

PB2003-102818



**CALIFORNIA AGRICULTURAL ERGONOMICS  
PROGRAM TRIAL**



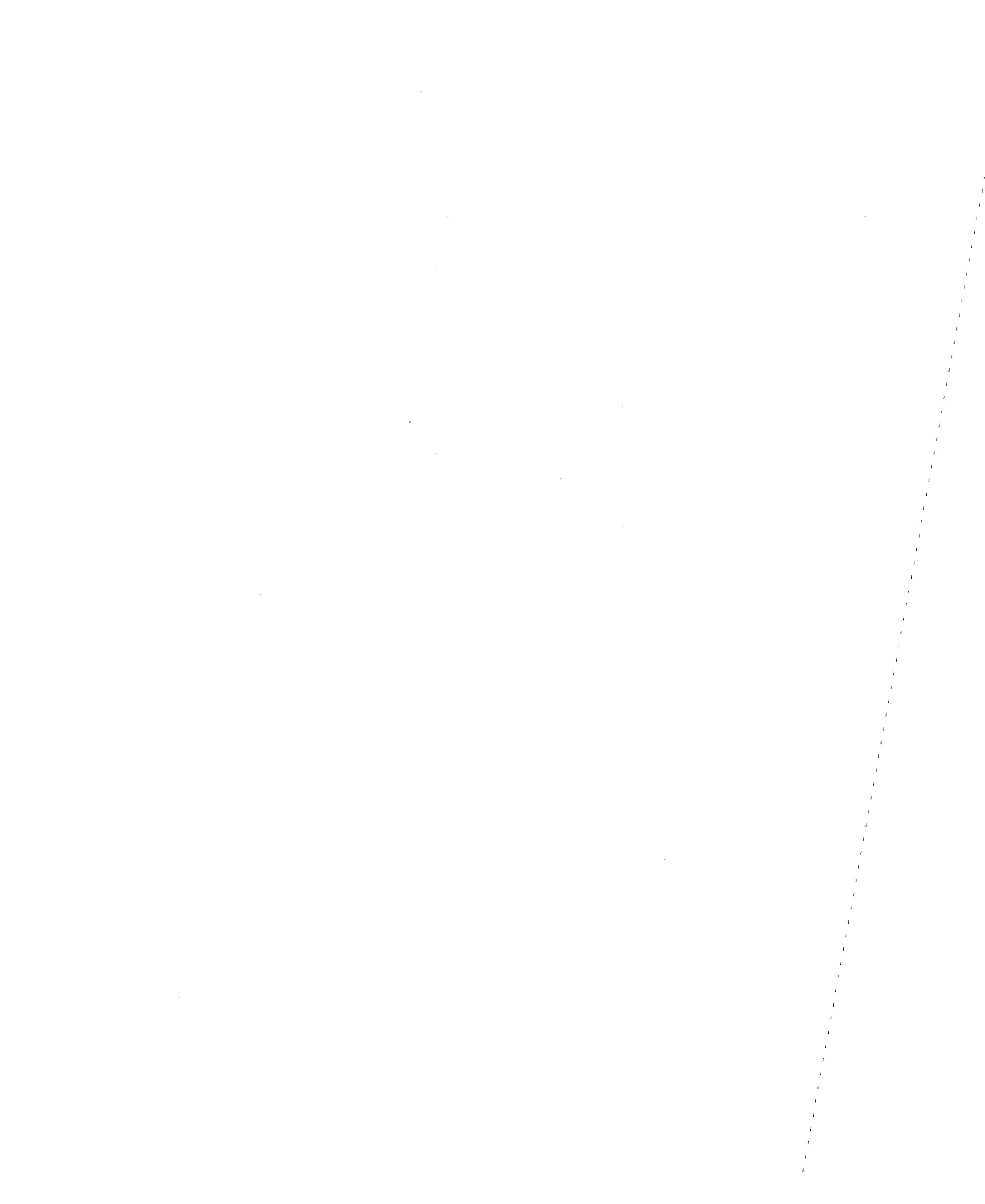
**INTERVENTION STUDIES IN AGRICULTURAL  
SAFETY AND HEALTH**

**FINAL REPORT**

**UNIVERSITY OF CALIFORNIA  
AGRICULTURAL ERGONOMICS RESEARCH CENTER**

**June 2002**

**FUNDED BY  
NATIONAL INSTITUTE FOR  
OCCUPATIONAL SAFETY & HEALTH  
COOPERATIVE AGREEMENT PHS-RO1 OH14508**



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## PREFACE

This is a report on the goals, methods, implementation and results of the California Agricultural Ergonomics Program Trial of the University of California as proposed to and funded by the National Institute for Occupational Safety and Health in Continuing Agreement PHS-RO1 OH14508. This project terminated in November 2001 however a 3-month extension was awarded to enable assessment of data from the 2001 tomato harvest.

This report is intended to serve as the final project report. Publications emanating from the project up to the time of report submission are attached.

The principal investigators, staff, and cooperators involved express their appreciation to the NIOSH Intervention Studies in Agricultural Safety and Health program and to Ms. Terry Palermo and Ms. Janet Ehlers, NIOSH project officers for their unstinting support in making the project possible and successful.

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## **EXECUTIVE SUMMARY**

The California Agricultural Ergonomics Program Trial of the University of California was funded by the National Institute for Occupational Safety and Health in Continuing Agreement PHS-RO1 OH14508. This project terminated in November 2001 however a 3-month extension was awarded to enable assessment of data from the 2001 tomato harvest.

Project Goal – to conduct cooperative demonstration programs that will result in a set of “best practices” guidelines for ergonomics programs in agricultural workplaces and also serve as intervention trials to help determine the efficacy of such programs as implemented in agriculture.

The project proposed to:

1. provide the agricultural community with peer demonstrations of model ergonomics programs for their workplaces;
2. provide information from which a “best practices” model program can be developed for agriculture;
3. provide data on the performance of “best practices” ergonomics programs in different agricultural workplaces in reducing reported incidence and symptoms of musculoskeletal disorders; and
4. add to research knowledge about the preventive efficacy of ergonomics programs

All project goals and specific aims were successfully achieved. The project conducted cooperative trials of implementation of the California OSHA ergonomics standard with five different agricultural cooperators of different sizes and growing different commodities.

A best practices approach to implementation of the California OSHA standard was developed based on UC Agricultural Ergonomics Research Center(UC AERC) experience and consultation with both cooperators and California OSHA. That approach and the associated educational materials were employed to develop ergonomics programs with five different cooperators. The results were evaluated for each cooperator according to an assessment of 5 aspects as follows.

1. Satisfactory employer compliance with 8 CCR Section 5110, including:
  - evaluation of worksite ergonomic hazards
  - implementation of feasible hazard exposure controls; and
  - employee training on repetitive motion injuries and their prevention
2. Transferability potential of hazard controls implemented
3. Ergonomics effects of hazard controls implemented
4. Health effects of hazard controls implemented, and
5. Productivity effects of hazard controls implemented.

Each of the five cooperators complied at least minimally with the standard, implementing hazard controls appropriate to their operation. The effectiveness of these controls varied considerably, and in one case, cotton, the strategy employed merely transferred the exposure from company employees to contractor employees. For the most part the project was faced with a serious lack of proven engineering controls commercially available to apply to the exposures involved.

In addition to engineering controls, the project employed an administrative control in two instances of stoop labor tasks. This control consisted of increasing rest and recovery time to 5 minutes in each working hour in which no other break was scheduled. This strategy was found to have positive health effects and not to cause serious productivity losses. This strategy will be further investigated. However, its use is indicative of the real lack of engineering interventions available for jobs involving stooped posture.

The project determined that the best practices approach enabled satisfactory good faith response efforts for most involved employers. In turn, while the hazard controls involved were not all successful, a variety of new engineering approaches were investigated and some show promise for the future. Supplemented with effective administrative controls, it seems clear that dedicated agricultural employers can comply with the standard. However, simple compliance with the elements of the standard may not necessarily lead to significantly reduced worker hazard exposure. Because there is a lack of commercially available controls for many common agricultural hazards, there is need for expert engineering consultation in many instances.

**Goal 1. Provide the agricultural community with peer demonstrations of model ergonomics programs for their workplaces.**

Five different agricultural employers, involving more than 1300 employees, participated in this project. Each employer complied with the requirements of the California OSHA ergonomics standard and each implemented one or more hazard control interventions that were evaluated by the research team.

These cooperators represented different commodities and sizes and scales of operation. A wide variety of workplace ergonomics risk factors were identified and evaluated. Twelve different types of hazard controls were evaluated for seven different jobs, for their field practicality, ergonomics and health outcomes efficacy, and effects on workplace productivity.

The project provided a demonstration to the agricultural community that employers in widely differing circumstances and hazard situations could satisfactorily comply with the California OSHA ergonomics standard.

**Goal 2. Provide information from which a “best practices” model program can be developed for agriculture.**

The “best practices” model put to field trial in this study, derived from two primary sources. First, was California OSHA itself, which has published extensive compliance resource information (e.g., Easy Ergonomics, DIR, Sacramento, 1999) and which provided specific feedback on project activities. Second, was the extensive field research experience of the UC Agricultural Ergonomics Research Center in identifying and developing interventions for worker ergonomics risk factor exposures in agricultural workplaces.

The “best practices” model itself consists of the following procedures, all explained and supported in an employers’ guide and supporting educational materials.

1. Identify priority workplace ergonomics hazards
  - a) Review of OSHA 200 log and injury records for jobs associated with MSDs
  - b) Evaluation of workplace jobs' ergonomics risk factor exposures
  - c) Survey workers' and supervisors' opinions about "risky" jobs
  - d) Identify jobs ranking high on all three lists as priorities for intervention
  
2. Educate and involve workers
  - a) Appoint a worker-supervisor ergonomics committee
  - b) Involve committee in ergonomics program development and implementation
  - c) Provide information on ergonomics program, MSDs and their control in workers' primary language
  
3. Develop and implement hazard controls
  - a) Identify most serious ergonomics risk factor exposures in priority jobs
  - b) Consult workers, engineers, safety experts, and others on possible controls
  - c) Give priority to engineering controls that eliminate or reduce targeted exposures
  - d) Employ administrative controls where no practical engineering controls are available
  
4. Evaluate efficacy and practicality of controls
  - a) Evaluate practicality of controls
  - b) Evaluate productivity effects of controls
  - c) Evaluate worker satisfaction with controls
  - d) Monitor injury prevention effect of controls

**Goal 3. Provide data on the performance of "best practices" ergonomics programs in different agricultural workplaces in reducing reported incidence and symptoms of musculoskeletal disorders.**

**Goal 4. Add to research knowledge about the preventive efficacy of ergonomics programs.**

The above best practices model was articulated in a special employers' guide to ergonomics used to develop and guide interventions with five cooperating agricultural employers. All but one of the cooperators complied with all steps set out in the model approach.

During the course of the project more than 12 different types of ergonomics hazard controls were given field trial and evaluation in these five different agricultural workplaces. The intervention trials themselves directly involved over 250 workers. Table 1 below summarizes those interventions and their outcomes.

Table 1  
INTERVENTION SUMMARY

COOPERATOR	JOBS TARGETED	INTERVENTIONS	OUTCOMES
Citrus Packing	Box Sealer	Removed Conduit Under Footing	Eliminated underfoot contact stress
	Grading-Choice	Removed Upper Conveyor-Relocated to Center of Main Conveyor	Eliminated awkward upward toss. No significant change in reported symptoms
	Grading-Export	Provided Kneeling Chairs for Graders	Allowed graders to sit at conveyor facing fruit. No significant change in reported symptoms.
Cotton Production	Hand Weeding	Contracted Job Out	Permanent worker exposure eliminated
		Alternate Weeding Tools	Not Implemented
Tomato Harvest	Sorter	Padded Sorter Apron	Workers liked aprons. No significant fatigue or symptom reduction
		Padding on Machine	Not Practical
		Shading on Machine (to reduce temperature)	Reduced airflow-increased temperature
Strawberry Harvest	Hand Harvest	Added Rest Breaks	Significant symptom reduction
		Weight Transfer Devices	Not Practical – one judged potentially effective
		Prone Cart	Not Practical
Tree Nursery	Grafting/Budding	Added Rest Breaks	Significant symptom reduction
		Prone Cart	Not Practical
		Kneeling Cart	Not Practical

Among the important findings of this study of the implementation of the California workplace ergonomics standard in agricultural workplaces are the following.

- 1) *Responsive agricultural employers can and will make positive, "good faith" efforts at complying with both the language and the intent of the regulation.*
- 2) *Responsive agricultural employers may need external consultation to develop compliance programs that are efficacious in reducing ergonomics hazard exposures.*

- 3) *There are not commercially available, "off-the-shelf" tools or technologies for most of the most serious ergonomics hazards found in these agricultural workplaces.*
- 4) *Agriculture's generally low profit margins inhibit capacity and enthusiasm for expensive or fundamental changes in technology or practice.*
- 5) *It is unclear that good faith compliance with the elements of the California regulation will result in significant reduction of the most serious ergonomics hazard exposures.*
- 6) *Active involvement of workers in improved prevention programs faces obstacles in agricultural workplaces.*

In summary, it is clear from this study that agricultural employers can and will find means of complying in good faith with the state's ergonomics standard. Further, it seems clear that at minimum the standard will bring about much improved and widespread understanding of the nature and causes of MSDs, which may, in turn, lead to improved prevention in the future. But, it also seems clear that serious investment in development and testing of new engineering interventions designed to address the most egregious and common ergonomics hazards found in agricultural workplaces is badly needed. Especially needed are those associated with sustained or repetitive stooped posture and with highly repetitive handwork such as cutting or clipping.

The results reported here have importance in both the policy and research areas. The California workplace ergonomics standard was the first in the nation of its kind and remains politically controversial. It is important to communicate the finding from this study that agricultural employers can achieve satisfactory compliance without feared damage to workplace productivity. In addition, we have provided a best practices model for agricultural employers with supporting written information. Finally, information has been provided on the relative efficacy of a variety of hazard control approaches and the serious lack of commercially available alternatives for situations that will be faced by many agricultural employers seeking to reduce workplace hazard exposure.

To date, 12 papers reporting findings from this research have been published or presented at scientific meetings. Additional research publications are planned or are in review.

## **PROJECT GOALS AND OBJECTIVES**

The UC Agricultural Ergonomics Research Center (UC AERC) is a multi-disciplinary team of UC researchers dedicated to application of ergonomics methods to the identification, analysis and prevention of musculoskeletal disorders (MSDs) in agricultural work. In 1997, the California Occupational Safety and Health Administration (CAL-OSHA) implemented the nation's first workplace regulation regarding prevention of MSDs. Because the UC AERC was familiar with the high rate of MSD incidence in agricultural workplaces and enjoys excellent cooperative relations with the industry, a project was envisioned to subject the new standard to field trial by treating it as an intervention in multiple agricultural workplaces.

Project Goal – to conduct cooperative demonstration programs that will result in a set of “best practices” guidelines for ergonomics programs in agricultural workplaces and also serve as intervention trials to help determine the efficacy of such programs as implemented in agriculture.

The project proposed to:

1. provide the agricultural community with peer demonstrations of model ergonomics programs for their workplaces;
2. provide information from which a “best practices” model program can be developed for agriculture;
3. provide data on the performance of “best practices” ergonomics programs in different agricultural workplaces in reducing reported incidence and symptoms of musculoskeletal disorders; and
4. add to research knowledge about the preventive efficacy of ergonomics programs.

Stated specific aims included:

- ◆ Recruit cooperating partners from agricultural industry, community, and other groups;
- ◆ Describe and prioritize ergonomic risk factors and hazards for MSDs (including back injuries and CTDs) in cooperators' operations;
- ◆ Assess the incidence of MSDs among workers;
- ◆ Cooperatively agree on ergonomics program priorities;
- ◆ Cooperatively design and agree on ergonomics program plan;
- ◆ Articulate a “best practices” model for agricultural ergonomics programs;
- ◆ Implement ergonomics programs with cooperators;
- ◆ Measure post-intervention impact of programs on incidence of MSDs with involved workers;
- ◆ Re-evaluate ergonomic risk factors and hazards for MSDs in cooperators' operations;
- ◆ Assess productivity impacts and perceived “adoptability” of programs;
- ◆ Evaluate cooperative program intervention trials in comparison with pre-intervention analyses;
- ◆ Communicate project findings to agricultural groups, workers, and community interests; and
- ◆ Report project findings in appropriate research and professional publications.

## PROJECT COOPERATORS

Four farming operations and one packing company participated in this project. The farming operations included a cotton grower, a strawberry grower, a general farming company with focus on tomato production, and a tree nursery. More than 300 workers directly participated in the project and training information was disseminated beyond the direct participants.

Participating operations were of different sizes and different commodities by design. These industries are almost completely non-union in California, and there was no active union representation at any of the cooperator sites. The majority of workers in these operations are Spanish-speaking, from Mexico. They earn an average of about \$8-10 per hour. All of these cooperators have active injury and illness prevention programs. Provision of worker's compensation insurance benefits is required in California.

Table 2, below summarizes cooperating partners' descriptive information. More detailed descriptions for each cooperator are included in the appendix.

Table 2  
Cooperating Employers' Descriptive Information

Operation type	Total # workers	# workers in intervention studies	Operation size
Citrus Packing	106	54	424,694,460 cases packed/yr
Cotton Production	500	43	80,000 acres
Strawberry Harvest	108	80	65 acres
Tree Nursery	250	54	900 acres
Tomato Harvest	400	21	2000 acres

These cooperators were true partners in the project in the fullest sense of the term from the beginning of project implementation planning. In securing their agreement to cooperate, the project staff specified with each cooperator that they would:

- participate for the full term of the project
- provide for direct participation of both workers and management
- provide full access to injury and 1st aid records as required by the project
- appoint a workers' ergonomics committee to interact with the research team
- provide full access to participating workers and the worksite for project purposes for the full term of the project
- communicate project goals, methods, and procedures in understandable form (including provision of information in Spanish)
- participate on a cooperative and interactive basis (including shared evaluation and decision making about intervention development and trials) with research team on all action steps
- decide what intervention trials will be conducted at their worksite
- conduct intervention trials as agreed to and supervised by the research

- team at their worksite
- participate in result review and analysis
- participate in agricultural industry dissemination of results.

In a fully cooperative project, all procedures must be understood and accepted by all participants if they are to be appropriately performed and confidence held in the resulting data. All interventions must have the full approval of both workers and employers if they are to be given fair and full trial. We made a point of actively involving workers and managers in all aspects of this project, including development. Bi-lingual project field staff visited cooperating worksites at least monthly (and often daily) throughout each intervention trials' active phase, directly interacting with workers and managers. Much of this project's success is founded on the approach of making the cooperators full partners in key project decision-making.

## **METHODS**

The study was designed as a series of intervention trials, with workers in most trials serving as their own controls in the pre-intervention conditions. The project focused on differing types of agricultural operations as a means of ensuring that recommended practices would prove practical and efficacious in the diversity of commodities, workplaces, and tasks involved in the agriculture industry. Operations representing five quite different commodities, and of different sizes were involved. Most were known to have histories of reported employee MSDs. Most employees are Mexican farmworkers, with the majority resident in local communities. For the most part, workers involved had limited English, being fluent in Spanish. Workers participating in pre- and post-intervention studies were those identified as regularly assigned to perform the task in question. Random selection of workers was not possible since many of the tasks require special skills or experience. Thus, all workers performing the selected tasks were asked to participate

### *California OSHA Ergonomics Standard*

The heart of the California ergonomics standard is a requirement that subject employers implement a three-part ergonomics program. Employers reporting two or more workers with medically diagnosed "repetitive motion injuries" (California OSHA, 1997) in a 12-month period among workers performing the same job must:

1. conduct an evaluation of worksite ergonomic hazards;
2. implement feasible hazard exposure controls; and
3. provide employee training on repetitive motion injuries and their prevention (California OSHA, 1997).

### *Best Practices Model*

To generate the information needed to develop a "best practices" model program, three broad steps were planned. The first step was to review California OSHA's published materials on the standard, implementation of the standard, recommended ergonomics procedures and resources. The second step was to use the field experience of the UC AERC to create a set of informational guidelines for employers, supplemented with educational information for workers and supervisors. Third, after the model had been implemented with at least one cooperator, it was reviewed in depth by the staff and with California OSHA Consultation staff for its regulatory adequacy and its field usability.

The resulting best practices model is described as follows.

1. Identify priority workplace ergonomics hazards
  - e)* Review OSHA 200 log and injury records for jobs associated with MSDs
  - f)* Evaluate workplace jobs ergonomics risk factor exposures
  - g)* Survey workers and supervisors opinions about “risky” jobs
  - h)* Identify jobs ranking high on all three lists as priorities for intervention
  
2. Educate and involve workers
  - d)* Appoint a worker-supervisor ergonomics committee
  - e)* Involve committee in ergonomics program development and implementation
  - f)* Provide information on ergonomics program, MSDs and their control in workers’ primary language
  
3. Develop and implement hazard controls
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4. Evaluate efficacy and practicality of controls
  - e)* Evaluate practicality of controls
  - f)* Evaluate productivity effects of controls
  - g)* Evaluate worker satisfaction with controls
  - h)* Monitor injury prevention effect of controls

In order to implement the model approach, each cooperating employer was required to appoint an ergonomics committee made up of supervisors and workers of their choice. This committee interacted with the research team on every step of workplace ergonomics program planning and implementation at their worksite. This included: 1) participating in ergonomics hazard evaluation; 2) participating in selection and development of hazard controls and recommendation of controls to management; and 3) participation in development and delivery of worksite ergonomics education programs.

Interaction with cooperator's ergonomics committees generally proceeded in 4 stages as follow:

#### 1. Orientation and Training

This stage consisted of three meetings during which the committee was educated in the basics of ergonomics and repetitive motion injuries (RMI). During the first meeting, the committee was oriented to the Cal OSHA standard and introduced to the concepts of ergonomics and ergonomics risk factors. During the second meeting, the committee was introduced to the Quick Check risk factor checksheet and used it to analyze jobs at the worksite under supervision by the researchers. During the third meeting, the committee was introduced to the nature of RMIs and analyzed the company's workplace safety records under the supervision of the researchers.

## 2. Evaluation of High Risk Jobs

In the second stage the committee reviewed three types of data to identify jobs with the highest risk for RMIs. First, data on workplace injuries were reviewed and jobs were ranked according to associated reported and diagnosed RMIs and for high and repeated incidence of strain and sprain injuries. Second, data from the checklist analysis of risk factor exposure were used to identify jobs with greatest exposures. Third, committee members solicited input from supervisors and workers to identify jobs that they found most physically demanding and hazardous. Jobs ranking high on each dimension were listed and those jobs appearing high on each list were identified as high-risk jobs and priorities for intervention.

## 3. Training and Intervention

During this third phase, committees undertook design and provision of training on RMIs for workers as required. All of these cooperators utilized provided educational materials and provided worker training as part of their ongoing workplace safety program.

Committees were also asked to meet with engineering researchers to consider various preventive intervention ideas for each of the targeted jobs. Because most high-risk jobs involved exposure to multiple risk factors it was not always possible to design interventions that eliminated all problem exposures. The committees reviewed suggestions from the research team and contributed their own ideas. Once preferred intervention ideas were selected, committees communicated their suggestions to company management for approval. In those cases where no proven intervention could be readily identified, the committee and the team agreed on a set of pilot concepts to be tried. Committees helped provide information to workers as required and helped with intervention trials. In most cases, the actual interventions were developed by UC AERC faculty after consultation with committees and worksite review.

## 4. Analysis of Results & Future Planning

Finally, the committees were convened to review the interventions. Committee members had their own assessments from the workers involved. The research team had its analysis of ergonomics risk factor reduction and data from the pre intervention symptom surveys. Based on these data, the committees were able to recommend either continuation or removal of interventions. Following this, they reviewed operation-wide risk information and determined what problems should have priority for intervention planning over the next 12 to 24 month planning period. Reports were added to written ergonomics safety records.

Finally, ergonomics programs and activities for cooperators were reviewed in two meetings with California OSHA staff to ensure that the process as implemented was in acceptable compliance from the agency's perspective.

### *Cooperative Intervention Trials*

The underlying approach utilized was the interactive approach often described within Land Grant University circles as the Cooperative Demonstration Method. This method has developed in practice over the decades since its emergence in the early part of the Twentieth Century. Fundamentally, it is predicated on the idea that individuals are more likely to attend to and

eventually adopt practices which either they themselves or persons they identify as counterparts are engaged in trying in the context of their own business operation. While there are a variety of more detailed analyses of the process of practice adoption by individuals and communities (Rogers, 1983), the cooperative demonstration has remained central to most successful Extension practice.

The cooperative demonstration consists of enlisting community partners external to the research and education establishment and essentially conducting a field-based research trial directed by academic staff, but implemented by the cooperating partners themselves. The results are jointly evaluated and generally the entire community is invited to observe both the trial and its evaluation. Over decades of practice, this approach has evinced two distinct advantages over most other methods of introducing practice change into communities that are not already motivated to seek the practice in question. First, because the trial is field-based and implemented by a practitioner instead of being laboratory-based, modifications on the initial theoretical approach are almost always made to fit the practice to the field operations context. This inevitably makes the resulting practice or technology model more successful in use. Practitioners add to both understanding and technology when given a chance. Second, this approach has proven immensely powerful in introducing and stimulating acceptance of new ideas and technologies in a wide variety of community types, especially where there was no pre-existing demand for or even interest in the specific technology involved.

This approach dictates the recruitment of partners who are capable of undertaking implementation of the trial envisioned and who are willing to act as full partners in the development, implementation and evaluation of the trial. In this case, both owner/operators and workers were identified as partners. Full partnership in this context means that the partners share authority and expertise throughout. While this approach is old, it is finding new application in occupational settings under the label of community-based action-oriented research (Sclove, Scammell, Holland, 1998). Once partners are recruited, trial development, implementation and evaluation proceed with shared decision making throughout and preferably in a context open to community observation and review.

Applicability of methods and materials employed among the broader population of employers and agricultural worksites is facilitated by the method of having project participants make all final implementation decisions themselves and by having their committees and employees conduct each of the required compliance steps. Because the methods reported here were actually decided upon and implemented by the participating cooperators themselves, rather than by the research staff, and so represent a range of employer and worker interpretation and action, they can be judged applicable to the broader community of employers targeted.

### *Ergonomics Methods*

#### Priority Task Identification

In order to identify job tasks involving high risk for exposure to ergonomics risk factors, a three-part strategy was implemented as follows:

1. cooperator's injury and first aid records were reviewed for reported MSDs and injuries determined to be likely MSDs in development;

2. all jobs were described and screened for ergonomics risk factors using a checklist method used in previous studies; and
3. workers and supervisors were asked to identify jobs deemed especially physically difficult or demanding.

Ergonomics committees used this information to identify jobs involving high musculoskeletal injury risk and to select priorities for intervention. As part of this process, worker exposure was estimated by management and committees and used to inform final job selection for intervention. This resulted in identification of jobs for intervention. Mr. Janowitz then subjected these jobs to detailed ergonomics task analysis for comparison to the post-intervention condition.

#### Risk Factor Screening

Workers in the agricultural industry perform a wide variety of physically demanding tasks. Job surveillance involves a brief assessment of each of these tasks so as to prioritize those that warrant further investigation. All tasks associated with work in the subject operations were screened using our own modification of one of the ANSI Z-365 checklists for preliminary screening. Job surveillance was conducted by cooperators onsite at each cooperating workplace, overseen by Ergonomist Janowitz.

#### Task Analysis

Those tasks identified as high risk and cited by cooperators as priorities for risk factor control were subjected to more detailed analysis. This included listing all tasks, tools, materials, forces, and body positions involved in the conduct of the task. This process forms the foundation for intervention analysis. In addition, further investigation may reveal that certain steps in the task are unnecessary or inefficient. The elimination or modification of such steps can reduce exposures to ergonomic hazards as well as increase productivity. Task analysis was performed by Ergonomist Janowitz.

#### *Health Effects Methods*

The assessment of occupational MSDs related to ergonomics intervention in the agricultural setting is difficult for several reasons. First, work-related MSDs sometimes take months or years to develop and it is unlikely that significant results would be shown in terms of reportable or diagnosable injuries given the duration of this study period. The oversupply of labor in this industry also provides a disincentive to report occupational injury to employers. Additionally, a class/cultural propensity to disregard physical discomfort, and when in discomfort to utilize self or home remedies in place of seeking help from organized community health care systems, made it unlikely that health records would provide an accurate picture of MSD incidence. To enhance our power to test differences in musculoskeletal outcomes we employed a musculoskeletal pain and symptoms survey developed and used in our prior studies. This is a Spanish language questionnaire compatible with the cultural, linguistic, and educational characteristics of Mexican field workers who have immigrated to work in California (Faucett, et al.).

The interview uses previously tested measures of pain severity, location, and duration and includes items to assist with determining the work-relatedness of the symptoms. The FACES Scale, for example, initially validated for measuring pain among multicultural pediatric

populations, was chosen by agricultural workers to evaluate their pain severity. Similarly, the body diagram used to indicate pain location is one commonly used by other NIOSH researchers investigating musculoskeletal discomfort and has been used before by Dr. Faucett, but the symptoms to be identified are those suggested by the agricultural worker population.

The Spanish translation of the interview has undergone extensive forward and backward translation to ensure the appropriateness of the vocabulary and syntax for agricultural workers from the population to be evaluated. This questionnaire was administered to all workers participating in interventions in both pre- and post-intervention conditions.

#### *Acculturation Scores*

Many farm workers travel regularly between Mexico and the United States, maintaining relationships with family in their home country despite relatively stable, although intermittent, work opportunities here in the US. Poor English skills are common, even for those who have worked for many years in the US, and by and large Hispanic farm workers remain poorly integrated into the US culture. Because their level of acculturation is likely to be an important predictor of injury reporting and health care utilization by immigrant farm workers, and may in fact be associated with greater risks for injury, we have collected data on this variable in addition to other demographic descriptors such as age, gender and years of working in the US. To capture acculturation for these studies, we have used the brief scale developed by Marin and Marin (1991). The scale includes four items reflecting the use of English vs. Spanish for daily activities with family and friends, as well as for thinking. It is scored from 1-4, with 1 representing Spanish only speakers and 4, highly bilingual speakers. The scale is commonly used to evaluate overall acculturation because of its high association with other measures of cultural integration. Surveys are conducted in Spanish or English depending upon the worker's language preference and are administered by bilingual, bicultural interviewers following the principles for research with Hispanic populations suggested by Marin and Marin (1991).

#### *Intervention Development Methods*

Once priority job tasks for intervention were decided, design constraints for intervention development were developed. Among design constraints employed were the following:

1. Isolate problems that all parties agree are problems.
2. Look for opportunities to do things which will have a positive effect on prioritized ergonomics risk factors:
  - a. reduce the amount of force required (change the size of a "load")
  - b. improve posture (less bending, reaching or twisting)
  - c. reduce task frequency
  - d. reduce static loads or pressures.
3. Concentrate on engineering interventions by providing tools and procedures which will automatically meet objectives above, without extensive training or behavior modification for workers.
4. Recognize fiscal constraints associated with engineering changes; concern for large capital expenditures, preferred focus on inexpensive solutions with the potential for short pay back periods.
5. Consult with workers involved on design and prototype development and testing.

In addition, one other fundamental constraint was added. This was a commitment to avoid or minimize job displacement for workers involved in the selected tasks.

In addition to engineering interventions, field conditions forced us to consider administrative interventions in situations where no engineering alternative was judged practical. Thus, in two field situations, standardized increased rest breaks were implemented where no engineering alternative was practically appropriate. The approach was developed by Dr. Faucett based on studies by Galinsky et al. (2000) showing that workers given supplemental breaks of 5 minutes for every hour in which conventional work breaks were not provided (totaling 20 minutes additional break time per day) reported fewer musculoskeletal symptoms with no loss in productivity. In some cases, symptoms were eliminated entirely. Additionally, research findings from Genaidy et al. (1995), in a study of meatpackers, supported the investigators' hypothesis that that brief intermittent microbreaks resulted in lower levels of musculoskeletal discomfort. Findings from Henning et al. (1985) also indicated that workers tended to terminate voluntary breaks before complete recovery could occur.

In both cases in which increased breaks were implemented, they consisted of supplemental breaks of five minutes for every hour in which another break was not provided and that breaks were monitored to ensure that workers did not return to work too early.

In all cases, as intervention concepts were defined with ergonomics committees, they were also shared with participating workers and managers for evaluation and feedback. At each stage in the development process, prototypes and pilot versions were brought to the field for examination, assessment and feedback by workers. This highly interactive process resulted in important insights for everyone involved and significantly improved eventual acceptance of interventions subjected to field trial.

#### *Productivity and Acceptability Methods*

Innovations in equipment, process or practice are usually adopted because they have a demonstrated positive impact on productivity, an impact sufficient to offset their costs in both economic and administrative terms. The establishment of complete cost-benefit analysis with respect to occupational health and safety is a more complex matter involving the true costs of injury and illness (Oxenburgh, 1994). However, most employers give priority to the simpler question of an innovation's impact on crude productivity as it is normally calculated in their workplace. Most often this will involve observations of worker or process productivity before and after implementation of the innovation.

A second major factor in workplace acceptance of an innovation is worker opinion. Worker's views are commonly based on whether an innovation improves their task performance without increasing physical demand while also not making their job newly accessible to persons without their own skills and experience. In order to facilitate innovation adoption in the workplace, we are concerned with both the productivity assessment of interventions as evaluated by managers and workers.

Dr. Meyers and cooperator committees developed adoptability information via inquiry with owner/operators and workers based on the adoptability elements cited by Rogers (1983) to describe the attributes of innovations that affect adoption. These are: perceived relative advantage, perceived compatibility with current procedures, perceived complexity of innovation, trialability, and observability of results. Productivity data is based on common industry performance measures suggested by cooperating managers.

#### *Educational Materials Development*

Staff of the AERC had developed and employed a set of materials explaining ergonomics and giving graphic descriptions of ergonomics risk factors for a statewide series of training meetings for owners and safety coordinators during the years immediately following the promulgation of the California OSHA ergonomics standard. These materials were used as a basis for initial instructional pamphlets and training seminars with cooperators and their ergonomics committees. As the project proceeded, they were modified according to their field acceptance and perceived efficacy. These materials now consist of:

- ◆ an introductory pamphlet;
- ◆ an ergonomics program workbook;
- ◆ an ergonomics risk factor checklist; and
- ◆ training informational sheets on musculoskeletal injuries and prevention.

Samples of these materials are provided in the appendix.

#### *Evaluation Methods*

Evaluations of intervention effectiveness are based on pre- and post-intervention findings about (1) musculoskeletal injuries and symptoms, (2) ergonomic factors, and (3) adoptability factors. These are described above.

## **RESULTS**

Results are organized by cooperator due to the specificity of both detailed methods and intervention trials involved with each. Detailed reports on each cooperators' experience are included in the Appendix.

#### *Cooperator Descriptions*

This study involved five cooperators, each engaged in a different aspect of agricultural work in California. Table 3, below briefly summarizes their descriptive characteristics.

Table 3  
Summary Descriptors for Cooperators  
Study Participants

Cooperator	Size	Total # workers	Male/Female	Mean Age	Mean Yrs in US
Citrus Packer	424,694,460 cartons/season	106	M 42, F 64	39.7	30.44
Cotton Producer	80,000 acres	500	weeders F 43	43.56	26.56
Tomato Producer	4,000 acres	400	hvstrs M 3, F 18	47.19	17.3
Strawberry	65 acres	108	M 79, F 29	30.4	6.9
Tree Nursery	900 acres trees	250	M 38, F 16	44.74	13.48

With the exception of the tree nursery, virtually all workers involved were either Mexican immigrants or of Mexican heritage. The tree nursery worker population was split nearly evenly between workers from Mexico and workers from India. Worker training and information with this cooperator was conducted in both Spanish and Punjabi. Because only permanent workers were involved in intervention trials to minimize subject loss, descriptive information on ages and years in the US is not descriptive of the worker population as a whole.

Table 4, below summarizes OSHA 200 Log information for each cooperator, demonstrating that most had experience with musculoskeletal disorders in their workplaces.

TABLE 4  
OSHA 200 Logs - MSDs

	# injured workers	Disability Status			Location of Injury					
		Days Lost	Days Restricted	Quit/Terminated	Back	Upper Extr	Lower Extr	Neck/Shoulder	Other	
<b>Citrus Packing</b>										
Year 1	15	37	230	3	5	5	0	3	1	
Year 2	9	90.5	268	1	3	3	0	2	1	
Year 3	9	229	49	1	3	4	2	0	0	
<b>Cotton Production</b>										
Year 1	12	Not Available			Not Available					
Year 2	2	Not Available			Not Available					
Year 3	1	Not Available			Not Available					
3 yr totals	15	802	NA	NA	4	2	12	2	0	
<b>Tomato Harvest</b>										
Year 1	0	0	0	0	0	0	0	0	0	
Year 2	1	6	0	0	1	0	0	4	0	
Year 3	6	14	121	1	2	2	1	0	1	
<b>Strawberry Harvest</b>										
Year 1	0	0	0	0	0	0	0	0	0	
Year 2	0	0	0	0	0	0	0	0	0	
Year 3	1	28	0	0	0	0	1	0	0	
<b>Tree Nursery</b>										
Year 1	9	33	34	0	2	4	2	0	0	
Year 2	13	133	312	1	1	2	10	1	0	
Year 3	8	101	49	5	4	3	2	2	0	
Year 4	7	5	181	2	3	1	1	1	0	

Note: A worker may have more than one injury location

#### *Other Partners*

Throughout the project the team met with staff of California OSHA Education and Training and State Compensation Insurance Fund to review methods and materials and to seek their advice and input.

### *Best Practices and Regulatory Compliance*

All five of the cooperators complied with all elements of the California OSHA regulation and with all elements of the recommended best practices model. One cooperator elected to contract out the targeted job, relieving their own employees from the risk factor exposures that terminated the cooperative project prior to other hazard control intervention trials.

### *Ergonomics Hazard Control Trial Outcomes*

Intervention trials had to be custom developed with each cooperator based on their priority exposures and their preferences for and availability of acceptable intervention systems. In most cases a variety of interventions were researched and provided to cooperator ergonomics committees for their review with both workers and management. In some cases, multiple interventions were conducted with the same cooperator, based on their interests and situation.

In all cases (except the two administrative interventions), baseline data were collected before interventions were introduced and then (usually the following season) post-intervention data were collected following defined periods of use of each intervention. Post-intervention data were collected with workers performing the same tasks at the same time of season as pre-intervention data collection. In the cases of the rest and recovery break interventions with strawberries and the tree nursery, baseline data were collected before the interventions were initiated but post-intervention data were collected daily from experimental and control groups.

### *Priority Ergonomics Hazards and Interventions*

Priority concerns for each cooperator were determined by a three-part strategy of assessing a) workers and supervisors opinions about job risks, b) evaluation of operators' OSHA 200 logs for reported and probable musculoskeletal disorders, and c) observation of ergonomics risk factors associated with jobs as performed at the worksite. Cooperators' ergonomics committees shared in this work and made recommendations to management. In all cases, management finalized the list of high-risk jobs. Following this the engineering team studied exposures and recommended interventions to the committees. Committees and management determined what interventions would be implemented.

Because each cooperator's situation and hazards varied so much, each is presented separately.

### *Citrus Packing*

Our citrus packing cooperator is a mid-sized operation. This packinghouse grades, sorts and packs oranges for sale or processing by other companies. The company has a workplace safety program that conforms to California OSHA requirements and includes incentives for periods worked without reported injuries. The cooperator had previously instituted rotation schedules for workers on the conveyor lines, but had not explored engineering approaches to hazard reduction.

The ergonomics committee consisted of 4 workers, one supervisor and was effectively chaired by the company safety manager (also the company personnel manager). This committee functioned only with direct support from company management and the research team.

Three interventions were agreed to and conducted on two grading jobs and in the box sealing area. The first involved relocating conduits from the floor near the sealing machine to under the machine. By relocating them under the conveyor, a minor hazard and annoyance was eliminated.

The second intervention concerned awkward reaches in the choice grading area. Here the workers had to routinely lift a substantial amount of fruit from the grading table to a conveyor located 16 inches above the table. The intervention consisted of relocating the conveyor to the same level as the primary conveyor. The relocated conveyor saved worker energy and reduced the hazards associated with awkward arm and shoulder activity.

The final intervention concerned awkward postures and reaches in the export grading area. The grading table was too low to allow sitting workers to put their legs under the table. Instead they had to either stand for a full shift or sit sideways reaching across their bodies. The research team recommended raising the table and sorting conveyor. Instead, management provided commercially available kneeling stools that allowed workers to get closer to the table with their bodies oriented to the table.

It should be noted that these interventions did not address exposures to highly repetitive handwork, likely the most serious risk exposure involved in this workplace. Slowing lines or altering line construction in major ways was deemed too costly by management at this time.

In this workplace, each season begins with a required daylong safety orientation. Workers are required to attend and are paid. A presentation was made on the ergonomics program by committee members and the senior manager. Ergonomist Janowitz participated in describing ergonomics risk factors. In addition, information on risk factors, prevention and the company's ergonomics program was provided to the company safety committee and subsequently included in regular "tailgate" training meetings by supervisors throughout the seasons in which interventions took place.

One year after intervention implementation, all of these interventions proved acceptable to both management and workers and were continued.

Table CIT I shows that reports of symptoms for the lower extremities and neck and shoulders declined, while reports of symptoms for the upper extremities and back increased after the intervention.

Table CIT 1  
 Frequency of packing house graders (n=33)  
 reporting MSD symptoms in various body locations  
 before and after grading line interventions (2000)

	Number of graders reporting MSD symptoms			
	Pain in the upper extremity	Pain in the lower extremity	Pain in the neck & shoulders	Pain in the mid or lower back
	% (n)	% (n)	% (n)	% (n)
Before intervention	45.5% (15)	39.4% (13)	63.6% (21)	18.2% (6)
After intervention	51.5% (17)	21.2% (7)	54.5% (18)	33.3% (11)

We examined the reports of MSD symptoms using the composite symptom score. This score is constructed from data about the severity and frequency of MSD symptoms of three different types (aching, sharp pain, and numbness) and about the extent of the body affected by these symptoms (Faucett et al. 2001). Workers' symptom scores were compared pre- and post-intervention, using subjects as their own controls in these paired t-test comparisons. Graders did not differ significantly in their pre- and post-intervention composite scores, indicating no overall improvement in their symptoms as a result of the intervention (Pre: mean=251.6, sd=216.5; Post=298.2, sd=399.8;  $t=-.62$ ;  $p=ns$ ). Non-graders also did not demonstrate a difference over the same period of time; and there was no difference in the amount of change in symptom scores for the two groups (with the interaction term: total  $R^2=.13$ ;  $R^2$  change for interaction term=.01;  $F$  change=.04,  $p=ns$ ).

We re-examined these differences in symptom scores during the second year of the intervention trial in 2001, comparing the second year post-intervention scores to the pre-intervention year scores. Twenty graders who had responded to pre-intervention surveys also completed surveys during the third year of the study. Thirty of the non-graders completed both pre-intervention and third year surveys. For this small sample of graders, we could not detect significant differences in symptom scores (Pre: mean=261.4, sd=207.3; Second post: mean=315.8, sd=522.9;  $t=-.41$ ;  $p=ns$ ). Differences for symptom scores among the non-graders were also non-significant in paired t-test comparisons. Again, there was no difference in the amount of change in symptoms experienced by graders as opposed to non-graders from pre- to second year post-intervention, indicating that the intervention to the grading task did not improve the symptoms of graders to any greater extent than the change in symptoms experienced by the workers who were not involved in the grading line intervention (with the interaction term: total  $R^2=.13$ ;  $R^2$  change for interaction term=.04;  $F$  change=2.06,  $p=ns$ ).

In sum, although it appears that the intervention resulted in modest improvements to symptoms in some areas of the body (e.g. lower extremity, neck and shoulders), other parts of the body

became more severely symptomatic. It also appears that this worsening of symptoms in some areas resulted in no improvement to the overall symptom experience of workers in the grading task, as evaluated by the composite scores. However, workers liked and kept all interventions in place.

No productivity effects were observed using carton/tonnage throughput measures. Similarly, no changes were observed in productivity of sealers following conduit removal.

### *Cotton Production*

This is a very large farming company (100,000 acres) located in the San Joaquin Valley growing cotton, some grains and vegetables. They employed 500 permanent and about 600 seasonal employees during the study period (1999, 2000).

Permanent workers are paid on an hourly basis. The company has a workplace safety program that conforms to California OSHA requirements and includes incentives for periods worked without reported injuries. Weekly and monthly safety meetings are held for all employees. There is a program of training for new and returning (seasonal) employees. Medical and dental benefits are provided to all employees.

The ergonomics committee, four workers and two supervisors, was selected by the company safety manager from among the weeding crews and met only with his participation. All were experienced workers, most supervisors or crew leaders. All spoke fluent English. Generally participants were interested and willing to speak up without invitation by the research team. All interaction with either senior company management or operations managers was accomplished through the safety manager. This committee would have continued to function with the direct administration of the safety manager.

The safety manager and the company safety committee had previously identified hand weeding as exposing workers to the greatest risk of MSD injury. Injury records and risk factor analysis supported this. Review of injury logs for cotton weeders in this operation showed 9 reported MSDs in the 1996-98 period. Injury logs also showed 20 sprain/strain injuries among these workers in the same period. The mean number of days lost from work per MSD was 40 days (total 802 days). For comparison, the mean number of days lost from work for the sprain/strain non-MSD injuries was 13.7 days.

This is high value specialty cotton, so freedom from contaminating fibers is important. Generally, female workers using hoes perform hand weeding. The job involves walking along cotton rows, cutting out weeds with a hoe. It often requires a cut 2-3 inches below the ground surface to be sure the weed is killed. Because some weeds (nightshade) regenerate easily and detract from the value of the harvested cotton, workers use shoulder bags to collect cut weeds for removal from the field. Weeders are assigned to one of several crews and number 43 in total.

While hand weeding was viewed as a necessary task, it was also viewed as a means of employing these permanent workers' time during the growing season.

The job exposes workers to the following risk factors:

- 1) walking on uneven surfaces;
- 2) repetitive exertion of upper body force to hoe weeds;
- 3) repetitive awkward postures of the neck, trunk and arms;
- 4) continuous exertion of force to carry 24-40# weeding bags;
- 5) awkward postures associated with putting weeds in bags and emptying bags;
- 6) sustained contact stress from continuous carrying and use of hoe;
- 7) sustained forearm pronation while gripping hoe handle
- 8) discomfort as bags and clothing gets wet in early mornings (rubber pants & boots used in mornings); and
- 9) temperature extremes (up to 100° F).

After multiple consultations with the committee and workers in the field, the engineering team decided to explore five approaches as follow:

1. alternate hoes or weed cutting tools employing better ergonomics and requiring less force application;
2. improved footwear to prevent ankle injuries;
3. dragging weighted boluses in furrows in early season to reduce soil clodding;
4. lighter, water resistant, easier dumping weed bags; and
5. use of a small hand trailer moved in rows by workers to put weeds in.

Prior to the next planting season (during which interventions would have been given field trial), the research team was advised that company management had reviewed information on the hand-weeding job from the ergonomics committee. As a result management had decided to contract the weeding job out, meaning regular seasonal employees of the company would no longer be exposed to the risk factors involved. The ergonomics committee was dismissed and this collaboration was terminated. No controlled trial of exposures was implemented.

While this did not alter the risk factor exposures involved, it did ensure that the company's permanent workers would not be exposed to them, and transferred primary ergonomics standard responsibility and workers compensation liability for this job to the labor contractors involved.

The research team provided the ergonomics committee with detailed training on ergonomics and methods for preventing MSDs. Prepared educational materials in Spanish and English were used (examples in appendix). However, the cooperater terminated the project before training was extended to any personnel beyond the committee itself.

#### *Tomato Production*

While this is a large farming company located in the San Joaquin Valley, their tomato production operation would be considered mid-size (2000 acres). They employed 175 permanent and 225 seasonal workers during the study period. However, only 21 of the company's own workers were employed in tomato harvest. The majority of the harvest was conducted by contractors. This employer has a safety program that conforms to California OSHA requirements. A safe work orientation is held for all employees at the beginning of the season, followed by tailgate sessions monthly thereafter. The safety program includes incentives for time periods worked without a

reportable injury. The employer provides workers' compensation insurance and medical insurance for workers who have been with the company at least one year.

The cooperator's OSHA 200 logs reported MSD injuries that made them subject to the California OSHA ergonomics standard.

Work with this cooperator proceeded in two phases because they changed their worker's compensation insurer during the project. Initially, an eleven-member committee was appointed representing the entire operation and including the human resources director and safety consultant. Most members were primarily Spanish speaking and information was translated. Most committee members were supervisors of field units and were reasonably comfortable with group process. Before the project's intervention targets had been agreed to, the company made the decision to change its worker's compensation insurer, safety consultant, and senior production manager that we had been working with were replaced. This brought the project to a temporary halt as the company reorganized its safety program.

When the project was re-initiated, the research team was informed that management had decided to focus all effort on the tomato harvest job alone. The former committee was not reconvened. Instead, permanent employees working in tomato harvest and the company human resources manager served as the project committee from this point on. Because the research team and management had agreed at the project's re-initiation that the focus would be on the tomato harvest job, there was no need for multiple job screening or other priority job selection activity.

Most California tomatoes are grown for machine harvest and processing uses. Mechanical tomato harvesters deroot plants funneling them to a broad conveyor belt. The belt passes the tomato plants along a sorting station on which workers stand. Workers on the machines must remove damaged fruit and plant materials so that only tomatoes are dumped into truck trailers for shipping. These sorters are exposed to the most severe ergonomics risk factors. These include:

- Highly repetitive hand work (12+ grasps per minute) to remove stems, sort tomatoes
- Sustained standing on an unstable platform subject to both jolting low frequency and continuous high frequency vibration
- Multiple awkward postures including trunk, shoulder and elbow flexion
- Pronation of hands and forearms.

In response to pre-intervention pain and symptom surveys seventy percent (70%) of these workers reported significant pain in the mid or lower back at season end and thirty percent (30%) reported other lower extremity pain. It is clear that the most serious risk exposures in this operation involve the back and upper extremities.

The research team provided training on the ergonomics standard, on MSDs and their prevention, and on the project itself directly to involved workers.

Research by the engineering team confirmed that there were no "off-the-shelf" tools or technologies short of complete machine redesign which would alleviate either high rates of repetition or the awkward posture exposures that were agreed to be the most serious risk factor

exposures. Initially, two risk factor exposures were targeted. First, heat stress risk involved in working in the dust and sunlight in high temperatures (up to over 100 degrees F). A set of shades were developed and hung on one harvester. However, field testing quickly showed that the shades actually increased both heat and dust exposures as they inhibited air movement on the sorting platforms. Consequently they were removed and eliminated.

The primary intervention consisted of an apron padded with dense foam that was designed to relieve the stress of leaning on the conveyer's edge, which provided not only contact stress but also vibrated with the motion of the harvester. Data were collected from the tomato sorters (n=9) on their pain and fatigue at the end of each of four weeks: for two weeks without using the apron and for two additional weeks using the apron. Data were analyzed to see if there was any improvement in fatigue or pain scores after the two-week trial of the apron. Although three subjects reported pain at the end of the first baseline week (prior to intervention), no subjects reported pain at the end of the second baseline week; or for either of the two weeks of the intervention period that followed. Fatigue scores demonstrated more variability than pain scores. Pairwise t-tests were computed to compare fatigue scores at the end of the two week baseline period (prior to intervention) to fatigue scores following two weeks of using the aprons. Differences in fatigue scores were not found to be significant. These findings suggest that the apron had little impact on the symptoms that we chose as outcome measures, although the subjects reported anecdotally that the aprons had a positive impact.

Productivity effects were assessed by company management using trucks/tonnage throughput measures commonly used. This is a machine-paced job and there were no changes in speeds of the harvester or sorting conveyors. No productivity impacts were noted. Because no changes were made in machine pacing, it is not surprising that no changes in productivity were observed.

In sum, it appears that the intervention did not result in symptom or pain reduction. This is not entirely surprising since the intervention did not relieve repetition or awkward postures that were more likely to be sources of musculoskeletal symptoms.

### *Strawberry Harvest*

This is a small strawberry production operation (60 acres) located in Southern California, specializing in early season fresh market and processing fruit. They employed 8 permanent workers and 106 seasonal workers during the study period. This employer has a safety program conducted by an outside contractor that conforms to California OSHA requirements. A safe work orientation is held for all employees at the beginning of the season, followed by tailgate sessions every two weeks thereafter. The safety program includes incentives for time periods worked without a reportable injury. The employer provides workers' compensation insurance but no medical insurance.

The cooperator's OSHA 200 logs did not report any injuries for the first season of cooperation or for the season before. However, this is an industry under public scrutiny for the degree of stooped posture involved in the job.

The ergonomics committee, five workers and one supervisor, were selected by the owner/manager and only met in his presence. Most members of the committee were either solely or primarily Spanish speaking. All presentations were translated and all discussions took place in Spanish. This committee functioned only in response to questions or inquiries. Participants had little or no experience with formal group process. The owner/manager directed that attention be focused on the picking job. Since this is the task performed by the most workers, most of the time, and involving the most extreme ergonomics risk factor exposures, this focus was readily acceptable to both workers and the research team.

Strawberry picking involves walking down furrows (approximately 12" wide and 300 yards long) between moderately raised beds and pushing or carrying a wire cart with strawberry boxes in it. Berries are twisted from vine with the fingers and placed in boxes. Normally pickers remain in a stooped or crouched posture for the length of a row. Workers paid on incentive basis move as fast as possible.

Risk factor exposures include:

- Severe trunk flexion
- Sustained neck extension
- Shoulder and elbow flexion
- Highly repetitive hand picking
- Constant deviation of both hands
- Contact pressure on knee from kneeling on bed.

Injury logs showed only two reported injuries over the previous 24 months- neither an MSD. However, the symptom survey showed that seventy percent (70%) of these workers reported significant pain in the mid or lower back at season end and thirty percent (30%) reported other lower extremity pain. It is clear that the most serious risk exposures here involve the back.

Extensive research by the engineering team confirmed that there were no "off-the-shelf" tools or technologies that would alleviate either the stoop or the repetitive hand picking exposures. The research team recommended that a dual approach be adopted. First, to implement increased rest and recovery breaks as an administrative control. Second, to explore the adaptation potential of alternative engineering approaches to the problem of stooped posture.

Dr. Faucett and Mr. Janowitz designed a rest and recovery protocol based on the work of Galinsky, Henning, Rodgers and others (Galinsky et al., 2000; Henning et al., 1985; Eastman Kodak, 1986). The rest and recovery intervention protocol called for an additional 5 minute break for every working hour in which there was no other scheduled break (e.g., lunchtime).

A 2-week field trial was undertaken during February, 2001. We gathered baseline data about musculoskeletal symptoms, fatigue and productivity from 72 participating workers on Day 1 of the trial. Workers were then randomly assigned to an experimental group and a control group. Symptom data were gathered at the end of each shift, using a shortened variation of our standard questionnaire. Productivity was assessed for each worker on a daily basis.

Two engineering intervention concepts were subjected to limited testing by participating workers. The first consisted of two variations of a harness intended to reduce the effect of the weight of a workers upper body on the spine when working in a stooped posture. In the absence of a generic term the research team referred to these as “Weight Transfer Devices” (or WTDs), since it is their intended function to transfer the load of upper body weight to the worker’s thighs when in a forward bending posture. The second was a prototype prone position picking cart. This concept was based on prior research at both UCD and in Europe.

The research team provided the ergonomics committee with prepared brochures in Spanish for employee use (examples in the appendix). In this seasonal workplace, each season begins with a required daylong safety orientation. Workers are required to attend and are paid. A presentation was made of the ergonomics program by research team members and the senior manager. In addition, information on risk factors, prevention and the company’s ergonomics program was provided to the company’s safety consultant and the information was included in their regular tailgate meetings.

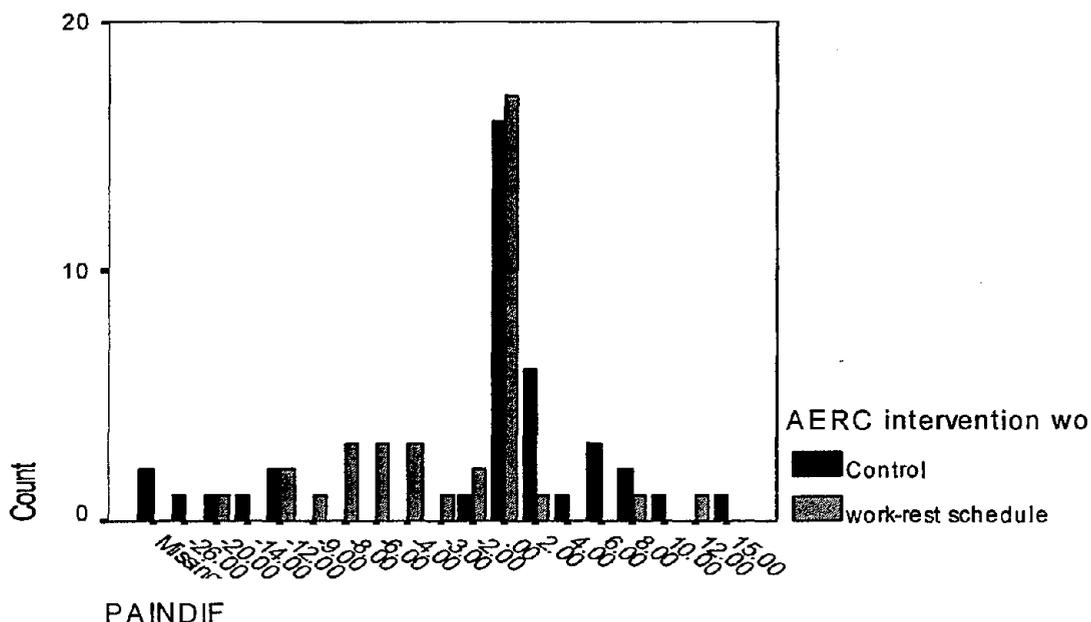
Because the engineering mechanisms available were not proven, no attempt was made to collect health outcomes data on them. They were evaluated only for ergonomics effects and employee and management adoptability opinions. All were judged impractical for field use at this time.

For each day of the rest and recovery trial, workers in the experimental group reported less severe symptoms than workers under the control conditions (the usual work conditions), but were also less productive. Nonetheless, after statistically controlling for differences in levels of productivity, better symptom control continued to be associated with the experimental condition.

The bar graph below describes difference scores for workers’ musculoskeletal symptoms. It graphs the observed frequency that a particular total symptom score difference occurred. Each symptom score difference was calculated by taking the sum of the symptom scores for days 2 and 3 and subtracting twice the symptom score for day 1 from the day 2 and day 3 composite. This variate can be interpreted as twice the difference between, on the one hand, the day 2 and day 3 average and, the day 1 score. The Mann U Whitney value is 466.5 ( $p < 0.04$ , two tailed).

A negative score value indicated that the average musculoskeletal symptom score measured during days 2 and 3 was less than the score measured on day 1, while a positive score indicates that during these two days symptoms increased. For an intervention group measurement, a value of zero indicates that there was no change in the symptom severity after the break intervention. The table shown below was based on the subset of workers who experienced a change in their symptoms. It shows that most of the workers whose symptoms worsened on days 2 and 3 were in the control group. It also shows that those workers, whose symptoms decreased, tended to be in the experimental group. (Among all workers whose responses were complete, 33 expressed no change in pain experienced, while 39 indicated either an increase or a decrease in pain.)

Table STR-1  
Symptom change contingency table for strawberry harvest workers (n=72).



**Productivity**

This strawberry operation calculates productivity in terms of boxes picked. Productivity effects were assessed by company management using worker barcodes as boxes are brought to the trucks on three full days for both control and intervention groups. The crews averaged about a 9.4% reduction of productivity as a result of the increased rest break schedule. This productivity reduction would require a crew of 35 about 29 minutes to make up at an additional labor cost per crew of \$114.10 (9.7%) per day. While the grower might be willing to absorb this cost in return for reduced injury risk, it seems unlikely that workers would under incentive pay conditions.

*Tree Nursery*

This is a large orchard tree nursery (900 acres, 1.5-2 million trees annually). The trees are all grown in the field and the work is highly labor intensive. They employ 75 permanent workers and 175 seasonal workers. This group of employees was nearly equally made up of workers from India and those from Latin America. The employer provides workers' compensation insurance and full time employees are eligible for a package of benefits that include medical, dental and vision benefits after one full year of employment.

This employer has a safety program that conforms to California OSHA requirements. The safety program includes incentives for time periods worked without a reportable injury. A safety committee meets on a monthly basis. This cooperator's OSHA 200 logs reported diagnosed MSDs that made them subject to the California OSHA ergonomics standard.

The ergonomics committee, consisting of four workers, one supervisor and the personnel manager, was selected by the operations manager. Three of the committee members were native

Punjabi speakers and three were native Spanish speakers. All discussions, meetings and materials were translated into both Spanish and Punjabi. The company's worker's compensation representative provided active leadership and it seems likely that this committee will continue to function. Committee recommendations were presented directly to the operations manager who was quite supportive.

Analysis of observed MSDs, job risk factor screening, and worker opinion suggested that digging, budding, and grafting should have priority attention. Based on worker exposures (# workers for most days), jobs for intervention were identified as follow: budding, grafting, digging. Budding and grafting workers are paid on an incentive basis and move as fast as possible.

The budding and grafting jobs were observed to feature the following risk factor exposures of concern:

- Sustained kneeling to reach appropriate work area
- Highly repetitive handwork to make cuts, insert buds, and tie off graft (18/min.)
- Trunk flexion up to 80°
- Trunk twisting up to 15°
- Elbow flexion up to 90°
- Pinch grips on both knife and bud
- Static postures of the neck, trunk, and lower extremities for periods of up to two hours.

Injury logs did not show any reported MSDs associated with budding and grafting over the previous 24 months. However, in response to pre-intervention symptom surveys sixty seven percent (67%) of these workers reported significant pain or symptoms. Over sixty percent (60%) reported pain and symptoms in the lower extremities and fifty seven percent (57%) reported back pain and symptoms. It is clear that the most serious risk exposures in this stoop labor operation involve the lower extremities and back.

With no "off-the-shelf" tools or technologies for the intervention priorities, a dual approach was adopted for budding/grafting. First, to implement increased rest and recovery breaks as an administrative control. Second, to explore the adaptation potential of alternative engineering approaches to the problem of sustained kneeling posture.

Dr. Faucett and Mr. Janowitz designed a rest and recovery protocol based on the work of Galinsky, Henning, Rodgers and others (Galinsky et al., 2000; Henning et al., 1985; Eastman Kodak, 1986). The intervention protocol called for an additional 5 minute work break for every working hour in which there was no other regularly scheduled break (e.g., lunchtime). This trial was designed as a cross-over trial, using 16 pairs of workers randomly assigned to two groups. The intervention was delivered in two trials of three days each; the two trials followed a baseline day of data collection before assignment into the two groups. Fatigue and musculoskeletal symptom scores were obtained by surveying each worker at the end of each day. Productivity was obtained by counting the number of trees budded by each crew each day.

In the first trial, Group One received the intervention as described above for three days, while Group Two worked under the usual work conditions. After a weekend break, the second trial was run; Group Two received the intervention while Group One served performed budding under the usual conditions.

The bar graphs TN 1, 2, 3, and 4 below show that the intervention improved worker reports about the severity of fatigue and musculoskeletal symptoms (see graphs for Fatigue and Musculoskeletal Discomfort below); although the groups demonstrated a wider variance for productivity under the intervention condition (see graphs for Productivity below). The first two bar graphs below show that for both fatigue and musculoskeletal discomfort, the intervention condition resulted in a lower mean symptom severity score than the control condition, as well as less variation (note that the bars representing the intervention condition are narrower and lower on the graph).

Table TN-1  
Fatigue Scores – Tree Nursery

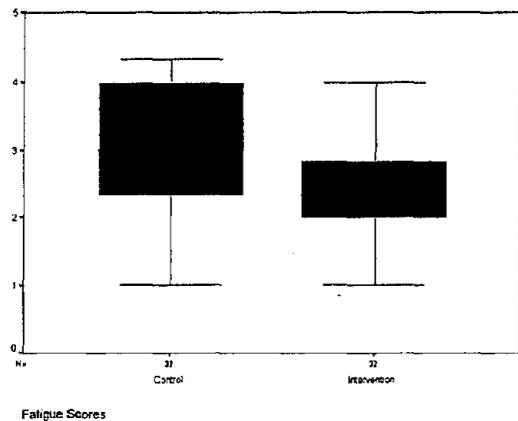
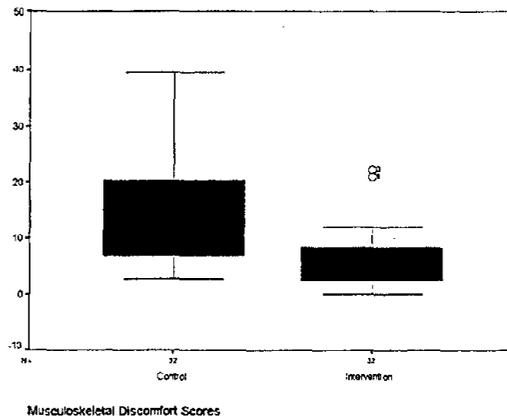


Table TN-2  
MSD Discomfort Scores – Tree Nursery



The variation in productivity was associated with the order in which the intervention was given (see graph for Productivity by Group below). Group Two, who received the intervention during the second trial, demonstrated greater productivity under the control condition as compared to the intervention condition; the opposite was true for Group One. One explanation of this difference may be related to competition between the crews relative to who was first assigned to the intervention condition. Fatigue and musculoskeletal symptoms, on the other hand, were consistently in the expected direction for both groups - improving in the intervention condition.

Table TN-3  
Summary Productivity Scores – Tree Nursery

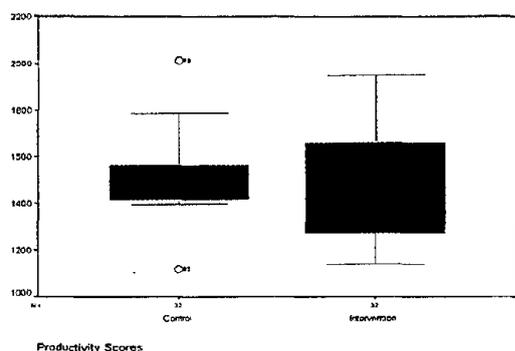
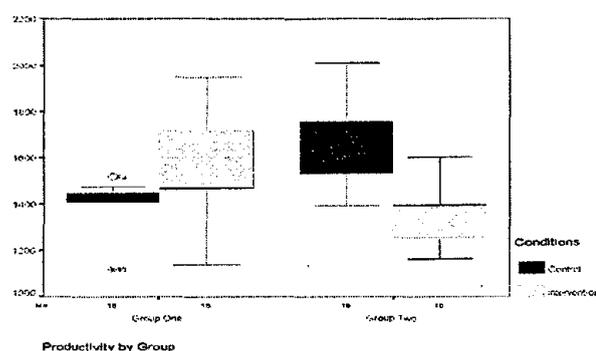


Table TN-4  
Group Productivity Scores – Tree Nursery



Analysis of Covariance shows that when both group and productivity variates are controlled, there is a highly significant ( $p=0.002$ ) change in symptom outcomes attributable to the intervention condition. Additionally, changes in musculoskeletal symptoms were associated with changes in fatigue ( $r=0.62$ ,  $p=0.01$ ) over the three days of each trial. This association increases when the productivity is partially out ( $r=0.69$ ,  $p=0.001$ ).

Table TN-6  
Tests of Between-Subjects Effects

Dependent Variable: PNCOM1

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	456.732 <sup>a</sup>	1	456.732	1.636	.214
Intercept	4650.357	1	4650.357	16.654	.000
GROUP	456.732	1	456.732	1.636	.214
Error	6143.101	22	279.232		
Total	11530.500	24			
Corrected Total	6599.833	23			

a: R Squared = .069 (Adjusted R Squared = .027)

Dr. Miles and his colleagues developed two types of carts with the objective of reducing exposure to sustained kneeling. The first was a small cart on which the worker could place one knee in a padded area. The cart was wheeled, allowing for it to be moved by pushing with the non-kneeling foot. The second was a prone position cart. This cart had adjustable padding to fit different workers, and was fitted with a counter-balanced hard hat to relieve stress on neck. Neither cart was found to be fully practical at this time.

The research team provided the ergonomics committee with prepared information. A special ergonomics training session was conducted by the committee for all employees with the leadership and support of the company's worker's compensation loss control representative.

In addition, information on risk factors, prevention and the company's ergonomics program was provided to the company's safety committee for use in their regular tailgate meetings.

#### *Summary Intervention Trial Outcomes*

Table 5, below, summarizes interventions and outcomes by cooperator.

TABLE 5  
Intervention Summary

COOPERATOR	JOBS TARGETED	INTERVENTIONS	OUTCOMES
Citrus Packing	Box Sealer	Removed Conduit Under Footing	Eliminated underfoot contact stress
	Grading-Choice	Removed Upper Conveyor- Relocated to Center of Main Conveyor	Eliminated awkward upward toss. No significant change in reported symptoms
	Grading-Export	Provided Kneeling Chairs for Graders	Allowed graders to sit at conveyor facing fruit. No significant change in reported symptoms.
Cotton Production	Hand Weeding	Contracted Job Out	Permanent worker exposure eliminated
		Alternate Weeding Tools	Not Implemented
Tomato Harvest	Sorter	Padded Sorter Apron	Workers liked aprons. No significant fatigue or symptom reduction
		Padding on Machine	Not Practical
		Shading on Machine (to reduce temperature)	Reduced airflow-increased temperature
Strawberry Harvest	Hand Harvest	Added Rest Breaks	Significant symptom reduction
		Weight Transfer Devices	Not Practical – one judged potentially effective
		Prone Cart	Not Practical
Tree Nursery	Grafting/Budding	Added Rest Breaks	Significant symptom reduction
		Prone Cart	Not Practical
		Kneeling Cart	Not Practical

#### *Project Information Dissemination*

During the course of this project more than 500 persons engaged in agricultural work in five different agricultural industries were provided information and training on MSDs, their associated risk factors and means of their control. These recipients included farm workers, owner/operators, and managers and supervisors.

Cooperating managers and their ergonomics committee participants received the most information and had the added opportunity to directly participate in project development and implementation, providing hands-on experience. One owner/operator, 2 operations managers, 3 company personnel officers, 4 company safety officers, and 12 operations supervisors were directly involved in project planning and implementation on their operations. In addition, 1 worker's compensation loss control officer, 1 cooperative association manager and 1 cooperative association safety official were directly involved in project implementation.

Forty-three (43) workers and supervisors participated on ergonomics committees in the project's implementation. They received detailed education on the California OSHA ergonomics regulation and the UC AERC best practices approach to compliance. They participated actively in data collection, intervention trial planning, implementation and evaluation, and they assisted with employee training. Each cooperator was left with a core group of permanent employees who have the skill and knowledge to continue a best practices ergonomics program in their workplace. All directly participating workers and managers demonstrate understanding of these issues at a level beyond that one would expect of an "informed" practitioner.

The broader industry community has received information on the nature and results of this project and will be the target of more focused information dissemination following project termination. Project investigators participated annually at regional industry meetings. Other state and national industry presentations included:

- Meyers, J, High Risk Tasks for MSD's in Agricultural Field Work (1999) Presented at NIOSH/NORA Industry Meeting, Houston, TX
- Meyers, J, Ergonomics Interventions Prevent Back Injuries (1999) Presented at 9<sup>th</sup> Annual Western Migrant Stream Forum, San Diego, CA
- Faucett J. (2000) World Affairs Council. Women, work, health, & quality of life: Rural work. Aired on National Public Radio, September 16, 2000.
- Faucett, J, (2001) National Institute for Occupational Safety and Health, National Occupational Research Agenda: (research poster)
- Faucett, J, (2001) University of Michigan & University of California, Ergonomics and cumulative trauma disorders conferences: San Francisco, (invited paper)
- Faucett, J, (2001) California Nurseryman's Association, Sacramento (invited report)
- Meyers, J, (2001) California Farm Bureau Federation, Health & Safety Committee, Sacramento (invited report)
- Meyers, J, (2002) California Farm Bureau Federation, Health & Safety Committee, Sacramento (invited report)

Twelve papers and presentations to research audiences included:

- Miles, J. (1999) Research Priorities for NORA from Agricultural Ergonomics. Presented at NIOSH/NORA Research Meeting, Houston, TX

- Faucett, J. (2000) Bridging culture, education and language differences: Developing assessment tools for immigrant workers. Presented at Northern California Association of Occupational Health Nurses, Asilomar.
- Faucett, J. (2000) Pan American Nursing Research Colloquium: Bogota, Colombia, SA, (research paper)
- Faucett, J. (2000) International Occupational Health Commission, Triennial Congress: Singapore, (invited research symposium)
- Meyers, J, Faucett, J, Miles, J, Janowitz, I, Fathallah, F, Suriano, S, Sutter, S, Tejada, D, Duraj, V, Shafii, M. (2001) Implementing the California Ergonomics Standard in Agricultural Operations. Paper presented at NIFS, Pittsburgh.
- Faucett, J., Meyers, J., Tejada, D., Janowitz, I., Miles, J., Kabashima, J. (2001). Musculoskeletal symptoms in agriculture: Measuring pain among immigrant Hispanic farmworkers. Journal of Agricultural Safety & Health, 7(3), 185-198.
- Barrett, A, Fathallah, F. (2001) Evaluation of four weight transfer devices for reducing loads on the lower back during agricultural stoop labor. Paper presented at ASAE, Sacramento.
- Chapman, L, Meyers, J, (2001) Ergonomics and Musculoskeletal Injuries in Agriculture: Recognizing and Preventing the Industry's Most Widespread Health and Safety Problem. National Agricultural health & Safety Conference, Baltimore.
- Faucett, J. (2002) Back Injury Symptom Reduction Through Job Modification. American Pain Society: Baltimore, (research poster)
- Miles, J. (2002) Ergonomic Interventions in Labor Intensive Agriculture, Delivered to NIOSH, Cincinnati Ohio, on May 7, 2002.
- Fathallah, F. (2002) Agricultural Ergonomics Research in California. Invited paper presented at Ohio State University Institute for Ergonomics, Columbus.
- Faucett, J., Meyers, J., Miles, J., Janowitz, I., Tejada, D., Suriano, A. (Accepted, in revision). Measuring pain among vulnerable Hispanic workers. AAOHN Journal.
- Other research publications and presentations are in preparation.

## CONCLUSIONS

It was the goal of this study to develop a set of “best practices” guidelines for ergonomics programs in agricultural workplaces based on collaborative field research. Additionally, we were interested in finding out how difficult compliance would prove to be in agricultural workplaces and how effective compliance on terms acceptable to employers would prove to be in reducing hazard exposures. Our conclusions are as follow.

1) *Responsive agricultural employers can and will make positive, "good faith" efforts at complying with both the language and the intent of the regulation.*

All cooperating employers in this study expressed clear concern for employee welfare and were willing to undertake efforts new to their management styles and operations in order to better understand and address ergonomics hazards.

Our work suggests that many, if not most, agriculture employers have interest in reducing musculoskeletal injuries, especially back injuries. All those participating in this study that were, or are likely to become, subject to the California OSHA ergonomics standard were interested making good faith efforts to comply with the standard. Certainly, no difficulty was encountered in finding and recruiting industry participants in the study. Further, with supporting information such as the best practices materials employed here, it appears that most agricultural employers can reasonably comply with the essential requirements of the standard. Each of these employers was able to develop a program that complied with the standard. The employers participating in this study represent a wide range of types and scales of agricultural operations, including some known to be particularly problematic in their ergonomics risk factor exposures. In each case, together, we found interventions to apply that were neither dramatically deleterious to productivity nor prohibitively expensive.

2) *Responsive agricultural employers may need external consultation to develop compliance programs that are efficacious in reducing ergonomics hazard exposures.*

Left to their own devices, most of our project cooperators would have focused much more heavily on worker training as a preventive mechanism. There appears to be a grounding belief among employers and even some safety professionals that worker education and training is the central element of prevention programs. Certainly, worker education, training and involvement are a critical part of effective programs. However, decades of safety research literature make plain that the most effective hazard controls are engineering changes that eliminate or reduce hazards themselves. Followed by equipment or practices that reduce worker exposures. Worker training alone is not an effective prevention strategy.

While no control employers were observed in non-consultative conditions, our cooperators' uncertainty as to how to proceed with regulation compliance was clear throughout. It may be that some responsive employers can develop effective programs without external consultation, but it is also clear that many, if not most, will not. The most serious problem appears to be with the need for engineering consultation to envision, find or develop, and fit appropriate exposure controls for the many different task situations involved.

The "best practices" approach and supplementary instructional materials we employed, especially the workbook format guide to compliance, was helpful to clarifying how to proceed. Employers and cooperating managers found most readily available information on ergonomics and compliance to be too detailed to meet their interests or perceived time constraints. However,

even with these, engineering consultations proved both necessary and helpful in getting managers and workers to re-envision tools and practices.

*3) There are not commercially available, "off-the-shelf" tools or technologies for most of the most serious ergonomics hazards found in these agricultural workplaces.*

This lack is a significant obstacle to the near-term reduction of risk factor exposure in agricultural workplaces and points to the need for applied research and development in this area. Because agriculture has a much shorter history of workplace regulation than recognized industrial workplaces, there are fewer commercially available remedies for commonly found hazards. In this study, we found commercially available remedies for only two of seven workplace hazards. Of these two, one (the weight transfer devices) proved impractical and unusable in the field and of questionable efficacy at this time. We believe that the lack of a commercially available remedy for the cotton hand-weeding job was one factor leading to the questionable remedy of contracting out of that job. There are simply not commercially available and proven effective remedies for some of agriculture's most common and problematic hazards. Two types of ergonomics hazards stand out in this respect. First, awkward postures, especially stoop. Second, highly repetitious handwork, especially cutting or picking. These are difficult ergonomics problems under the best of circumstances. Addressing them effectively in agricultural workplaces is more difficult yet due to the wide variation in worksite complications, variation in specific task demands, and the lack of available power sources or even fixed worksites for workstation consideration.

Further exacerbating this problem is the fact that there are no available publicly funded research funding programs that address the issue of equipment and tool research and development at this time. Neither NIOSH nor USDA, the two primary funders of health and safety programs for agriculture sponsor such research at this time. So, there is no ongoing stream of organized research and development that would increase the availability of commercially available and efficacious remedies for the future.

*4) Agriculture's generally low profit margins inhibit capacity and enthusiasm for expensive or fundamental changes in technology or practice.*

Agricultural production has faced economic difficulty for at least the past two decades with the result that production operations generally experience low marginal profits. This inhibits capacity and enthusiasm for ergonomics solutions that are viewed as expensive by managers. Additionally, this outlook combined with a generally conservative approach to innovations that do not readily fit within current practices results in a climate that works against re-envisioning and re-engineering work processes. Instead, both workers and managers in this study clearly preferred to focus on interventions featuring low capital cost and that readily fit with existing work processes and practices with the result that interventions frequently focused on only part of a problem or on problems of lower priority because intervention concepts were less expensive and were less demanding of process re-engineering.

Examples in this study were several, including the citrus packing operation where conveyor line redesign was not considered financially feasible at this time. Also, the redesign of tomato harvesters to better position and protect workers was neither financially nor technically feasible for the employer.

*5) It is unclear that good faith compliance with the elements of the California regulation will result in significant reduction of the most serious ergonomics hazard exposures.*

While MSD symptom data results indicate that the engineering interventions put in place often reduced worker pain and symptoms, none of the most significant hazards identified in any of these workplaces was effectively addressed. In part, this was due to a lack of readily available interventions. In part, it was due to a tendency to focus on more easily addressed but marginal exposures. This outcome does not mean that engineering approaches to ergonomics hazard control in agriculture are unproductive. Rather it points to the need for development of new tools and technologies for the wide variety of hand tasks involved in agricultural workplaces. There appears to be a general supposition that where hand labor becomes too expensive, mechanization is the preferred (or feared) alternative. However, many agricultural tasks will not lend themselves to complete mechanization anytime soon. Strawberry harvest, for example, presents a currently insoluble problem for full mechanization. As do many of the other tasks reviewed here. In order to successfully address these tasks, new tools and technologies for use by field workers are needed.

As a result, we and our cooperators found ourselves implementing administrative controls (increased rest and recovery time) in some of the most problematic situations, including strawberry harvest. The results were promisingly positive despite the small sample sizes involved. This is clearly an approach that deserves further research. Obviously, in many agricultural workplaces, this may prove to be the best immediate approach to improving MSD prevention. However, as it does not directly eliminate ergonomics hazards themselves, it is not the best solution for the longer term.

Finally, the cotton employer's solution demonstrates a completely alternative means of addressing the regulation - transfer of risk exposure to a contractor. While this approach will clearly help prevent MSDs among the employer's own workers, it simply transfers the risk to another set of workers. While this cooperator did conceivably comply with the state regulation, it is not clear that this approach technically frees them from shared liability for any resulting on-the-job MSDs that may result. California OSHA subscribes to a principle of "shared liability" between owner/operators and contract employers. Since California case law in this area is still sparse, we can only speculate as to any long-term outcomes of this approach.

*6) Active involvement of workers in improved prevention programs faces obstacles in agricultural workplaces.*

There are three obvious elements to this issue. First, is language. Most workers in California agriculture speak Spanish either as their only language or as their preferred language while most owner/operators speak English. This issue may actually be the easiest to overcome. In fact,

most California agricultural employers have already found practical measures to overcome the language problem by utilizing bi-lingual supervisors.

The second element is the lack of worker recognition of their stake in improved workplace safety. Low wages, difficult to find housing, and many other issues take precedence in workers' day-to-day lives. Both workers and farmers have a recognized tendency to accept relatively high risk of work-related injury and illness as a normal expectation of their profession. Until we can find effective means of changing the beliefs and expectations of those involved, we will continue to face difficulty in stimulating adequate and effective participation in developing and implementing improved prevention practices.

Finally, in general, agricultural workplaces (beyond the simple family scale) have little history or experience with active employee involvement in workplace decision-making or problem solving at the group level. While all of these cooperators had active, representative workplace safety committees, it was clear that the type of aggressively involved worker participation envisioned by many in the ergonomics community is not common in this industry. Both workers and managers had little experience with, nor much confidence in, such active worker involvement. This may be due to a history of reliance on temporary and unskilled labor and a workplace in which goals and priorities are viewed as externally driven. But, this is an industry that will benefit much from information and support on the issue of worker involvement.

In summary, it is clear from this study that agricultural employers can and will find means of complying in good faith with the state's ergonomics standard. Further, it seems clear that at minimum the standard will bring about much improved and widespread understanding of the nature and causes of RMIs, which may, in turn, lead to improved prevention in the future. But, it also seems clear that serious investment in development and testing of new engineering interventions designed to address the most egregious and common ergonomics hazards found in agricultural workplaces is badly needed. Especially needed are those associated with sustained or repetitive stooped posture and with highly repetitive handwork such as cutting or clipping.

The educational and diagnostic materials developed and tested in this study were effective in assisting employers and workers better and more quickly understand the nature of ergonomics hazards and injuries and the requirements of the California ergonomics standard. Future publication and distribution of these materials is a problem yet to be solved. Similarly, it is not clear how to best deal with the apparent need for consultative assistance for best compliance with the standard. Most often the private sector is relied upon for this type of assistance. However, if the same emphasis on worker training results from this approach as was the case in implementation of the Cal OSHA Injury and Illness Prevention Program (IIPP), we would expect significantly less eventual prevention improvement than this study indicates.

## **DISCUSSION**

This study is subject to a number of methodological concerns, beginning with the fact that it did not employ truly experimental design, thus results should be considered as associative at best and possibly only descriptive at worst. However, that weakness applies most directly to the data on intervention contributions to improved occupational injury prevention. From the broader

perspective, which is of most interest here (i.e., how will the regulation be implemented), the descriptive data presented should give a valid indication of industry behavior.

These companies all volunteered to participate, meaning that they were already motivated to comply with the regulation. While they all have tasks that would likely lead to being subject to the regulation sooner or later, all expressed real interest in new ideas and approaches that might lower risks. Finally, they represent a spectrum of commodity types, management styles and commercial scale common to California agriculture. From this perspective, we should see their implementation behavior as indicative of how the most responsive companies will act. We would expect lesser commitment to results and lesser investment in effort from companies not as strongly motivated.

These intervention trials were conducted with procedural similarity, by the same staff performing the same roles. The relationship between the research team and cooperators' committees was pedagogical in nature due to the very newness of the information being presented. Certainly, in this type of intervention, there was awareness on the part of participating workers that the research team was experts and had been given access by operation management at the highest levels. Additionally, the cooperators chose the workers who participated on committees.

Individual cooperator intervention trials were virtually all subject to some difficulty. Most had relatively small numbers of subjects involved, detracting from statistical power and impact on the workplace. Additionally, weather and job scheduling presented problems in both strawberries and the tree nursery. The citrus packing operation offered the most stable workforce in a fixed workplace, and in that way it is uncharacteristic of agricultural field jobs. Still, the positive results reported for some interventions make it clear that interventions that do contribute to improved prevention are feasible for even the most difficult of field jobs. How much preventive efficacy is achieved is a more difficult question and one that will require more research in the future.

While these factors undoubtedly influenced committee members and other workers response to the research team and to the ergonomics interventions themselves, if anything this influence should have had the effect of improving likelihood of program acceptance and success. Additionally, and perhaps more importantly, these influences were more supportive of active worker participation than would likely be found in these or similar operations without the external influence of the research team. In that sense, any resulting influence here is likely to bias results toward positive impact rather than negative.

This series of interventions was clearly and heavily biased in favor of engineering interventions over administrative or personal protection strategies. This did appear to reduce both the range of available "off-the-shelf" alternatives and the capability of cooperators to contribute effectively to intervention development. This approach was based on the demonstrated superiority of engineering interventions over all other strategies in significantly reducing hazards and hazard exposure. However, it likely deflected cooperator attention away from training as a preventive strategy or consideration of a wide range of administrative alternatives.

Because of the chronic nature of MSDs, it would be overly optimistic to expect to see large reductions in reported MSD incidence in such a short-term intervention effort. For that reason we have chosen to rely on Dr. Faucett's original approach to assessing MSD pain and symptomatology. The instrument used is an individual survey, administered in Spanish by trained interviewers. We have previously used this instrument in other NIOSH-funded studies. As with any self-report survey method, there is potential for subjective bias on the part of the respondent and the interviewer. Still it is an approach that has demonstrated merit in its potential for capturing changes in subject-recognized symptom development and changes in MSD development short of full disorder presentation.

The MSD pain and symptom measure is particularly relevant for this group of Hispanic workers who do not recognize early discomfort as "symptoms" of a potentially impairing disorder and are reluctant to report injuries. Many of the asymptomatic workers undertook symptom self-treatment. We believe that these workers do indeed feel work-related symptoms sufficiently to attempt self-management, but for cultural, educational or occupational reasons do not identify their sensations as symptoms of health disorders or report them as such. We know that these workers have a strong work ethic and are fearful of losing work days or even their jobs.

#### **FUTURE RESEARCH**

Future research is needed in three general categories. First, and most important, is a need to increase priority for development and demonstration of engineering controls for specific agricultural jobs with a focus on tool and task redesign. There is currently no national public funding program dedicated to this work. Yet the results reported here make clear that there is great need if we expect to make significant headway in improving prevention of musculoskeletal injuries in agricultural workplaces. The need is sharpened by the growing realization among farm safety professionals that musculoskeletal injuries constitute the most common, the most costly and the most debilitating of the excessive job-related injury risks faced by farmers and farmworkers in this country.

Second, there is real need to increase the support for and conduct of field-based intervention trials across the full range of types of agricultural operations. Currently there is a lamentable tendency to believe that various new or assistive technologies found feasible in industrial workplaces can and will be readily transferred to other sectors, agriculture included. This simply is not happening and will not happen by itself largely due to the wide variety of tasks and task settings to be found in agriculture. Coupled with the lack of power sources in the field and the lack of workplace standardization, this means that most agricultural jobs will require specific intervention development and research to be effectively addressed.

Finally, there is a priority need to conduct larger scale studies of the efficacy of the rest and recovery time administrative control approach. The results reported here make it clear that this approach holds promise for those jobs where no engineering controls are either available or feasible. We need to determine how much efficacy is gained in various job task situations from this approach.



# **APPENDIX**

# **COOPERATOR CASE RECORDS**

## SJV CITRUS PACKING CASE HISTORY

Our citrus packing cooperator is a mid-sized operation. This packing house grades, sorts and packs oranges for sale or processing by other companies. Their work is seasonal, usually beginning in December and ending around late May. Workers are paid on an hourly basis, augmented by a ten cent per box incentive. The company has a workplace safety program which conforms to California OSHA requirements and which does include incentives for periods worked without reported injuries. This cooperator's OSHA 200 logs did report diagnosed MSDs which made them subject to the California OSHA ergonomics standard. The cooperator had previously instituted rotation schedules for workers on the conveyor lines, but had not explored engineering approaches to hazard reduction. Like the other cooperators in this study, most at this worksite tended to think of workplace safety as a largely individual concern involving personal control of exposures to be addressed by training.

### *Cooperator Descriptive Data*

This is a mid-sized packing operation (just over 4 million cartons packed per season) located in the San Joaquin Valley, specializing in custom packing of fresh citrus fruit. They employed 106 permanent workers during the study period (1999, 2000, and 2001 seasons). Descriptive demographic data from initial survey of MSD symptoms are displayed on Table CIT 1 below.

Table CIT 1  
Descriptive statistics for the initial sample of packing house employees  
(N=106, Male: n=42, female: n= 64,1999)

	Pre-Intervention				
	mean	sd	median	min	max
Age	39.70	11.45	39.0	19.0	64.0
Years of education	9.16	3.24	9.5	2	18
Years spent in the US	30.44	14.13	26	9	64
Years worked in agriculture	11.74	7.91	11	0	33
Years worked with this company	8.04	6.51	7	0	26
Acculturation score	11.98	6.84	12	4	20

Data from initial review of OSHA 200 logs and first aid records is presented in Table CIT 2 below.

Table CIT 2  
OSHA Log 200 Data  
Citrus Packing

Year	Number Injured	Disability Status			Injury Location				
		Lost Days	Restricted Duty	Quit/Terminated	Back	Upper Ext.	Lower Ext.	Neck/Shldr	Other
	15	37	230	3	5	5	0	3	1
	9	90.5	268	1	3	3	0	2	1
	9	229	49	1	3	4	2	0	0

### *Ergonomics Committee*

The ergonomics committee consisted of 4 workers, one supervisor and was effectively chaired by the company safety manager. This committee functioned only with direct support from company management and the research team. The company's safety manager (also personnel chief) participated in all meetings and personally took care of all communications to management. For the most part, committee members were experienced workers and usually second-generation farmworker immigrant family members who spoke excellent English. Despite their experience, committee members did not know how to function as a committee and were initially quite reticent about speaking during meetings. Even when the committee met to review results one year later, most member inputs came as responses to questions from research staff.

Committee members were provided training on ergonomics and the California OSHA ergonomics standard by the research team. The committee participated in job screening, priority task identification, and intervention planning and implementation. When the committee presented its priorities to management, the plant manager attended but declined to give a firm response about suggested exposure controls citing "reduced income" as a result of a severe freeze that season. Committee members did have input suggestions for reduction of some hazards. Approval for controls to be implemented was later relayed from management to the research team and committee by the safety manager. While the company had a physical plant maintenance crew it had no engineering staff and no one was assigned to assist with exposure control development. Maintenance staff made the physical plant changes called for, but were never provided direct interaction with either the committee or the research team. This committee has continued to function in the same mode.

### *Evaluation of Worksite Ergonomics Hazards*

The first element called for by the California OSHA ergonomics standard is the evaluation of worksite ergonomics hazards. In accordance with our research methods, three approaches were employed (observed MSDs, job risk factor screening, and worker opinion) with the results displayed on Table CIT 3 below.

Table CIT 3  
Summary of Ergonomics Risk Rankings  
Citrus Packing

Observed MSDs	Ergonomics checklist	Workers & supervisors ranking	Management ranking
Grading	Bagging/stacking	Palletize-setoff line	Bagging/stacking
Set-off line	Grading - choice	Bagging/stacking	Palletize - setoff line
Floor tech - packing	Sealer	Hand packing	Hand packing
Pre-grade dump op.	Machine packing	Bag packing	Bag packing
Floor tech - sealer	Palletize-setoff line	Grading - choice	
Hand packing	Grading - export		
Clean up	Hand packing		

The most serious risk factor exposures in citrus packing overwhelmingly involve highly repetitive motions involved in grading and sorting fruit on conveyor lines. Other risk factors addressed involved

sustained awkward positions and unstable footing. The cooperators' ergonomics committee and company management made a final priority job ranking as follows:

- ◆ Palletize- Set Off Line
- ◆ Hand Packer
- ◆ Grading-Choice & Export
- ◆ Floor Tech-Bagging/Stacking & Carton Prep
- ◆ Sealer

These jobs were re-observed based on samples of at least 4 different workers performing each for 5-10 minutes each. The following descriptions delineate the most common risk factors for the development of work-related musculoskeletal problems in these selected tasks for intervention planning:

1) Palletizing/set off line – this job involves removing full boxes from a conveyor and hand stacking them on pallets for loading in trucks. It exposes workers to highly repetitive lifting of heavy loads (30-50 lbs), and to a repetitive reach/throw maneuver to stack. This job usually involves 10-15 workers and recorded 5 reported injuries in the 1996-1998 period;

2) Hand packing – this job involves removing fruit from gravity flow bins and placing them in paper or plastic packing sheets in boxes. It exposes workers to highly repetitive hand and upper extremity motions to reach and grasp fruit and to place fruit in boxes. This job involves 22 workers and recorded 1 injury in the 1996-98 period;

3) Grading – this job involves standing beside a conveyor filled with moving fruit, examining fruit and removing wrong-sized or blemished fruit by tossing into disposal chutes. It exposes workers to highly repetitive hand (20+ grasps per minute) and upper extremity movements, to repetitive reaches and throwing maneuvers, and to continued standing on a hard surface. It involves 35-45 workers and recorded 17 reported injuries in the 1996-98 period;

4) Floor tech (bagging, stacking, carton preparation) – this job involves various assistive tasks to packers, primarily removal of cartons from bales and pre-forming boxes. These workers also perform stacking of full boxes. The work exposes workers to repetitive lifting, folding and reaching motions. It involves 10 workers and recorded 3 reported injuries in the 1996-98 period; and

5) Sealing (cartons) – this job involves folding carton tops and sealing with tape. It is partially mechanized with metal forms for closing and a tape applicator on a manual conveyor. This job exposes workers to repetitive upper extremity motions including reaching, grasping, pushing and shaping. It involves 2 workers and recorded no reported injuries in the 1996-98 period.

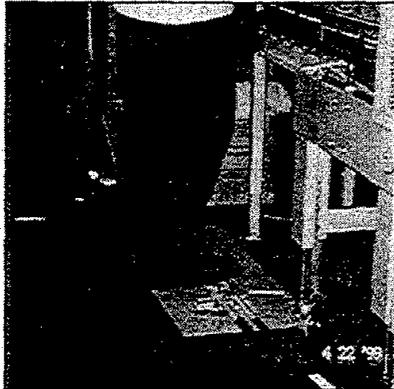
Of these, the grading job, which consists of hand sorting fruit on machine driven conveyors, exhibited the most injuries and involved the most workers.

#### *Implement Hazard Controls*

The second required element of the California OSHA ergonomics standard is the implementation of feasible hazard controls. Three interventions were agreed to and conducted on two grading jobs and in the box sealing area. It should be noted that the company had already implemented regular job rotation schedules for workers, so that exposures to the grading jobs involving very high rates of repetition (20-22 hand grasps per minute) were interrupted.

No solutions were recommended as practical for the hand pack jobs (some packing machines were already in place) or for the problems in the floor tech area. While mechanical palletizing machines would be helpful, the space and physical layout available dictate against them at this time. A horizontal palletizing scheme advanced by the engineering team that would have much reduced lifting and throwing forces was rejected by management as impractical within the space requirements allowed.

The first intervention implemented involved relocating the conduits on the floor near the sealing machine. These conduits were on the floor where the machine operator has to stand. By relocating them under the conveyor a minor hazard and annoyance was eliminated.

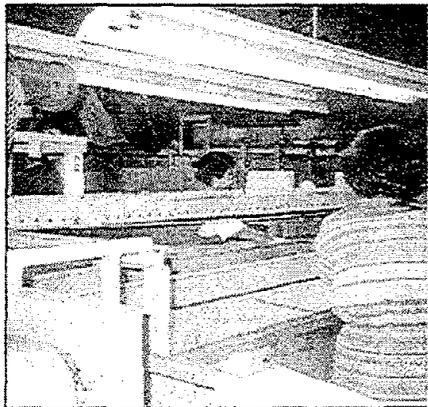


Conduits in Sealer Area

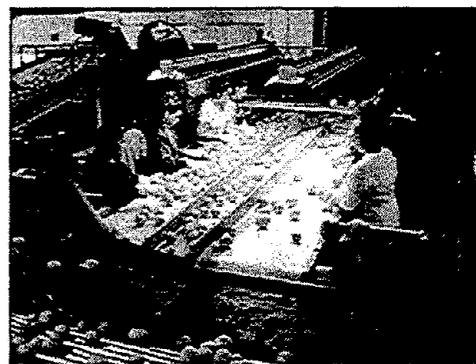


Conduits Relocated

The second intervention implemented concerned awkward reaches in the choice grading area. Here the workers had to routinely lift a substantial amount of fruit from the grading table to a conveyor located 16 inches above the table. The intervention consisted of removing the top conveyor and relocating it to the center of the grading table. The relocated conveyor saved worker energy and reduced the hazards associated with awkward arm and shoulder activity.



Raised Conveyor



Lowered Conveyor

The final intervention implemented concerned awkward postures and reaches in the export grading area. The select grading table was too low to allow sitting workers to put their legs under the table. Instead they had to either stand for a full shift or sit sideways reaching across their bodies. The research team had recommended raising the table and sorting conveyor.

Instead, management elected to utilize commercially available kneeling stools that allowed workers to get closer to the table with their bodies oriented to the table.



Grading Table Before



Grading Table with Ergonomic Stools

It should be noted that these interventions did not address exposures to highly repetitive handwork, likely the most serious risk exposure involved in this workplace. Slowing lines or altering line construction in major ways were deemed too costly at this time.

#### *Provision of Employee Training*

The third required element of the California OSHA ergonomics standard is that of providing employee training on repetitive motion injuries and their prevention. The research team provided the ergonomics committee with prepared brochures in Spanish and English for employee use (examples in the appendix). In this seasonal workplace, each season begins with a required daylong safety orientation. Workers are required to attend and are paid and provided a barbecue lunch. A presentation was made of the ergonomics program by committee members and the senior manager. Ergonomist Janowitz participated in describing ergonomics risk factors. In addition, information on risk factors, prevention and the company's ergonomics program was provided to the company safety committee and subsequently included in regular "tailgate" training meetings by supervisors throughout the seasons in which interventions took place.

#### *Intervention Evaluation*

While not specifically required by the California OSHA standard, any good safety practice would involve followup assessment of effects. One year after intervention implementation, the company ergonomics committee met to review intervention results. All of these interventions proved acceptable to both management and workers and were continued. Similarly, they appeared to be effective in terms of reported injuries, since none were reported in these areas during the intervention period. However, given the development period for MSDs this in itself is not conclusive.

Mr. Janowitz assessed ergonomics risk factor exposure changes due to the interventions by repeating his detailed checksheet analysis. This is a detailed job task analysis including the listing of all tasks, tools, materials, forces, and body positions involved in the conduct of the task and has been used in all of our prior ergonomics studies.

### Grading Job Ergonomics

The worker sits or stands facing the conveyor, reaches in with the dominant hand to comb through fruit performing an inspection task. The fruit is separated into the following categories: damaged, juice, export, and choice. The fruit that is removed from the line is grasped and tossed onto a parallel conveyor with the dominant hand, or into a bucket or chute at the worker's side with the non-dominant hand. All conveyor belts have 8" high sheet metal guards containing the return belts; the top edges have been padded in all areas where workers are stationed.

The worker leans forward up to 15 degrees and reaches forward with shoulder flexion up to 65 degrees with the dominant hand to sort fruit. Some workers place three to four pieces in the non-dominant hand in a "staging area" before depositing the fruit in a bucket by the worker's side. Workers bend their head forward with up to 17 degrees neck flexion while inspecting fruit. The non-dominant arm remains by the worker's side resting on the edge of the conveyor or holding sorted fruit. The non-dominant hand is periodically used to redirect or divert fruit towards the middle of the belt. Elbow flexion varies from 5 to 90 degrees. The wrists are generally in a neutral range (less than 15 degrees extension or flexion). Dominant hand is pronated for most of the job cycle, whereas the non-dominant hand is in a neutral to semi-pronated position.

This task involves frequent pinch grips with the dominant hand, 20-22 grasps per minute. Some workers alternate hands when combing and sorting fruit, so the number of repetitions per hand vary from 10-11 per hand per minute. Each orange weighs approximately .5 lb. The fruit is grasped in a wide 4-5 finger pinch grip. Cotton gloves are worn to protect workers from the chemical residue on the outside of the fruit. Workers will toss fruit with the dominant hand either pronated or supinated – the latter to reduce grip force.

Whether seated or standing, workers are in static postures of the neck, trunk, and lower extremities for periods of up to two hours. Workers lean against the housing of the conveyor belt to reduce the load on the spine and lower extremities. Contact stresses include pressure from the conveyor housing on the non-dominant forearm and against the knees of the seated worker and pressure from the edge of stools (where used) on the ischial tuberosities.

### *Ergonomics Outcomes*

Removal of the electric conduit in the sealer area removed a trip hazard and eliminated sustained contact stress on the feet when required to stand on the conduit. The change was received positively by workers involved.

Relocation of the choice sorting conveyor eliminated the repetitive and awkward upward reach and toss to sort fruit. This action was replaced by a near reach into chutes placed at the workers' sides. The change was received positively by workers and made permanent.

Provision of kneeling stools was received positively by workers and made permanent. These stools have an adjustable forward-sloping seat and padded knee support to keep the worker from sliding out of the chair. The effect of this was to allow the worker to sit 2-3" closer to the point of operation (grasping the fruit) and reduce maximum shoulder flexion in this area from 60 to 52 degrees. Peak shoulder abduction (53 degrees) was not significantly affected by the chair. Subjective comfort ratings by workers indicated an improvement of 1.9 points in the mean rating on a 5-point scale.

### *Health Outcomes*

Dr. Faucett, using the health and symptom survey, conducted health effects evaluation. There were 42 workers enrolled in the study prior to intervention in the grading task who spent more than 50% of their time grading or sorting fruit. Graders were compared to other workers in the packing operation. Non-graders (n=64) spent less than 50% of their time grading fruit and 90% of these workers spent less than 20% of their time grading. Table 1 demonstrates the proportion of workers who were graders as compared to other workers, in terms of their reports of painful musculoskeletal symptoms before the intervention. As can be seen in table CIT 4 graders were more than twice as likely to report pain in the neck and shoulders. They were somewhat more likely to report pain in the upper or lower extremities.

TABLE CIT 4  
Frequency of pain experienced in various body locations for the total sample (n=106) of packing house employees (1999).

	Number of workers reporting MSD symptoms <i>pre-intervention</i>				
	Female Gender	Upper Extremity	Lower Extremity	Neck & Shoulders	Mid or Low Back
	% (n)	% (n)	% (n)	% (n)	% (n)
Graders (n=42)	95.2% (40)	47.7% (20)	38.1% (16)	61.9% (26)	26.2% (11)
Non-graders (n=64)	37.5% (24)	34.4% (22)	23.4% (15)	29.7% (19)	28.1% (18)
Total number	60.3% (64)	39.6% (42)	29.2% (31)	42.4% (45)	27.4% (29)
Total number of subjects reporting any kind of pain: 71.7% (76)					

Table CIT 5  
Frequency of packing house graders (n=33) reporting MSD symptoms in various body locations before and after grading line interventions (2000):

	Number of graders reporting MSD symptoms			
	Pain in the upper extremity	Pain in the lower extremity	Pain in the neck & shoulders	Pain in the mid or lower back
	% (n)	% (n)	% (n)	% (n)
Before intervention	45.5% (15)	39.4% (13)	63.6% (21)	18.2% (6)
After intervention	51.5% (17)	21.2% (7)	54.5% (18)	33.3% (11)

After intervention (conveyor line changes and ergonomic chairs), 33 of the graders completed surveys (all female), the rest had been reassigned or left their jobs. Over the entire packing house sample, workers who were older and less well educated were more likely to respond to the follow up surveys, suggesting that younger workers and those who were better educated were more likely to change their job situation. Table 2 shows the proportions of workers reporting MSD symptoms after the intervention to the grading operation. Reports of symptoms for the lower extremities and neck and shoulders declined, while reports of symptoms for the upper extremities and back increased after the intervention.

We examined the reports of MSD symptoms using the composite symptom score. This score is constructed from data about the severity and frequency of MSD symptoms of three different types (aching, sharp pain, and numbness) and about the extent of the body affected by these symptoms (Faucett et al. 2001). Workers' symptom scores were compared pre- and post-intervention, using subjects as their own controls in these paired t-test comparisons. Graders did not differ significantly in their pre- and post-intervention composite scores, indicating no overall improvement in their symptoms as a result of the intervention (Pre: mean=251.6, sd=216.5; Post=298.2, sd=399.8;  $t=-.62$ ;  $p=ns$ ). Non-graders also did not demonstrate a difference over the same period of time; and there was no difference in the amount of change in symptom scores for the two groups (with the interaction term: total  $R^2=.13$ ;  $R^2$  change for interaction term=.01;  $F$  change=.04,  $p=ns$ ).

We re-examined these differences in symptom scores during the second year of the intervention trial in 2001, comparing the second year post-intervention scores to the pre-intervention year scores. Twenty graders who had responded to pre-intervention surveys also completed surveys during the third year of the study. Thirty of the non-graders completed both pre-intervention and third year surveys. For this small sample of graders, we could not detect significant differences in symptom scores (Pre: mean=261.4, sd=207.3; Second post: mean=315.8, sd=522.9;  $t=-.41$ ;  $p=ns$ ). Differences for symptom scores among the non-graders were also non-significant in paired t-test comparisons. Again, there was no difference in the amount of change in symptoms experienced by graders as opposed to non-graders from pre- to second year post-intervention, indicating that the intervention to the grading task did not improve the symptoms of graders to any greater extent than the change in symptoms experienced by the workers who were not involved in the grading line intervention (with the interaction term: total  $R^2=.13$ ;  $R^2$  change for interaction term=.04;  $F$  change=2.06,  $p=ns$ ).

In sum, although it appears that the intervention resulted in modest improvements to symptoms in some areas of the body (e.g. lower extremity, neck and shoulders), other parts of the body became more severely symptomatic. It also appears that this worsening of symptoms in some areas resulted in no improvement to the overall symptom experience of workers in the grading task, as evaluated by the composite scores. These results suggest that a modest or incomplete improvement in the ergonomic risk factors of a job task may not be sufficient to decrease workers' overall symptom experience. Furthermore, attention should be paid to the interplay among the risk factors as one component of the job is altered (such as the height of the conveyor line). Intervention in a job as complex as the fruit sorting task must repeatedly evaluate changes in the ergonomic risk factors and how those changes relate to symptom changes for the workers.

#### *Intervention Transferability*

All of the interventions employed here should be readily transferable to any similar packing operation. Changes in conveyor lines to reduce or eliminate awkward postures are most likely

readily achievable on older lines such as the ones encountered here. The kneeling chairs used by the cooperator are commercially available.

*Productivity Outcomes*

Productivity effects were assessed by company management using carton/tonnage throughput measures commonly used. There were no observed changes in speeds of grading conveyor lines or graders' productivity following the intervention changes. Similarly, no changes were observed in productivity of sealers following conduit removal. In the case of both of these jobs, individual worker productivity over a shift is determined by grading and packing line paces. Hence, it is not surprising that no changes were observed.

## SJV COTTON PRODUCTION CASE HISTORY

Our cotton production cooperator is a very large operation. Their operation is seasonal (March/April through September) and involves ground preparation, planting, irrigation, weeding, pest control, harvest and delivery of raw cotton to cotton ginning operations. Increasingly tasks are mechanized and very large equipment is utilized in planting, harvest, etc. While machine operation jobs do involve numerous ergonomics risk factor exposures, in general they are neither as stressful nor as injury prone as manual jobs. However, some jobs remain manual. Weeding is one of these and was identified by the cooperator as the job of interest. This was supported by injury record and risk factor analyses.

Permanent workers (including the weeding crews) are paid on an hourly basis. The company has a workplace safety program which conforms to California OSHA requirements and which does include incentives for periods worked without reported injuries. Weekly and monthly safety meetings are held for all employees. There is a program of training for new and returning (seasonal) employees. The full-time safety office holds two half-day meetings with company management to report on safety issues. This cooperator's OSHA 200 logs did report diagnosed MSDs which made them subject to the California OSHA ergonomics standard. Medical and dental benefits are provided to all employees.

### *Cooperator Descriptive Data*

This is a very large farming company(100,000 acres) located in the San Joaquin Valley. They grow cotton, some grains and vegetables. They employed 500 permanent and about 600 seasonal employees during the study period (1999, 2000). Descriptive demographic data from our initial survey of MSD symptoms are displayed on Table COT 1 below.

Table COT 1  
Descriptive statistics for the initial sample of cotton weeders  
(N=43, all subjects were female, 1999)

	Early Weeding				
	mean	sd	median	min	max
Age	43.56	9.63	44	19	62
Years of education	7.74	2.88	8	0	14
Years spent in the US	23.56	11.65	24	3	60
Years worked in agriculture	17.16	9.18	17	3	43
Years worked with this company	10.35	6.16	10	1	34
Acculturation score	6.6	3.74	4	4	20

Data from initial review of OSHA 200 logs and first aid records is presented in Table COT 2 below.

Table COT 2  
OSHA Log 200 Data -  
Reportable MSDs Cotton Weeders

	# injured workers	Disability Status			Location of Injury				
		Days Lost	Days Restricted	Quit/ Terminated	Back	Upper Extr	Lower Extr	Neck/ Shoulder	Other
Year 1	12	Not Available			Not Available				
Year 2	2	Not Available			Not Available				
Year 3	1	Not Available			Not Available				
3 yr totals	15	802	NA	NA	4	2	12	2	0

Note: A worker may have more than one injury location

#### *Ergonomics Committee*

The ergonomics committee, consisting of four workers and two supervisors, was selected by the company safety manager from among the weeding crews and met only with his participation. All were experienced workers, most supervisors or crew leaders. All spoke fluent English. Generally participants were interested and willing to speak up without invitation by the research team. All interaction with either senior company management or operations managers was accomplished through the safety manager. This committee would have continued to function with the direct administration of the safety manager.

Committee members were provided training on ergonomics and the California OSHA ergonomics standard by the research team. The committee participated in job screening, priority task identification, and intervention planning and implementation. Committee members did have input suggestions for reduction of some hazards (mostly concerning the weeding bags and the use of rain gear for foggy days).

#### *Evaluation of Worksite Ergonomics Hazards*

The first element called for by the California OSHA ergonomics standard is the evaluation of worksite ergonomics hazards. This cooperator's safety manager and the company safety committee identified hand weeding as exposing workers to the greatest risk of MSD injury. As a result the research teams' focus was limited to the cotton weeding job. Injury records and risk factor analysis supported this. Review of injury logs for cotton weeders in this operation showed 9 reported MSDs in the 1996-98 period. Injury logs also showed 20 sprain/strain injuries among these workers in the same period. The mean number of days lost from work per MSD was 40 days (total 802 days). For comparison, the mean number of days lost from work for the sprain/strain non-MSD injuries was 13.7 days.

This is high value specialty cotton, so freedom from contaminating fibers is important. Generally, female workers using hoes perform hand weeding. The job involves walking along cotton rows, cutting out weeds with a hoe. It often requires a cut 2-3 inches below the ground surface to be sure the weed is killed. Because some weeds (nightshade) regenerate easily and detract from the value of the harvested cotton, workers use shoulder bags to collect cut weeds for removal from the field. Weeders are assigned to one of several crews and number 43 in total.

It is important to note that the crews assigned to weeding by this company were permanent seasonal employees, most of long tenure with this company. All of these workers were employed in other tasks at other times in the season, the most important being as drivers of

cotton harvesters during the harvest. While hand weeding was viewed as a necessary task, it was also viewed as a means of employing these workers' time during the growing season.

This job was observed based on samples of at least 4 different workers performing each for 5-10 minutes each. The following description delineates the most common risk factors for the development of work-related musculoskeletal problems in this task for intervention planning.

The worker either stands facing the row or at an angle to it and performs an inspection task looking for weeds. When one is found she swings the hoe rapidly in order to cut the weed as close to the root as possible. Workers move along the row in search of weeds, holding the hoe across the body with both hands. Typically, the use of the hoe involves 1-second "wind up" to raise it to the highest position and one second to lower it to make the cut and move the weed to the center of the furrow. These are interspersed with relatively long periods of walking through the fields, carrying the hoe. Workers report that exertion to cut weeds is about 50% of maximum.

Postural analysis:

The worker's trunk is flexed up to 45 degrees when swinging the hoe, with trunk rotation and lateral bending of up to approximately 20 degrees each. The neck is flexed up to 30 degrees. When swinging the hoe the forward arm is flexed up to 95 degrees and the rear arm extended up to 50 degrees. Wrists are generally in neutral with respect to flexion/extension and ulnar/radial deviation. At the point of impact the rear arm is abducted up to 75 degrees and the forward arm adducted inward past the midline of the body, accompanied by mild ulnar deviation.

Periodically, workers must stoop to place the cut weeds into sacks, which are then carried up to .5 mile to the nearest truck. It is estimated that these sacks weigh up to 40 lbs. Full weed bags are carried to row end and dumped into a trailer. This requires about a 50 inch lift and dump.

The main complaint of the workers performing this job was the difficulty of walking through fields that were muddy or had many hard clods of dirt.

The job exposes workers to the following risk factors:

- 1) walking on uneven surfaces;
- 2) repetitive exertion of upper body force to hoe weeds;
- 3) repetitive awkward postures of the neck, trunk and arms;
- 4) continuous exertion of force to carry 24-40# weeding bags;
- 5) awkward postures associated with putting weeds in bags and emptying bags;
- 6) sustained contact stress from continuous carrying and use of hoe;
- 7) sustained forearm pronation while gripping hoe handle
- 8) discomfort as bags and clothing gets wet in early mornings (rubber pants & boots used in mornings); and
- 9) temperature extremes (up to 100° F).

### *Implement Hazard Controls*

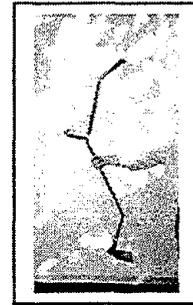
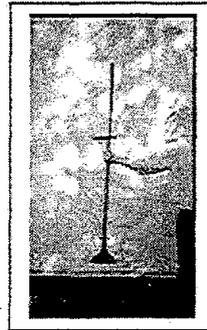
The second required element of the California OSHA ergonomics standard is the implementation of feasible hazard controls.

After multiple consultations with the committee and workers in the field, the engineering team decided to explore five approaches as follow:

1. alternate hoes or weed cutting tools employing better ergonomics and requiring less force application;
2. improved footwear to prevent ankle injuries;
3. dragging weighted boluses in furrows in early season to reduce soil clodding;
4. lighter, water resistant, easier dumping weed bags; and
5. use of a small hand trailer moved in rows by workers to put weeds in.



Weeding Crew



Sample Alternate Hoes

Prior to the next planting season (during which interventions would have been given field trial), the research team was advised that company management had reviewed information on the hand weeding job from the ergonomics committee. As a result management had decided to contract the weeding job out, meaning regular seasonal employees of the company would no longer be exposed to the risk factors involved. The ergonomics committee was dismissed and this collaboration was terminated. No controlled trial of exposures was implemented.

While this did not alter the risk factor exposures involved, it did ensure that the company's permanent workers would not be exposed to them, and transferred primary ergonomics standard responsibility and workers compensation liability for this job to the labor contractors involved.

#### *Provision of Employee Training*

The third required element of the California OSHA ergonomics standard is that of providing employee training on repetitive motion injuries and their prevention. The research team provided the ergonomics committee with detailed training on ergonomics and methods for preventing MSDs. Prepared educational materials in Spanish and English were used (examples in appendix). However, the project was terminated by the cooperator before training was extended to any personnel beyond the committee itself.

#### *Transferability of Intervention*

It seems likely that this intervention strategy may be utilized by other employers, especially if confronted with risk exposures for which no satisfactory engineering control is readily available.

## SJV TOMATO HARVEST CASE HISTORY

Our tomato production cooperator is a large operation (4000 acres at this site) employing around 175 permanent and 225 seasonal workers. This is a multi-commodity farming company that grows a variety of vegetable crops and raises cotton and livestock. After a series of orientation discussions, the company decided to invite us to work on their tomato harvest job. As in other crops, the bulk of the labor input and the majority of injuries occur in the harvest season. In keeping with the cooperator's priorities, we focused our efforts on the tomato harvest job.

Most tomatoes grown in California are grown for processing as are this cooperator's. These tomatoes are varieties specially bred for processing, having harder skins to facilitate machine harvest. While most of this cooperator's harvesting is contracted out, they do keep several harvest machines of their own. Our work focused on these machines and their crews. Tomato harvest begins in late July and extends into September. Harvest workers are paid \$6.25 per hour.

This employer has a safety program that conforms to California OSHA requirements. A safe work orientation is held for all employees at the beginning of the season, followed by tailgate sessions monthly thereafter. The safety program includes incentives for time periods worked without a reportable injury. The employer provides workers' compensation insurance and medical insurance for workers who have been with the company at least one year.

The cooperator's OSHA 200 logs did report MSD injuries making them subject to the California OSHA ergonomics standard. While this employer wanted to be proactive concerning the state's new ergonomics rule, they did have some hesitations based on concern for increasing injury reporting and potential fraud. Like the other cooperators in this study, most at this worksite tended to think of workplace safety as a largely individual concern involving personal control of exposures to be addressed by training.

### *Cooperator Descriptive Data*

While this is a large farming company, their tomato production operation would be considered mid-size (2000 acres) located in the San Joaquin Valley. They employed 175 permanent workers and 225 seasonal workers during the study period. However, only 21 of their own workers participated in tomato harvest. Farm labor contractors employed the majority. Descriptive demographic data from our initial survey are displayed on Table TMO 1 below.

Table TMO 1  
Descriptive statistics for the sample (n=9) 2001.

	Pre-Intervention				
	mean	sd	median	min	max
Age	43.89	10.91	41.0	25	59
Years of education	3.33	2.18	4.0	0	6
Years spent in the US	12.56	4.78	14.0	6	19
Years worked in agriculture	12.11	4.48	14.0	5	17
Years worked with this company	8.78	4.21	8.0	3	14
Acculturation score	5.0	1.0	5.0	4	7

Table TMO 2  
OSHA Log 200 Data  
Tomato Harvest

Year	Number Injured	MSD	Disability Status			Injury Location				
			Lost Days	Restricted Duty	Quit/Terminated	Back	Upper Ext.	Lower Ext.	Neck/Shldr	Other
1997	0	0	0	0	0	0	0	0	0	0
1998	2	1	6	0	0	1	0	0	0	0
1999	7	6	14+*	121	1	2	2	1	0	1**
2000										

(\* one injured worker quit, \*\*abdominal muscle sprain)

#### *Ergonomics Committee*

Work with this cooperator proceeded in two phases as they changed their worker's compensation insurer during the project. Initially, an eleven member committee was appointed representing the entire operation and including the human resources director and safety consultant. Most members were primarily Spanish-speaking and information was translated. Most committee members were supervisors of field units and were reasonably comfortable with group process.

This committee was trained by the research team and made preliminary identification of the following critical tasks:

Moving main line irrigation pipe- 10 to 12 inch diameter pipe

Weeding-using a hoe

Spraying pesticides

Sorting on tomato harvester

Shoveling-irrigation related.

Before further work could begin, the company made the decision to change its worker's compensation insurer and the safety consultant we had been working with as well as the farm manager were replaced. This brought the project to a temporary halt as the company reorganized its safety program.

When the project was re-initiated, the research team was informed that management had decided to focus all effort on the tomato harvest job alone. The former committee was not reconvened. Instead, tomato workers and the company human resources manager served as the project committee from this point on.

#### *Evaluation of Worksite Ergonomics Hazards*

The first element called for by the California OSHA ergonomics standard is the evaluation of worksite ergonomics hazards. Because the research team and management had agreed at the project's re-initiation that the focus would be on the tomato harvest job, there was no need for multiple job screening or other priority job selection activity.

Most California tomatoes are grown for machine harvest and processing uses. Mechanical tomato harvesters deroot plants funneling them to a broad conveyor belt. The belt passes the tomato plants along a sorting station on which workers stand. Workers must remove damaged fruit and plant materials so that only tomatoes are dumped into truck trailers for shipping.

The worker stands facing the conveyor and reaches with both hands to comb through and remove damaged tomatoes and tomato plant stems. Tomatoes and stems are deposited in a chute located in the near wall of the conveyor belt railing. Workers' arms are constantly in motion combing through and removing tomatoes and plant stems in order to uncover damaged fruit or plant stems. At times, the worker rests the forearm that is upstream against the metal edge of the conveyor railing, leaving the downstream arm to comb and sort out tomatoes and stems. Combining the activity of both hands, a tomato or stem is removed from the conveyor approximately 12 times per minute. About 12 seconds per minute is spent removing tomatoes or stems. The remainder of the time (80% of the job cycle) is spent combing, providing partial recovery time for the upper extremities in that this represents a less intense level of activity. Approximately every 15-20 minutes the conveyor is stopped to allow a full trailer to be pulled away, and an empty trailer to be pulled into place. This provides a 10+ second pause – the only true recovery time for the upper extremities during the job cycle. There is no recovery time from the constant standing.

The worker constantly scans the conveyor for the next tomato or stem to be removed. Some workers rotate their head to look upstream. Accessing the conveyor requires bending over the conveyor railing that is located at elbow height and reaching with both arms to tomatoes located several inches below the conveyor railing. Workers partially “unload” the weight of their trunks by leaning on the conveyor railing as they maintain trunk flexion for the duration of the task. This produces a virtually constant contact stress on the forearms. Video analysis was conducted to determine body posture at key joints; a range is provided because this depends on the worker observed.

Table TMO 3  
Tomato Sorter Range of Motion

Range of motion observed	Range of means	Peak
Trunk flexion	33° - 45°	65°
Right shoulder flexion	72° - 92°	105°
Left shoulder flexion	55° - 72°	100°
Elbow Flexion	35° - 45°	90°

The worker rotates the forearm between a pronated and neutral “handshake” position while performing the task. The workers' hands remain pronated while combing and grasping the tomatoes and stems and neutral while placing tomatoes and stems in the chute.

Workers experience substantial high frequency vibration exposure through the feet, thighs and pelvis, from standing on and leaning against vibrating machinery. They also experience substantial low frequency vibration or “jolting” as the machine moves over uneven terrain.

Workers wear poorly fitting gloves that increase grip forces while grasping the tomatoes and stems.

Injury logs showed seven reported MSD injuries over the previous 24 months. Three of these involved the back and two the upper extremities. In response to pre-intervention pain and symptom surveys seventy percent (70%) of these workers reported significant pain in the mid or lower back at season end and thirty percent (30%) reported other lower extremity pain. It is clear that the most serious risk exposures in this operation involve the back and upper extremities.

### *Implement Hazard Controls*

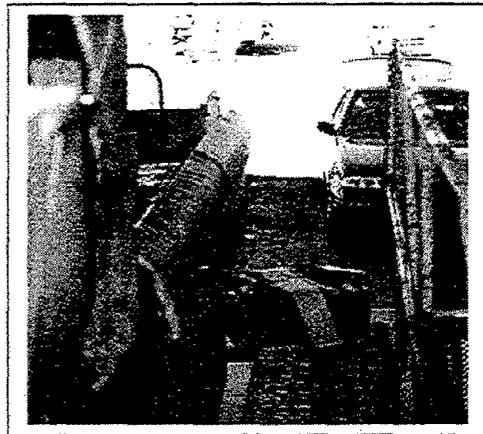
The second required element of the California OSHA ergonomics standard is the implementation of feasible hazard controls. Research by the engineering team confirmed that there were no "off-the-shelf" tools or technologies short of complete machine redesign which would alleviate either high rates of repetition or the awkward posture exposures which were agreed to be the most serious risk factor exposures. Initially, two risk factor exposures were targeted. First, heat stress involved in working in the dust and sunlight in high temperatures (up to over 100 degrees F). A set of shades were developed and hung on one harvester. However, field testing quickly showed that the shades actually increased both heat and dust exposures as they inhibited air movement on the sorting platforms. Consequently they were removed and eliminated.

The second initial intervention involved installing padding along the edge of the sorting conveyor to protect workers from machine vibration as they leaned against it. This padding was left in place for the length of one harvest season, but no health impact data was collected as workers pointed out that their concern was less for the high frequency vibration than for the heavy jolts encountered as the machine crossed furrows or other major soil disturbances, often throwing them against the sorting edge hard enough to cause contusions.

Prior to the final season, workers were given padded aprons to try for protection against both ongoing high frequency vibration and the lower frequency vibration or jolting caused by uneven terrain. The apron was also intended to help relieve sustained pressure points from leaning on the conveyor edge. The apron is 35" in length and 27 1/2" wide, it has three pockets and is adjustable. The chest pocket is 18 3/4" x 11 1/4". The foam used in this pocket was Conofor CF-45 Series, 1" thick. The two side pockets are 10 1/2" x 7 3/4". Each pocket has a 1/2" foam pad.



Tomato Sorting on Harvester



Padding Installed on Harvester



Padded Apron



Padded Apron in use

### *Provision of Employee Training*

The third required element of the California OSHA ergonomics standard is that of providing employee training on repetitive motion injuries and their prevention. The research team provided training on the ergonomics standard, on MSDs and their prevention, and on the project itself directly to involved workers. Participating workers acted as an ergonomics committee and assisted in hazard analysis, in proposed intervention assessment and in intervention evaluation.

### *Intervention Evaluation*

While not specifically required by the California OSHA standard, any good safety practice involves follow-up assessment of effects. The initial intervention concepts (shading and workstation padding) were considered engineering assessments and due to early worker rejection no health data were collected on them.

### *Apron Intervention*

The intervention trial was conducted on 9 workers (sorters) using 2 harvesters over a 4 week period in 2001. The design was a simple pre-post using the symptom interview as an outcome measure. Workers served as their own controls. The trial schedule was as follows;

Week 1 of harvest - no aprons (baseline interview at the end of the week)

Week 2 of harvest - no aprons (interview at the end of the week )

Week 3 of harvest - give out aprons at beginning of week (interview at the end of the week)

Week 4 of harvest - continue workers with aprons (interview at the end of the week)

### *Ergonomics Outcomes*

The apron provided insulation for the abdominal area from continued low amplitude, high frequency vibration from leaning against the conveyor mechanism and from high amplitude, low frequency jolting as the harvester moved over rough ground. The aprons appear to provide some protection from reported contusions from being thrown against the conveyor frame edge.

### *Health Outcomes*

Health effects evaluation was conducted by Dr. Faucett, using the health and symptom survey. There were only nine workers enrolled in the study of intervention. Table TMO 3 presents baseline or pre-intervention symptoms results from workers. As can be seen, these workers experience substantial pain associated with the job. Nearly half (47.7%) reported upper extremity pain and just under a quarter (23.8%) reported pain in the neck and shoulders.

Table TMO 3  
Frequency of Pain Reported by Tomato Sorters  
N=21, 1999

Number of workers reporting MSD symptoms <i>pre-intervention</i>						
	Right Upper Extremity	Left Upper Extremity	Right Lower Extremity	Left Lower Extremity	Neck & Shoulders	Back
Sorters (n=21)	47.7%	14.3	9.5%	9.5%	23.8%	14.3%
Total Reporting Any Symptom		47.6%				

The intervention consisted of an apron padded with dense foam that was designed to relieve the stress of leaning on the conveyer's edge, which provided not only contact stress but also vibrated with the motion of the truck and the conveyer. Data were collected from the tomato sorters (n=9) on their pain and fatigue at the end of each of four weeks: for two weeks without using the apron and for two additional weeks using the apron. Data were analyzed to see if there was any improvement in fatigue or pain scores after the two week trial of the apron. Although three subjects reported pain at the end of the first baseline week (prior to intervention), no subjects reported pain at the end of the second baseline week; or for either of the two weeks of the intervention period that followed. Fatigue scores demonstrated more variability than pain scores. Pairwise t-tests were computed to compare fatigue scores at the end of the two week baseline period (prior to intervention) to fatigue scores following two weeks of using the aprons. Differences in fatigue scores were not found to be significant. These findings suggest that the apron had little impact on the symptoms that we chose as outcome measures, although the subjects reported anecdotally that the aprons had a positive impact.

In sum, it appears that the intervention did not result in significant MSD symptom or pain reduction. This is not entirely surprising since the intervention did not relieve repetition or awkward postures, more likely to be sources of musculoskeletal symptoms. These results suggest that a modest or incomplete improvement in the ergonomic risk factors of a job task is likely to prove insufficient to decrease workers' symptom experience. At the same time, workers liked the aprons and reported that they improved comfort.

#### Productivity Outcomes

Productivity effects were assessed by company management using trucks/tonnage throughput measures commonly used. This is a machine paced job and there were no changes in speeds of the harvester or sorting conveyors. No productivity impacts were noted. Because no changes were made in machine pacing, it is not surprising that no changes in productivity were observed.

#### Transferability of Intervention

The padded apron is an easily transferred item of personal protection. It is already in use in some industries and is commercially available.

## SJV STRAWBERRY CASE HISTORY

Our strawberry production cooperator is a small operation (60 acres at this site) employing 8 permanent and 108 seasonal workers. The work is highly seasonal, beginning in December and ending by June (in Southern California). While strawberry production involves planting and cultivation (special fumigation tasks are contracted out to specialists), the primary work involves harvest of mature strawberries for fresh and processed marketing. This is performed by hand since it requires selection of mature strawberries from among many per plant. Strawberry plants produce berries continuously throughout the season.

At the beginning of the season (December) berries are picked for fresh market. Employees are paid hourly ( \$5.75) and work from 5 to 9 hours a day depending on production and demand. Around March production and demand increase to the point that employees are paid by incentive rate (\$1.75 per box of fresh and about \$1.00 for processing in the research period). Workers average about 6 boxes per hour and will work about 9 hours a day during the incentive pay period. Workers start in a designated furrow and fill up a box, when box is full they turn it in to a truck at the end of the furrow. Fresh market berries go directly to the market and so must be fully ripe, attractive and oriented properly in the box. Berries for processing are used for juice or frozen products. Processing berry harvest begins in April. Processing berries must have the calyx (the green stem and stem leaves) removed, hence the pace is slower (average 4 boxes per hour). Workers wear latex gloves for this task and use a metal tool for calyx removal. Processing berry harvest is paid at the same incentive rate.

This employer has a safety program conducted by an outside contractor that conforms to California OSHA requirements. A safe work orientation is held for all employees at the beginning of the season, followed by tailgate sessions every two weeks thereafter. The safety program includes incentives for time periods worked without a reportable injury. The employer provides workers' compensation insurance but no medical insurance.

The cooperator's OSHA 200 logs did not report any injuries for the first season of cooperation nor for the season before. However, this is an industry under public scrutiny for the degree of stooped posture involved in the job. Hence, this employer wanted to be proactive concerning the state's new ergonomics rule. Like the other cooperators in this study, most at this worksite tended to think of workplace safety as a largely individual concern involving personal control of exposures to be addressed by training.

### *Cooperator Descriptive Data*

This is a small strawberry production operation (60 acres) located in Southern California, specializing in early season fresh market and processing fruit. They employed 8 permanent workers and 106 seasonal workers during the study period. Overall, this group of employees was made up of workers newer to the US than observed with our other cooperators. In part, that may be because this work is demanding and comparatively low paid. Descriptive demographic data from our initial survey of MSD symptoms are displayed on Table STR 1 below.

Table STR 1  
Descriptive statistics for the initial sample of strawberry employees  
(N=108, Male: n=79, female: n= 29,2000)

	Pre-Harvest				
	mean	sd	median	min	max
Age	30.40	11.3	26	16	61
Years of education	5.22	3.34	6.0	0	13
Years spent in the US	6.90	7.75	4.0	0	34
Years worked in agriculture	5.48	6.53	3.0	0	30
Years worked with this company	3.17	4.76	2.0	0	27
Acculturation	4.14	0.45	4.0	4	7

Table STR 2  
OSHA Log 200 Data

Year	Number Injured	Disability Status			Injury Location				
		Lost Days	Restricted Duty	Quit/Terminated	Back	Upper Ext.	Lower Ext.	Neck/Shldr	Other
1	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0
3	1	28	0	0	0	0	1	0	0

*Ergonomics Committee*

The ergonomics committee consisted of five workers and one supervisor. Committee members were selected by the owner/manager and only met in his presence. Most members of the committee were either solely or primarily Spanish speaking. Research staff translated all presentations and all discussions took place in Spanish. This committee functioned only in response to questions or inquiries. Participants had little or no experience with formal group decision-making and primarily focused their inputs on issues of how tasks were performed. Priority and intervention decisions were made on the spot by the owner/manager. Committee members and participants expressed much interest in the idea of technical aides to a job they all considered demanding. However, they did not develop a good grasp of ergonomic vision nor were they able to contribute effectively to thinking about intervention ideas or alternatives except in reaction to external input. This committee probably cannot and will not function without either external support or direct management administration.

Committee members were provided training on ergonomics and the California OSHA ergonomics standard by the research team. The committee participated in job analysis and intervention planning and implementation. The owner/manager directed that attention be focused on the picking job. Since this is the task performed by the most workers, most of the

time, and involving the most extreme ergonomics risk factor exposures, this focus was readily acceptable to both workers and the research team.

### *Evaluation of Worksite Ergonomics Hazards*

The first element called for by the California OSHA ergonomics standard is the evaluation of worksite ergonomics hazards. Because the research team and management had agreed at the outset that the focus would be on the hand harvest job, there was no need for multiple job screening or other priority job selection activity.

Strawberry picking involves walking down furrows (approximately 12" wide and 300 yards long) between moderately raised beds and pushing or carrying a wire cart with strawberry boxes in it. This growers beds were 41-42" wide and 14" high with plants about 6" apart. The beds were covered with black plastic for weed and insect control. The workers must assume a stooped posture to see berries within plant foliage and must pick discriminately to select only mature berries. Berries are twisted from vine with the fingers and placed in boxes. Normally pickers remain in a stooped posture for the length of a row.

The worker stoops, kneels, or squats in the path between rows of strawberry plants, reaches in with both hands, grasps several strawberries with a pinching and twisting motion, and pulls them free. Strawberries are placed in a box, a "flat", on a metal cart 6" off the ground at the worker's feet. As necessary, the worker moves along the path between two rows to access more fruit. The worker must constantly alter his/her body position, to see, reach, grab, and place the strawberries. Workers paid on incentive basis move as fast as possible.

The worker advances the cart approximately 6" at a time by grabbing the handle and pushing the cart with either the right or left hand. This is done approximately 19 times per flat. Prior to advancing the cart, workers "pick and place" strawberries by twisting between rows. When the flat is full (8-12lbs.), workers lift it from a stooped or kneeling position and carry it to the truck where another worker logs in the weight of the flat and stacks the box on the truck at a height of 48". An empty flat is retrieved by the worker who runs back to the next picking location. Workers often carry flats on one shoulder or between the waist and shoulder with one hand and run with flats, so that they are often lowering the flats from shoulder height position to place them on the truck.

When pulling strawberries off the plant, both hands are engaged in very repetitive gripping. There is direct pressure on the knee when kneeling on the strawberry beds imparted to the knee when kneeling on the strawberry beds to stabilize the trunk while leaning over the bed.



Strawberry Harvest Workers

Typically, the job cycle consists of:

<u>TASK</u>	<u>TIME (SECONDS)</u>
Pulling (picking)	170
Placing strawberries in flat	99
Roll cart to next location	19
Carry full cart to trailer and carry empty flat back to next picking location	50
<b>TOTAL JOB CYCLE</b>	<b>338 seconds</b>

Moderate force is required when lifting and carrying the flat when it is full (8-12 lbs), especially as it is rapidly accelerated to carry it and stack it.

Awkward postures in the strawberry harvest task include shoulder flexion between 20 and 90 degrees; elbow flexion between 60-90 degrees; frequently severe forearm pronation (up to 90 degrees); radial and ulnar deviation greater than 15 degrees and shoulder abduction up to 45 degrees. Trunk flexion ranges from severe while stooping (110 degrees, sustained for about 30-45 seconds) and moderate while squatting (up to 75 degrees, sustained for about 15-30 seconds) and sustained neck extension (> 20 degrees).

Additional risk factors include:

- Poor visibility through leaves; leading to forward bent trunk
- Constant deviation of both hands
- Contact pressure on knee from kneeling on bed.

Injury logs showed only two reported injuries over the previous 24 months- neither an MSD. However, in response to pre-intervention pain and symptom surveys seventy percent (70%) of these workers reported significant pain in the mid or lower back at season end and thirty percent (30%) reported other lower extremity pain. It is clear that the most serious risk exposures in this operation involve the back.

#### *Implement Hazard Controls*

The second required element of the California OSHA ergonomics standard is the implementation of feasible hazard controls. Extensive research by the engineering team confirmed that there were no "off-the-shelf" tools or technologies which would alleviate either the stoop or the repetitive hand picking exposures which were agreed to be the most serious risk factor exposures and the foci for intervention. This left the committee and the research team with the problem of how to comply with the Cal OSHA standard requirement that "feasible hazard controls" be implemented. What is the requirement or even the most advisable approach where no practical or feasible hazard controls exist? The research team recommended that a dual approach be adopted. First, to implement increased rest and recovery breaks as an administrative control. Second, to explore the adaptation potential of alternative engineering approaches to the problem of stooped posture.

Dr. Faucett and Mr. Janowitz designed a rest and recovery protocol based on the work of Galinsky, Henning, Rodgers and others (Galinsky et al., 2000; Henning et al., 1985; Eastman Kodak, 1986). The rest and recovery intervention protocol called for an additional 5 minute work break for every working hour in which there was no other regularly scheduled break (e.g., lunchtime). Thus over the typical work day, under current state regulations, workers receive a 10 minute break after two hours of morning work, a 30 minute lunch break two hours after that, and a 10 minute break two hours after lunch is completed for a total of 50 minutes of break time. The intervention added 20 minutes break time, for an intervention study total of 70 minutes.

In the strawberry setting, we provided a field trial for a 2 week period during hourly wage work in February, 2001. This proved to be a difficult season for such a trial – rain cancelled the data collection for most days. We were only able to apply the trial protocol for three five hour work days out of the intended ten day work period. We gathered baseline data about musculoskeletal symptoms, fatigue and productivity from 72 participating workers on Day 1 of the trial. Workers were then randomly assigned to an experimental group and a control group. Symptom data were gathered at the end of each shift, using a shortened variation of our standard questionnaire. Productivity was assessed for each worker on a daily basis. Workers wear a bar code that is swiped each time they bring a new flat of harvested berries to the collection area - thus we were able to count how many flats they produced each shift.

Two engineering intervention concepts were subjected to limited testing by participating workers. The first consisted of two variations of a harness intended to reduce the effect of the weight of a workers upper body on the spine when working in a stooped posture. In the absence of a generic term the research team referred to these as “Weight Transfer Devices” (or WTDs), since it is their intended function to transfer the load of upper body weight to the worker’s thighs when in a forward bending posture.

The engineering team actually acquired and reviewed three WTDs for possible field trial -the BNDR, Bendeze and the Happy Back. However, only the BNDR and Happy Back models were judged even potentially practical for field strawberry work. The BNDR consists of a metal frame which is hinged and spring-loaded transferring upper body weight to the front of the thighs. The BNDR was commercially available at the time of the study. The Happy Back consists of a light-weight frame and employs shoulder and thigh straps and bungee cords to transfer upper body weight to the front of the thighs. The Happy Back was in development and not commercially available at the time of the study. Both are pictured below.



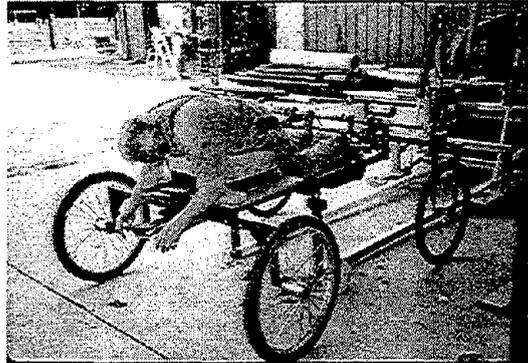
Happy Back WTD



BNDR WTD

Dr. Miles also developed a prototype prone position picking cart for field testing. This concept was based on prior research at both UCD and in Europe using frames behind slow moving tractors to place workers in a prone position for selected field tasks usually requiring stooped posture. Because of the density of the strawberry beds, it was judged impractical to use tractors so Dr. Miles and his associates developed a cart propelled by the worker using a modified bicycle arrangement. The cart was wide enough to straddle beds allowing the worker to reach around the full bed.

Prone position  
picking cart



#### *Provision of Employee Training*

The third required element of the California OSHA ergonomics standard is that of providing employee training on repetitive motion injuries and their prevention. The research team provided the ergonomics committee with prepared brochures in Spanish for employee use (examples in the appendix). In this seasonal workplace, each season begins with a required daylong safety orientation. Workers are required to attend and are paid. A presentation was made of the ergonomics program by research team members and the senior manager. In addition, information on risk factors, prevention and the company's ergonomics program was provided to the company's safety consultant and the information was included in their regular tailgate meetings.

#### *Intervention Evaluation*

While not specifically required by the California OSHA standard, any good safety practice involves follow-up assessment of effects. In this case, because the engineering mechanisms were not proven, no attempt was made to collect health outcomes data. They were only evaluated for ergonomics effects and employee and management opinions about adoptability. While the rest and recovery intervention was subjected to health effects evaluation, obviously it offered no effect on the risk factors themselves and no ergonomics evaluation was conducted. The number of subjects participating in the rest and recovery trial was insufficient to yield significant results. However, the results were positive enough that this intervention was later repeated with another cooperator group.

#### *Rest and Recovery Intervention*

For each day of the strawberry trial, workers in the experimental group reported less severe symptoms than workers under the control conditions (the usual work conditions), but were also less productive. Nonetheless, after statistically controlling for differences in levels of productivity, better symptom control continued to be associated with the experimental condition. These results are shown in the table below.

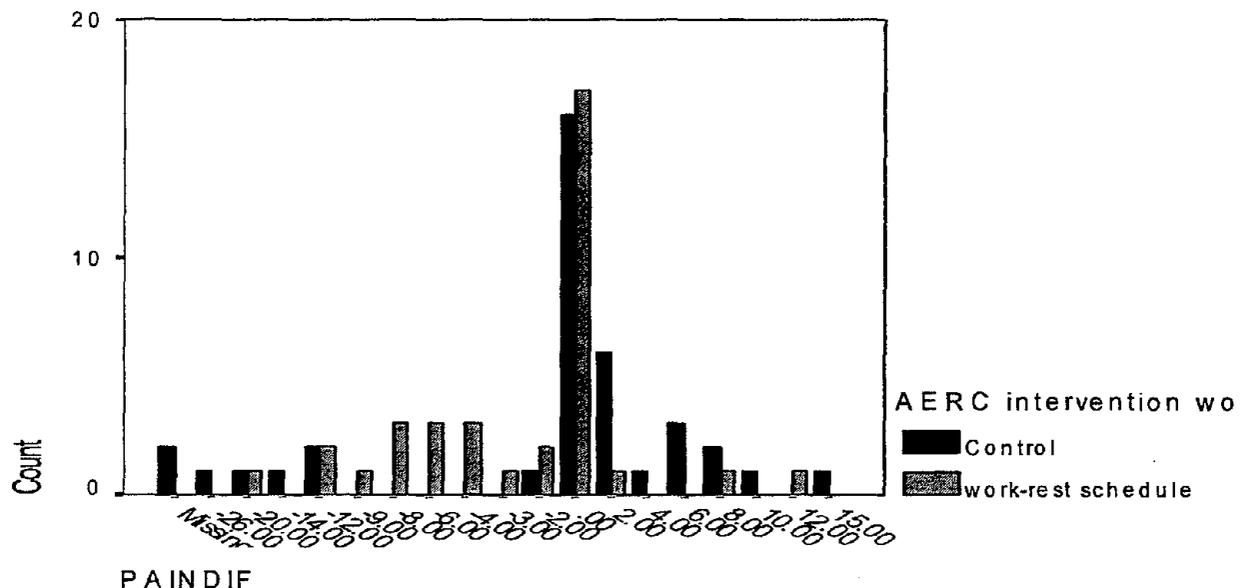
The bar graph below describes difference scores for workers' musculoskeletal symptoms. It graphs the observed frequency that a particular total symptom score difference occurred. Each symptom score difference was calculated by taking the sum of the symptom scores for days 2 and 3 and subtracting twice the symptom score for day 1 from the day 2 and day 3 composite. This variate can be interpreted as twice the difference between, on the one hand, the day 2 and day 3 average and, on the other, the day 1 score. The Mann U Whitney value is 466.5 ( $p < 0.04$ , two tailed).

A negative score value indicated that the average musculoskeletal symptom score measured during days 2 and 3 was less than the score measured on day 1, while a positive score indicates that during these two days symptoms increased. For an intervention group measurement, a value of zero indicates that there was no change in the symptom severity after the break intervention. The table shown below was based on the subset of workers who experienced a change in their symptoms. It shows that most of the workers whose symptoms worsened on days 2 and 3 were in the control group. It also shows that those workers whose symptoms decreased, tended to be in the experimental group. (Among all workers whose responses were complete, 33 expressed no change in pain experienced, while 39 indicated either an increase or a decrease in pain.)

Table STR 3  
Worker MSD Symptom Reports  
Strawberry Harvest Rest Break Trial

	More severe symptoms on days 2&3	Less severe symptoms on days 2&3	Total Number of Workers in Group
Control group	14	6	20
Experimental group	3	16	19
Change in Pain Totals	17	22	39 workers with nonzero symptom change reports

Table STR 4  
Symptom change contingency table  
Reported MSD Symptoms (n=72).



### *Engineering Intervention Trials*

Two WTDs (Happy Back and BNDR) were given field trial by workers. Both were judged to be impractical for the strawberry harvest task. Both severely inhibited any sideward movement meaning that workers could not stretch to either side and had to move down a row in a series of awkward front-facing turns and steps. In addition, the Happy Back was quite difficult to put on and required assistance. Workers did report that they seemed to relieve some back strain from the stooped posture, but the devices were deemed too awkward and work slowing to be used.

In addition, four WTDs were subjected to ergonomics laboratory analysis by Dr. Fathallah and Research Assistant Amy Barrett (paper in Appendix). The objective of this study was to evaluate four personal weight transfer devices (BNDR, Bendeze, modified Bendeze, and Happy Back) with respect to their practicality and effectiveness in reducing the load on the spine during stoop labor. The results indicate that all four devices reduced trunk muscle activities to varying degrees. However, two of the devices (Happy Back and Bendeze) generated increased activities in the knee flexor muscle. The practicality for field use of three out of the four devices (BNDR, Bendeze, and Happy Back) were also questioned. One device (modified BNDR) showed potential applicability for field use if modifications can be made to increase comfort.

Despite the real practical limitations of current models, the concept of personal weight transfer devices seems to offer an approach that is worth pursuing in the effort to prevent low back disorders due to agricultural stoop labor.

The prone position cart was also given field trial by workers. It was also judged to be impractical for the strawberry harvest task. The cart was severely inhibited by mud in the furrows and was difficult to propel as designed. In addition, the cart inhibited the worker's reach to the sides of beds where a significant proportion of fruit is located. Like the WTDs, the cart was judged by workers to be too difficult to use and work slowing to be practical at this time. Dr. Miles believes that this approach has potential, but that significant development research will be required.

### *Productivity*

This strawberry operation calculates productivity in terms of boxes picked. Productivity effects were assessed by company management using worker barcodes as boxes are brought to the trucks on three full days for both control and intervention groups with results as described in Table STR 5. The crews averaged about a 9.4% reduction of productivity as a result of the increased rest break schedule. This productivity reduction would require a crew of 35 about 29 minutes to make up at an additional labor cost per crew of \$114.10 (9.7%) per day. While the grower might be willing to absorb this cost in return for reduced injury risk, it seems unlikely that workers would under incentive pay conditions.

Table STR 5  
 Rest Break Intervention Productivity Effects  
 (all 35 member crews)

Period	Hours worked	Control Group		Intervention Group		Production Effect	
		total boxes	boxes/hr avg	total boxes	boxes/hr avg	total boxes	boxes/hr avg
Day 1	5	404	80.8	363	72.6	- 41	- 8.2
Day 2	5.25	541	103.05	508	96.76	- 33	- 6.29
Day 3	5.25	492	93.83	446	84.95	- 46	- 8.88

*Intervention Transferability*

The work rest break intervention used here is readily transferable to other work situations. Its primary drawback from an employers' perspective is concern for productivity. Productivity effects are likely to vary between commodities and tasks.

## SJV TREE NURSERY CASE HISTORY

Our tree nursery cooperator is a large operation of its type, employing around 75 people full-time and up to 175 on a seasonal basis. This company specializes in raising trees for bare root fruit and nut nurseries and to orchardists throughout California, the western U.S. and many countries worldwide. The company grows trees from seeds and cuttings, for one year, or two, depending on the type of tree. The majority of their inventory is trees for processing crops including cling peaches, prunes, almonds and walnuts. They also grow fruit crops such as apricots, freestone peaches, nectarines, apples, pears and cherries. The trees are all grown in the field and the work is highly labor intensive.

Currently, this company farms approximately 900 acres, of which about 200 acres are in trees at any one time. The annual harvest is in the range of 1.5 to 2 million trees. The rest of the land is farmed as grain rotation crops, or orchards for rootstock and budwood sources, as well as a few acres of fresh market peaches. The busiest seasons for this industry are during the early summer budding, the late summer, when peach harvest is added to the rest of the nursery work, and the months of December and January when the tree harvest and shipping is done.

The majority of the work force is comprised of immigrants from India, with most of the balance being from Latin America. For the most part, work here is remunerated on an hourly basis. The company does employ incentive pay at two seasonal points. Budding crews are offered incentive pay during the spring, dormant and June budding. Budders are given a percentage bonus based on the number of successful grafts. The second incentive program is given during the color coding of the trees for shipping. Crews are assigned to code a specific number of trees. Crews exceeding their quota are paid a bonus. The employer provides workers' compensation insurance and full time employees are eligible for a package of benefits that include medical, dental and vision benefits after one full year of employment.

This employer has a safety program that conforms to California OSHA requirements. All employees are given an orientation at the time of hire and an annual refresher thereafter. Foremen and supervisors conduct monthly tailgate training in the field. Any other required training, such as for a job or process change is given immediately by foremen. The safety program includes incentives for time periods worked without a reportable injury. A safety committee meets on a monthly basis. All supervisors, foremen and some full time hourly employees attend. Prior to the meeting a comprehensive inspection is done by a team of foremen and supervisors. Results of the inspection are reviewed at the meeting along with any new injuries and recommendations.

This cooperator's OSHA 200 logs did report diagnosed MSDs that made them subject to the California OSHA ergonomics standard. The cooperator was actively interested in finding and testing interventions for the tasks involved with these injuries and was cooperating with their worker's compensation insurer in researching the problems. Like the other cooperators in this study, most at this worksite tended to think of workplace safety as a largely individual concern involving personal control of exposures to be addressed by training.

### *Cooperator Descriptive Data*

This is a large orchard tree nursery (900 acres, 1.5-2 million trees annually) located in Northern California. They employ 75 permanent workers and 175 seasonal workers. This group of employees was nearly equally made up of workers from India and those from Latin America.

Descriptive demographic data from our initial survey of MSDs from the Log 200 are displayed on Table TN 1 below.

Table TN 1  
Descriptive statistics for the initial sample of tree nursery employees  
(N=54, Male: n=38, female: n= 16, 2000)

	Pre-Harvest				
	mean	sd	median	min	max
Age	44.74	12.36	43.5	21	70
Years of education	6.96	4.04	6.5	0	14
Years spent in the US	13.48	9.32	11	2	52
Years worked in agriculture	9.43	7.06	6.5	2	25
Years worked with this company	9.28	7.16	6.0	0	25
Acculturation	5.94	2.1	6.0	4	18

Table TN 2  
OSHA Log 200 Data

Year	Number Injured	Disability Status			Injury Location				
		Lost Days	Restricted Duty	Quit/Terminated	Back	Upper Ext.	Lower Ext.	Neck/Shldr	Other
1	9	33	34	0	2	4	2	0	0
2	13	133	312	1	1	2	10	1	0
3	8	101	49	5	4	3	2	2	0
4	7	5	181	2	3	1	1	1	0

#### *Ergonomics Committee*

The ergonomics committee consisted of four workers, one supervisor and the personnel manager. In addition, the company's worker's compensation insurance field representative was an active participant. Committee members were selected by the manager. Three of the committee members were native Punjabi speakers and three were native Spanish speakers. While all could follow most English discussion, research staff routinely translated into Spanish while a hired translator translated into Punjabi. Standard written materials were available in Spanish, but were also translated into Punjabi for this employer.

Initially, this committee was largely passive, but since work with this employer covered a 3 year period, the committee became much more interactive over time. As with other committees, these members were trained in the research team's approach to ergonomics, risk factor evaluation and problem solving. Both participating supervisors and the company's worker's compensation representative provided active leadership roles and with their continued support it seems likely that this committee will continue to function.

Committee recommendations were presented directly to the operations manager who was quite supportive of the committee and the project. The committee participated in job analysis and

intervention planning and implementation. This committee participated fully in onsite project planning, priority setting and decision making.

*Evaluation of Worksite Ergonomics Hazards*

The first element called for by the California OSHA ergonomics standard is the evaluation of worksite ergonomics hazards. Primary jobs (other than standard cultivation tasks such as irrigating) in this tree nursery are as follow:

**Planting** Planting trees from seed.

**Making Cuttings** Cuttings are selected shoots with buds cut from pruned branches.

**Budding and Tying** Budding is one method of inducing a different fruiting variety to grow from a preferred rootstock by inserting buds into cuts on young trees.

**Grafting** Grafting is the process of inserting a piece of a branch of a desired fruiting variety into cuts on the trunks of young trees

**Snubbing** Cutting the tops of young trees. For some varieties this is done with a tractor, for others it must be done by hand.

**Bamboo** Taping a bamboo stick alongside the growing tree to train it to grow straight.

**Suckering** Removing unwanted shoots and leaves from growing trees with shears or knives.

**Thinning** Removing extra trees that have grown too close together.

**Stringing & Staking** Straightening larger trees that have grown at angles by tying to stakes.

**Digging** This is the harvest task. Trees are pulled and stacked.

**Warehouse Work** Trees are sorted and bundled for shipping.

In accordance with our research methods, three approaches were employed (observed MSDs, job risk factor screening, and worker opinion) with the results displayed on Table TN 3 below.

Table TN 3  
Summary of Ergonomics Risk Rankings

Observed MSDs	Ergonomics checklist	Workers & supervisors ranking
Digging	Grafting	Digging
Field	Budding	Budding
Grafting	Tying	Grafting
Planting	Snubbing	Suckering
Lifting	Bamboo	Planting
Shop	Tying & Tape	Irrigation
Fruit Harvest	Suckering	
	Planting	
	Digging	

From the above analysis the ergonomics committee reported that digging, budding, and grafting should have priority attention. Based on the report of the ergonomics committee, senior managers ranked jobs for intervention as follow: budding, grafting, digging. Their reasoning was based on exposures. Budding involves around 45 workers for 8 weeks twice a year. Grafting involves an additional 12 workers for 4-6- weeks. By contrast, digging only involves 10-12 workers for 3-5 weeks. So, budding (and grafting which is a quite similar task) was designated as the priority job for intervention.

The budding and grafting jobs were re-observed based on samples of at least 4 different workers performing each for 5-10 minutes each. The following descriptions delineate the most common risk factors for the development of work-related musculoskeletal problems in these selected tasks for intervention planning.

The worker kneels facing or at an angle to tree seedlings, reaches in with the non-dominant hand, grasps the seedling and bends it laterally to expose the stem, the dominant hand uses a knife to make two cuts: 1) a vertical cut removing an existing bud from the seedling and 2) a angled cut creating a flap at the bottom of the exposed stem, and then the dominant hand retrieves a stem from a bag of stems located at the workers side and cuts a bud off and “grafts” it on the seedling by placing the new bud in the flap. A second worker secures the graft to the seedling stem by wrapping tape above and below the bud. Seedlings are about a 1’-1.5’ tall. This work takes place on the stem seedling approximately 7” from the ground. Workers use a kneepad that is large enough to fit under one knee. The worker remains kneeling with the trunk flexed for up to two hours. Workers are paid on an incentive basis and move as fast as possible.

As necessary, the workers move along the row of seedlings. When moving, the worker must drag her kneepad with her. The worker’s trunk can be flexed up to 80 degrees, especially when using the knife to perform cuts and place the new bud, but is more typically flexed at 55 degrees. Trunk flexion is typically coupled with trunk twisting up to 15 degrees and elbow flexion up to 90 degrees. The task is visually intensive because it requires precise hand movements with the knife. The worker’s neck is flexed and extended in a neutral range.

Ulnar deviation is required to hold and use the knife to make cuts and to hold back the seedling to expose the stem for cutting. A pinch grip is used when holding the knife and holding the seedling back to expose the stem.

When cutting, the dominant hand is engaged in very repetitive gripping, and averages 18 cuts per minute. Pulling and pushes forces on the knife average 1-2 lbs.

When wrapping grafts with tape, the hands are moving rapidly, and average 6 wraps per minute.

Workers are in static postures of the neck, trunk, and lower extremities for periods of up to two hours. Contact stress includes pressure on the knees of the kneeling worker. Cotton gloves are worn.

As seedlings mature they must be staked to promote an upright growing direction. The worker kneels facing the row of seedlings and uses string to tie seedlings to stakes. As necessary, the worker moves along the row “staking” seedlings.

Additional risk factors include:

- Poor visibility through leaves of seedling; leading to forward bent trunk
- Constant ulnar deviation of dominant hand
- Contact pressure on knees from kneeling for long periods of time

Injury logs did not show any reported MSDs associated with budding and grafting over the previous 24 months. However, in response to pre-intervention pain and symptom surveys sixty seven percent (67%) of these workers reported significant pain or symptoms. Over sixty percent (60%) reported pain and symptoms in the lower extremities and fifty seven percent (57%)

reported back pain and symptoms. It is clear that the most serious risk exposures in this operation involve the lower extremities and back.

### *Implement Hazard Controls*

The second required element of the California OSHA ergonomics standard is the implementation of feasible hazard controls. Extensive research by the engineering team confirmed that there were no "off-the-shelf" tools or technologies which would alleviate either the sustained kneeling or the repetitive hand work exposures which were agreed to be the most serious risk factor exposures and the foci for intervention. This left the committee and the research team with the problem of how to comply with the Cal OSHA standard requirement that "feasible hazard controls" be implemented. What is the requirement or even the most advisable approach where no practical or feasible hazard controls exist? The research team recommended that a dual approach be adopted. First, to implement increased rest and recovery breaks as an administrative control. Second, to explore the adaptation potential of alternative engineering approaches to the problem of sustained kneeling posture.

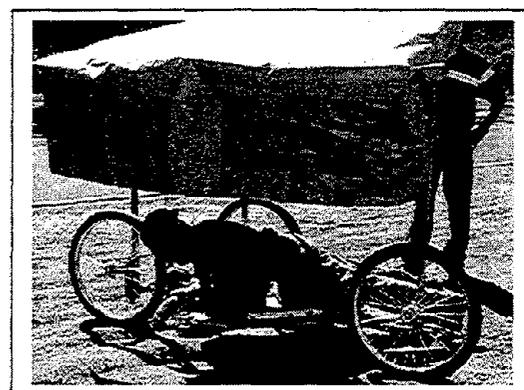
Dr. Faucett and Mr. Janowitz designed a rest and recovery protocol based on the work of Galinsky, Henning, Rodgers and others (Galinsky et al., 2000; Henning et al., 1985; Eastman Kodak, 1986). The rest and recovery intervention protocol called for an additional 5 minute work break for every working hour in which there was no other regularly scheduled break (e.g., lunchtime). Thus over the typical work day, under current state regulations, workers receive a 10 minute break after two hours of morning work, a 30 minute lunch break two hours after that, and a 10 minute break two hours after lunch is completed for a total of 50 minutes of break time. The intervention added 20 minutes break time, for an intervention study total of 70 minutes.

Dr. Miles and his colleagues developed two types of carts with the objective of reducing exposure to sustained kneeling. The first was a small cart (fig. TN 1) on which the worker could place one knee in a padded area. The cart was wheeled, allowing for it to be moved by pushing with the non-kneeling foot. The second was a prone position cart (fig. TN 2). This cart had adjustable padding to fit different workers, and was fitted with a counter-balanced hard hat to relieve stress on neck. Both carts were given enthusiastic field trial by both male and female workers. Neither was found to be fully practical at this time. Workers found that the kneeling cart slowed their progress somewhat and did not find it significantly more comfortable than kneeling with kneepads. Workers found working in the fully prone position for a sustained period to be uncomfortable and the cart did not move satisfactorily. Female workers found the prone position both extremely uncomfortable and socially inappropriate.

Figure TN 1  
Kneeling Cart



Figure TN 2  
Prone Position Cart



### *Provision of Employee Training*

The third required element of the California OSHA ergonomics standard is that of providing employee training on repetitive motion injuries and their prevention. The research team provided the ergonomics committee with prepared information. A special ergonomics training session was planned by the committee for all employees with the leadership and support of the company's worker's compensation loss control representative.

Employees were introduced to Sierra Gold's ergonomics program, briefed on the California OSHA standard, given information on risk factors recognized associated with musculoskeletal disorders, along with an explanation of the symptoms and consequences of MSD's. The importance of prompt reporting of a suspected MSD was included as was an explanation of the ergonomics program underway and planned strategies to reduce MSDs in this workplace. The ergonomics committee was introduced and employees were encouraged to contact committee members for ergonomics concerns and questions.

In addition, information on risk factors, prevention and the company's ergonomics program was provided to the company's safety committee for use in their regular tailgate meetings.

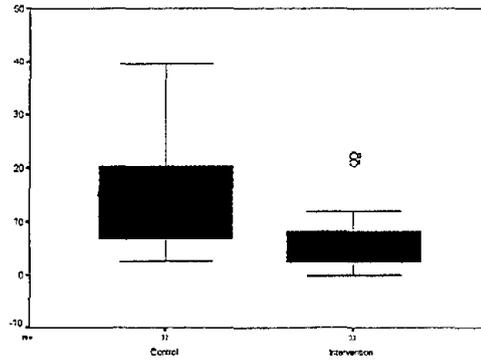
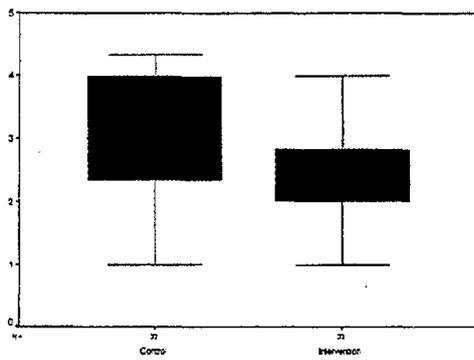
### *Intervention Evaluation*

While not specifically required by the California OSHA standard, any good safety practice involves follow-up assessment of effects. In this case, because the engineering mechanisms were not proven, no attempt was made to collect health outcome data. They were only evaluated for ergonomics effects and employee and management opinions about adoptability. While the rest and recovery intervention was subjected to health effects evaluation, obviously it offered no effect on the risk factors themselves and no ergonomics evaluation was conducted.

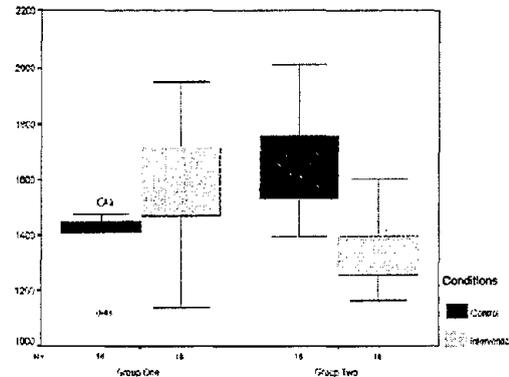
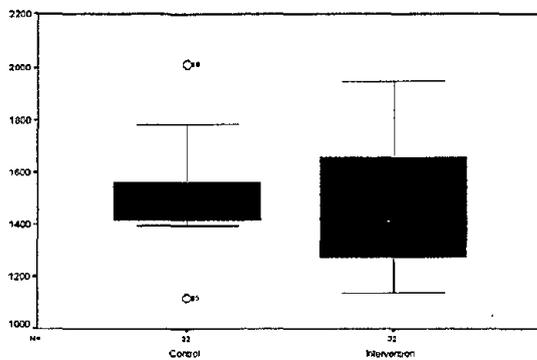
The trial of the rest break intervention was designed as a cross-over trial, using 16 pairs of workers randomly assigned to two groups. The intervention was delivered in two trials of three days each, the two trials followed a baseline day of data collection before assignment into the two groups. Fatigue and MSD symptom scores were obtained by surveying each worker at the end of each day. Productivity was obtained by counting the number of trees budded by each crew over the work day.

In the first trial, Group One received the intervention as described above for three days, while Group Two worked under the usual work conditions. After a weekend break, the second trial was run. Group Two received the intervention while Group One served performed budding under the usual conditions.

The bar graphs below show that the intervention improved worker reports about the severity of fatigue and musculoskeletal symptoms (see graphs for Fatigue and Musculoskeletal Discomfort below); although the groups demonstrated a wider variance for productivity under the intervention condition (see graph for Productivity below). The first two bar graphs below show that for both fatigue and musculoskeletal discomfort, the intervention condition resulted in a lower mean symptom severity score than the control condition, as well as less variation (note that the bars representing the intervention condition are narrower and lower on the graph).



The variation in productivity was associated with the order in which the intervention was given (see graph for Productivity by Group below). Group Two, who received the intervention during the second trial, demonstrated greater productivity under the control condition as compared to the intervention condition; the opposite was true for Group One. One explanation of this difference may be related to competition between the crews relative to who was first assigned to the intervention condition. Fatigue and musculoskeletal symptoms, on the other hand, were consistently in the expected direction for both groups - improving in the intervention condition.



Analysis of Covariance shows that when both group and productivity variates are controlled, there is a highly significant ( $p=0.002$ ), change in symptom outcomes attributable to the intervention condition. Additionally, changes in musculoskeletal symptoms were associated with changes in fatigue ( $r=0.62$ ,  $p=0.01$ ) over the three days of each trial. This association increases when the productivity is partially out ( $r=0.69$ ,  $p=0.001$ ).

Table TN 4

Tests of Between-Subjects Effects

Dependent Variable: PNCOM1

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	456.732 <sup>a</sup>	1	456.732	1.636	.214
Intercept	4650.357	1	4650.357	16.654	.000
GROUP	456.732	1	456.732	1.636	.214
Error	6143.101	22	279.232		
Total	11530.500	24			
Corrected Total	6599.833	23			

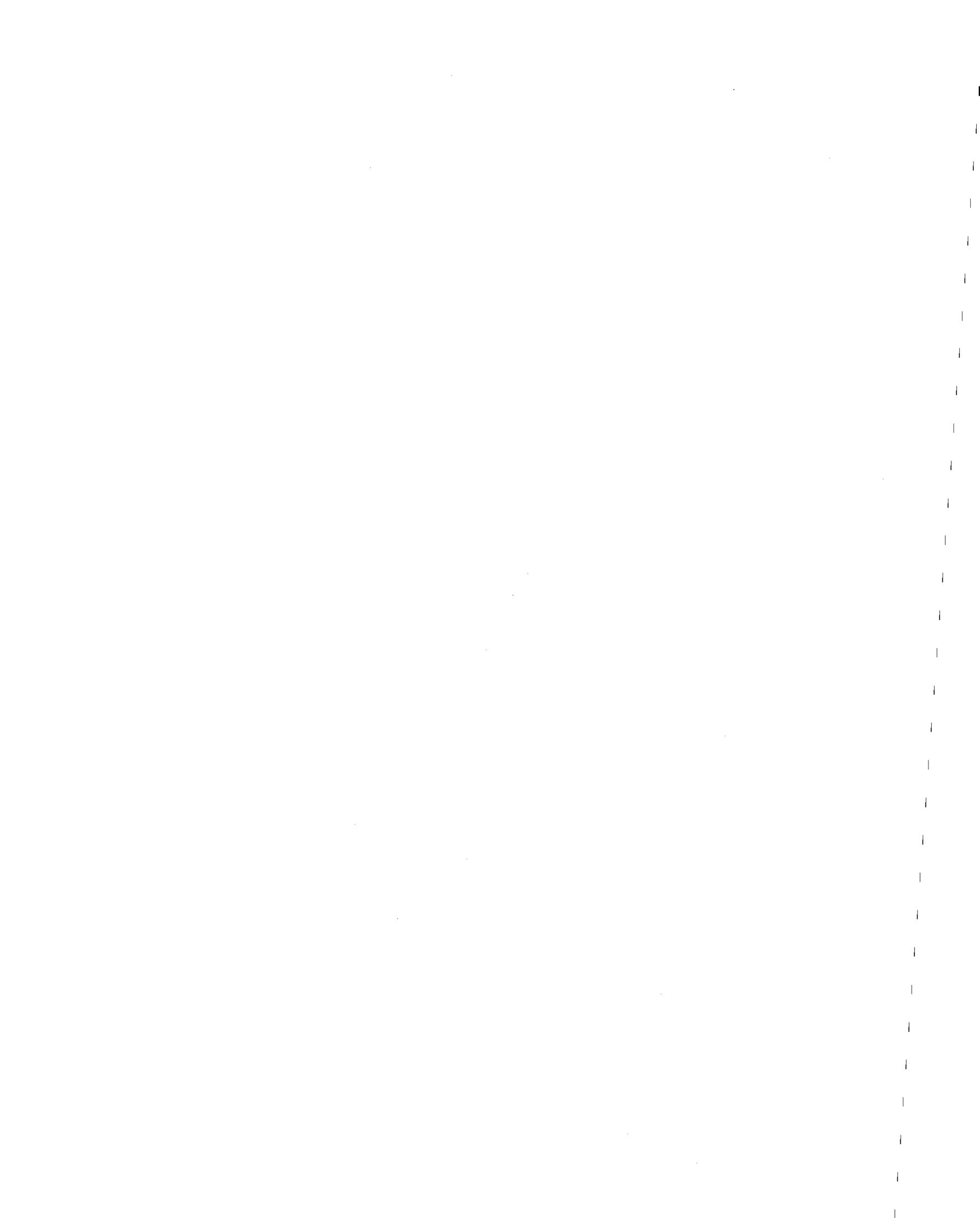
<sup>a</sup>. R Squared = .069 (Adjusted R Squared = .027)

Results of the rest and recovery trial were significantly positive and suggest that where no satisfactory engineering control is available, this approach may be useful.

*Intervention Transferability*

The increased rest and recovery administrative intervention is highly transferable with acceptance largely resting on worker and employer estimation of productivity impacts.

# **WEIGHT TRANSFER DEVICES ANALYSIS**



## **Evaluation of Four Weight Transfer Devices for Reducing Loads on the Lower Back During Agricultural Stoop Labor**

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**Written for presentation at the  
2001 ASAE Annual International Meeting  
Sponsored by ASAE  
Sacramento Convention Center  
Sacramento, California, USA  
July 30-August 1, 2001**

**Abstract.** *Low back disorders (LBDs) in agricultural settings are one of the most prevalent and costly occupational disorders. LBDs are particularly prevalent in manual harvesting, which is still a major method used in harvesting a wide range of fruits, vegetables and other crops. In most instances, this method requires the worker to assume a stooped posture for prolonged periods, which has been identified as an important risk factor for developing occupational LBDs. Several devices have been developed in an attempt to reduce the likelihood for developing LBDs during stooped labor. All these devices, using various mechanical means, share the same design principle of transferring the loads imposed on the lower back to the hips and lower limbs. The purpose of this study was to quantitatively assess the effectiveness of four commercially available devices in reducing the loads on the spine under assumed stooped postures. The results indicated that all four devices reduced trunk muscle activities to varying degrees. Two of the devices generated increased activities in the knee flexor muscle. The practicality for field use of three out of the four devices also was assessed. Overall, the concept of personal weight transfer devices offers an approach that is worth pursuing in the effort to prevent LBDs due to agricultural stoop labor.*

**Keywords.** Ergonomics, low back disorders, stoop labor, electromyography.

### **Introduction**

The Bureau of Labor Statistics clearly identifies agriculture to have one of the highest rates of reported musculoskeletal disorders (BLS, 2000). Furthermore, low back disorders (LBDs) in agricultural settings are considered the most important disorders in terms of their prevalence and costs to both the worker and employer alike. Manual harvesting is still considered a major method of harvesting a wide range of fruits, vegetables and other crops. In most instances, this method requires the worker to assume a stooped posture for prolonged periods, which has been identified as an important risk factor for developing occupational LBDs (Punnett et al., 1991, Marras et al., 1993). Stoop labor is defined as prolonged extreme trunk sagittal flexion (over 60 degrees), while mostly maintaining straight legs. Aside from mechanization, there has been little effort extended to solve the problem of stoop labor in agriculture. Several personal devices have been developed in an attempt to reduce the likelihood for developing LBDs during stooped labor. All these devices, using various mechanical means, share the same design principle of transferring the loads imposed on the lower

back to the hips and lower limbs. However, no biomechanical evaluation has been conducted on these weight transfer devices (WTDs) to determine their efficacy in reducing loads on the lower back. Hence, the purpose of this study was to quantitatively assess the effectiveness of four commercially available WTDs in reducing the loads on the spine under assumed stooped postures.

### ***Safety Emphasis***

This paper presents information about several devices that may help reduce the risk of developing low back disorders for agricultural workers who perform stoop labor.

## **Methods**

### ***Subjects***

Nine subjects (4 males and 5 females) volunteered for this study. All subjects were college students at the University of California, Davis. All subject had no prior history of low back disorders.

### ***Apparatus***

Four WTDs were evaluated in this study, including: (1) The Happyback (ErgoAg Company, Aptos, CA; Figure 1), (2) the Bendezy (Bendezy LiteTop Company, Mount Barker, Western Australia; Figure 2), (3) a modified Bendezy (Figure 3), and (4) the Bending Non-Demand Return (BNDR) (Limbic Systems Inc., Ventura, CA; Figure 4).

The Happyback basic components are fiberglass rods and fabric, which have high resistance to corrosion and wear. The chest harness is washable and is made up of a breathable mesh-like material that is washable. The Happyback contains a gray vest (chest harness), a pad located near the low back, and thigh straps that wrap around and buckle together above the knees. It is designed to transfer weight from the lower back to the buttocks, thighs, knees, and legs. It is adjustable by threading a strap through a plastic clasp and clamping it down. The height of the pad adjusts slightly, and the tension can be adjusted by changing the length of the bungee cords attached to the fiberglass rods.

The Bendezy is an all-metal support, with soft backpack-like straps, along with feet and ankle straps. Bendezy is made of a light aluminum frame that straps to the back (like a backpack) and weighs only 1.8 kg. Springs extend from a counterweight lever, then as a person bends, these "load up" lifting the weight off the back, relieving the pressure and strain on the spine and back muscles. This weight is transferred from the shoulders via the lumbar region and back onto the legs. It is adjustable with a spring button spine to allow the length of the spine to be adjusted for the wearer. There is also an adjustable range of tensions to reduce or increase the resistance during bending. The modified Bendezy differs from the original Bendezy in that the foot and ankle straps as well as the springs were removed from the device. A counterweight weighing 2.5 kg was attached to the end of the metal below the lumbar region.

The BNDR is a metal frame that has resistive articulation around the hip joint, with pads at the chest and thighs and a belt at the hips. Raw electromyographical (EMG) signals were digitally sampled using the Biopac Student Lab System hardware and software (Biopac Systems, Inc., Santa Barbara, CA). Integrated EMG signals were collected at 200 Hz.

The cardboard box used in the experiment was 11 in. high x 13.5 in. deep x 13.75 in. wide.

### ***Experimental Design***

The design was a two-factorial (device x weight) within-subject design. The device had five levels: no device, Happyback, Bendezy, modified Bendezy, and BNDR; the weight had three levels: no weight, 10 lbs, and 20 lbs. The main dependent variables were the percentage of maximum EMG

activities for the erector spinae, the gastrocnemius, the tibialis anterior, and the biceps femoris muscles. Subjective preference response also was collected.

### ***Procedure***

The subject was first briefly introduced to the purpose of the experiment, followed by preparation of the muscle sites for placement of the EMG electrodes. The first set of electrodes was placed on the right erector spinae muscle. The ground pad was placed on the bone of the anterior superior iliac spine or the iliac crest. The second set was placed similarly on the right gastrocnemius muscle. It was grounded on the head of the fibula. The third set was placed on the left tibialis anterior muscle. It was grounded on the medial malleolus. The last set of electrodes was placed on the long head of the biceps femoris and grounded to the head of the fibula bone.

After checking the integrity of the EMG signals, the subject was ready to generate maximum voluntary contractions of the four muscles under study. The erector spinae (ES) muscle actions are to extend the back and bend laterally. The maximum ES was found during extension of the back, since this is closest to the posture used during stoop labor. Maximum voluntary contraction of the ES was gathered by having the subject in the stooped position while two people stabilized the subject by placing one hand on a shoulder blade and one hand on a hip. Then the subject pushed back as hard as he or she could while the two stabilizing people pushed on the subject providing resistance.

Maximum voluntary contraction of the gastrocnemius (GN) was measured during plantarflexion of the ankle, which is the main action of the GN. The subject was seated in a chair, with a nylon strap wrapped underneath his or her foot. Maximum voluntary contraction was gathered while the subject pointed his or her toes (plantarflexed the ankle) and pulled up on the ends of the strap, creating his or her own resistance. Maximum voluntary contraction for the tibialis anterior (TA) were gathered similarly, but with the strap held in place on the top of the subject's foot during dorsiflexion of the ankle, since the TA is a dorsiflexor of the ankle.

Finally, maximum voluntary contraction for the biceps femoris (BF) was gathered in two ways, since the long head of the BF is responsible for both flexion of the leg (knee), and extension of the thigh. The subject was standing and stabilized his/her body next to a table while the data were collected. While the knee was being flexed, resistance was applied to the heel of the foot. While the thigh was being extended (leg straight), resistance was also applied to the heel.

After the maximum voluntary contractions were determined, each subject performed the 15 stooped conditions (five device levels by three weight levels combinations). The levels of the device factor were randomly assigned. Also, within a given device, the weight levels were randomly assigned. Randomization was necessary to avoid any learning or training carry-over effect. Each condition lasted for 30 seconds. For each lift, all subjects stood 6 inches away from the box, with their feet spread apart in a comfortable position, and lifted the box approximately 2 inches off the ground.

To get feedback from each subject, a questionnaire was administered at the end of the experiment to capture the subjects' response with regard to the practicality, ease of use, and mechanical load transfer of the devices. The questionnaire asks for ratings on a scale of 1 to 10 (10 = the highest score) for five criteria: overall impression (personal taste—like it or not?), fit (does it fit the average person?), adjustability (easy or difficult), ease of use (how simple is it for daily use?), and performance (does it seem to lessen back stresses?).

### ***Analysis***

Within each stoop condition, the percentage of maximum EMG for each muscle was determined by dividing the average integrated EMG by the corresponding maximum EMG obtained during the

maximum voluntary contractions. Descriptive statistics and analysis of variance (ANOVA) were conducted on the resulting data.

## Results and Discussion

Activity levels of the erector spinae muscle was reduced in all subjects on average with all devices as compared with no support at all. All muscles showed a decrease in the percent of MVC except the tibialis anterior which increased in muscle activity with the Happyback and Bendezy devices. These designs did reduce the ES back muscle activity, but they increased loading on the knees. Figure 5 shows the EMG results averaged over the three weight conditions (0, 10, and 20 lbs).

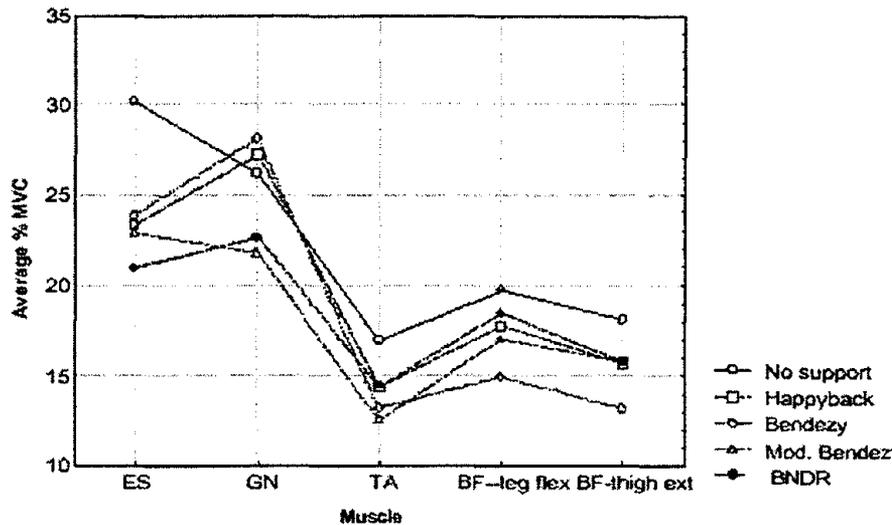


Figure 5. Average percentage of maximum voluntary contraction (MVC) for each of the device and muscle combinations. Note that the results are averaged over all weights.

The results also showed that the most significant drop in the erector spinae muscle activity occurred when comparing the BNDR device with no device. The BNDR reduced the % MVC from an average of 30.2% of maximum to 20.9%. This is approximately a 31% reduction in back muscle activity. A comparison of the Bendezy device against no support showed a statistically significant reduction in back muscle activity of about 21%. The Happyback device reduced the ES activity by about 23% compared with no device, whereas with the modified Bendezy vs. no device, ES activity was reduced by about 24%.

The results for the gastrocnemius muscle, showed no significant differences between means for percentage of muscle activity. For the tibialis anterior muscle, a comparison of the modified Bendezy with the no device condition showed a statistically significant reduction in muscle activity of 26%. Thus, it seems that the counterweight provided a good amount of torque to pull stress away from the anterior leg muscles. The Bendezy compared with no device reduced TA muscle activity by 22%. The BNDR and the Happyback compared with no device reduced TA activity by about 15%. For the biceps femoris, with the thigh extended, the Bendezy showed the most reduction in EMG activity (27%) when compared to the no device condition.

Based on the averages, most subjects preferred the BNDR overall, then the Happyback, and the Bendezy and modified Bendezy were tied for third place. The modified Bendezy had the highest rating for best fit, followed by the Bendezy, Happyback, and BNDR. The modified Bendezy also had the highest rating for adjustability, followed by the Bendezy, Happyback, and BNDR. For ease of use, the BNDR was rated highest, followed by modified Bendezy, Happyback, and Bendezy.

Other comments included that the BNDR was favored for providing good back support without compromising balance, due to the thigh pads. Another remark about the BNDR was its simplicity to put on, with few adjustments needed. However, subjects complained that the BNDR is uncomfortable around the chest pad. One subject said "It jabs you". Another said the BNDR made it easier to lift, but the front part aggravated the neck area. After a full day's work, one subject remarked that the BNDR would be uncomfortable due to pressure against the supports. Suggestions were made for an adjustable chest part for the BNDR and more comfort needed in the armpit area.

The Happyback was well-liked for providing back support but made some feel like it pulled them forward too much. One person felt that the Happyback distributed equal forces over the shoulder area and led to minimal hindering of movement but might get hot in the summer. Others thought the Happyback was awkward and uncomfortable to wear. The feet straps on the Bendezy were noted as awkward. The modified Bendezy made one subject feel like leaning backwards. The Bendezy stirrups dug into one person's legs, so the metal piece needed to be wrapped up.

Two of the devices were tested in strawberry fields in Irvine, CA. The BNDR and Happyback were demonstrated and several workers were given an opportunity to try them out. Feedback was that the Happyback was way too complicated to even be considered for daily use, and the BNDR was uncomfortable but may be considered if it was improved. The workers did not like either device. The importance of applicability to daily work and ease of use are very important for any of these personal weight transfer devices to succeed.

From the results of this study, it appears that the BNDR would be a good device that may be field-usable with certain modifications. The chest strap should be widened so that it does not slip up to the neck region. There should be some adjustability to the length of the poles that attach the chest and thigh pads. This could easily be done with a type of metal poles that slides into another pole and can be moved to its position and then tightened down by rotating the poles in opposing directions. More subjects need to be tested to determine whether this design will work the best for a large majority of body types. Because weight and height are important anthropometric design factors, information on the majority of body types who will most likely use the device would be helpful.

## **CONCLUSION**

The objective of this study was to evaluate four personal weight transfer devices with respect to their practicality and effectiveness in reducing the load on the spine during stoop labor. The results indicate that all four devices reduced trunk muscle activities to varying degrees. However, two of the devices generated increased activities in the knee flexor muscle, and the practicality for field use of three out of the four devices were also questioned. One device showed potential applicability for field use if modifications can be made to increase comfort.

Overall, the concept of personal weight transfer devices seems to offer an approach that is worth pursuing in the effort to prevent low back disorders due to agricultural stoop labor.

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**EXAMPLES OF  
EDUCATIONAL MATERIALS**



# What is Ergonomics ?

**er·go·nom·ics** (er' go-nom" ics) [Greek ergon, work + nomos, law] 1. Fitting the task or tool to the person. 2. Working smarter, not harder. 3. Optimizing worker wellbeing and productivity. 4. Planning work so that it fits the body's physiological efficiencies.

## GOOD ERGONOMICS...

Keeps the body in a natural, neutral position while the job is done.

Reduces strain on muscles, tissues, and joints.

Reduces effort required.

Reduces potential for strain, sprain, or overexertion.



**UCAERC** AGRICULTURAL  
ERGONOMICS  
RESEARCH  
CENTER

Development supported by National Institute for Occupational Safety and Health cooperative agreement PHS-R01 OH14508

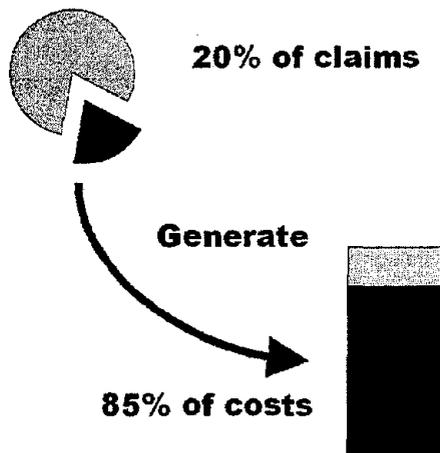
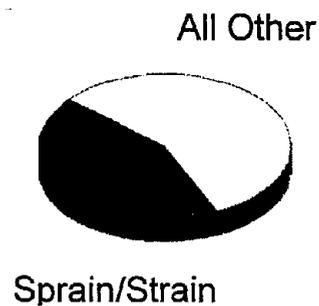
## Why is Ergonomics important to you?



### High incidence and cost of injuries!

**Serious sprains and strains –including back injuries- are the most common and most costly of all workplace health problems!**

**Sprain and Strain injuries make up 43% of all lost time injuries each year. Nearly half of these are back injuries! Even a small reduction of these injuries would greatly improve productivity and the health of both farmers and farm workers.**



**85% of injury costs come from 20% of claims.**

**40% of all “serious” claims involve strains.**

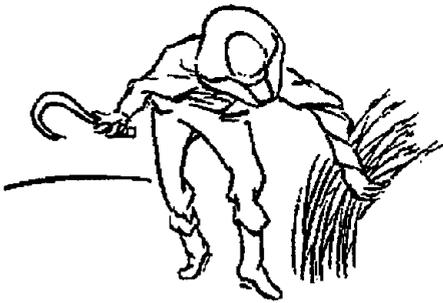
**35% of strain injuries result from lifting, or push/pull activities.**

**Ergonomic changes to tools and tasks improve the body’s efficiency in work, and help prevent injuries – especially sprains and strains – associated with difficult, awkward, or repetitive jobs.**

## #2 Ergonomics Improves Efficiency and Productivity

Ergonomic inefficiencies that contribute to injury and also points where productivity can be improved.

**Productivity is increased by reducing work inefficiencies.**



**Productivity is not working harder!**

Simply increasing work pace does not always increase productivity. Sooner or later, just working faster will increase costs due to injuries and errors.

**Working smarter, not harder, improves productivity!**

Most lasting increases in productivity involve improved tools, work organization, or work methods that reduce inefficiency rather than increasing effort!

**Increased efficiency should reduce effort demanded.**

Improved tools or work methods that make efficient use of human energy can dramatically increase output per worker while actually making the job easier.

For example, the two-handed scythe used a long handle to let the worker stand upright, reducing strain on the back and energy demanded. It had two-handed, angled grips that reduced stress on shoulders and wrists. As a result, a worker using the two-handed scythe can cut more grain in a day with less effort than a worker using the older single-handed sickle.



# Ergonomics Risk Factors

Ergonomic risk is usually associated with biomechanical or environmental factors that contribute to overexertion, stress or strain, and inefficient use of human energy.

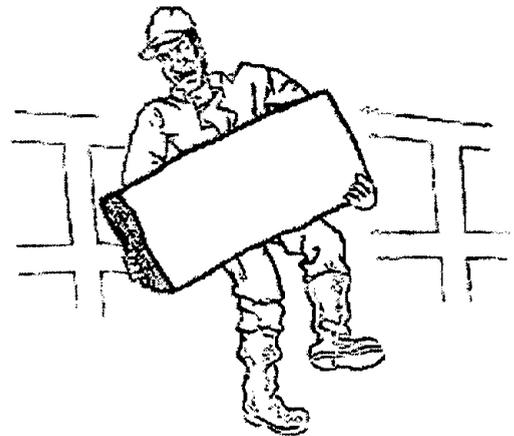
Looking for these risk factors is one way to identify tasks that may be associated with both inefficiency and injury hazard.

## HIGH FORCE / WEIGHT

Exertion of force to overcome weight, resistance, or inertia.

Work Elements:

- Move – push, pull, lift, lower, place
- Grasp or hold
- Overcome resistance – cut or pick
- Resist reaction – hold

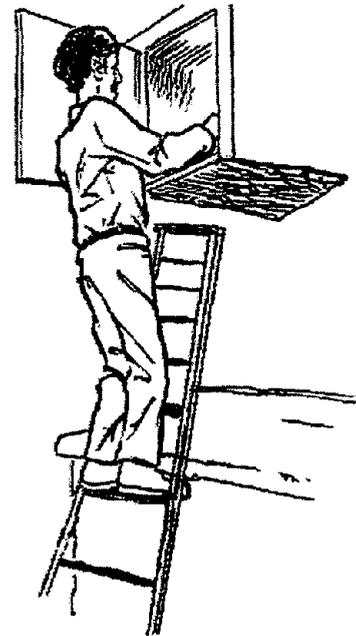


## STATIC FORCE

Static force is a constant, unrelieved pressure on a body part or a sustained exertion of force in the same position over time. Both cause stress on tissues and potential for overexertion.

Work Elements:

- Sustained pressure from hard surface  
-standing on ladder, leaning against table
- Sustained exertion of force – pressure of tool on palm of hand
- Prolonged position or posture – sustained stoop, overhead work, sitting/standing.



## VIBRATION



Sustained contact with vibrating surfaces or equipment can cause damage to joints, organs, and tissues. Vibration also contributes to physical demand. Length of time exposed and recovery time are important factors.

Work Elements:

- sustained use of power tools, handheld saws, etc.
- prolonged exposure to whole body vibration from operating equipment.

## AWKWARD POSTURE

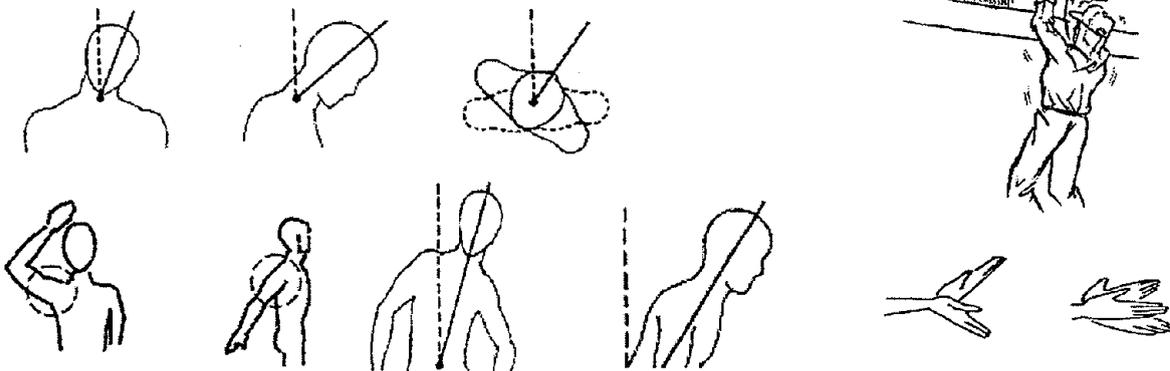
Positions of the body or limbs that require more effort and which stretch or compress soft tissues in and around joints.

Work Elements:

- Stoop, bend
- Reach, stretch
- Twist, turn, tilt



Any body part can be put in an awkward posture resulting in physical strain. Generally speaking, any posture which involves more than 20 degrees change from normal, neutral should be given consideration.



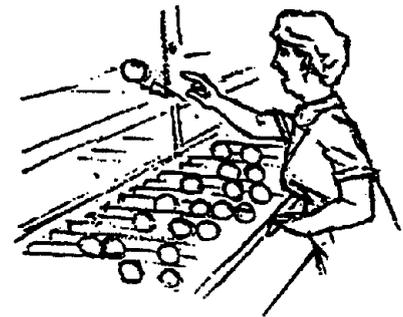
## HIGH REPETITION

Repetition involves performing the same actions over and over. Repetition can result in overexertion and a task that might be made more efficient with assistance.

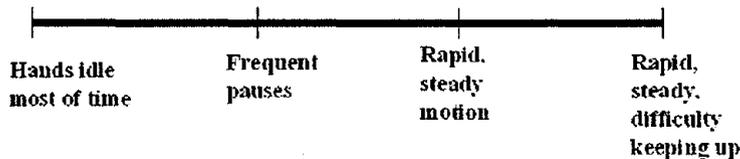


Work Elements;

- Repeated actions –more than 30 per minute
- Repeated actions requiring force or awkward posture
- Repeated actions with high ratio of work to recovery time



Repetition can be evaluated with a simple scale



## TEMPERATURE EXTREMES

Prolonged exposure to extremes of heat or cold (below 50°F or above 85°F). both add to bodily burden and drain physical strength.

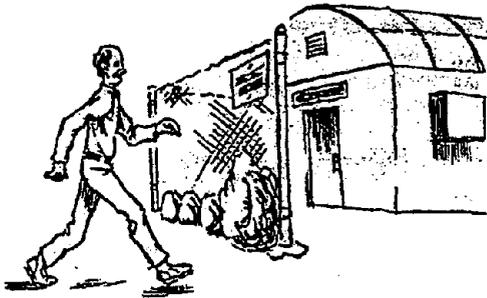
Work Elements;

- Sustained work in high heat, high humidity
- Sustained work in cold, especially concern for extremities.



## WHAT KIND OF INJURIES?

Most musculoskeletal injuries are simple sprains or strains that respond well to rest and gradual return to work.



**Acute** muscle and tendon injuries result from immediate causes such as falls, wrenching, etc. Normally, simple sprains and strains will heal in a short time.

**Chronic** injuries result from long-term exposure to risk factors that cause tiny, daily damage to tissues. Damage builds up over time and cause is not always obvious. Such injuries can become permanently disabling if not recognized and treated. These are the most serious concerns of ergonomics and are referred to as musculoskeletal disorders or repetitive strain injuries, etc.

## BACK BELTS AND STRETCHING?

A major study of available evidence by NIOSH failed to show any protective benefit from wearing back belts.



Being in good physical condition is helpful in preventing some of these injuries. Regular exercise, including stretching can help, but does not substitute for dealing with risk factors.

**The guiding principal of ergonomics is to make the job fit the person,...**

**not to make the person fit the job!**

**This is best accomplished by changing tools, work layout or process to reduce or eliminate ergonomic inefficiencies and risk factors.**

### **Some ideas...**

- For problems of awkward posture include:
  - Altering tools – change handles, grips, change locations, change work station to reduce extreme bends or reaches (keep loads between knee and shoulder height);
  - Moving the part or operation with respect to the worker; or
  - Changing workers position with respect to task.
- For problems of prolonged or excessive exertion of force include:
  - Reduce force required – reduce loads, keep cutting edges sharp, use spring loaded or powered tools, use jigs or clamps to hold items;
  - Spread force – use handles or levers to spread force from fingers to hands, alternate hands;
  - Use mechanical advantage – use mechanical assists, tools with longer handles, use stronger muscle groups.
- For problems involving high repetition include:
  - Mechanical power – specialized tools (ratchets, power drivers, etc) to reduce repetition;
  - Task enlargement – restructure jobs so that each worker has more varied tasks to perform to reduce exposure, combine or re-sequence jobs, provide more frequent rest or recovery pauses.

# ¿Qué es la ergonomía?

Ergonomía (del griego: ergon: trabajo; nomos: ley) 1. Adaptación de las tareas o de las herramientas a la persona. 2. Énfasis puesto en trabajar más inteligentemente y no más fuertemente. 3. Optimización de las condiciones de trabajo y productividad. 4. Planificación del trabajo de manera que el mismo se adapte a las capacidades fisiológicas del cuerpo.

## La buena ergonomía...

Permite mantener una postura natural y neutra durante el trabajo.

Disminuye la tensión de los músculos, tejidos y articulaciones.

Reduce el nivel de esfuerzo necesario para realizar las tareas.

Disminuye el riesgo de fatiga, torcedura o esfuerzo excesivo.



**UCAERC** AGRICULTURAL  
ERGONOMICS  
RESEARCH  
CENTER

Development supported by National Institute for Occupational Safety and Health cooperative agreement PHS-R01 OH14508

## ¿Por qué es importante la ergonomía para Ud.?



### #1 Por la alta incidencia de lesiones y por los costos que las mismas originan

Las torceduras y esguinces graves – incluyendo las lesiones en la espalda– son los problemas de salud más frecuentes y costosos ocasionados por el trabajo.

Las torceduras y dislocaciones constituyen el 43 por ciento de las lesiones causantes de pérdida de horas de trabajo cada año. Casi el 50 por ciento de las mismas tiene que ver con lesiones en la espalda. Una reducción leve de estas lesiones, mejoraría considerablemente la productividad y la salud, tanto de los agricultores como de los trabajadores del campo.



El 20 por ciento de las demandas genera el 85 por ciento de los costos por concepto de lesiones laborales.

El 40 por ciento del total de “demandas graves” corresponde a lesiones por esfuerzo excesivo.

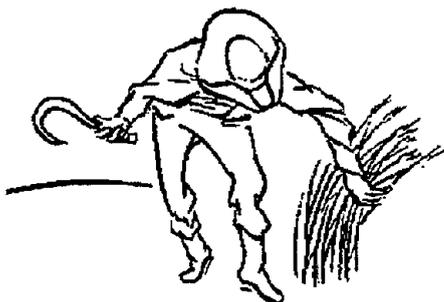
El 35 por ciento de dichas lesiones es provocado por tareas que involucran el levantar, jalar o empujar objetos.

Los cambios ergonómicos que modifican las herramientas y las tareas a realizar mejoran la eficacia del cuerpo para el trabajo y ayudan a prevenir lesiones –especialmente torceduras y tensión por esfuerzo excesivo– relacionadas con tareas difíciles, incómodas o repetitivas.

## #2 La ergonomía mejora la eficiencia y la productividad

La ergonomía permite detectar las deficiencias que pueden ocasionar lesiones y señalar los aspectos donde puede mejorarse la productividad.

La productividad mejora al reducirse factores de ineficacia en el trabajo.



**¡La productividad no consiste en trabajar más fuertemente!**

Un simple incremento del ritmo de trabajo no siempre genera un aumento de la productividad. Un aumento en la velocidad del trabajo tarde o temprano ocasionará un aumento de los costos debido a lesiones y errores.

**Trabajar más inteligentemente –y no más fuertemente– mejora la productividad**

Los incrementos más duraderos en la productividad incluyen mejoras de las herramientas de trabajo, de la organización del trabajo y de los métodos de trabajo que reducen la ineficacia en vez de aumentar el esfuerzo.

**El aumento de la eficiencia debe dar lugar a una reducción del esfuerzo requerido**

Los cambios que se hacen para mejorar las herramientas o los métodos de trabajo de tal manera que permitan optimizar el uso de la energía del personal pueden aumentar dramáticamente la producción individual y, al mismo tiempo, hacer que el trabajo sea realmente más fácil.

Por ejemplo, la guadaña que se usaba con ambas manos tenía un mango largo que permitía trabajar erguido, reduciendo la tensión en la espalda y el esfuerzo. Esta guadaña tenía una empuñadura en ángulo que reducía el estrés en los hombros y muñecas. Por lo tanto, permitía segar más grano por día y con menos esfuerzo que la hoz que se utilizaba con una sola mano.



## Factores ergonómicos de riesgo

Generalmente, el riesgo ergonómico está relacionado con factores biomecánicos o propios del ambiente que contribuyen al esfuerzo excesivo, al estrés, a la fatiga y a un uso ineficaz de la energía del personal.

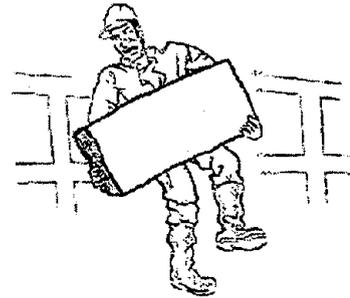
La detección de dichos factores de riesgo es una manera de identificar las tareas que pueden estar relacionadas con la ineficacia y con el peligro de lesiones.

### Fuerza extrema-Levantamiento de cargas

Uso de la fuerza muscular para levantar cargas, vencer una resistencia o la inercia.

#### Actividad corporal específica del trabajo

- Movimiento: empujar, jalar, levantar, bajar, colocar
- Asir o sostener
- Vencer la resistencia: cortar o recoger
- Resistir la reacción: sostener



### Fuerza estática

La fuerza estática es una presión constante y uniforme en una parte del cuerpo o el uso prolongado de la fuerza muscular en una misma posición. Ambas actividades causan estrés en los tejidos y el riesgo de esfuerzo excesivo.

#### Actividad corporal específica del trabajo:

- Presión prolongada ejercida por una superficie dura; por ejemplo, estar parado en una escalera de mano o apoyar contra una mesa.
- Ejercer fuerza durante un período prolongado; por ejemplo, la presión de tener una herramienta en la palma de la mano.



- Posturas prolongadas; por ejemplo, estar agachado durante mucho tiempo; trabajar con objetos que se encuentran por lo alto, encima de la cabeza; permanecer sentado o de pie.

## Vibraciones



El contacto prolongado con superficies o equipo que vibra puede perjudicar las articulaciones, órganos y tejidos. La vibración también aumenta la tensión física. El período de tiempo que se esté expuesto a las vibraciones y el tiempo de recuperación constituyen factores importantes.

Actividad corporal específica del trabajo:

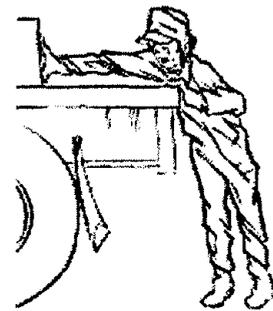
- Uso prolongado de herramientas eléctricas, sierras manuales, etc.
- Exposición prolongada de todo el cuerpo a vibraciones causadas por equipo o herramientas en uso.

## Posturas incómodas

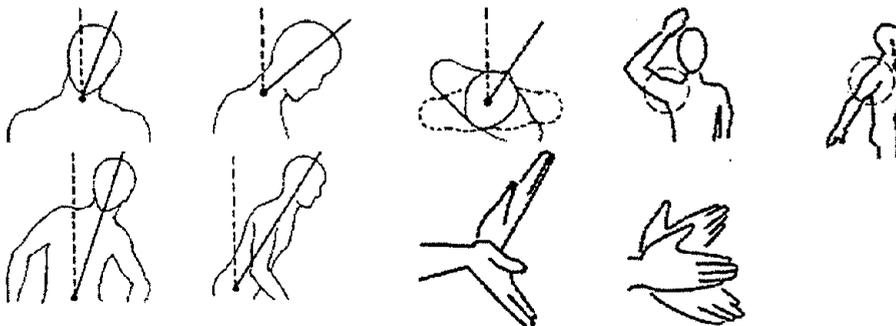
Son aquellas posturas del cuerpo o de las extremidades que requieren más esfuerzo y que estiran o comprimen los tejidos blandos de las articulaciones y de la zona que las rodea.

Actividad corporal específica del trabajo:

- Agacharse, encorvarse o doblarse
- Estirarse, tratar de alcanzar algo
- Torcerse, dar la vuelta, inclinarse o ladearse



Cualquier parte del cuerpo puede adoptar una postura incómoda que causa tensión física. En general, debe tomarse en cuenta toda postura que involucre una modificación de más de 20° de la posición normal o neutra.

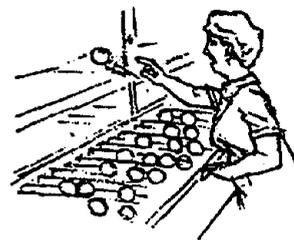


## Mucha repetición

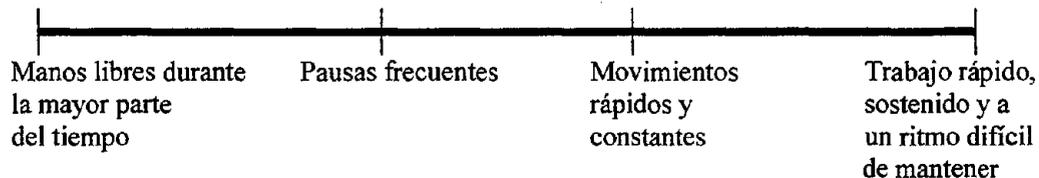
La repetición de un mismo movimiento puede dar lugar a esfuerzo excesivo. La misma tarea podría realizarse mucho más eficientemente con ayuda.

Actividad corporal específica del trabajo:

- Movimientos repetidos – más de 30 por minuto
- Movimientos repetidos que requieren el uso de fuerza muscular o adoptar posturas incómodas
- Movimientos repetidos que requieren de un período largo de recuperación, después de concluir la labor.



La repetición puede evaluarse utilizando esta simple escala



## Temperaturas extremas

Le exposición prolongada a temperaturas extremas (menos de 10° C o más de 30° C) representa una carga adicional para el cuerpo y ocasiona una pérdida de fuerza muscular.

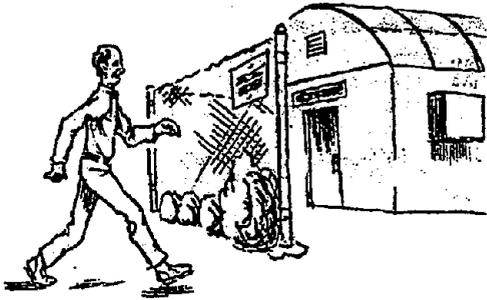
Actividad corporal específica del trabajo:

- Trabajo prolongado en condiciones de alta temperatura y humedad
- Trabajo prolongado en condiciones de baja Temperatura; esto afecta especialmente las extremidades.



## ¿Qué tipo de lesiones?

La mayoría de las lesiones músculo esqueléticas son simples torceduras, esguinces o lesiones por esfuerzo excesivo que responden bien al descanso y a una reanudación gradual de la actividad laboral.



Las causas inmediatas de las lesiones **agudas** de los músculos y tendones son las caídas, torceduras, etc. Normalmente, las torceduras y lesiones por esfuerzo excesivo se curan rápidamente.

Las lesiones **crónicas** son resultado de la exposición prolongada a factores de riesgo que dañan los tejidos de una manera leve, pero diariamente. El daño aumenta a medida que pasa el tiempo, y la causa del mismo no siempre se manifiesta. Estas lesiones pueden ocasionar una discapacidad permanente si no se les detecta y trata a tiempo. Estas lesiones son el punto principal de interés de la ergonomía y se les conoce como “trastornos músculo esqueléticos”, lesiones causadas por esfuerzo repetitivo, etc.

## ¿Cinturones para la zona lumbar al realizar trabajos que requieren de estirarse?

Un estudio a fondo realizado por NIOSH no pudo comprobar que el uso de cinturones para la zona lumbar brinde protección alguna.



Una buena condición física ayuda a prevenir este tipo de lesiones. Hacer ejercicio físico con regularidad, inclusive ejercicios de estiramiento, puede ser útil, pero no sustituye el tomar en cuenta y eliminar los factores de riesgo.

**El principio básico de la ergonomía es hacer que el trabajo se adapte al individuo y no que el individuo se adapte al trabajo.**

**Esto se logra modificando las herramientas, la organización del trabajo y del proceso productivo, de tal manera que se eliminen o reduzcan los factores de ineficacia en términos ergonómicos y los factores de riesgo.**

### **Algunas sugerencias...**

- Para los problemas causados por posturas incómodas:
  - Modificar las herramientas: Cambio de manijas o empuñaduras; ubicación; modificación de los puestos de trabajo para que el personal no tenga que agacharse o estirarse demasiado (mantener las cargas a levantar a una altura entre las rodillas y los hombros);
  - Cambiar la labor o trabajo teniendo en cuenta al trabajador; o
  - Rotar el personal asignándole otras tareas.
  
- Para los problemas relacionados con trabajos que exigen fuerza muscular excesiva o prolongada:
  - Reducir la fuerza requerida: Reducir la carga; mantener afiladas las herramientas para cortar; utilizar herramientas con dispositivos accionados por resortes, electricidad o combustible; utilizar guías, grapas o abrazaderas para sujetar los objetos.
  - Distribuir la fuerza: Usar manijas o palancas para que la fuerza se distribuya de los dedos a toda la mano; alternar usando ambas manos.
  - Aprovechar las ventajas mecánicas: Usar dispositivos mecánicos y herramientas con manijas más grandes; al trabajar, usar los grupos musculares más fuertes
  
- Para los problemas causados por mucha repetición de movimientos:
  - Energía mecánica: Usar herramientas especializadas, como trinquetes, para reducir las repeticiones.
  - Diversificar las tareas: Reestructurar las actividades de manera que cada empleado tenga tareas más variadas; reducir el tiempo de exposición a una misma actividad; combinar o rediseñar la secuencia de las tareas; proporcionar a los trabajadores intervalos más frecuentes de descanso y de recuperación.

# NOTAS





# ERGONOMICS PROGRAM WORKSHEETS



Development supported by National Institute for Occupational  
Safety and Health cooperative agreement PHS-R01 OH14508

# **CAL OSHA WORKPLACE ERGONOMICS STANDARD**

*California's workplace "ergonomics" standard (Title 8 section 5110), required by statute to minimize work-related repetitive motion injuries became effective July 3, 1997.*

*The regulation is triggered when at least 2 employees performing identical tasks have been diagnosed by a licensed physician with work-related repetitive motion injury (RMI) within 12 consecutive months. Should that occur, the employer must establish and implement a program designed to minimize the condition. The regulation calls for the employer to:*

- 1. evaluate ergonomics hazards at the worksite,*
- 2. control the exposures that cause RMI and*
- 3. provide training to affected employees.*

## **COMMITTEE MEMBERS**

# WORKPLACE HAZARD EVALUATION

## 1. INJURY RECORDS REVIEW

Review the injuries reported on your OSHA log 200 and your own (non-reported) first aid records if you keep them, for at least a 24 month period. List below sprain/strain type injuries along with information on lost work days, reported cause, and body part.

List below the two or three jobs associated with the most (and/or most serious) injuries.

1.

2.

3.

# WORKPLACE HAZARD EVALUATION

## 2. ERGONOMICS RISK FACTORS

Have new processes or procedures been implemented which would change results of previous risk factor evaluation? If so, describe briefly and use the ergonomic risk factor checksheet to score. If not, list highest scoring risks from previous evaluation.

## 3. WORKERS CONCERNS

Have workers reported any new concerns in the past year? If so, list them here.

## HAZARD CONTROL

### **4. WHAT WERE PRIORITIES FOR ACTION LAST YEAR?**

- 1.
- 2.
- 3.
- 4.

### **5. WHAT CONTROLS WERE IMPLEMENTED LAST YEAR?** Describe each control implemented for targeted high risk jobs.

### **6. HOW EFFECTIVE WERE CONTROLS IMPLEMENTED LAST YEAR?**

Measures might include: injury or symptom reduction, worker evaluation, reduced risk factor checksheet scores, etc.

## HAZARD CONTROL

### 7. IDENTIFY NEW PROBLEMS FOR ACTION

Carefully observe each priority job for activities that put stress on the targeted body part. Try to identify the specific action(s) that may be the biggest part of the problem. List problem actions for each priority job.

**JOB 1**

**JOB 2**

**JOB 3**

**JOB 4**

### 8. DEVELOP CONTROL IDEAS

Try to develop a list of alternative control ideas for each priority job.

**JOB 1**

**JOB 2**

**JOB 3**

**JOB 4**

# TRAINING

If your operation is subject to the ergonomics standard you are required to provide training "that includes an explanation of":

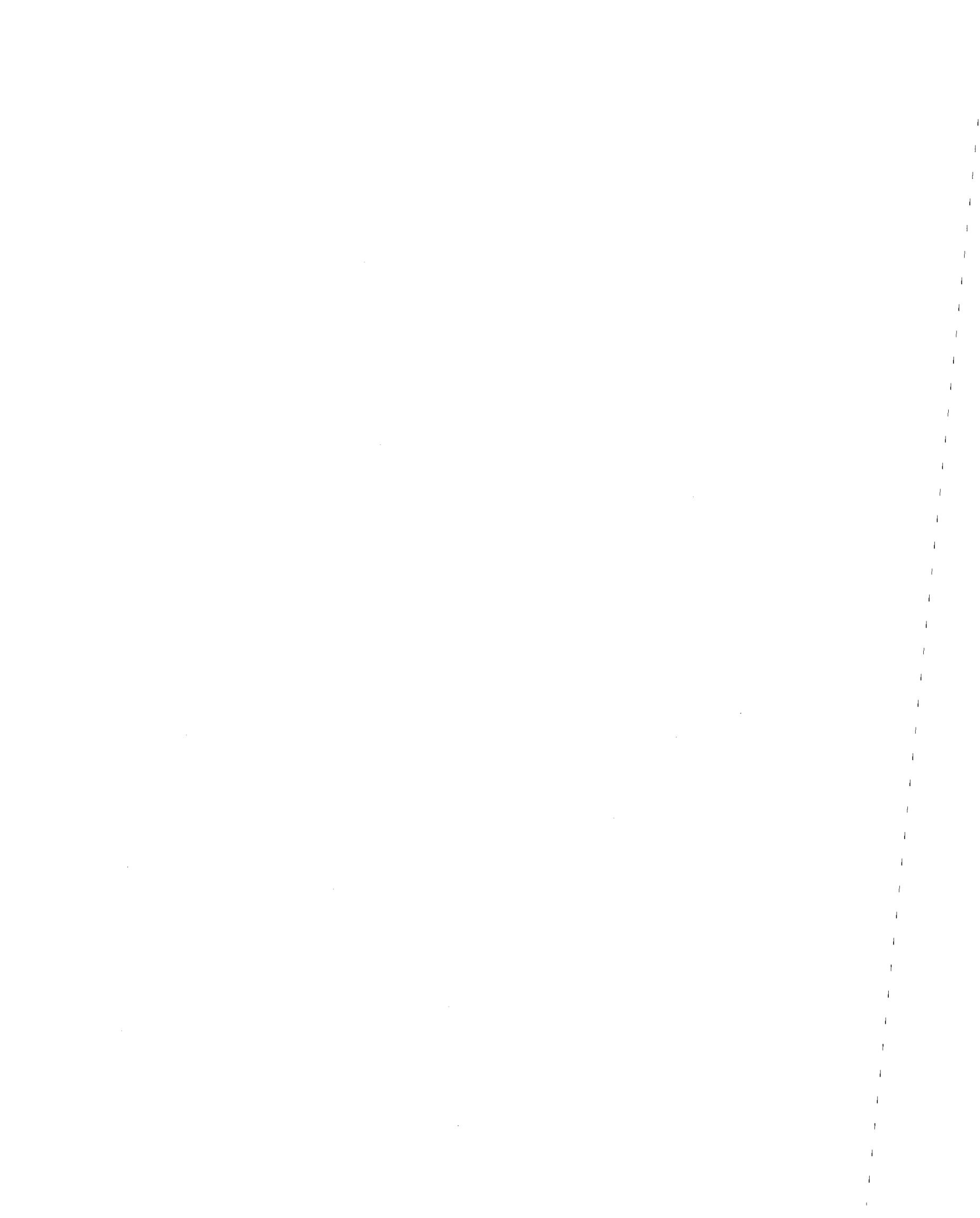
- "(A) The employer's program;
- (B) The exposures which have been associated with RMIs;
- (C) The symptoms and consequences of injuries caused by repetitive motion;
- (D) The importance of reporting symptoms and injuries to the employer; and
- (E) Methods used by the employer to minimize RMIs."

## 9. TRAINING PLAN

DATE	TOPICS	ATTENDANCE
------	--------	------------

## 10. TRAINING REPORT

DATE	TOPICS	ATTENDANCE
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## **SUSTAINED VIBRATION**

Some jobs involve exposure to fairly long periods of vibration from tools or equipment. Tractor drivers, equipment operators, and persons working on moving equipment all have some exposure to vibration. Persons using powered tools also. Insulation from vibration (gloves, seat pads, floor pads, etc) helps. If sustained exposure to vibration cannot be avoided, consider rotating workers through jobs daily and increasing breaks for relief.

### **Effective injury prevention requires everyone's serious attention:**

#### **1. BE AWARE**

Know the specific hazards in your workplace.

#### **2. CONTROL HAZARDS**

Take corrective actions to protect against or prevent hazardous conditions which you can.

#### **3. REPORT UNSAFE CONDITIONS**

Any serious hazard should be reported to your supervisor immediately. If the hazard is life threatening stop work until corrective action is taken.

#### **4. USE PROTECTIVE EQUIPMENT AND PRACTICES**

Always use required protective equipment. Make sure it is in operating condition. Always use safe work practices as described in training.

#### **5. KNOW WHAT TO DO IF INJURY OCCURS**

Know how to get help if injury occurs. Know where first aid supplies and phone are. Know basic life-saving first aid.



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# AGRICULTURE "HIP POCKET" SAFETY TIPS

## CUMULATIVE MUSCULOSKELETAL INJURIES

Improving on-the-job safety and preventing injuries is a priority for everyone in California agriculture. Agricultural work often involves highly repetitive actions (such as cutting or clipping), carrying heavy loads, or awkward positions (such as full stoop). Sustained exposure to such risk factors over years can contribute to cumulative injuries of the musculoskeletal system (examples, back injuries, cumulative trauma disorders, repetitive strain injuries, etc). There is a difference between acute (or immediate) injuries and chronic (or slowly developing) and persistent injuries. An acute sprain or strain may indicate an ergonomic inefficiency, chronic disorders, which take years to develop, and may indicate that workplace factors are a cause. Some chronic disorders can become disabling if untreated. Early recognition and reporting are important.

## RECOGNIZING CUMULATIVE MS INJURY SYMPTOMS

Occupational musculoskeletal disorders may affect muscles, tendons, joints, nerves and related soft tissues anywhere in the body. The lower back and upper extremities, including the neck and shoulders, are the most common sites. Because repeated exposure to force of the same muscle, tendon, or region may result in trauma, injury, and inflammation to the affected area, names such as cumulative trauma disorder, repetitive motion injury, repetition strain injury, and occupational overuse syndrome have been applied to these disorders.

As a group, occupational musculoskeletal disorders are characterized by one or all of the following localized symptoms, depending on the type of disorder:

- √ pain,
- √ numbness,
- √ stiffness,
- √ tingling, and
- √ weakness.

Complaints may also refer to aching, burning, or buzzing and swelling. Referred pain may occur such as from the neck and shoulder region down the arm, into the hand, or up to the head and face.

Diagnoses most commonly associated with cumulative or repetitive trauma include:

- \*tendinitis or inflammation of a tendon,
- \*tenosynovitis or inflammation of the sheath surrounding the tendon,
- \*bursitis or inflammation of the sack surrounding a joint,
- \*nerve entrapments such as carpal tunnel syndrome which pinches the median nerve at the wrist or cubital tunnel syndrome which pinches the ulnar nerve at the elbow, and
- \*myalgia or muscle pain, which may also be referred to as muscle strain, tension neck, or neck and shoulder syndrome

An individual may also have more than one type of a disorder at one time. It is not unusual, for example, to have an elbow tendinitis (epicondylitis) and pain in the neck and shoulder muscles at the same time or to have wrist tendinitis along with carpal tunnel syndrome.

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## **PREVENTING CUMULATIVE MS INJURIES COMMON HAZARDS**

### **HIGHLY REPETITIVE TASKS**

Highly repetitive jobs mean making the same movement over and over. High rates of repetition for hand work are usually noted around 20-30 times a minute. Whole body bending, twisting, stooping, etc might be 10 or more per minute. Examples include hand clipping, cutting, twisting wires, sorting materials, or even bending, stooping or reaching. If the job cannot be changed with a new tool or approach, then take "micro breaks" (e.g., 20-30 seconds every few minutes) to give muscles and joints time to rest and recover. Another approach is to rotate workers through different jobs during the day.

### **AWKWARD POSITIONS**

Many jobs involve long reaches, bending or stooping, or awkward twisting of the body, arms, hands, etc. These can cause tissue damage if repeated often in a work cycle or if held (sustained) for long periods (e.g., sustained stoop or reach to pick). Awkwardness is relative to a simple standing or sitting position. The more a body part is moved from these starting positions, the more awkward it is. If the job cannot be changed with a tool or new approach, then take "micro breaks" (e.g., 20-30 seconds every few minutes) to give muscles and joints time to rest and recover. Another approach is to rotate workers through different jobs during the day.

### **HEAVY LOADS**

Lifting or carrying heavy loads or exerting high forces (e.g., grip, push, pull) on a highly repetitive or sustained basis for long periods causes musculoskeletal stress. Many agricultural jobs involve such tasks. To reduce risk of injury carry loads correctly, get help with any heavy loads (e.g., over 50#), and take regular "micro" breaks from jobs involving continuous lifting or exertion of force. Use mechanical assistance with loads wherever possible. Another approach is to rotate workers through different jobs during the day.

## **SUSTAINED VIBRATION**

Some jobs involve exposure to fairly long periods of vibration from tools or equipment. Tractor drivers, equipment operators, and persons working on moving equipment all have some exposure to vibration. Persons using powered tools also. Insulation from vibration (gloves, seat pads, floor pads, etc) helps. If sustained exposure to vibration cannot be avoided, consider rotating workers through jobs daily and increasing breaks for relief.

### **Effective injury prevention requires everyone's serious attention:**

#### **1. BE AWARE**

Know the specific hazards in your workplace.

#### **2. CONTROL HAZARDS**

Take corrective actions to protect against or prevent hazardous conditions which you can.

#### **3. REPORT UNSAFE CONDITIONS**

Any serious hazard should be reported to your supervisor immediately. If the hazard is life threatening stop work until corrective action is taken.

#### **4. USE PROTECTIVE EQUIPMENT AND PRACTICES**

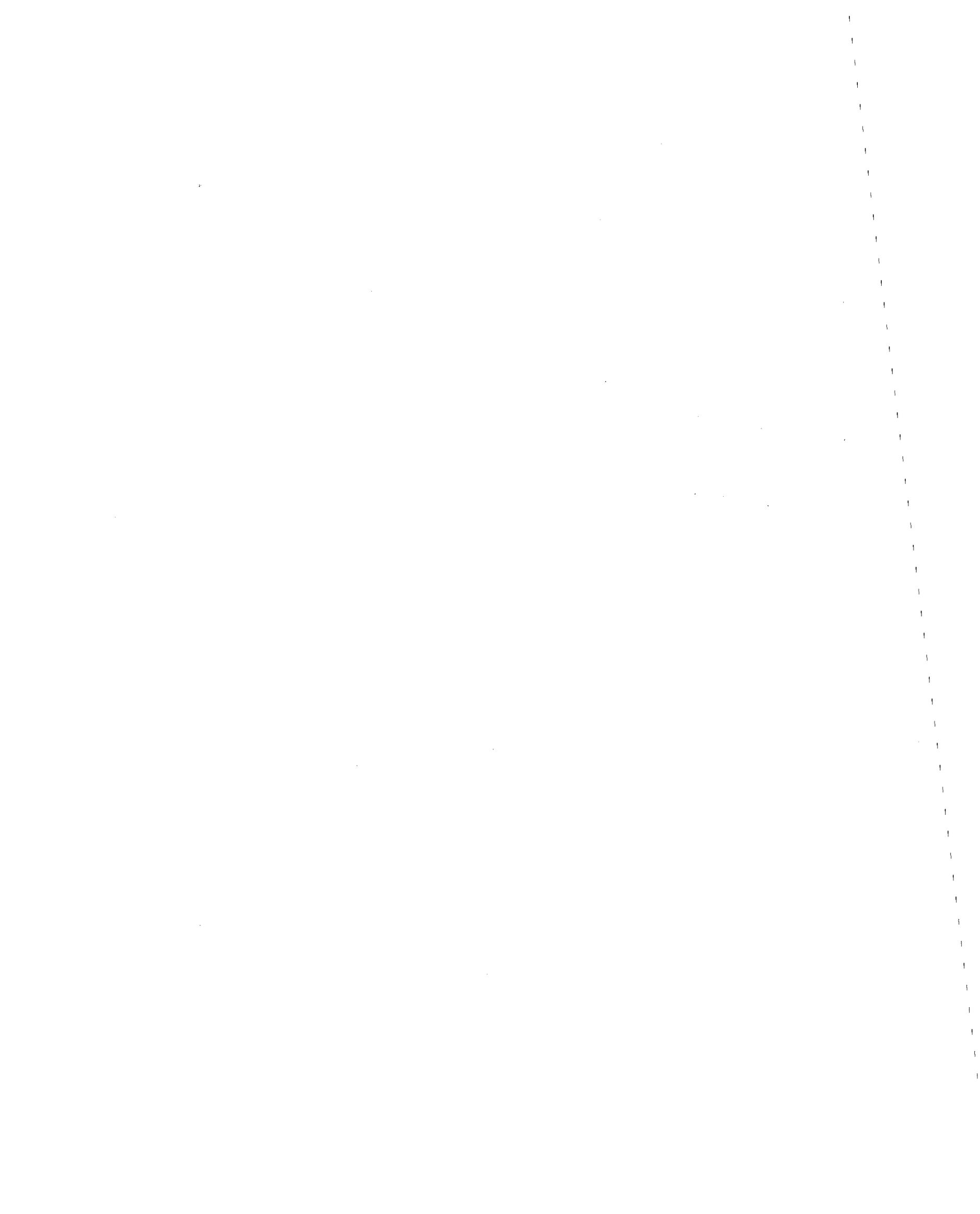
Always use required protective equipment. Make sure it is in operating condition. Always use safe work practices as described in training.

#### **5. KNOW WHAT TO DO IF INJURY OCCURS**

Know how to get help if injury occurs. Know where first aid supplies and phone are. Know basic life-saving first aid.



Development supported by National Institute for Occupational Safety and Health cooperative agreement PHS-R01 OH14508



# **ERGONOMICS CHECKSHEET**



## QUICK CHECK ERGONOMICS RISK FACTOR CHECKLIST

### Instructions

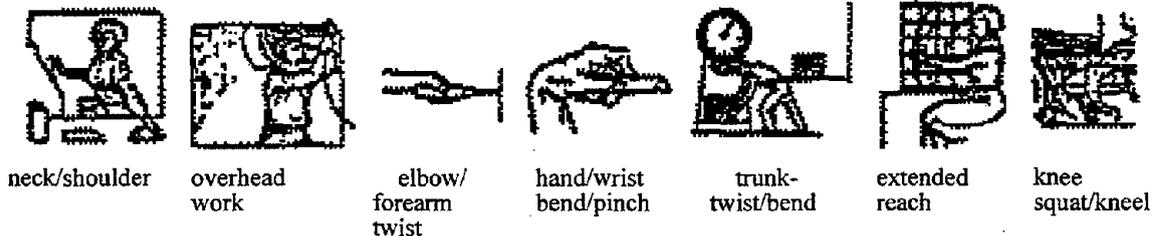
The Hazard Surveillance Checklist is a crude method of estimating the risk of developing MSDs from performing a specific job or task. Each repetitive task being performed as part of an employees job is scored separately. If more than one repetitive task is performed, the scores are additive. Employees (jobs) whose risk factors exceed a score of 10 surpass the lower risk threshold and should be considered for further ergonomic study. Following are brief explanations of each of the risk factors contained in the Quick Check List (on the following page).

A. If a motion such as striking a nail, or turning a handle is repeated more than 15 time/min (on the average) over an extended period of time the risk should be rated under "every few seconds". If the motion is repeated more than 20 times/hr then the risk should be rated under "every few minutes". Single tasks (such as driving a nail) which are completed in less than two minutes but repeated several times over periods of one or more hours should be considered "repetitive".

B. The weight of the object should be determined if possible. Potential lifting problems should be evaluated with the NIOSH Work Practices Guide. Push & pull force is difficult to determine without a strain gauge but can be estimated by asking employees to rate difficulty of task on a scale of 1-10.

1	2	3	4	5	6	7	8	9	10
easy			moderate				heavy		

C. The following pictorial illustrations are good examples of "awkward postures":



D. Power tools impart different types of stresses to the body based on the vibration and torque they produce during use.

E. Pressure points result from the repeated or sustained contact of hand, arm or other body part with a solid object or hard surface. This may be due to the use of a poorly designed tool such as a pliers or scissors, resting an arm or palm on the edge of a desk, or repeated use of the hand as a hammer.



F. Jobs which are highly repetitive or require intense concentration may cause the worker to maintain the same posture for extended periods of time resulting in static loading of certain body parts.

G. Environmental extremes (especially cold) impair muscle and tendon function while continuous whole body vibration from operating equipment or driving fatigues muscle groups.

H. Such as pay incentives, machine, or quota paced jobs.

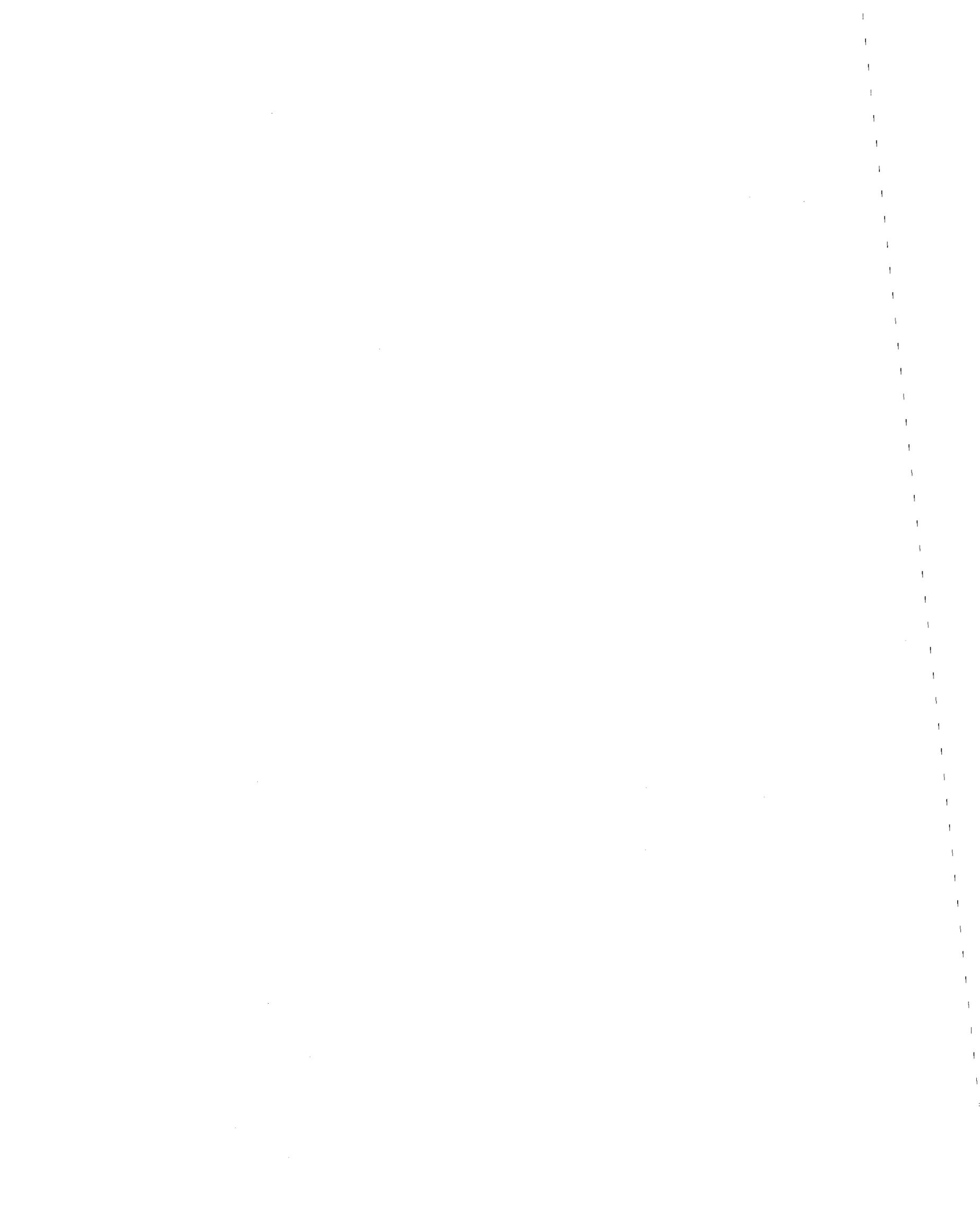
I. Employees (jobs) whose risk factors exceed a score of 10 surpass the lower risk threshold and should be considered for further ergonomic study.

**Quick Check  
Ergonomics Risk Factor Checklist**

RISK FACTOR	<1hr	1-4hr	>4hr	Cause of Risk Factor	Proposed Solution	Comments
REPETITIVE						
every few seconds	0	1	3			
every few minutes	0	0	1			
LOAD/FORCE (lift)						
>5-15 lbs	0	0	1			
>15-30 lbs	1	1	2			
>30-50 lbs	2	2	2			
>50 lbs@	3	3	3			
LOAD/FORCE (Push/Pull)						
easy	0	0	1			
moderate	0	1	2			
heavy	1	2	3			
LOAD/FORCE (Carry>10 ft)						
>5-15lbs	0	0	1			
>15-30lbs	0	1	2			
>30lbs	1	2	3			
AWKWARD POSTURES:						
Neck/shoulder: overhead/bend	0	1	2			
Extended reach	0	1	2			
Elbow/forearm: twist	0	1	2			
Hand/wrist: bend/pinch	0	1	2			
Trunk: twist/bend	0	1	2			
Knee: squat/kneel	0	1	2			
USE POWER TOOLS	0	1	3			
PRESSURE POINTS	0	1	2			
SAME POSITION	0	1	2			
ENVIRONMENT cold, hot, light, glare, vibration	0	1	2			
CONTINUOUS KEYBOARD USE	0	1	2			
INCENTIVE WORK or NO WORKER CONTROL OVER JOB PACE	0	1	2			
TOTAL Score = 10 or more?						

@Single Lift > 50 lbs increases risk of low back problems

**HEALTH OUTCOMES SURVEY  
FORM**





## AGRICULTURE HEALTH QUESTIONNAIRE - ENGLISH KEY

Nuestro equipo de investigación de la Universidad de California quisiera ayudar a los trabajadores de los viñedos para que mejoren su estado de salud. Para poder hacer esto, estamos preguntándole a algunos trabajadores de los viñedos acerca de sí mismos y de cómo se sienten físicamente. Nos interesa especialmente conocer las molestias físicas que sienten día a día, aquí en el viñedo y también en la casa. Estamos seleccionando trabajadores de áreas específicas de viñedo - gente como usted - para preguntarles acerca de esas molestias. Para que podamos ayudar a todos los trabajadores de viñedo, es muy importante que usted nos cuente acerca de sus molestias físicas, aunque le parezcan de poca importancia o sean diferentes a lo que sienten las demás personas. Nos interesa especialmente saber más acerca de sus dolores persistentes, dolores agudos y molestias que siente en sus músculos, articulaciones o nervios.

Hoy quisiera hacerle varias preguntas acerca de las molestias de su cuerpo y músculos, que siente ahora o que ha sentido anteriormente. Yo no le voy a decir a nadie de (viñedo) qué es lo que usted me ha contado. A nuestro equipo le interesa solamente conocer su opinión. Las preguntas no tienen respuesta correcta ni respuesta equivocada - se trata de su opinión solamente. La información que usted me dé servirá para que nuestro equipo de investigación pueda ayudar a **todos** en el viñedo, para que puedan trabajar en una forma más saludable.

¿Le parece bien si le hago estas preguntas? ¿Sí? Bueno, entonces empecemos.

(Our UC research team wants to help the vineyard workers improve their health. To do that, we are asking some vineyard workers to tell us more about themselves and how they feel physically. We are especially interested in what physical discomforts are experienced day to day here at the vineyard and at home. We're selecting workers from specific areas of the vineyard, such as yourself, to ask about such discomforts. For us to help everyone at the vineyard, it is very important that you tell us what physical discomforts you feel even if they seem minor to you or different from what everyone else may experience. We particularly want to know more about your physical aches and pains, those discomforts that you feel in your muscles, joints, or nerves.

Today I want to ask you several questions about the musculoskeletal discomforts that you feel now or have felt in the past. The personal information that you give me won't be shared with anyone else associated with the vineyard. Our team is only interested in your opinion - there are no right or wrong answers to any of the questions. The information you give me will help our research team to help everyone at the vineyard work in a healthy way.

Is it all right with you to ask you these questions? Then, let's begin: )

**SECTION A.** Ahora quisiera preguntarle acerca de la clase de trabajo que hace en (the vineyard).  
(Now I'd like to ask you about the kind of work you do at the vineyard.)

- 1) ¿Cuántos años tiene trabajando en la industria de (wine grapes)?    Números de años \_\_\_\_\_  
(How many years have you worked in the wine grape business?)
- 2) ¿Cuántos años tiene trabajando en la industria de (wine grapes in California)?  
Números de años \_\_\_\_\_  
(How many years have you worked in the wine grape business in California?)
- 3) ¿Cuántos años tiene trabajando para esta empresa?    Mes \_\_\_\_\_ Año \_\_\_\_\_  
(What month and year did you begin working for this company?)
- 4) En los últimos 12 meses, ¿ha cambiado su trabajo? ¿En qué forma?  
(In the past 12 months, has your work changed? In what way?)

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- 5) (We'd like to know how much of your time you spent doing specific job tasks during the past month. Think about just this last month when you answer. Let us say that one dollar represents all of the time that you have spent working in the vineyards over the last month. So here are ten dimes, that is one dollar, which represent all of your work in raising wine grapes over the last month. Divide the dimes between the tasks you see pictured for the vineyard operations that have taken place in the last month). *Interviewer: consult task list attached as last page and ask only items that feasibly pertain to the last month in the vineyard.*

**SECTION B** Ahora, quisiera hacerle algunas preguntas personales:  
(Now, I'd like to ask you some personal questions:)

- 6) Interviewer: Circle gender of subject                      Sexo masculino = 1    Sexo femenino = 2
- 7) ¿Cuántos años tiene?    Número de años \_\_\_\_\_  
(How old are you?)
- 8) ¿De cuál país (región o STATE) viene usted o su familia?    STATE \_\_\_\_\_  
(From what region or state in Mexico do you or your family come?)  
Or what other country: Nicaragua    El Salvador    Puerto Rico    COUNTRY \_\_\_\_\_
- 9) ¿Cuántos años completó en la escuela?                      Número de años \_\_\_\_\_  
(How many years of school did you complete?)
- 10) ¿Durante cuántos años ha estado viviendo en los Estados Unidos?    Número de años \_\_\_\_\_  
(How many years have you lived in the United States?)
- 11) ¿Cuántas semanas se va de los Estados Unidos durante el año pasado? Numero de  
semanas \_\_\_\_\_

(How many weeks did you spend in Mexico during this last year?)

**SECTION C**

Ahora, por favor use el dibujo del cuerpo para colorear los lugares donde ha tenido dolores agudos, dolores persistentes o molestias en sus músculos, huesos o nervios en los últimos 30 días. Aquí hay un ejemplo del dibujo que coloreó otra persona.

(Please use the body drawing to color in the places where you've had aches and pains or discomfort in your muscles, bones, or nerves in the past 30 days. Here is an example of the way another person completed the diagram.)

***Interviewer: Show the interviewee the sample diagram with the symptomatic body regions colored.***

- 12) Con el color azul, coloree los lugares donde el dolor ha sido leve a moderado.  
(With the color blue, color in the places where the pain has been mild or moderate.)
- 13) Con el color rojo, coloree los lugares donde el dolor ha sido fuerte o agudo.  
(With the color red, color in the places where the pain has been sharp.)
- 14) Con el color amarillo, coloree los lugares donde ha sentido hormigueo o adormecimiento.  
(With the color yellow, color in the places where you've felt numbness or tingling.)

**SECTION D**

Piense en los lugares que usted pintó con el color AZUL. Estas preguntas son solamente para los dolores o molestias que marcó con el color AZUL.

(Think about the places that you colored with BLUE. These questions are only for the discomforts or pains you indicated with the color BLUE.)

- 15) ¿Durante cuántos días \_\_\_\_\_ ha tenido estos dolores o molestias?  
(During how many days \_\_\_\_\_ have you had these discomforts or pains?)  
¿En los últimos 7 días - (In the last seven days?) Número de días \_\_\_\_\_  
¿En los últimos 30 días - (In the last thirty days?) Número de días \_\_\_\_\_

- 16) Cuando tiene este dolor, ¿cuántos días en promedio le dura cada episodio?  
(When you have this pain, how many days does the usual episode last?)  
Número de días \_\_\_\_\_

**Interviewer:** *Check here if symptoms occur every day or all the time:* \_\_\_\_\_

- 17) Durante los últimos 30 días, ¿cuál fue el mayor número de días que tuvo este dolor en forma continua?  
días \_\_\_\_\_ Número de días \_\_\_\_\_  
(During the past 30 days, what is the longest number of days that you've had this pain continuously?)

- 18) En sus días de descanso, siente que su dolor ¿se mejora? - (Get better?) \_\_\_\_\_  
(On your days off, does your pain...)  
¿se empeora? - (Get worse?) \_\_\_\_\_  
¿sigue igual? - (Stay the same?) \_\_\_\_\_

- 19) Durante los últimos 30 días, ¿cuál fue la (usual) gravedad de este dolor? **Face #** \_\_\_\_\_  
(During the past thirty days, what was the usual severity of this pain?)  
**Interviewer:** *Use Faces scale and enter the face the subject points to.*

Piense en los lugares que usted pintó con el color ROJO. Estas preguntas son solamente para los dolores o molestias que marcó con el color ROJO.

(Think about the places that you colored with RED. These questions are only for the discomforts or pains you indicated with the color RED.)

- 20) ¿Durante cuántos días \_\_\_\_\_ ha tenido estos dolores o molestias?  
(During how many days \_\_\_\_\_ have you had these discomforts or pains?)  
¿En los últimos 7 días - (In the last seven days?) Número de días \_\_\_\_\_  
¿En los últimos 30 días - (In the last thirty days?) Número de días \_\_\_\_\_

- 21) Cuando tiene este dolor, ¿cuántos días en promedio le dura cada episodio?  
(When you have this pain, how many days does the usual episode last?)  
Número de días \_\_\_\_\_

**Interviewer:** *Check here if symptoms occur every day or all the time:* \_\_\_\_\_

22) Durante los últimos 30 días, ¿cuál fue el mayor número de días que tuvo este dolor en forma continua?  
(During the past 30 days, what is the longest number of days that you've had this pain continuously?)

Número de días \_\_\_\_\_

23) En sus días de descanso, siente que su dolor ¿se mejora? - (Get better?) \_\_\_\_\_  
(On your days off, does your pain...) ¿se empeora? - (Get worse?) \_\_\_\_\_  
¿sigue igual? - (Stay the same?) \_\_\_\_\_

24) Durante los últimos 30 días, ¿cuál fue la (usual) gravedad de este dolor? **Face #** \_\_\_\_\_  
(During the past thirty days, what was the usual severity of this pain?)  
**Interviewer: Use Faces scale and enter the face the subject points to.**

Piense en los lugares que usted pintó con el color AMARILLO. Estas preguntas son solamente para los dolores o molestias que marcó con el color AMARILLO.

(Think about the places that you colored with YELLOW. These questions are only for the discomforts or pains you indicated with the color YELLOW.)

25) ¿Durante cuántos días \_\_\_\_\_ ha tenido estos síntomas?  
(During how many days \_\_\_\_\_ have you had these discomforts or pains?)  
¿En los últimos 7 días - (In the last seven days?) Número de días \_\_\_\_\_  
¿En los últimos 30 días - (In the last thirty days?) Número de días \_\_\_\_\_

26) Cuando tiene este síntomas, ¿cuántos días en promedio le dura cada episodio?  
(When you have this pain, how many days does the usual episode last?)  
Número de días \_\_\_\_\_  
**Interviewer: Check here if symptoms occur every day or all the time: \_\_\_\_\_**

27) Durante los últimos 30 días, ¿cuál fue el mayor número de días que tuvo este dolor en forma continua?  
(During the past 30 days, what is the longest number of days that you've had this pain continuously?)  
Número de días \_\_\_\_\_

28) ¿Se ha despertado de noche a causa de este síntoma? Si \_\_\_\_\_ No \_\_\_\_\_  
(Have you woken up at night because of this pain?)

29) En sus días de descanso, siente que su dolor ¿se mejora? - (Get better?) \_\_\_\_\_  
(On your days off, does your pain...) ¿se empeora? - (Get worse?) \_\_\_\_\_  
¿sigue igual? - (Stay the same?) \_\_\_\_\_

30) Durante los últimos 30 días, ¿cuál fue la (usual) gravedad de este dolor? **Face #** \_\_\_\_\_  
(During the past thirty days, what was the usual severity of this pain?)

**Interviewer: Use Faces scale and enter the face the subject points to:**

Piense en todos los síntomas o molestias que marcó en el dibujo: azul, rojo y amarillo.  
(Think about all of the discomforts or symptoms you indicated in the drawing.)

- 31) De las actividades que hace usted en su casa, ¿cuáles empeoran sus molestias?  
(What activities do you do at home that make your discomfort worse?)

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- 32) De las actividades que hace usted en el trabajo, ¿cuáles empeoran sus molestias?  
(What activities do you do at work that make your discomfort worse?)

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- 33) En los últimos 12 meses, ¿ha consultado a un médico debido a sus síntomas o molestias?  
(In the last 12 months have you consulted a doctor because of your discomforts or symptoms?)  
**Interviewer: If NO, enter date as zeros and SKIP to #30. If YES, enter the date of the visit if a single visit, or, if there were several visits during an episode, enter the date of the first visit:**

\_\_\_/\_\_\_/\_\_\_

- 34) ¿El médico pudo diagnosticarle su problema? ¿Cuál fue ese diagnóstico?  
(Was the doctor able to diagnose your problem? What was that diagnosis?)

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- 35) Según el médico, ¿cuál fue la causa de sus síntomas o molestias?  
(What was the cause of your discomforts or symptoms according to the doctor?)

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**Interviewer: Check if physician indicated diagnosis was work-related:** \_\_\_\_\_

## SECTION E

- 36) Now I'm going to read to you a list of remedies and activities that people here at the nursery have told us they use to relieve their pain and discomfort. Sometimes these remedies are used at home and sometimes they are used at work. I'd like you to tell me if you have ever used any of these remedies or treatments when you have discomforts in your muscles, bones, or nerves. Please say yes to treatments that you use at home as well as at work. **Interviewer: Read the Remedies Checklist and check all items that the subject says he/she uses.**

Are there any treatments or remedies that you think should be added to the list?

- 37) I'm going to read the list again, reading only the remedies that you have used in the past. Please tell me how many days in the past month you've used each of these remedies or treatments to relieve the discomforts in your bones, muscles or nerves.

*Interviewer: Enter the number of days the treatment was used during the last month.*

- 38) ¿Hay algo más que quisiera decirnos acerca de como el trabajo en el viñedo le afecta su salud?  
(Is there anything else you want to tell us about how doing field work in the vineyards that might affect your health?)
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**THANK YOU VERY MUCH FOR YOUR HELP AND EFFORT IN COMPLETING THIS  
QUESTIONNAIRE.**



**SECTION E: Remedies checklist**

<b>REMEDY/TREATMENT AT HOME &amp; WORK</b>	<b>SUBJECT USES</b>	<b>DAYS USED IN LAST MONTH</b>
Medicinas con receta médica - (Prescribed medicines)		
Medicinas sin receta médica - (Non-prescription medicines)		
Remedios caseros - (Home remedies)		
Hierbas, incluyendo los tés e infusiones (Herbs, including teas and infusions)		
Pomadas o ungüentos - (Salves or ointments)		
Aplicaciones de frío - (Applying cold (like an ice pack))		
Almohadillas o mantas calientes (eléctricas) (Heating pads or electric blankets)		
Jomentos / Toalla caliente - (Hot compresses/hot towels)		
Baños de agua caliente o al vapor- (Hot water or steam baths)		
Ejercicio - Exercise		
Calentamiento- (Warm ups (for relief))		
Tomar tiempo libre del trabajo - (Taking time off from work (eg take a day off))		
Tabilla - (Splint (entablado - local term))		
Faja para el trabajo - (Back belt for work)		
Faja recetada por el médico - (Corset (prescribed by the doctor))		
Vendajes -(Bandages)		
Guantes - (Gloves (for relief, not work))		
Usar la imaginación o soñar despierto - (Using imagination or daydreaming)		
Distracciones como mirar le television, escuchar radio, placticar con las personas (Distractions like watching television, listening to the radio, chatting with people (for relief))		
Oración (rezar) - (Prayer (praying))		
Pulsera de cobre o balance - (Copper bracelet, balance bracelet)		
Masajes - (Massage)		
Sobado - (Folk massage)		
Acupuntura - (Acupuncture)		
Servicios de un quiropráctico - (Chiropractic services)		
Fricciones con alcohol - (Rubbing alcohol)		

## TASK LIST

Durante esta temporada usted:

### Pruning

- a. poda *Prunes*
- b. amarra *ties*
- c. fumigado/espreyado *sprays*
- d. maneja tractor *drives tractor*
- e. other - have worker name task

### Between pruning & harvest

- f. injerta *Graft*
- g. planta nuevo fil *Planting*
- h. corta cabezas. *Cutting heads*
- i. corta la cabeza y la cinta *cut head and tape*
- j. cubrir el injerto *covering root stock*
- k. paleando para limpiar hierbas o zacates entre las viñas. *Hand cultivation*
- l. soquear o desbrotar *Suckering*
- m. corta o desahije retoños. *Shoot Thinning*
- n. desahije racimos extras. *Fruit Thinning*
- o. guiar viñas nuevas o entrenar parras chicas *Training young vines*
- p. desahije hojas. *Leave removal*
- q. posesiona los retoños en el soporte. *Shoot positioning*
- r. other - have worker name task

### Harvest

- s. pizca *harvest*
- t. maneja tractor *drive tractor*
- u. reparación? *At end of harvest repair work*

### Between harvest and pruning season:

What work have you been doing since harvest?

How much vacation time did you take between harvest and now?

Did you do any work outside the vineyard during the time between harvest and now?