand sewing is performed for in-

place repairs to blankets installed on a module. This activity does involve awkward positions of the hands, wrists and body joints.

Repetition: Low – Although sewing may seem like a repetitive task, the sewing that is performed in this shop is one step in the blanket fabrication process. The sewing operator performs other steps including gathering the raw materials, laying out the materials and cutting the materials. Each blanket has unique dimensions and does not involve repetitive sewing. Different types of stitches are performed in different areas of the blankets. Repairs to blankets are performed unique to the deformation. Sometimes the shop is asked to sew labels on garments and this task is repetitive. However, the machines are programmable and the operator just needs to sew the first label on the garment to be set up for sewing labels on multiple garments. The operator will line up the label on the second garment, run the program and the machine will stitch the label onto the garment using the programmed pattern. Sewing of labels is performed on rare occasions.

<u>Hand Tool Use</u>: Low – On occasion grommets need to be installed in the blankets. This activity requires the use of hand tools.

<u>Force</u>: Medium – The blankets can be heavy and bulky. The shop is setup with rolling tables that can be used to support ends of blankets while sewing. After a run of stitching, the blanket will need to be readjusted to support the next run. The machines feed the material through the machine while sewing therefore the operator does not have to apply much force at the sewing needle.

<u>Task Duration</u>: Medium – The operator does not normally sit at the machine for an entire shift. On occasion, the sewing of labels on garments will require sewing for the

entire shift. A typical sewing operation can take anywhere from 10 minutes to about one hour and multiple tasks are performed throughout the day.

<u>Vibration</u>: None – The sewing machines are very well made and do not vibrate the operators' hands, feet or tables.

#### Personal Risk Factors

The personal risk factors were evaluated using a hypothetical employee, female, age 52. The personal related risk factors were: Previous CTD; Hobbies & Habits; Diabetes; Thyroid Problems; Age; and Arthritis or DJD. Each of the factors was evaluated as high, medium, low or none (no risk associated with the factor).

<u>Previous CTD</u>: Low – The hypothetical employee had minor complaints of wrist pain on an infrequent basis. The pain experienced did not warrant the employee to seek medical attention and on occasion the employee would take over the counter medication for relief of symptoms.

Hobbies and Habits: Medium – The hypothetical employee does have hobbies in her spare time. She also knits and couchettes at home, which use the same tendons, ligaments and muscles, used at work.

<u>Diabetes</u>: Low – The hypothetical employee has a family history of diabetes but does not exhibit any symptoms and gets tested regularly for signs of diabetes.

<u>Thyroid Problems</u>: None – The hypothetical employee does not have thyroid or thyroid hormone production problems.

Age: Medium - The hypothetical employee is 52 years old.

Arthritis or DJD: Low – The hypothetical employee has minor symptoms of arthritis. The employee takes medication to relieve the symptoms on an as needed (infrequent) basis.

## Organizational Risk Factors

The organizational risk factors were: Equipment; Production Rate/ Layout; Ergonomics Program; Peer Influence; Training; CTD Level and Awareness. Each of the factors was evaluated as high, medium, low or none (no risk associated with the factor).

Equipment: Medium – The sewing machines that are used in the shop are state of the art equipment. The machines are programmable and include a task light. Although there is some level of automation, the sewing task involves the use of manually manipulating the blankets during the sewing process.

<u>Production Rate/ Layout</u>: Low – Although the blanket repairs need to be timely, there is not a production rate that is implemented or enforced. The layout of the room is specifically designed for the task. The height of the side tables is adjustable and the tables can easily be relocated (on wheels) so the operator can support the extra fabric on the side tables as required. There was a recent LEAN activity conducted in the sewing shop, which identified improvements to increase the efficiency of the shop. Included were ergonomic improvements explained in the Ergonomic Program section.

<u>Ergonomics Program</u>: Low – The recent LEAN activity identified a number of improvements to the efficiency of the shop including ergonomic improvements. The ergonomic improvements included purchasing new ergonomic adjustable chairs and height adjustable rolling tables. These tables are used to support the extra fabric while being stitched.

<u>Peer Influence</u>: Low – The supervisor explained that the workers tend to complement one another rather than compete against one another. Different workers specialize in different tasks of the fabrication effort. There is no set quota or production rate.

<u>Training</u>: Medium – The supervisor, other shift managers and engineers received training at the manufacturer to operate and be able to fix the machines if they break down. This appears to be the only training provided at the sewing machine vendor. The operators of the sewing machines receive On-the Job (OJT) training from the managers and other experienced operators. The training includes cutting the raw materials, reading engineering drawings and performing other blanket fabrication and repair tasks.

<u>CTD Level</u>: Medium - The CTD level was evaluated as medium because operating a sewing machine does involve movement of the tendons and ligaments in the wrists and hands.

Awareness: Medium – The awareness was assessed as medium, because prior to the LEAN activity (possibly for years), the shop had chairs that could not be adjusted to an ergonomically correct height for the sewing machine operators. They had two sets of chairs. One set were ergonomic office chairs (Blue Chairs *in Figure 4*) but the maximum height was too low and one set were bar stool size where the minimum height was too high for the operator. They did not realize this to be a problem until the LEAN activity identified this and purchased the correct chairs for them (Black chairs in *Figure 4*). Although they eventually performed the LEAN activity, they would still have the incorrect chairs if this activity was not a corporate sponsored activity.



Figure 4. Chairs Used in Sewing Shop

The level of existence for each factor (High, Medium, Low and None) was given a numerical score of 1.0, 0.5, 0.2 and 0.0 respectively. The relative weights of each of the risk factors were multiplied by the level of existence for each factor to obtain a numerical score for each of the three modules (Task, Personal and Organizational) and are presented in the Results section. An aggregate risk level was obtained by multiplying the module relative weights by the risk values (R-Values).

### Results

The task related, personal and organizational risk factors are presented in the following tables.

Task-Related Risk Factors

	Awkward Joint Posture	Repetition	Hand Tool Use	Force	Task Duration	Vibration
	roctaro	ropoulon	- 000	1 0100	Duration	Vibration
Relative Weight	0.299	0.189	0.180	0.125	0.124	0.083
evel of Existence	0.5	0.2	0.2	0.5	0.5	0.0
	0.450	0.000	0.000	0.000		
	0.150	0.038	0.036	0.063	0.062	0.000

Task-Related
Risk Value
(R<sub>1</sub>) = 0.348

Table 1. Task-Related Risk Factors

Of the task related risk factors, the posture of the employee had the highest relative weight and represents the highest risk to the employee developing a cumulative trauma disorder.

#### Personal Risk Factors

	Previous CTD	Hobbies and Habits	Diabetes	Thyroid Problems	Age	Arthritis
Relative Weight	0.383	0.223	0.170	0.097	0.039	0.088
Level of Existence	0.2	0.5	0.2	0.0	0.5	0.2
	0.077	0.112	0.034	0.000	0.020	0.018

Personal Risk Value (R<sub>2</sub>) = 0.259

Table 2. Personal Risk Factors

Of the personal risk factors, Hobbies and Habits had the highest relative weight and represents the highest risk to the employee developing a cumulative trauma disorder.

### Organizational Risk Factors

		Production Rate/	Ergonomics	Peer		CTD	
	Equipment	Layout	Program	Influence	Training	Level	<u>Awareness</u>
Relative Weight Level of Existence	0.346 0.5	0.249 0.2	0.183 0.2	0.065 0.2	0.059 0.5	0.053 0.5	0.045 0.5
	0.173	0.050	0.037	0.013	0.030	0.027	0.023

Organization	
al Risk Value	
$(R_3) =$	0.351

*Table 3.* Organizational Risk Factors.

Of the organization risk factors, the equipment had the highest relative weight and represents the highest risk to the employee developing a cumulative trauma disorder.

## **Interpretation and Discussion of Results**

A summary table of the aggregate risk level is shown below.

Determination of Aggregate Risk Level

		Risk	Module
	Relative	Value	Overall
	Weight	(R-value)	Risk
Task	0.637	0.348	0.222
Personal	0.258	0.259	0.067
Organizational	0.105	0.351	0.037
		Comprehensive Risk of Injury Value =	0.325

Table 4. Determination of Aggregate Risk Level.

Of the three modules, the Task related risk factors were shown to represent the greatest risk to the employee (module overall risk is 0.222). This is due to the larger relative weight value of the task-related risk factors (0.637).

The overall comprehensive risk of injury value is 0.325, which correlates to "some risk" to the employee. The employee may be in the early stages of CTD development. The employee may experience irregular irritation, but is not expected to experience regular musculoskeletal irritation. This interpretation correlates well with the employees' responses in the interview.

# Task B: Shaping Pizza Dough

The working environment was a dough station which consisted of a stainless steel table (32" in height) with a lower shelf (8" in height) for storage of other items. Included in the workstation were items used during the task: a flour bin, hand tools, and baking grates of three different sizes (See *Figure 4*).



Figure 4. Standard Dough Shaping Station at Papa John's Pizza Restaurant.

The task involves scraping a dough ball from a plastic container, coating it with a flour-like mixture, pressing the dough flat and circular, spreading the dough by hand to a larger size, and then slapping the dough to its final size. Flattening the dough by hand can be very hard on the wrists and upper body as the dough is very hard when fresh from the freezer. Force is applied at the finger tips while the wrists are bent in order to press the dough to a flat circular shape (See *Figure 5*). Often time's additional force from the

worker's body weight is required. This orientation creates a stressful moment at the wrists which over time could result in a CTD. Once flattened, the dough is spread by the left hand's outer edge held with some pressure against the inner edge of the dough's crust while the right hand is used in a similar fashion to spread and stretch the dough by making circular clockwise motions. This also requires a significant use of force, upper body strength and endurance. After spreading the dough it is picked up and slapped from hand to hand to further increase the size to its correct final diameter.



Figure 5. Pressing Pizza Dough with finger tips.

#### Methodology

Interviews were conducted with two employees, one male of 27 years of age and one female of 17 years of age, of Papa John's Pizza located in St. Petersburg, Florida.

Questions to the workers were asked regarding any discomfort and lasting pain in their bodies or extremities during or after work shifts. This information was taken into account to make assumptions of the CTD risk of the task of shaping pizza dough. A still color camera was used to photograph the work environment and details of the task. Both

subjects were interviewed independently without management present to eliminate outside variables and peer pressure.

### **Tools and Techniques**

In order to determine the risk of Cumulative Trauma Disorder (CTD) to this task the McCauley-Bell / Crumpton-Young Fuzzy Rating Scale for Evaluation of Cumulative Trauma Disorder Risk was applied. The three modules of task, personal and organizational were evaluated for relative significance and combined to calculate a comprehensive risk level for the three modules together.

#### Task Related Risk Factors

The task related risk factors were Awkward Joint Posture, repetition, Hand Tool Use, Force, Task Duration, and Vibration. Each of the factors was evaluated as high, medium, low or none (no risk associated with the factor).

Awkward Joint Posture: High – The task relies highly on the use of force exerted from the wrists and fingers. Cold dough is especially hard to work with as it is hardened in the freezer. As the dough warms to room temperature it becomes easier to use but decreases the quality of the end product and therefore cold dough is generally used. The hands are held at a near parallel angle with the table top as the worker presses firmly downward at the finger tips. While exerting great force (sometimes additional force is required in the form of the workers body weight by standing up on the toes) the wrists must rotate about the forearm. The movements become very unnatural and strenuous on the joints.

Repetition: High – Several hundred dough balls may need to be shaped in one night. The majority of which are done during a 3 hour time period know as "the dinner

rush." The task is done over and over until all orders are complete with no breaks during the dinner rush. This can become very exhaustive quickly without some bit of endurance training.

<u>Hand Tool Use:</u> Low – For the task of spreading dough a scraper is used to remove the dough from a plastic container. This portion of the task is very quick and requires little effort. Other menu items do require the use of hand tools but the task analyzed was limited to strictly spreading dough.

<u>Force:</u> Medium – The force required is significant but is not at a maximum level such that a person would be limited to a few cycles.

<u>Task Duration</u>: High – The task is performed at an approximate average
 maximum rate of 2 dough balls a minute. This results in several hundred cycles over a single shift with no break.

<u>Vibration:</u> None – There are no mechanical machines producing any vibration that the worker would encounter at the workstation.

#### Personal Risk Factors

The personal risk factors were evaluated using a female, age 17 and a male, age 27. The personal related risk factors evaluated were Previous CTD, Hobbies & Habits, Diabetes, Thyroid Problems, Age, and Arthritis or DJD. Each of the factors was evaluated as high, medium, low or none (no risk associated with the factor).

<u>Previous CTD:</u> None – Both subjects were of a young age and have not experienced or had been diagnosed with any CTD's.

<u>Hobbies and Habits:</u> Low – Both subjects engaged in athletics as well as other activities that involve hand manipulation for periods that exceed one hour.

<u>Diabetes:</u> None – Neither of the subjects have been diagnosed with Diabetes.

<u>Thyroid Problems:</u> None – Neither of the subjects have been diagnosed with Thyroid problems.

Age: Low – Both subjects were less than 30 years of age.

<u>Arthritis or DJD:</u> None – Neither of the subjects have been diagnosed with or experience symptoms of Arthritis.

## Organizational Risk Factors

The organizational risk factors were Equipment, Production Rate/ Layout, Ergonomics Program, Peer Influence, Training, CTD Level and Awareness. Each of the factors was evaluated as high, medium, low or none (no risk associated with the factor).

Equipment: High – There was no automation or any mechanical devices used in the task to aid the worker. Nearly every aspect of the task was performed by hand manipulation.

<u>Production Rate/ Layout:</u> High – On the days which are known to be busier the rate of production can be extremely high and exhaustive on the worker. The layout of the workstation provides the worker with everything he/she needs within arms reach and the worker will often have runners when supplies (dough or flour mix) run out.

<u>Ergonomics Program:</u> High – The workers were not aware of any ergonomic concerns, nor were any ergonomic plans in place that the workers were aware of. They reported receiving no training on ergonomic concerns.

<u>Peer Influence:</u> High – The whole operation of making a pizza begins with the dough station. The other workers down the "make line" and delivery drivers depend on

the production keeping up with their pace. High levels of pressure are on the dough worker to keep the output of the restaurant up to pace with the incoming calls.

<u>Training:</u> Medium – Becoming an experience and fast dough worker takes several weeks of training by the more experience workers to become proficient enough to work a rush shift. There is no training to address ergonomic issues, only training to perform the task as quickly as possible while maintaining quality.

<u>CTD Level:</u> High - The CTD level was evaluated as high because spreading the dough does involve movement of the tendons and ligaments in the wrists and hands for long durations with significant amounts of force.

<u>Awareness:</u> High – The level of ergonomic awareness was evaluated as none because no one was informed or trained on ergonomic issues. Employees were aware of the discomfort and pain they experienced after long shifts.

The level of existence for each factor (High, Medium, Low and None) was given a numerical score of 1.0, 0.5, 0.2 and 0.0 respectively. The relative weights of each of the risk factors were multiplied by the level of existence for each factor to obtain a numerical score for each of the three modules (Task, Personal and Organizational) and are presented in the Results section. An aggregate risk level was obtained by multiplying the module relative weights by the risk values (R-Values).

#### **Presentation of Results**

The task, personal and organizational risk factors are presented in the following tables:

	Levels	of Existence	High	Medium	Low	None
	for eve	ry Factor	1.0	0.5	0.2	0.0
	Task-Rela	ited Risk Fa	ctors			
	Awkward Joint Posture	Repetition	Hand Tool Use	Force	Task Duration	Vibration
Relative Weight Level of Existence	0.299 1.0	0.189 1.0	0.180 0.2	0.125 0.5	0.124 1.0	0.083 0.0
	0.299	0.189	0.036	0.063	0.124	0.000
			Task-F	Related Risk	Value (R₁) =	0.711

Table 5. Task-Related Risk Factors

Of the task related risk factors, the joint posture of the employee had the highest relative weight and represents the highest risk to the employee in developing a cumulative trauma disorder.

		f Existence ry Factor	High 1.0	Medium 0.5	0.2	None 0.0
	Personal F	Risk Factor	s			
Relative Weight	Previous CTD	Hobbies and Habits	Diabetes	Thyroid Problems	Age	Arthritis
Level of Existence	0.383 0.0	0.223 0.2	0.170 0.0	0.097	0.039	0.088
	0.000	0.045	0.000	0.000	0.008	0.000
			Pe	rsonal Risk \	/alue (R <sub>2</sub> ) =	0.052

Table 6. Personal Risk Factors

Of the personal risk factors, Hobbies and Habits had the highest relative weight and represents the highest risk to the employee in developing a cumulative trauma disorder.

	Organizati	onal Risk I	Factors				
	Equipment	Production Rate/ Layout	Ergonomics Program	Peer Influence	Training	CTD Level	Awareness
Relative Weight	0.346	0.249	0.183	0.065	0.059	0.053	0.045
Level of Existence	1.0	1.0	1.0	1.0	0.5	1.0	1.0
	0.346	0.249	0.183	0.065	0.030	0.053	0.045
				Organiza	ational Risk \	Value (R <sub>3</sub> ) =	0.971

Table 7. Organizational Risk Factors.

Of the organization risk factors, the Production Rate/Layout had the highest relative weight and represents the highest risk to the employee in developing a cumulative trauma disorder.

## Interpretation and discussion of Results

A summary table of the aggregate risk level is shown below:

	Determina	Determination of Aggregate Risl							
	Relative Weight	Risk Value (R-value)	Module Overall Risk						
3.510									
Task	0.637	0.711	0.453						
Personal	0.258	0.052	0.014						
Organizational	0.105	0.971	0.102						
Comprehens	ive Risk of In	jury Value =	0.568						

Table 8. Determination of Aggregate Risk Level.

Of the three modules, the Task-Related risk factors were shown to represent the greatest risk to the employee (module overall risk was calculated to be 0.453). This is due to the high relative weight value of the task-related risk factors (0.637) and the high calculated R-value.

The overall comprehensive risk of injury value is 0.568, which correlates to "average risk" to the employee. The table listing the categorization of aggregate numeric risk levels indicates the worker may experience minor musculoskeletal irritation regular basis but not excessive irritation.

# Task C: Use of a Becton-Dickinson FACSAria Flow Cytometer

The Becton-Dickinson FACSAria flow cytometer is used for the analysis and separation of distinct bacterial, plant and mammalian cells for biochemical and biomedical research. It is located in the DNA sequencing laboratory of the Biomedical Sciences building at the University of Central Florida. It is a highly complex and specialized piece of equipment that requires extensive training and is used by only a select few individuals that have received said training. *Figure 1* shows the work area of the BD FACSAria, which includes the flow cytometer (blue object, at central to upper left), the fluids cart (beneath) and the associated computer work station (on right).

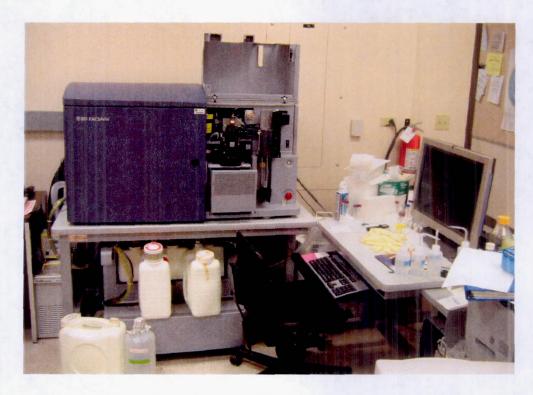


Figure 6. Becton-Dickinson FACSAria Flow Cytometer work station.

The two primary areas of the work station that are used by an operator during the processing of cells, the flow cytometer and the computer workstation. *Figure 2* shows the region of the flow cytometer where the samples are placed and the resultant separation of

the cells occurs. The computer workstation that controls the flow cytometer is shown in *Figure 3*. The fluidics cart is maintained by the administrator of the FACSAria and is typically not adjusted during normal use.



Figure 7. Flow Cytometer



Figure 8. Computer Work Station

## Methodology

As a qualified operator of the BD FACSAria flow cytometer, I (Martin Kline) used my knowledge of this system to determine the ratings for the task-related risk factors and the organizational-related risk factors. A digital camera was used to record images of the work station. For purposes of this lab exercise, three employees were utilized to complete the personal risk factors.

#### Effective use of tools and techniques

The technique that was used to determine the risk of Cumulative Trauma Disorder (CTD) was to apply the McCauley-Bell Fuzzy Rating Scale for Evaluation of Cumulative Trauma Disorder Risk. The three modules: task; personal and organizational were evaluated for relative significance.

#### Task Related Risk Factors

The task related risk factors were: Awkward Joint Posture; repetition; Hand Tool Use; Force; Task Duration; and Vibration. Each of the factors was evaluated as high, medium, low or none (no risk associated with the factor).

Awkward Joint Posture: Low – Occasionally during the use of the work area, adjustments are required on the flow cytometer. This includes the application of samples on the sample port, placement and insertion of post-sorting collection tubes and the occasional replacement/changing of solution containers on the fluidics cart. It also may involve the opening of the shield cover and movement of the nozzle and charge plates for optimal performance. Typically this is done either from the chair located at the station, or by the operator when standing.

Repetition: Low – Though a large number of samples may be worked with, the time between the changing of the samples is usually on the order of two to twenty minutes depending upon the method utilized. Most of the process is controlled through the computer, and while adjustments may be necessary through the use of the keyboard and mouse, they are not highly repetitive.

<u>Hand Tool Use</u>: Low – Placement of the nozzle and its very small rubber o-ring (approximately 2 mm in diameter) into the flow cytometer is very tedious and requires

the use of fine motor skills and tools. This, however, is usually only done once during each session. Also, due to the nature of the samples, latex gloves must be worn by the operator when they are manipulated.

<u>Force</u>: Low – The only need for any force is during the opening and closing of sterile tubes used to transport and collect separated samples.

<u>Task Duration</u>: High – Non-stop operational times of the machine can run from one to four hours, depending upon the number of samples and analysis/separation required. Due to the complexity of the flow cytometer, it cannot be left unsupervised.

<u>Vibration</u>: Low – The flow cytometer works under high pressure which is created by a pump. This pump is somewhat noisy and creates a low, but constant vibration during use of the work station.

#### Personal Risk Factors

The personal related risk factors were: Previous CTD; Hobbies & Habits; Diabetes; Thyroid Problems; Age; and Arthritis or DJD. Each of the factors was evaluated as high, medium, low or none (no risk associated with the factor). These personal risk factors were evaluated for three operators:

- (1) female age 28 in with a history of CTD probably onset by mild multiple sclerosis (MS) which at times results in fatigue and numbness in the extremities
- (2) male age 46 in good health, but slightly arthritic
- (3) female, age 58 previously diagnosed with carpal tunnel syndrome (CTS) and several other health issues (mild diabetes, thyroid problems and ex-smoker)

<u>Previous CTD</u>: (1) High – due primarily to MS; (2) Low – due to many years of lab work; (3) High – previously diagnosed with CTS

<u>Hobbies and Habits</u>: (1) Low – few hobbies; (2) Medium – long history of participation in impact sports; (3) Medium – past history of hobbies that required manual dexterity, however, reduced now due to chronic CTS

<u>Diabetes</u>: (1) None; (2) None; (3) Medium – recently diagnosed with type 2 diabetes

<u>Thyroid Problems</u>: (1) None; (2) None; (3) Medium – previous history of thyroid problems

Age: (1) Low; (2) Medium; (3) Medium

Arthritis or DJD: (1) Low – numbness of extremities, primarily from MS, but not arthritic (2) Medium – due to minor sports-related injuries; (3) Low – due to age, however, despite previous diagnosis of CTS, not diagnosed as arthritic Organizational Risk Factors

The organizational risk factors were: Equipment; Production Rate/ Layout; Ergonomics Program; Peer Influence; Training; CTD Level and Awareness. Each of the factors was evaluated as high, medium, low or none (no risk associated with the factor).

<u>Equipment</u>: Low – Despite the potential for long periods of time to be spent at the work station, the potential risk of acquiring CTD due to the machine is low.

<u>Production Rate/ Layout</u>: Low – The emphasis associated with this work station is on quality, not quantity. Therefore, the production rate would be considered low.

<u>Ergonomics Program</u>: Low – There is a safety department that oversees all aspects of the university, however, very little has been done to implement an ergonomics program within the department itself. Typically, laboratories are designed by outside vendors with little, to no input from the laboratory workers in regards to ergonomics.

<u>Peer Influence</u>: Medium – As with most large academic research endeavors, there is often a great deal of stress amongst the researchers to obtain publishable results.

<u>Training</u>: Low – All laboratory personnel are highly trained, especially before being allowed to use particular workstations (i.e., BD FACSAria flow cytometer).

CTD Level: Medium – While many activities within a laboratory setting have the capability of promoting a large number of highly repetitive movements, the CTD level was only evaluated as medium because typically these activities are often only a portion of the operators daily work load.

<u>Awareness</u>: Medium – While there is a safety department, an overall review of the changes in ergonomic awareness has not been viewed by this person.

The level of existence for each factor (High, Medium, Low and None) was given a numerical score of 1.0, 0.5, 0.2 and 0.0 respectively. The relative weights of each of the risk factors were multiplied by the level of existence for each factor to obtain a numerical score for each of the three modules (Task, Personal and Organizational) and are presented in the Results section. An aggregate risk level was obtained by multiplying the module relative weights by the risk values (R-Values).

#### Results

The task related, personal, and organizational risk factors are presented in the following tables.

Task-Related Risk Factors

	Awkward Joint Posture	Repetition	Hand Tool Use	Force	Task Duration	Vibration
Relative Weight Level of	0.299	0.189	0.180	0.125	0.124	0.083
Existence	0.2	0.2	0.2	0.2	1.0	0.2
	0.060	0.038	0.036	0.025	0.124	0.017

Task-Related
Risk Value (R<sub>1</sub>) = 0.299

Table 9. Task-Related Risk Factors

Of the task-related factors, the factor with the greatest contribution was the duration of the task.

Personal Risk Factors

Operator #1 Age - 28	Previous CTD	Hobbies and Habits	Diabetes	Thyroid Problems	Age	Arthritis
Relative Weight Level of Existence	0.383	0.223	0.170	0.097	0.039	0.088
	0.383	0.045	0.000	0.000	0.008	0.018

Personal Risk Value (R<sub>2</sub>) = 0.453

## Personal Risk Factors

Operator #2 Age - 46	Previous CTD	Hobbies and Habits	Diabetes	Thyroid Problems	Age	Arthritis
Relative Weight Level of Existence	0.383	0.223	0.170	0.097 0.0	0.039	0.088
	0.077	0.112	0.000	0.000	0.020	0.044

Personal Risk Value (R<sub>2</sub>) = 0.252

# Personal Risk Factors

Operator #3 Age - 58	Previous CTD	Hobbies and Habits	Diabetes	Thyroid Problems	Age	Arthritis
	010	riabits	Diabetes	1 100101113	7.90	74411143
Relative Weight Level of	0.383	0.223	0.170	0.097	0.039	0.088
Existence	1.0	0.5	0.5	0.5	0.5	0.2
	0.383	0.112	0.085	0.049	0.020	0.018

Personal Risk Value (R<sub>2</sub>) = 0.665

Table 10. Personal Risk Factors

Of the personal risk factors, it can be seen that operator #3, with her history of carpal tunnel syndrome, diabetes and prior thyroid condition has the highest personal risk

value. Even with her mild multiple sclerosis, operator #1 has a lower personal risk value than operator #3. Operator #2 has by far, the lowest personal risk value.

# Organizational Risk Factors

	Equipment	Production Rate/ Layout	Ergonomics Program	Peer Influence	Training	CTD Level	Awareness
Relative Weight Level of	0.346	0.249	0.183	0.065	0.059	0.053	0.045
Existence	0.2	0.2	0.2	0.5	0.2	0.5	0.5
	0.069	0.050	0.037	0.033	0.012	0.027	0.023

Organizational Risk Value (R<sub>3</sub>) = 0.249

Table 11. Organizational Risk Factors.

Of the organization risk factors, the equipment had the highest relative weight and represents the highest risk to the employee developing a cumulative trauma disorder.

# Interpretation and Discussion of Results

A summary table of the aggregate risk level for each operator is shown below.

# Determination of Aggregate Risk Level

Operator #1		Risk	Module
Age - 28	Relative	Value	Overall
	Weight	(R-value)	Risk
Task	0.637	0.299	0.191
Personal	0.258	0.453	0.131
Organizational	0.105	0.249	0.026

# Determination of Aggregate Risk Level

Operator #2	Relative	Risk	Module
Age - 46		Value	Overall
	Weight	(R-value)	Risk
Task	0.637	0.299	0.191
Personal	0.258	0.252	0.065
Organizational	0.105	0.249	0.026
		Comprehensive Risk of Injury Value =	0.282

# Determination of Aggregate Risk Level

Operator #3 Age - 58	Relative	Risk Value	Module Overall
	Weight	(R-value)	Risk
Task	0.637	0.299	0.191
Personal	0.258	0.665	0.172
Organizational	0.105	0.249	0.026
		Comprehensive Risk of Injury Value =	0.388

Table 12. Determination of Aggregate Risk Level.

After determination of the aggregate risk level it was seen that operator #3 has the highest overall comprehensive risk of injury value at 0.388. This places operator #3 in the upper end of the "some risk" category. The values for operator #1 and #2 also were

in the "some risk" category, but at a much lower value, especially for #2. Within this level the operators may be in the very early stages of CTD development. Irritation may be experienced, however, they are not expected to experience regular musculoskeletal irritation.

Of the three modules, only the Personal Risk accounts for the differences in the overall Comprehensive Risk Injury Value for each operator. This is due to the fact that the task and organizational risk is constant for each operator. The personal risk value contribution to the Comprehensive Risk Injury value for operator #3 is by far much greater than the other two.

### **Overall Conclusion**

This lab examined the CTD risk for three different tasks, those being constructing and repairing the Multi-Layer Insulation (MLI) blankets, preparing the dough for a pizza, and operating the Becton-Dickinson FACSAria flow cytometer. All three tasks were quite different from each other, but with McCauley-Bell and Badiru's (1993) formula, we were able to standardize the amount of risk across task, personal, and organizational factors to compare each task in the amount of CTD risk. With all the tasks, it was clear that the task related risk factors were highest, which was largely due to the high weight given to this factor. The risk for the personal and organizational factors for the MLI task were relatively close to each other, although the values depicted that the personal risk was slightly greater than the organizational risk. The operation of the flow cytometer yielded similar results to the MLI task. The greatest risk was with task related factors, and the least risk was associated with the organizational factors. All three values for the personal risk factor in the flow cytometer task, given that three different participants were used, ranged from .065 to .172. There was a clear difference between the participants, with one having significantly more risk than the other. This reveals how individual difference variables certainly need to be considered as the risk varies widely for each individual, which affects the overall risk.

The preparation of the pizza dough task resulted in widely different values from what was obtained with the other two tasks. There was a substantially larger risk from the task related factor, more than twice as much as with the other tasks. On the other hand, there was a very low personal risk as compared to the individuals used in the other tasks. Remarkably high as well for the pizza dough task was the organizational risk, which is

not really surprising given the other tasks were performed in labs, whereas this task was performed in a less formal setting. This large value, in addition to the large value for task related risk, resulted in a high overall risk, relative to the other two tasks analyzed.

Overall risk is calculated by the aggregation of task, personal, and organizational risk factors. The MLI task and flow cytometer task resulted in similar overall risk, even across the three different participants in the flow cytometer task. Whereas the pizza dough task resulted in the highest overall risk by far (.568), the flow cytometer task yielded the smallest overall risk for one of the participants (.282).

These results would suggest that there is certainly some risk of CTDs in all three of these tasks, across all of the participants. However, as significantly more risk was observed with the pizza dough task, a further ergonomic evaluation should continue with this task and some interventions should be implemented to lower this overall risk. Particularly alarming with the pizza dough task is that the personal risk factor was rather low. Had the personal risk been higher, in other words, if a person who was more prone to CTDs was used, the overall risk would have been even higher.

Across all three tasks, ergonomic interventions could take place with any of the risk factors. To reduce the organizational risk can be very difficult, given that the management might think it is a waste of time and money on something that may not ever be a problem, and because they are used to doing things a certain way. It can also be quite difficult to screen out everyone that might be a high risk for CTD. Therefore it would probably be easiest to lower the task related risk. Each of the three factors are multidimensional, thus being able to make a change in some of the subareas of the factor can make a difference.

Individual differences were clearly evident in this lab, showing the importance of considering those differences. Ideally, we would have assessed more workers that are typical of the population that does the particular task, as the goal is always to decrease the risk for as many people who do that task as possible. Using only one participant is likely not representative of the user population and thus can distort the results. The flow cytometer task was a good example of how analyzing several people gives a better idea of the overall risk, one that is likely more accurate of the entire user population.

This lab gave us practice using a very valuable ergonomic tool that we can use in future ergonomic evaluations. The ability to take any task and put everything on the same scale for standard assessment of the risk and comparison with other task is extremely useful. As mentioned in the introduction, CTDs are a major problem in the workplace environment and thus needs to be addressed. It causes a lot of pain, suffering, and loss of money and time for everyone involved. Most of this can be prevented with the combination of determining where the risks are and then lowering those risks through ergonomic intervention when possible. Although many ergonomic evaluations take place after an accident in the workplace has occurred, it is always better to prevent the accident from happening by assessing the risk beforehand, as opposed to waiting for an accident to happen.

#### References

- McCauley-Bell, P. R., & Crumpton, L. L. (2000). A fuzzy linguistic model for the prediction of carpal tunnel syndrome risks in an occupational environment. *IBM Journal of Research and Development*, 44 (5), 759-769.
- McCauley-Bell, P. & Badiru, A. (1993). Concept mapping as a knowledge acquisition tool in the development of a fuzzy rule-based expert system. *Proceedings of the Computers and Industrial Engineering Conference*, Vol. 25, No. 1-4, pp. 115-118.

Assessment of CTD Risk for 3 Different Tasks:
Constructing and repairing Multi-Layer Insulation
(MLI) Blankets, Preparing the Dough for a Pizza,
and Operating the Becton-Dickinson FACSAria
Flow Cytometer

Marc Gentzler, Marty Kline, Andrew Palmer,
Mark Terrone



- \*These injuries often fall under work related musculoskeletal disorders (e.g., Cumulative Trauma Disorders).
- \*Common CTDs occur in the areas of the back, neck, shoulders, hands, and other joints.
- \*A common CTD is carpal tunnel syndrome.

These disorders can be very painful and lower work efficiency and productivity. Eventually it can lead to the employee having to leave the job.



### CTD risk

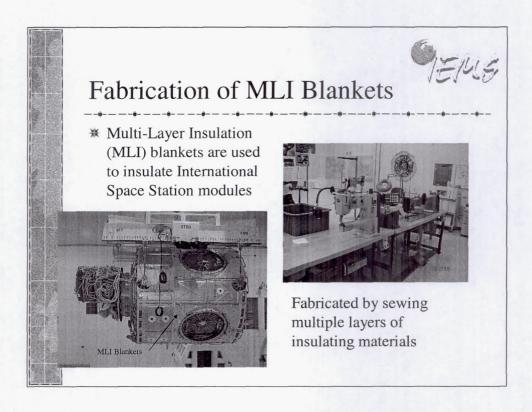
- \*Symptoms can develop without the person even realizing it.
- \* Of reported CTD cases, 48% of the victims were not well enough to return to work.
- \*The average rate of CTDs in high-risk occupations can be as high as 15-20%.
- ★ Costs for employees and employers.

These more long term musculoskeletal problems known in part as Cumulative Trauma Disorders (CTDs), as opposed to sudden accidents due to a lack of safety, actually can be harder to prevent because employers may not think about the risk, and sometimes neither do the employees themselves.

# McCauley-Bell and Crumpton (2000) CTD risk formula

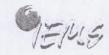
- ★ First step is to identify the risk factors.
- \*\* Three factors: task (weight = .637), personal (weight = .258), organizational (weight = .105).
- \* These risk factors themselves are multidimensional.
- \* Each factor subjectively assessed on a scale from 0 to 1.
  - 0 = no risk.
  - .2 = low risk.
  - .5 = medium risk.
  - ♦ 1 = high risk.

The drawback with McCauley-Bell and Crumpton's (2000) formula is the lower concentration on psychosocial factors compared to Goodson's (2006) study, which isolated psychosocial factors from task and personal risk factors. McCauley-Bell and Crumpton's (2000) formula can include some of these psychosocial factors as subcategories in the personal and organizational risk factors as opposed to having a separate category for those factors.



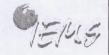
The work environment was located at the Kennedy Space Center in the Space Station Processing Facility. The environment was a sewing shop which is responsible for fabricating and repairing Multi-Layer Insulation (MLI) blankets. The MLI blankets are used externally to insulate the International Space Station elements. For the pressurized elements, the blankets are attached external to the pressure shell and underneath the Micrometeoroid Object Debris (MMOD) shields. *Figure 1* shows Node 1 with some of the MMOD shields (grey aluminum panels) missing and the MLI blankets (white) shown around the radial hatches. The raw materials are laid out on the tables in the sewing shop shown, and cut and trimmed per engineering drawings. The multiple layers of materials are stitched together using the sewing machines.

# MLI Blanket Task Task Factors



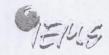
- \* Awkward Joint Posture: Medium Most of the sewing performed in the sew shop is done on a sewing machine.
- \* Repetition: Low Although sewing may seem like a repetitive task, the sewing that is performed in this shop is one step in the blanket fabrication process.
- \* Hand Tool Use: Low On occasion grommets need to be installed in the blankets.
- \* Force: Medium The blankets can be heavy and bulky.
- \* Task Duration: Medium The operator does not normally sit at the machine for an entire shift.
- \* <u>Vibration</u>: None The sewing machines are very well made and do not vibrate the operators' hands, feet or tables.

# MLI Blanket Task Personal Factors



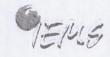
- \* The personal risk factors were evaluated using a hypothetical employee, female, age 52.
- \*\* Previous CTD: Low –minor complaints of wrist pain on an infrequent basis.
- \* Hobbies and Habits: Medium -has hobbies in her spare time.
- \* <u>Diabetes</u>: Low –has a family history of diabetes but does not exhibit any symptoms and gets tested regularly for signs of diabetes.
- \* Thyroid Problems: None –does not have thyroid or thyroid hormone production problems.
- \* Age: Medium.
- \* Arthritis or DJD: Low –has minor symptoms of arthritis.

# MLI Blanket Task Organizational Factors



- ★ Equipment: Medium The sewing machines that are used in the shop are state of the art equipment. The machines are programmable and include a task light.
- \*\* Production Rate/ Layout: Low Although the blanket repairs need to be timely, there is not a production rate that is implemented or enforced. The layout of the room is specifically designed for the task.
- \* Ergonomics Program: Low The recent LEAN activity identified a number of improvements to the efficiency of the shop including ergonomic improvements.
- \*\* Peer Influence: Low The supervisor explained that the workers tend to complement one another rather than compete against one another.

# MLI Blanket Task Organizational Factors



- \* Training: Medium The operators of the sewing machines receive On-the Job (OJT) training from the managers and other experienced operators. The training includes cutting the raw materials, reading engineering drawings and performing other blanket fabrication and repair tasks.
- \* <u>CTD Level</u>: Medium operating a sewing machine does involve movement of the tendons and ligaments in the wrists and hands.
- \* Awareness: Medium –prior to the LEAN activity (possibly for years), the shop had chairs that could not be adjusted to an ergonomically correct height for the sewing machine operators.

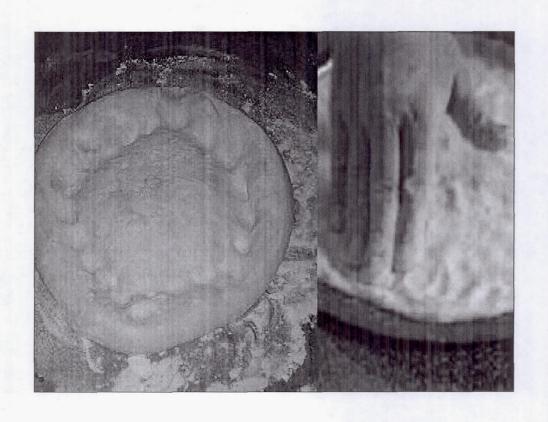
#### MLI Blanket Task Aggregate Risk Level Determination of Aggregate Risk Level Risk Module Overall Relative Value Weight (R-value) Risk 0.637 0.348 0.222 Task 0.067 0.258 0.259 Personal Organizational 0.105 0.351 0.037 Comprehensive Risk of Injury Value = 0.325



# Preparing Pizza Dough

- \* The working environment was a dough station which consisted of a stainless steel table (32" in height) with a lower shelf (8" in height) for storage of other items. Included were a flour bin, hand tools, and baking grates of three different sizes.
- \* The task involves scraping a dough ball from a plastic container, coating it with a flour-like mixture, pressing the dough flat and circular, spreading the dough by hand to a larger size, and then slapping the dough to its final size.

Flattening the dough by hand can be very hard on the wrists and upper body as the dough is very hard when fresh from the freezer. Force is applied at the finger tips while the wrists are bent in order to press the dough to a flat circular shape Often time's additional force from the worker's body weight is required. This orientation creates a stressful moment at the wrists which over time could result in a CTD. This also requires a significant use of force, upper body strength and endurance.





# Preparing Pizza Dough

- \*\* Once flattened, the dough is spread by the left hand's outer edge held with some pressure against the inner edge of the dough's crust while the right hand is used in a similar fashion to spread and stretch the dough by making circular clockwise motions.
- \*\* After spreading the dough it is picked up and slapped from hand to hand to further increase the size to its correct final diameter.

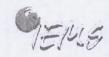
# Pizza Dough Task Task Factors



- \*\* Awkward Joint Posture: High The task relies highly on the use of force exerted from the wrists and fingers. The hands are held at a near parallel angle with the table top as the worker presses firmly downward at the finger tips. While exerting great force the wrists must rotate about the forearm.
- \*\* Repetition: High Several hundred dough balls may need to be shaped in one night. The majority of which are done during a 3 hour time period known as "the dinner rush." The task is done with no breaks during the dinner rush.

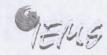
Cold dough is especially hard to work with as it is hardened in the freezer. As the dough warms to room temperature it becomes easier to use but decreases the quality of the end product and therefore cold dough is generally used. The movements become very unnatural and strenuous on the joints. (sometimes the workers use body weight by standing up on the toes)

## Pizza Dough Task Task Factors



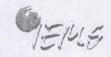
- \* Hand Tool Use: Low For the task of spreading dough a scraper is used to remove the dough from a plastic container. This portion of the task is very quick and requires little effort.
- \* Force: Medium The force required is significant but is not at a maximum level such that a person would be limited to a few cycles.
- \* Task Duration: High The task is performed at an approximate average maximum rate of 2 dough balls a minute. This results in several hundred cycles over a single shift with no break.
- \* <u>Vibration:</u> None There are no mechanical machines producing any vibration that the worker would encounter at the workstation.

# Pizza Dough Task Personal Factors



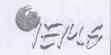
- ★ The personal risk factors were evaluated using a female, age 17.
- \* Previous CTD: None
- \* Hobbies and Habits: Low –engaged in athletics as well as other activities that involve hand manipulation for periods that exceed one hour.
- \* Diabetes: None
- \* Thyroid Problems: None
- \* Age: Low
- ★ Arthritis or DJD: None

# Pizza Dough Task Organizational Factors



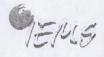
- \*\* Equipment: High There was no automation or any mechanical devices used in the task to aid the worker. Nearly every aspect of the task was performed by hand manipulation.
- \*\* Production Rate/ Layout: High On the days which are known to be busier the rate of production can be extremely high and exhaustive on the worker.
- \*\* Ergonomics Program: High The workers were not aware of any ergonomic concerns, nor were any ergonomic plans in place that the workers were aware of. They reported receiving no training on ergonomic concerns.
- Peer Influence: High –The other workers down the "make line" and delivery drivers depend on the production keeping up with their pace. High levels of pressure are on the dough worker to keep the output of the restaurant up to pace with the incoming calls.

# Pizza Dough Task Organizational Factors



- ★ <u>Training:</u> Medium Becoming an experience and fast dough worker takes several weeks of training by the more experience workers to become proficient enough to work a rush shift. There is no training to address ergonomic issues, only training to perform the task as quickly as possible while maintaining quality.
- \* CTD Level: High The CTD level was evaluated as high because spreading the dough does involve movement of the tendons and ligaments in the wrists and hands for long durations with significant amounts of force.
- \*\* Awareness: High The level of ergonomic awareness was evaluated as none because no one was informed or trained on ergonomic issues. Employees were aware of the discomfort and pain they experienced after long shifts.

# Pizza Dough Task Aggregate Risk Level

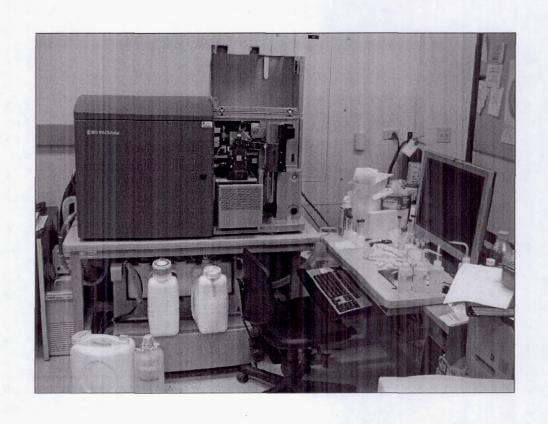


	Determination of Aggregate Risk Level			
	Relative Weight	Risk Value	Module Overall Risk	
Task	0.637	0.711	0.453	
Personal	0.258	0.052	0.014	
Organizational	0.105	0.971	0.102	
		Comprehensive Risk of Injury Value =	0.568	

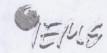


# Flow Cytometer Task

- \*\* The Becton-Dickinson FACSAria Flow
  Cytometer is used for the analysis and separation
  of distinct bacterial, plant and mammalian cells for
  biochemical and biomedical research.
- \*\* It is a highly complex and specialized piece of equipment that requires extensive training and is used by only a select few individuals that have received said training.



# Flow Cytometer Task Task Factors



- \* Awkward Joint Posture: Low Occasionally during the use of the work area, adjustments are required on the Flow Cytometer. Typically this is done either from the chair located at the station, or by the operator when standing.
- \* Repetition: Low Though a large number of samples may be worked with, the time between the changing of the samples is usually on the order of two to twenty minutes depending upon the method utilized.
- \* Hand Tool Use: Low Placement of the nozzle and its very small rubber o-ring (approximately 2 mm in diameter) into the Flow Cytometer is very tedious and requires the use of fine motor skills and tools. This, however, is usually only done once during each session.
- Force: Low The only need for any force is during the opening and closing of sterile tubes used to transport and collect separated samples.
- \*\* Task Duration: High Non-stop operational times of the machine can run from one to four hours, depending upon the number of samples and analysis/separation required.
- <u>Vibration</u>: Low The Flow Cytometer works under high pressure which is created by a pump. This pump is somewhat noisy and creates a low, but constant vibration during use of the work station.

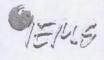
# Flow Cytometer Task Personal Factors Person 1



- ₩ Previous CTD: High due primarily to MS.
- ★ Hobbies and Habits: Low few hobbies.
- \* Diabetes: None.
- \*\* Thyroid Problems: None.
- \* Age: Low.
- \*\* Arthritis or DJD: Low numbness of extremities, primarily from MS, but not arthritic.

female age 28 in with a history of CTD probably onset by mild multiple sclerosis which at times results in fatigue and numbness in the extremitites

# Flow Cytometer Task Personal Factors Person 2



- \*\* Previous CTD: Low
- ★ Hobbies and Habits: Medium long history of participation in impact sports.
- <u>★ Diabetes</u>: None.
- \* Thyroid Problems: None.
- **★** <u>Age</u>: Medium.
- \*\* Arthritis or DJD: Medium due to minor sports-related injuries.

male age 46 in good health, but slightly arthritic

# Flow Cytometer Task Personal Factors Person 3



- \* Previous CTD: High previously diagnosed with CTS.
- \* Hobbies and Habits: Medium past history of hobbies that required manual dexterity, however, reduced now due to chronic CTS.
- <u>★ Diabetes</u>: Medium recently diagnosed with type 2 diabetes.
- \*\* Thyroid Problems: Medium previous history of thyroid problems.
- \* Age: Medium.
- \* Arthritis or DJD: Low due to age, however, despite previous diagnosis of CTS, not diagnosed as arthritic.

female, age 58 previously diagnosed with carpal tunnel syndrome (CTS) and several other health issues (mild diabetes, thyroid problems and ex-smoker)

# Flow Cytometer Task Organizational Risk Factors

- ors JEILE
- ★ Equipment: Low Despite the potential for long periods of time to be spent at the work station, the potential risk of acquiring CTD due to the machine is low.
- \* Production Rate/ Layout: Low The emphasis associated with this work station is on quality, not quantity.
- \*\* Ergonomics Program: Low There is a safety department that oversees all aspects of the university, however, very little has been done to implement an ergonomics program within the department itself. Typically, laboratories are designed by outside vendors with little, to no input from the laboratory workers in regards to ergonomics.
- \* Peer Influence: Medium As with most large academic research endeavors, there is a often a great deal of stress amongst the researchers to obtain publishable results.

# Flow Cytometer Task Organizational Risk Factors

- \* Training: Low All laboratory personnel are highly trained, especially before being allowed to use particular workstations (i.e., BD FACSAria flow cytometer).
- \* CTD Level: Medium While many activities within a laboratory setting have the capability of promoting a large number of highly repetitive movements, typically these activities are often only a portion of the operators daily work load.
- \* Awareness: Medium While there is a safety department, an overall review of the changes in ergonomic awareness has not been viewed by this person.

# Flow Cytometer Task Aggregate Risk Factors Person 1

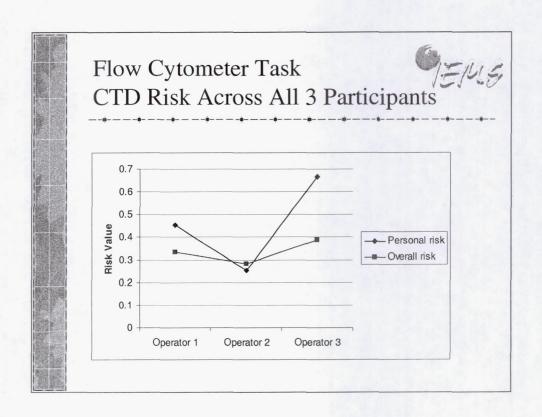
	Determination of Aggregate Risk Level			
	Relative Weight	Risk Value	Module Overall Risk	
Task	0.637	0.299	0.191	
Personal	0.258	0.453	0.117	
Organizational	0.105	0.249	0.026	
		Comprehensive Risk of Injury Value =	0.334	

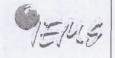
# Flow Cytometer Task Aggregate Risk Factors Person 2

	Determination of Aggregate Risk Level		
	Relative Weight	Risk Value	Module Overall Risk
Task	0.637	0.299	0.191
Personal	0.258	0.252	0.065
Organizational	0.105	0.249	0.026
		Comprehensive Risk of Injury Value =	0.282

# Flow Cytometer Task Aggregate Risk Factors Person 3

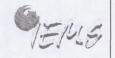
	Determination of Aggregate Risk Level		
W 72	Relative Weight	Risk Value	Module Overall Risk
Task	0.637	0.299	0.191
Personal	0.258	0.665	0.172
Organizational	0.105	0.249	0.026
		Comprehensive Risk of Injury Value =	0.388





### Conclusions

- \*\* For the Multi-Layer Insulation (MLI) blanket task, the task, personal, and organizational risks were at about the same moderate level.
- \*\* For the pizza dough task, the task and organizational risk was at quite dangerous levels. On the other hand, there was a very low level of personal risk factors, based on a female age 17.



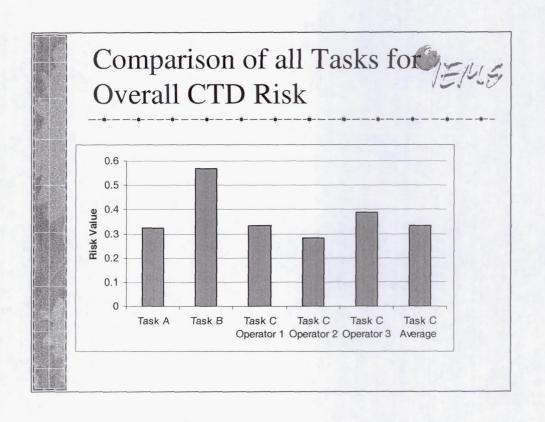
### Conclusions

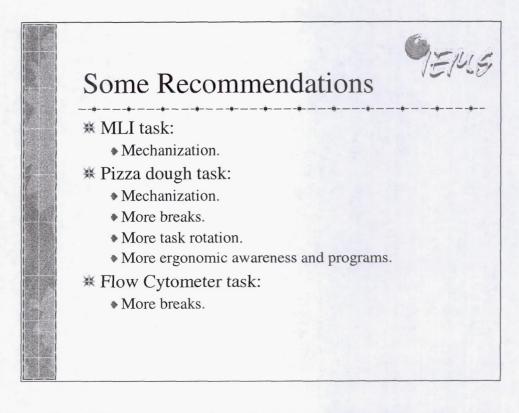
- \*\* The Flow Cytometer task was assessed with three different participants, all of whom had quite disparate levels of personal risk. This reveals how individual difference variables certainly need to be considered.
- \*\* The task and organizational risks for this task were rated at about the same moderate level. The overall CTD risk averaged across the three participants was .335, indicating some risk.



### Conclusions

\*\* Comparing across the tasks revealed that the pizza dough task created the greatest overall CTD risk by far (.568), with the MLI (.325) and Flow Cytometer task (.335) having some risk associated with them.





It would probably be easiest to lower the task related risk. Each of the 3 factors are multidimensional, thus being able to make a change in some of the subareas of the factor can make a difference.