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16. Abstract Strain/sprain-related incidents account for 40% of the total injuries of Texas Department of Transportation (TxDOT) employees. Over the past 5 years the most common strain/sprain injury was of the lower back; 50% of these injuries were caused by lifting tasks. The goal of this project is to create a guidebook presenting a set of ergonomic recommendations for common TxDOT workplace tasks and a Stretch and Flex program designed to reduce strain/sprain-related incidents. Research studies have shown that muscle strengthening exercises can reduce workplace strain/sprain-related incidents. However, most of the Stretch and Flex programs currently being implemented involve more stretching than flexing. Thus, current Stretch and Flex programs may not be as beneficial as they could be. Since injury of the low back is the most common work-related injury, strengthening the core musculature is the best preventative strategy. The challenge that current Stretch and Flex programs face in achieving this goal may be that traditional core-strengthening exercises are performed on the ground, which may not work well for employees who work outdoors or are not dressed for being on the ground. Thus, the Stretch and Flex program that will be created will involve exercises done in the standing position to strengthen the core musculature as well as target other muscles and joints susceptible to work-related injuries. The University of Texas at Austin (UT) has developed instructional videos for vertical core strengthening, and has developed and implemented exercise programs for field and office workers. The user-friendly guidebook that we will create for TxDOT employees will contain ergonomic recommendations for TxDOT maintenance and office workers as well as a Stretch and Flex program that will be superior to current programs. A guidebook will help TxDOT employees reduce their risk of injury through specific work-related ergonomic strategies and injury-prevention exercises designed to improve strength and flexibility. This program is expected to reduce the incidence of TxDOT strain/sprain-related incidents and substantially reduce associated costs, which have exceeded \$3.7 million over the past 5 years.				
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**THE UNIVERSITY OF TEXAS AT AUSTIN  
CENTER FOR TRANSPORTATION RESEARCH**

## **Stretch and Flex Program for TxDOT Office and Field Workers**

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Research Supervisor: Dr. Lisa Griffin

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## **Products**

This report includes as Chapter 5 a version of the P1: *Stretch and Flex Guidebook*. Also included as an appendix is the P2: *Scripts for Field Worker and Office Worker Video* (the scripts used for the instructional videos for vertical core strengthening that the CTR team developed).

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# **Chapter 1. Introduction**

## **1.1 Problem Statement**

Strain/sprain-related incidents account for 40% of the total injuries of Texas Department of Transportation (TxDOT) employees. Over the past 5 years the most common strain/sprain injury was of the lower back; 50% of these injuries were caused by lifting tasks. Research studies have shown that muscle strengthening exercises can reduce workplace strain/sprain-related incidents. However, most of the Stretch and Flex programs currently being implemented involve more stretching than flexing. Thus, current Stretch and Flex programs may not be as beneficial as they could be. Since injury of the low back is the most common work-related injury, strengthening the core musculature is the best preventative strategy.

## **1.2 Objectives**

The goal of this project is to create a guidebook presenting a set of ergonomic recommendations for common TxDOT workplace tasks and a Stretch and Flex program designed to reduce strain/sprain-related incidents. The challenge that current Stretch and Flex programs face in achieving this goal may be that traditional core-strengthening exercises are performed on the ground, which may not work well for employees who work outdoors or are not dressed for being on the ground. Thus, the Stretch and Flex program that will be created will involve exercises done in the standing position to strengthen the core musculature as well as target other muscles and joints susceptible to work-related injuries. The University of Texas at Austin (UT) has developed instructional videos for vertical core strengthening, and has developed and implemented exercise programs for both field and office workers. The scripts used for the instructional videos are included as Appendix A.

## **1.3 Expected Contributions**

The user-friendly guidebook for TxDOT employees contains ergonomic recommendations for TxDOT maintenance and office workers as well as a Stretch and Flex program. A guidebook will help TxDOT employees reduce their risk of injury through specific work-related ergonomic strategies and injury-prevention exercises designed to improve strength and flexibility. This program is expected to reduce the incidence of TxDOT strain/sprain-related incidents and substantially reduce associated costs, which have exceeded \$3.7 million over the past 5 years.

## **1.4 Report Overview**

The remainder of this report is organized as follows: Chapter 2 presents a thorough review and synthesis of state-of-the-art and state-of-the-practice Stretch and Flex programs. Chapter 3 describes both TxDOT's injury data and the development of a Stretch and Flex program and ergonomic recommendations for TxDOT employees. Chapter 4 presents the Stretch and Flex pilot program conducted in the Austin District. Chapter 5 presents the guidebook. Chapter 6 summarizes this report.



## **Chapter 2. Literature Review**

### **2.1 Background and Significance of Work**

Strain/sprain-related incidents account for 40% of TxDOT's total injuries. A *strain* is damage to muscle fibers caused by overuse or heavy lifting and associated with pain and swelling. A *sprain* is damage to a ligament caused by sudden twisting or impact that results in pain, swelling, and decreased mobility. The goal of this project is to design and test a Stretch and Flex Program with the aim of reducing strain/sprain-related incidents in TxDOT employees. Research studies have found that muscle strengthening exercises can reduce workplace strain/sprain-related incidents. However, most of the Stretch and Flex Programs that are currently being implemented involve more stretching than flexing. The user-friendly guidebook that we will create will involve ergonomic recommendations for TxDOT maintenance and office workers as well as a Stretch and Flex program that will be superior to current programs. Our guidebook and program will help TxDOT employees reduce their risk of injury through specific work-related ergonomic strategies and injury-prevention exercises designed to improve strength and flexibility. This is expected to reduce the incidence of TxDOT strain/sprain-related incidents and substantially reduce associated costs, which have exceeded \$3.7 million over the past 5 years.

### **2.2 Physical and Ergonomic Risk Factors for TxDOT Employees**

In the past 5 years, TxDOT employees sustained 482 sprain- or strain-related injuries (Table 2.1), excluding 53 caused by automobile accidents. Of the 482, 172 (36%) were of the back and approximately 30% of all injuries occurred during lifting/carrying. The most prevalent injury was to the lower back during lifting (67 injuries). Individual costs for lower back injuries incurred during lifting ranged from \$0 to \$284,530, and missed work days ranged from 0 to 164.

Another common cause of injury was a fall or slip (113 out of 482, or 23% of injuries). Following the lower back, the second-most prevalent injury was of the ankle following a fall or slip (35 injuries). Thus, for the Stretch and Flex program and the guidebook, we will specifically target these areas by improving core muscle strength and ankle flexibility and by providing ergonomic recommendations for lifting and fall/slip prevention. Other common injuries included the shoulder during lifting, the knee during falls, and the knee and ankle during twisting maneuvers. Thus, special attention will also be given to these areas.

**Table 2.1: TxDOT Sprain and Strain Injuries (09/01/2008–07/18/2013)**

	Neck	Low Back	Back/ Upper Back	Shoulder	Arm	Elbow	Wrist	Hand	Abs Side	Groin	Hip	Leg	Knee	Ankle	Foot	Total
<b>Lifting/Carrying</b>	3	73	16	23	4	2	-	4	6	6	-	1	4	3	1	<b>146</b>
<b>Push/Pull</b>	1	19	-	11	4	4	1	1	1	1	-	4	2	1	-	<b>50</b>
Twisting	-	10	-	-	-	-	-	-	-	-	1	1	15	21	1	49
Bending/Coning	-	3	1	-	-	-	-	-	-	-	1	-	-	-	-	5
Walking	-	-	1	-	-	1	-	-	-	-	-	3	3	9	1	18
Climbing	-	-	-	1			1		-	-	-	2	9	2	-	15
Jumping	-	-	-	1	-	-	-	-	-	1	-	1	-	4	-	7
<b>Fall/Slip</b>	1	19	8	5	2	2	2	3	1	1	4	7	20	35	4	<b>114</b>
Exiting	-	3	2	1	-	-	-	-		-	2	-	9	4	2	23
Repetitive Motion/Set Up Repairing/ Maintenance	1	5	1	1	1	1	2	1	-	1	-	1	3	-	-	18
Operating Equipment	3	9	2	7	3	1	3	5	-	-	-	-	1	3	-	37
<b>Total</b>	<b>9</b>	<b>141</b>	<b>31</b>	<b>50</b>	<b>14</b>	<b>11</b>	<b>9</b>	<b>14</b>	<b>8</b>	<b>10</b>	<b>8</b>	<b>20</b>	<b>66</b>	<b>82</b>	<b>9</b>	<b>482</b>

More people in the U.S. are disabled from musculoskeletal disorders than from any other group of diseases (for review, see Punnett et al. 2005). Musculoskeletal disorders account for 34% of total injuries and illnesses causing missed work (U.S. Bureau of Labor Statistics, 2002). Twenty-five percent of all workers compensation claims are for low back pain (Guo et al. 1995) and the recurrence rate of low back pain within 1 year is approximately 56% (Hestbaek et al. 2003). Construction workers are at a 50% higher risk of musculoskeletal disorders than workers who have less heavy work (for review, see Schneider 2001). These workers are exposed to several injury risk factors, including awkward postures, heavy lifting, forceful exertions, vibrations, and repetitive motions (Hartman and Fleischer 2005). For the first few months of this project, we will observe and assess the ergonomic parameters of both maintenance and office TxDOT employees in order to prepare a set of guidelines to test along with a Stretch and Flex Program.

Non-neutral trunk postures were the most frequently observed risk factor for low back pain in a study of 120 highway construction workers in Boston (Tak et al. 2011). A 3-year study of 861 workers across 34 companies found that a minimum of 60 degrees of trunk flexion for more than 5% of the working time, 30 degrees of rotation for more than 10% of the working time, and loads greater than 55 lbs/25 kg lifted more than 15 times per day were associated with low back pain (Hoogendoorn et al. 2000). In a study of 489 industry workers, extreme trunk flexion and whole-body vibration were the primary factors associated with work absence for low back pain (Murtezani et al. 2010). Heavy equipment vehicle operation is associated with poor working postures and whole body vibration doubles the risk of developing low back pain (for review, see Waters et al. 2008).

In a study of 202 pavers, the incidence of low back pain was 34% and shoulder pain was 17% (van der Molen et al. 2009). Not all injuries are reported, but working in pain may reduce productivity. For example, in a survey of 110 cement and concrete workers, 77% had at least one musculoskeletal disorder in a 1-year period and 66% experienced low back pain (15% of which caused work absence). Other injuries that caused work absences were of the neck (13%), shoulder (12%), ankle/feet (10%), upper back (9%), elbows (7%), wrists/hands (7%), and knees (5%). The major complaint of the workers was “working while in pain” (Goldsheyder et al. 2004).

Thus, for the TxDOT employees, we will identify specific posture and work demands that could be improved with better ergonomic design. This approach will not only reduce the costs associated with work absences but will improve the quality of life and productivity of TxDOT employees.

## **2.3 Injury Prevention**

In addition to creating a manual to improve work ergonomic factors for both maintenance and office workers, we designed a Stretch and Flex Program to improve overall strength and flexibility to help to reduce the risk of injury. Several studies have found that exercise training programs can prevent low back pain and are cost-effective for reducing musculoskeletal-related work absences.

A program provided to 158 California government employees that involved education, training, physical fitness activities, and ergonomic improvement found a decline in back pain prevalence and a 179% return on investment for the program (Leiyu 1993). However, another study, which simply gave ergonomic recommendations to 129 pavers and had them complete a survey at the study’s start and then again after 4.5 years, found that actual use of the ergonomic

recommendations varied from 15–66% and no statistical differences in low back or shoulder pain were observed. The authors stressed the importance of “applying and monitoring powerful implementation” for these types of programs to be successful (van der Molen et al. 2009).

The incidence of days off due to low back pain in 356 military personnel who received a 6-month intense exercise intervention and education program to improve control of their lumbar zone and to avoid full lumbar flexion in all daily tasks was significantly lower than in a control group who just participated in regular military service training (Sun et al. 2012). Furthermore, in a small group of 13 sedentary workers, mild training of just 6 daily callisthenic exercises to improve balance control of low back musculature also decreased the incidence of low back pain compared to a control group (Moore et al. 2012). Thus, strengthening programs can reduce the risk of low back pain in sedentary and highly active workers.

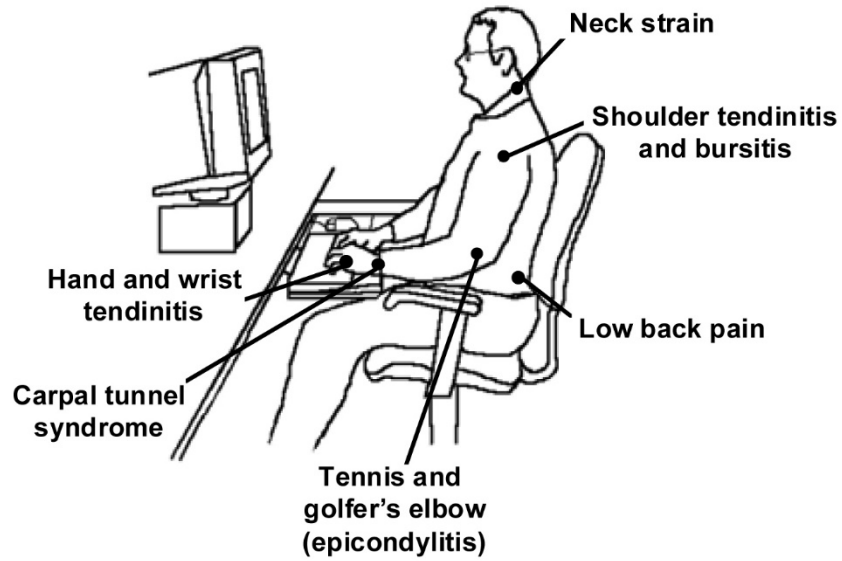
Post-treatment exercises are more effective than either no intervention to prevent recurrence of low back pain (for review, see Choi et al. 2010) or the implementation of exercise programs help to reduce obesity (body mass index > 30), which is a risk factor for low back pain (Heuch et al. 2012). Workplace rehabilitation programs are also effective for improving low back pain once it occurs (for review, see Williams et al. 2007) and are cost-effective (Loisel et al. 2002).

Much more literature is available on rehabilitation strategies post-injury than on strategies to prevent injury. Low back pain will affect 60–85% of the population at least once in their lifetime (World Health Organization 2003) and the rate of recurrence of low back pain is approximately 56% (Hestbaek et al. 2003). Strengthening exercises used to treat low back pain can decrease the time to return to work (Loisel et al. 1997) and may reduce the rate of recurrence (Mannion et al. 2001). Thus, we will incorporate strengthening exercises into our Stretch and Flex Program. This approach is innovative because most Stretch and Flex Programs do not incorporate strengthening exercises.

## **2.4 Office Ergonomics**

A separate guidebook will be prepared for office workers to prevent many of the work-related injuries shown in Figure 2.1. This book will also contain a section on exercises that can be done at the desk as well as a separate Stretch and Flex program that can be done as a group.





*Figure 2.1: Painful areas due to poor ergonomic positioning in the office*

## **2.5 Exercises That Have Been Used in Protocols Proven to Reduce the Incidence of Back Injury**

Moore et al. (2012) found that this set of exercises (depicted in Figure 2.2) completely prevented back pain over 1 year in 13 health care workers, compared to a control group in which 10 out of 17 reported back pain.

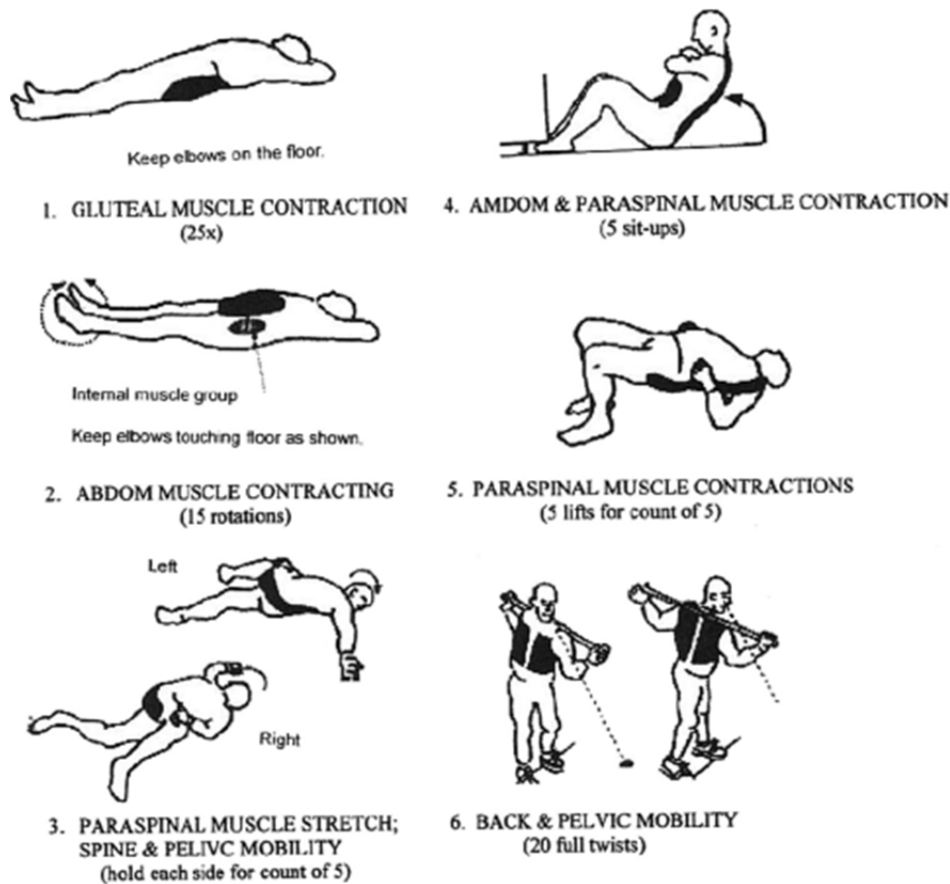


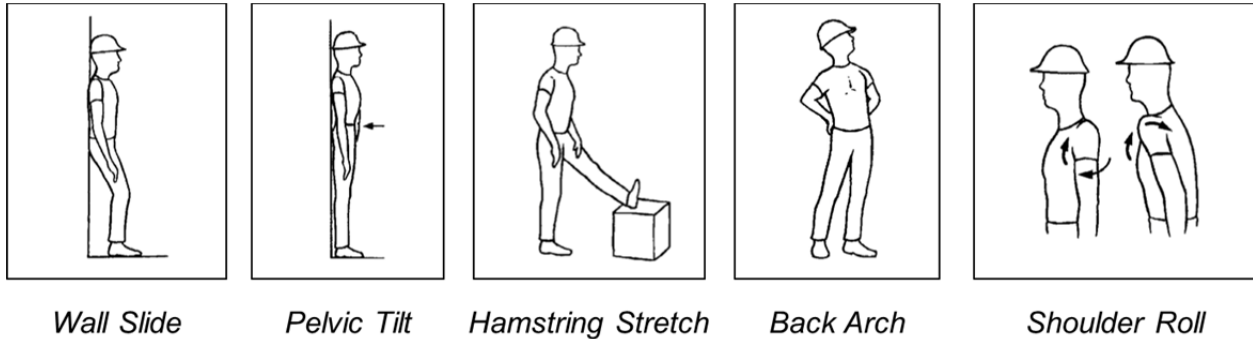
Figure 2.2: Exercises that reduced low back pain

## 2.6 Examples of Existing Injury Prevention Programs and Manuals

Several programs and manuals for injury prevention currently exist. Below is a description of some examples that are currently in use. We will assess all of the various existing programs that have been developed prior to developing the Stretch and Flex guidebook for TxDOT.

- MnDOT 554 Subcontractor Safety Plan (2011), Minnesota Department of Transportation
  - This 210-page work safety manual contains a Stretch and Flex Program consisting of a one-page description with photos of 12 different stretches. There is a lot of detail on how to do the stretches, but the names of the muscles being stretched are not mentioned. They recommend stretch hold times of 5–8 seconds, repeating the stretches three to five times.
- Stretch & Flex: A Multimedia Intervention to Reduce Work-Related Musculoskeletal Injuries in the Construction Industry (2009), Washington State Department of Transportation
  - This program is a multimedia intervention designed to reduce musculoskeletal injuries. It includes a YouTube video titled “Stretch & Flex for Construction,” posters for work sites, and a reference card.
  - They recommend 13 stretches to be done twice with a 20–30 second hold. The muscles stretched are the hamstrings, hip flexors, hip adductors, gastrocnemius, soleus, neck, pectoralis, biceps, trapezius, rhomboid, triceps, wrists, and hands.

- Ergonomics Working for Heavy and Highway Construction Laborers (2003), New York State Laborers' Health and Safety Fund
  - This 116-page manual begins with a brief review of musculoskeletal disorders and the majority of the manual is dedicated to proper ergonomics of work tasks (e.g., shoveling, pneumatic tools, sawing, lifting, stripping forms, and flagging).
  - They recommend two exercises (wall slide, pelvic tilt) and three stretches (hamstring stretch, back arch, shoulder roll), shown in Figure 2.3, and lying down with knees bent for 15 minutes at the end of the work day.



*Figure 2.3: Stretches recommended for heavy and highway construction laborers*

- Simple Solutions, Ergonomics for Construction Workers (2007), U.S. Department of Health and Human Services (National Institute for Occupational Safety and Health (NIOSH))
  - This 90-page manual describes ergonomic suggestions for floor- and ground-level work, overhead work, lifting, holding and handling materials, and hand-intensive work. It does not incorporate a Stretch and Flex Program.
- J.J. White Inc. (2012)
  - The web site for this general construction company contains a description of 12 stretches that are recommended but not required for their employees (Figure 2.4).

**Do these quick stretches regularly to reduce fatigue and avoid injury:**

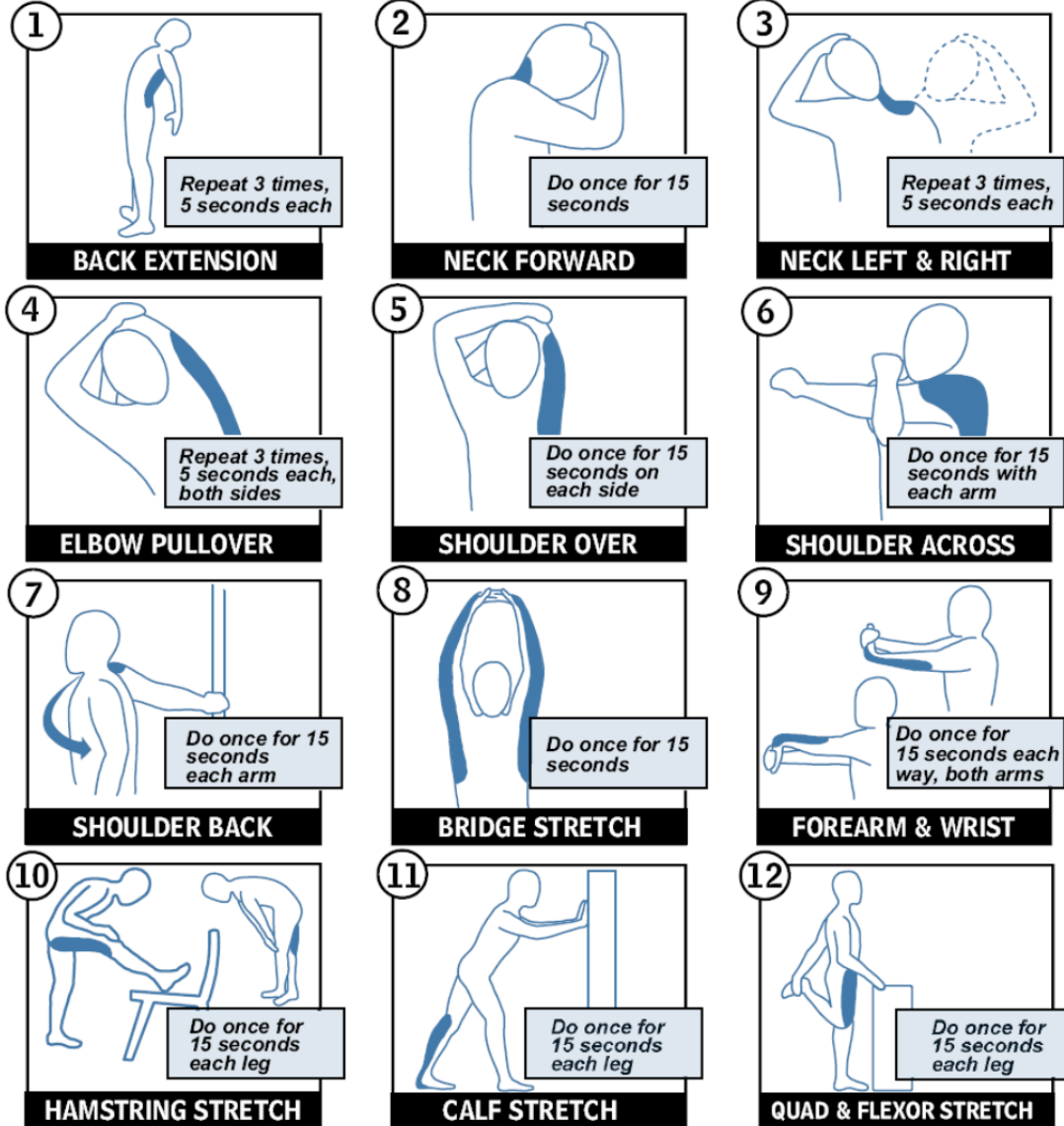


Figure 2.4: Stretches recommended by J.J. White Inc.

- Ergonomic Survival Guide for Laborers & Ergonomic Survival Guide for Cement Masons (2008), State of Hawaii, Department of Labor & Industrial Relations
  - These colorful pamphlets provide ergonomic tips for specific tasks and recommend the five stretches provided in Figure 2.5. However, they do not provide a written description of the stretches.



*Figure 2.5: Stretches recommended by State of Hawaii Department of Labor and Industrial Relations*

- Office Ergonomics, Practical Solutions for a Safer Workplace (2002) Washington State Department of Labor and Industries
  - This 73-page manual provides a comprehensive overview of correct ergonomics for office work. No exercises are included.

## **2.7 Summary**

In summary, most research studies have shown that reducing workplace strain/sprain-related incidents involves muscle strengthening exercises (Leiyu 1993, Suni et al. 2012, Moore et al. 2012). However, most of the Stretch and Flex Programs that are currently being implemented involve more stretching than flexing. Our guidebook will provide ergonomic recommendations for TxDOT maintenance and office workers as well as a Stretch and Flex program that will be superior to current programs. A draft of this guidebook is provided in Chapter 5.



## Chapter 3. Development of Pilot Stretch and Flex Program

The purpose of this task was to develop a Stretch and Flex program for TxDOT employees to be implemented during a pilot phase (as described in Chapter 4).

We have performed a thorough analysis of all TxDOT sprain/strain-related incidents over the past 5 years to determine the areas of the body most frequently affected by specific employee job tasks. This data was presented as part of Chapter 2 (Table 2.1). We found that the most prevalent of the 482 work-related injuries were of the back (172), ankle (82), knee (66), and shoulder (50). Thus, the exercises that we included in the Stretch and Flex programs were specifically designed to improve the strength and mobility of these target areas.

A wallet-sized pamphlet to be used by TxDOT employees participating in the pilot program was developed as part of this task. Selected pages of the pamphlet are shown in Figure 3.1 and have also been delivered to TxDOT as a PDF file. An updated version of the pamphlet will be delivered to TxDOT at the completion of this project.



Figure 3.1: Sample of the pamphlet





## Chapter 4. Implementation of Pilot Stretch and Flex Program

The purpose of this task was to conduct the Stretch and Flex pilot program in the Austin District. The pilot consisted of three training and/or feedback sessions with District staff, including office workers and maintenance foremen. Each session is described in detail as follows.

1. The first training session took place in August 2013 and focused on **field workers**. This session included brief field observations by the research team, as well as a training session for group leaders, in which the research team trained foremen and office leads in carrying out the targeted Stretch and Flex exercises. Foldable and pocket-size Stretch and Flex program pamphlets were also developed as part of this task and distributed during this training session. A draft version of the Field Worker Pocket Book is shown in Figure 4.1. The field workers then performed the Stretch and Flex program independently and daily for 2 weeks. Based on results from the pilot program and on feedback from TxDOT, edits will be made and a final version will be developed.
2. The second session took place in September 2013 and consisted of a progress meeting with office leads and foremen on the pilot program implementation. This session was also focused on **field workers**. During this session, the individual exercises within the Stretch and Flex program were reviewed and revised according to the feedback on implementation received.
3. The third training session took place in December 2013 and focused on **office workers**. This session included brief observations by the research team, as well as a training session for group leaders in carrying out the targeted Stretch and Flex exercises. Foldable and pocket-size Stretch and Flex program pamphlets were also developed as part of this task and distributed during this training session. An office ergonomics poster was also devised as part of this task and distributed during this session. A draft version of the Office Worker Pocket Book is shown in Figure 4.2 and a draft of the Ergonomics poster is down in Figure 4.3. Based on results from the pilot program and on feedback from TxDOT, edits will be made and final versions will be developed.

Two versions of pocket-size pamphlets to be used by TxDOT employees participating in the pilot program were developed as part of this task, one for field workers and another for office workers. An Office Ergonomics poster was also developed. These three draft products were delivered to TxDOT as PDF files as well as in hardcopy at the December 16, 2013, progress meeting. The final versions will be delivered at the end of this research project.

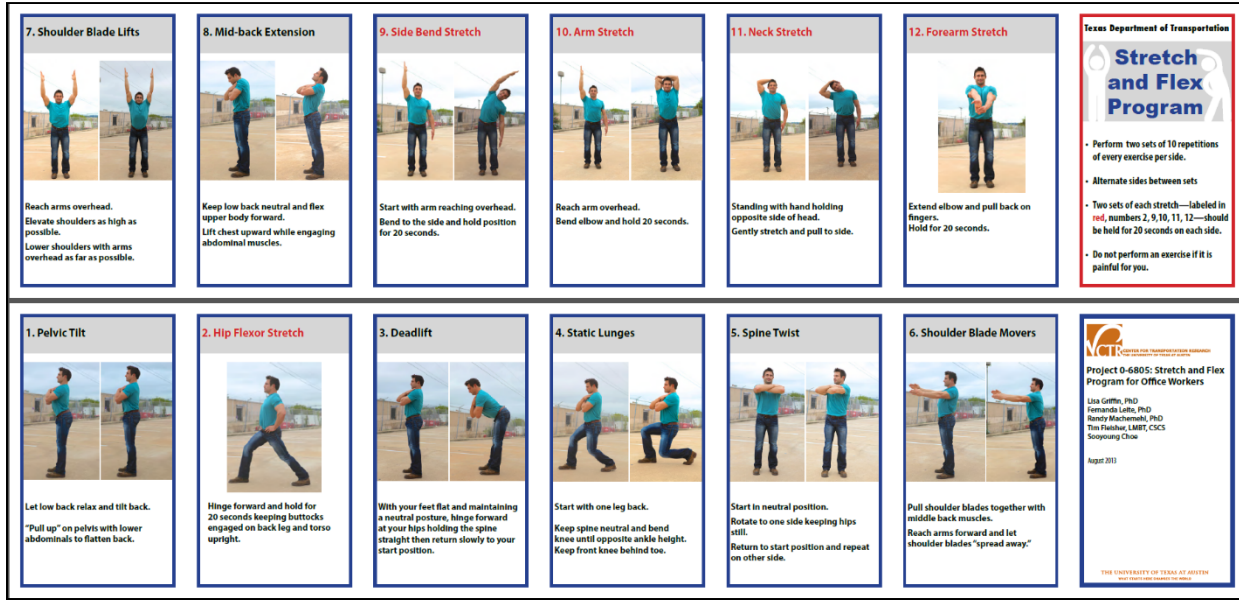


Figure 4.1: Field Worker Stretch and Flex Program Pocket Book

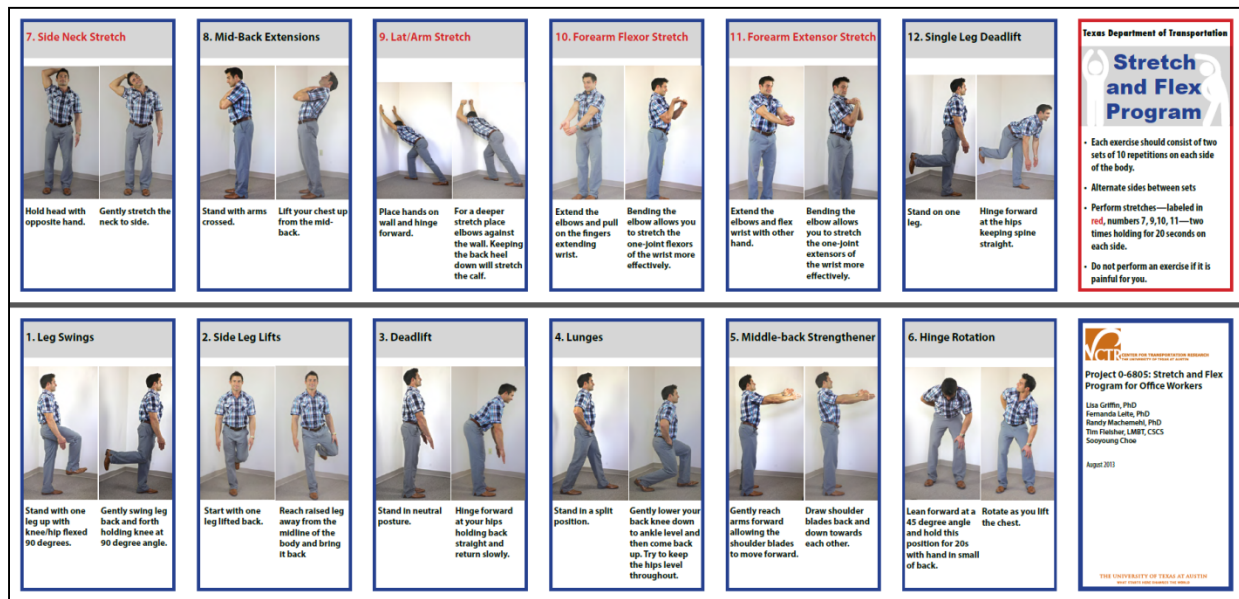


Figure 4.2: Office Worker Stretch and Flex Program Pocket Book

# OFFICE ERGONOMICS

## 1 Sitting Position

- "Slumped" inefficient posture



✘ Incorrect

## 2 Mouse Position

- Keep mouse close to you



✘ Incorrect

✔ Correct

## 3 Monitor Height

- Place top of monitor above eye level for a more neutral posture



✘ Incorrect

## 4 Back Support

- Sitting on an exercise ball overworks low back muscles and hips



✘ Incorrect



## 5 Desk Height

- Desk height should allow elbows to rest comfortably
- If provided, use arm rests



✘ Incorrect

## 6 Arm Rest Position

- Arm rest use relieves tension on the neck



✘ Incorrect

## 7 Ankle Comfort

- Keep feet flat on floor
- Use a foot support if necessary



✘ Incorrect

✔ Correct

## 8 Keyboard Position

- Allow room for wrist support
- Relax forearms on desk or chair



✘ Incorrect



Project 0-6805: Stretch and Flex Program for Office Workers  
 Lisa Griffin, PhD, Fernanda Leite, PhD, Randy Machemehl, PhD, Tim Fleisher, LMBT, CSCS, and Sooyoung Choe

Figure 4.3: Office Ergonomics Poster



## Chapter 5. Guidebook

Following the implementation of the Stretch and Flex program (described in Chapter 4) and a meeting with the field and office workers, the first draft of the guidebook was completed in February 2013. In March 2013, a revised version of the guidebook was completed after a second consultation and review with the field workers. Subsequent revisions yielded the following version of the guidebook.

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Use this guidebook to teach TxDOT field workers how to most appropriately and effectively use tools in the workplace in order to reduce injury. These guidelines are meant to provide general recommendations for basic tasks that field workers may perform. Note that the guidebook contains only recommendations—the authors realize that specific tasks may require more instruction. In these instances, many of the principles described in this guidebook can be carried over to various specific construction work-related tasks.

### 5.1 Introduction

Proper technique for any daily task should be accomplished with minimal effort and proper movement strategies. This is essential for the demands of a job that requires movement under heavy loads, such as construction. Construction workers may be required to lift heavy material, apply rapid load to an object (such as hammering a nail), as well as stabilize pieces of equipment that are not only dangerous, but extremely heavy (such as a jack hammer). Moving in a safe way to fulfill these requirements requires dynamic stability. *Dynamic stability* is the ability to accomplish a task despite kinetic, kinematic, or control disturbances. It is important to maximize the amount of loads being moved while putting the body in a safe position.

This guidebook provides ergonomic advice to field workers to help prevent injuries. The recommendations are designed to enhance dynamic stability during functional tasks to prevent injuries.

### 5.2 Facts

- Construction field work is one of the most dangerous industries in the United States.
- The injury rate among field workers is roughly 50% higher than in any other industry in the United States.
- The most common injury sites on field workers are the back, shoulders, neck, arms, and hands.
- Musculoskeletal injuries can cause both temporary and permanent damage and thus affect job productivity and quality of life.
- Between 2003 and 2010, construction accounted for 6% of the Texas workforce but 26% of the workplace fatalities (OSHA, 2013).

The rate of deaths for Texas construction workers is 10.7 per 100,000 workers, more than the national average (OSHA, 2013).

## 5.3 Work-Related Musculoskeletal Disorders

Back pain, carpal tunnel, rotator cuff problems, elbow tendonitis, and chronic neck pain are all musculoskeletal disorders. Work-related musculoskeletal disorders (WRMD) occur when musculoskeletal problems occur as a result of a work-related activity. Examples include low back pain, pulled muscles, muscle strains, rotator cuff injury, etc.

### 5.3.1 Musculoskeletal Disorders

*Definition: A musculoskeletal disorder is an injury or dysfunction involving the muscles, tendons, bones, ligaments, cartilage, and/or vertebral discs.*

These disorders can occur due to a blunt trauma (macro trauma) or repetitive motion (micro trauma). For example, a shovel hitting the arm of another coworker and causing a shoulder dislocation is an example of a macro trauma, whereas neck pain due to hammering overhead all day is clearly due to repeating one motion in a certain way. WRMD symptoms can range from mild and occasional to severe and chronic. These symptoms often occur in very specific parts of your body. For example, a construction worker who has been lifting heavy boxes overhead all day may feel pain just above his right shoulder, pointing to the upper inside edge of his shoulder blade. This is a muscle attachment for the levator scapula, which has been overworked due to the position of the arms, in addition to the constant load.

To perform field work activities, an individual must carry, lift, bend, pull, and hold. These movements are common for activities that can lead to WRMD and include the following:

- Working from your knees
- Lifting heavy objects
- Maintaining prolonged positions (particularly under load)
- Twisting the hands and wrists
- Performing overhead work
- Working with vibrating tools
- Performing repetitive movements
- Twisting the body

By examining the way people work and their job demands, we can provide effective solutions to help prevent WRMD. Throughout the manual, specific tasks will be highlighted to indicate when injuries frequently occur. Practical safety recommendations will be presented as well to make field work easier to perform.

### 5.3.2 Muscles

Muscles in the body connect to various bones via tendons that allow both movement and force to be generated. A *force* is defined as either a push or a pull. When the muscle activates or contracts, the fibers of the muscle squeeze together. The various types of contractions are concentric (shortening of the muscle belly under load), eccentric (lengthening of the muscle belly under load), or isometric (no length change to the muscle belly under load). An example of each can be related to a worker carrying a box. To lift the box, he/she has to squat down and grasp the box. As he/she lifts the box, the thigh muscles are working **CONCENTRICALLY** to bring the

box up. If the worker stands and holds the box in his/her arms without moving, the biceps muscles are now working ISOMETRICALLY. While they are contracting they are not moving, but rather supporting the weight of the box. As the worker sets the box down on the floor, the thigh muscles have to lengthen but they are still under the stress applied by the weight of the body and the box. These muscles are now contracting ECCENTRICALLY. Taking the science one step further, we will classify muscle activity into static and dynamic.

Based on what you just read, can you guess is static or dynamic? If you guessed static, then you are correct! *Static activity* would be standing in the same position or staying in a seated position for a prolonged period of time. *Dynamic activity* involves any movement required to complete an activity. This is where you would see movement occurring. The interesting point is that if you do not maintain a static position efficiently, or if you maintain it for a prolonged period of time, then you could possibly risk injury. Conversely, if you move (dynamically) too much in one particular pattern (i.e., lifting and lowering boxes the same way repetitively), you also risk an overuse injury. What's the solution? There is a two-part answer that we will continue to remind you of throughout the guidebook:

1. **Take frequent mini-breaks.** This does not mean stop and sit down. It means CHANGE YOUR MOVEMENT. Doing so will help relax the muscles that have been working and help fresh blood to circulate through those tired muscles; proper blood flow and oxygen delivery are needed for continued work. For example, after lifting boxes for a while, make sure to take a few minutes to stretch or rotate your torso a few times and shake out your hands. We have provided a booklet with several stretches and exercises to do on these mini-breaks. Choosing one or two of these movements will help you use these 2–3 minute mini-breaks as efficiently as possible, making you a more productive member of your crew and reducing your rate of muscle fatigue. Regardless of the exercise and/or stretch that you choose on these mini-breaks, the important thing right now is that you take them.
2. **Maintain proper position.** Proper position is going to equal proper muscle function. This principle cannot be stated enough, as it will allow you to lift more load with less effort. Understanding good form and proper technique during lifting is vital, particularly during tasks with high load.

Following these two basic principles can help save your back, shoulders, legs, hips, ankles, and neck from undue stress and injury.

### 5.3.3 The Spine

One of the most common sites for injuries within field work is the low back. The most common ways to injure the low back is by lifting. We will be providing a more in-depth review of proper ergonomic lifting technique later but for now we will explain the basic anatomy of the spine. The spine allows us to maintain an upright position and protects our spinal cord (which sends and receives signals from the brain to our legs and arms and trunk). It is made up of a series of 24 bones called *vertebrae*. Starting from the top, there are 7 cervical vertebrae, 12 thoracic vertebrae, and 5 lumbar vertebrae. The most efficient standing position of the spine is called *neutral*—where the natural curves of the spine rest. Looking from the side, there is a slight inward curve of the cervical spine, a slight outward curve of the thoracic spine, and then a slight inward curve of the lumbar spine.

Between each of the vertebrae is a shock-absorbing structure known as an *intervertebral disc*. The disc prevents the vertebral bones from rubbing against one another and—most importantly—decreases impact on these bones. The disc is made up of layers of cartilage with a gelatinous structure known as the *nucleus pulposus*. Water and proteins flow in and out of the disc to keep it hydrated and mobile internally. Fluid is pushed out of the disc on compression. During periods of unloading and rest (such as sleep), the disc is able to rehydrate—which is why your spine may feel stiffer when you get up in the morning. The discs in your spine are pumped up with water, and throughout the day this fluid gets pushed out of the disc, allowing for your spine to be more mobile. Proper hydration of the disc is important.

Proper exercise of the back is also important to take care of these discs. Repetitive motion due to excessive flexing and twisting of the spine under load can cause damage to the disc. One of the most common issues in field work is when the disc deforms and starts to bulge. If this bulge (known as a *herniation*) pushes on a nerve, it can be very painful and debilitating and may require a high-cost surgical intervention. These pains can occur anywhere, from localized at the point of herniation all the way to nerve pain radiating down to the leg or arm.

Wear and tear to the disc can result in a dehydrated fibrotic disc, and symptoms from the vertebrae pressing against one another due to decreased disc height can arise. If proper disc health is not maintained, the disc can fail to rehydrate. Proper technique and neutral positioning of the spine will help to maintain adequate disc health.

#### **5.3.4 Summary**

- Neutral posture keeps the natural curves of the spine; maintaining this posture when lifting a heavy object is important.
- Dynamic activity involves the movement of the body, whereas static activity involves maintaining a specific position.
- Muscular support of the body and its function is determined by the body's position.
- Disc health is important to prevent injuries.
- Mini-breaks are 2–3 minute breaks to be used for stretching muscles being used and exercising muscle that are not being used. Several of these breaks should be taken throughout the day.

### **5.4 Field Work Ergonomic Positioning Principles**

#### **5.4.1 Proper Ergonomics**

*Ergonomics* is the study of body position in the work environment. Proper ergonomics promotes maximal efficiency with minimal risk and/or injury. Therefore, ergonomics considers the interdependent relationship of four things:

- Task
- User
- Equipment
- Environment



Proper body position for the work task will determine how efficiently the body will be used. This involves the users' relationship to the equipment and the task within the given environment. Improper body position can result in WRMD.

#### **5.4.2 Head and Cervical Placement**

As covered earlier, the cervical spine (neck) is made up of seven vertebrae that act as a shock absorber for the skull. This area of the body has a large range of motion and therefore an awkward position under load can be compromising. Many small muscles surround the neck area and many neurological structures pass through as well. Improper positioning of the neck can lead to tightness and achiness throughout this area and all the way down to tingling of the fingers.

Neck pain can often result from maintaining a particular position or being subjected to a rapid jarring movement (i.e., whiplash). Therefore, taking frequent breaks during work activities such as looking up at a nail or holding a jackhammer is vital for neck health.

#### **5.4.3 Shoulder Girdle Stability**

The shoulder girdle is composed of the humerus (upper arm), scapula (shoulder blade), and the clavicle. Small muscles that protect the shoulder, known as the *rotator cuff*, support the bone structures.

These muscles also help to support the neck. Under maximal load and/or given poor movement strategies, this region is susceptible to rotator cuff problems, nerve damage, and head and neck pain. Common movements that can aggravate these structures are hammering overhead, operating a jack hammer, using a sledge hammer, and carrying large and heavy objects. Proper local strengthening of the smaller shoulder girdle muscles is necessary to provide optimal motion and stability for the shoulder girdle. Since the upper arm sits in such a shallow joint, shoulder dislocation is a common occurrence due to awkward positioning under intense load to the individual; Figure 5.1 depicts one example of improper positioning. One important note is that the position of the shoulder and mid-back will affect the muscles and support of the head and neck. Strong and flexible shoulder girdle and mid-back muscles (rhomboids and middle/lower trapezius) are essential to facilitate support for the neck and cervical spine regions. Furthermore, neurological issues such as carpal tunnel, radial nerve entrapment, and ulnar nerve entrapment can occur due to repetitive strain on the shoulder girdle. Learning how to position and move this area of the body with efficiency is a key component to prevention of neck pain, shoulder pain, and even low back pain.



Figure 5.1: Incorrect shoulder placement

#### 5.4.4 Foot and Ankle Motion

The foot is the first point of contact for load transfer in the body. If force is imposed during walking or running in an inefficient way, then other areas such as the knee and hip position and motion can be compromised. For example, consider a normal walking pattern. The movement of the ankle to help point the toes is called *plantar flexion*. The movement of the foot upward towards the shins is called *dorsiflexion*. There are two main phases to walking: stance phase and swing phase. Basically the ankle needs to plantar flex during the stance phase and dorsiflex on the swing phase. The dorsiflexion of the ankle allows the foot to clear the floor. If this does not happen properly, the hip will have to flex more to position the foot. This can cause undue strain on the hips. Limited dorsiflexion is common among individuals who wear boots that restrict ankle motion. This can cause excessive low back extension and hip flexion. Thus, it is important to stretch the calf muscles.

Issues such as plantar fasciitis (aggravation to the bottom of the foot that causes intense pain) and bunions (a dysfunction that results from poor biomechanics of the great toe) can be the result of poor range of motion through the ankle due to tight calf muscles. In addition to intense pain, debilitating injury and/or deformity can occur.

The foot and ankle can also cause many issues seen in other areas of the body. Therefore, during mini-breaks it is always a good idea to stretch out the muscles of the foot and ankle and to wear comfortable footwear that fits properly and provides support for the foot.

### 5.4.5 Hip and Knee Placement

The hip is composed of the pelvis and the femur (long bone of the upper leg). As the point of load transfer between the upper and lower body, substantial force runs through the hip.

Due to the amount of compressive (push) and tensile (pull) forces that pass through the hip, both the position and the strength of the hip muscles are significant factors. The hip is a ball and socket joint, giving it motion on all three planes. It is unique in that it is designed for tremendous mobility tasks and, unlike the shoulder, can take on immense loads. Dysfunction of the hip can cause pain in the low back and/or knee. Nerve pain such as *sciatica* (where the sciatic nerve is trapped either at the low back or in the lower leg by muscles) can develop. In addition, faulty mechanics can lead to pathologies such as hip osteoarthritis. Incorrect movement of the hip under load can cause pain if adequate mobility is not possible (Figure 5.2). The body is like water in that it will always move in the path of least resistance. If the hip is resistant, areas such as the knee and the low back may compensate, potentially resulting in pain and injury.



*Figure 5.2: Lack of hip mobility leads to low back pain (incorrect: left, correct: right)*

### 5.4.6 Hand/Wrist/Elbow Position

The purpose of the shoulder is to position the hand. If the shoulder is compromised, then the hand/wrist/elbow position may be compromised. Pathologies that result from poor wrist flexor use (i.e., gripping objects for prolonged periods of time) can lead to medial epicondylitis or “golfer’s elbow”—essentially, overuse of the wrist flexors. In addition, overuse of the wrist extensors can cause a painful condition known as lateral epicondylitis or “tennis elbow.” Either of these chronic injuries can limit the ability to grip objects effectively and can therefore be debilitating in almost any kind of manual labor. The position of the wrist and hand is particularly important given the neurological structures that run all the way down to the fingers. A straight wrist or neutral grip position should be used whenever possible to prevent compression of these structures that can cause neural tension.

### 5.4.7 Summary

- Proper ergonomics must take into account the position of the spine and the extremities and their relationship to the environment as well as the task being performed.

- Position of the head, neck, shoulder, wrist, elbow, hip, foot, and ankle are crucial when considering proper ergonomic recommendations.
- The shoulder girdle has a large range of motion; if put in an awkward position under load, it can become injured easily. An example of this scenario is working with the arms overhead.
- The hip has a large range of motion but can take on substantial load. If the muscles at the hip are compromised, then the low back and knees can become compromised too.
- Tight calves can have adverse effects on any other part of the lower extremity.

## 5.5 Ergonomic Hazards

One of the goals of good ergonomics is to fit the job to the laborer. Following proper ergonomic principles can help to prevent injury and thus preserve health. Using the proper positions will help to lessen the physical demands of the job. When dangerous or hazardous conditions exist, they must be identified and addressed immediately to ensure the safety of the worker. To determine whether a situation or task is hazardous, consider the following:

- Materials and tools being used for the task
- Work techniques to address the task
- Safety of the working environment
- Types of injuries the worker has experienced in the past.
- The task itself
- Possible solutions

**ONCE YOU IDENTIFY AN ERGONMIC HAZARD,  
LOOK FOR WAYS TO CHANGE IT!**

The following tasks will be reviewed and proper ergonomic recommendations will be made regarding each task.

- Shoveling and digging
- Power tools
- Cutting and sawing
- Lifting technique
- Large material handling
- Getting on/off trucks
- Stripping forms
- Flagging
- Cleaning

### 5.5.1 Shoveling and Digging

Shoveling and digging are common tasks among field workers. It is common for a field worker to spend a whole working day (which can range between 8 to 12 hours) doing one of these tasks. Depending on the material and the type of shovel used, this activity can be very hard on the body. The most common type of materials shoveled are concrete, dirt, sand, and asphalt. Most shovels tend to have shorter handles and require more bending of the knees, flexing of the hips, and dorsiflexion of the ankles to perform the task efficiently. In addition, shoveling is a unilateral task (with all the movement occurring on one side of the body). This can cause asymmetrical differences in the body, which can eventually cause pain. If proper technique is not maintained and adequate breaks taken, this can lead to injury.

#### Shoveling Risks and Solutions

- Take a mini-break every 15–20 minutes to stretch out the hands, hips, and torso. Lateral side bends, trunk rotations, and forearm stretches are very effective.
- Ensure that the hand holding the end of the shovel is in the palm position.
  - Try to find a shovel with a diameter that fits comfortably in your hand.
- Make sure that you are using your whole body to shovel, not just one part. Bend the knees, flex the hips, and relax the ankles on the way down and then extend these areas on the way up.
- Face the direction in which you will be throwing dirt, as opposed to keeping your feet planted in one direction and then twisting the body in the opposite direction.
  - This is particularly true when rotating towards the direction of the front leg in a split stance.
- Don't pick up everything at once! "Skim" the top. Try not to pick up too much for your size. A good rule of thumb is to have no more than 10 pounds worth of material at a time. Remember, SKIM OFF THE TOP.
- Select the right shovel for the right job. If you need a sharper edge to cut through the material, then use one.
  - Flat blade: shoveling material
  - Sharp blade: digging

Also, use a shovel with a handle length that will allow you to keep your spine as neutral as possible. This may vary based on hip and ankle mobility. You may have to try several.

- If shoveling wet concrete, always wear protection on the skin, as concrete can burn on contact.
- If shoveling ballast:
  - Use a long-handed pointy shovel.
  - Step on the end of the blade and push it in.
  - Wear shock-absorbing shoe inserts when walking on ballast.
- Wear gloves to prevent blisters.

- Consider bringing your own shovel to work if there is not one of appropriate length for you.
  - Usually the problem is that the shovel is too short.
- When shoveling, keep your arms in close to carry material more efficiently. The further away your arms are from your body, the heavier the material will be.

### Ergonomic Recommendations for Shoveling

1. Use correct shoveling technique based on the material you are shoveling.
2. Use the correct shovel for the job.
3. Avoid twisting the back when throwing the shovel load, especially towards the front leg.
4. Stand with your feet apart with one foot in front of the other for a stable base of support.
5. Wear gloves.
6. Take mini-breaks every 15–20 minutes to perform stretching and exercises.

Remember that shoveling with a handle that is too short forces the worker into an extreme forward bent position and places too much strain on the low back. This is particularly the case with tight hips and/or calves. As with all tools, make sure to select an appropriate length for not only the task but especially for you as the worker.

### Example of Shoveling with Proper Technique (Figure 5.3)



*Figure 5.3: Worker on left is incorrect; right is correct.*

- The individual on the left is more likely to experience back pain as she is not flexing her hips or bending her knees enough (both of which are required even though she is merely holding a bag). Over time, this improper position can create a macro trauma.

- The male worker (on the right) is bending his knees more and therefore can keep his spine more neutral.
- The male worker should probably be closer to the material (in this case, an animal) he is lifting as being further away can make the load heavy on the shoulders and neck.
- The male worker has a nice wide base of support to lift the material.
- The male worker should probably use a larger shovel to lift this dead animal. The shovel in use is not an appropriate size for the task at hand.
- Make sure that both hands are grasping the shovel. Notice the left hand of the male worker not fully grasping the handle. The palm and fingers should wrap around the shovel handle.

### **5.5.2 Power (Pneumatic) Tools**

Pavement breakers, jackhammers, and chipping guns weigh anywhere from 15 to 90 pounds. Due to the cost of these tools, sometimes the worker will have to use what's available regardless of whether it is the appropriate size tool for the worker. Further, operation will involve prolonged maximal squeezing to control the tool. Prolonged vibration creates repetitive strain on the body, and tasks involving these tools may be done for the entire workday. The worker's height and strength will often determine posture while operating this equipment, so following the recommendations for ergonomic positioning is particularly important. Also essential is wearing ear plugs to prevent damage to the inner ear.

#### Ergonomic Recommendations for Power Tools

- These are heavy pieces of equipment. Working in pairs to lower and lift these tools in and out of trucks and/or transport them through the job site is recommended. Use a dolly or cart to move heavy tools around the work site.
- Allow the tool to do what it should. Do not tense up and try and "manhandle" the tool.
- Use your body. Allow your thigh to help guide the tool and stand with your legs far apart enough to give yourself a wide, solid base. Keep your knees bent and body weight over the feet.
- Monitor your neck and shoulder muscles, keeping them relaxed. Press down on the tool from underneath your arm.
- Be sure to use sharpened drill bits to make the work easier.
- Make sure the equipment is cleaned properly when the task is finished to ensure proper functionality in the future.
- Take mini-breaks throughout the day. Due to the vibration of these tools, take breaks with greater frequency, possibly every 15 minutes.
- Make sure to stretch during the mini-breaks.
- If you experience pain from holding the trigger for a prolonged period of time, consider tapping the trigger.

- When using these tools in an overhead manner or horizontal position, make sure to use a sling that is held by a coworker to support the weight of the power tool.
- Position yourself as close to the work as possible, which allows your muscles to relax more.
- If required to operate equipment for a prolonged period of time, discuss the possibility of a frequent rotation among workers with the foreman.
- Make sure that you use personal protective equipment, including but not limited to a hard hat, hearing protection, breathing protection, goggles, ear plugs, and anti-vibration gloves.

### **5.5.3 Sawing**

Sawing and cutting tools are used to cut steel, pipe, wood, concrete, and sometimes asphalt. This task is usually done in a forward bend, positioning both hands on the saw. In addition to the ergonomic position, care must be taken for the eyes and ears as noises can be loud and debris can spray from the material being cut.

#### Ergonomic Recommendations for Sawing

- Avoid cutting on the ground whenever possible. Try to create a waist-high work surface.
- Rounding the spine will create back pain.
- Keep the shoulders relaxed and the elbows held in close to the body.
- If you are performing the work in a forward-bent position, then remember to take mini-breaks every 20–30 minutes.
  - Stretch the hands, arms, and back during these breaks.
- Due to the noise, vibration, and stress on the body, we recommend that the foreman rotate workers until the task is completed.
- Maintain tools, keeping them properly clean and sharpened.
- Wear anti-vibration gloves or at the very least protective gloves to increase the comfort level of the forearms and hands.
- Always wear a hard hat.

### **5.5.4 Lifting and Carrying**

Lifting large and heavy objects is an important part of construction work. It is important to make sure that your body is in the most appropriate position to lift. While strength is important, remember that body position dictates muscle function. We want to put the body in the most efficient position to accomplish the given task.

Rebar is one material often used during road work; it can be awkward to move because of its flexibility and length. Rebar pieces can be as long as 16 feet and may weigh as much as 30 pounds per piece. Usually rebar is carried on the shoulders and shared between one or two workers, but smaller pieces can be carried by one worker. In lifting and carrying a common



material like rebar, the shoulder girdle can be injured if weight is placed directly over the shoulder, as it is a shallow joint. Carrying larger objects may cause the shoulder to pull out further away from the body. This is why maximal loads should be carried with a coworker's assistance.

### Ergonomic Recommendations for General Lifting

- Place a pad on the shoulder and the object being loaded to protect soft tissue.
- If picking objects up off the ground, make sure to keep the spine as neutral as possible and flex the knees, hip, and ankles.
- Assess the load properly. If it's too heavy for you, then get help from another coworker.
- Always avoid twisting when lifting, carrying, or lowering a heavy load.
- Keep the load close to you while you walk.
- Keep the load well balanced on the shoulder to maximize body efficiency.
- Try to store materials off the ground when possible to make lifting these objects easier.
- Always wear gloves to prevent blisters and provide help with gripping.
- Take mini-breaks of 15–20 minutes.
  - Remember to stretch the back, shoulders, and hands during this time.

To carry these heavy loads without injury, maintain strong hip muscles and core muscles. Exercises that focus on these areas are indicated to condition the worker for these tasks. Strong hip and core muscles will help reduce the load on the low back.

### **5.5.5 Handling Materials**

Proper technique to lift and move materials involves bending the knees and the hips rather than rounding the back. As a general guideline, use dollies or carts whenever possible to move these common types of materials around the work site:

- Rock and road debris
- Rebar
- Beams
- Sheeting
- Tools of all sizes
- Bags of cement
- Manhole covers
- Cement blocks and boxes

In addition, having the materials delivered close to the work site is an easy way to reduce the amount of handling required.

#### Ergonomic Recommendations for Handling Materials

1. Reach for the load by bending and squatting, thus lifting the weight safely.
2. Transfer the weight of the load to a carrying position.
3. Walk the load to the needed location.
4. Lower the load to the ground, throwing it or handing it off to another worker.

#### Ergonomic Recommendations for Lifting Objects

1. Plan the lift by first assessing the weight: how big is it? How heavy is it?
2. Get as close as possible. Remember, the further away you are from the load, the heavier it will be.
3. Face the load. Approach the load from the front.
4. Bend your knees and flex your hips! This step will influence the position of the back.
5. Wear protective clothing.
6. Avoid twisting your back.
7. Take a mini-break!

#### Ergonomic Recommendations for Carrying Uneven Loads

- Uneven loads (e.g., carrying a bucket with one hand) can place uneven stress on the upper body and cause pain in the shoulder, neck, arms, and low back.
- Switch the loads to the opposite arm or hand frequently.
- Take mini-breaks.
- Wear gloves to decrease friction between the load and the body.

### **5.5.6 Getting On and Off Trucks**

Jumping can increase forces on the body up to 20 times that of walking, and can put unwanted strain on the low back. Care must be taken when jumping onto and off of trucks and other high surfaces. The areas of risk during jumping down or climbing up are the back, knees, and feet.

#### Ergonomic Recommendations for Getting Off and On Trucks

- Organize the truck area to allow clear passage.
- When possible, use a ladder to get off and on.
- Take your time! Do not rush getting onto or off of the truck.
- Instead of jumping off of the truck, sit down first and then hop down.

- Make sure that you are wearing proper footwear to absorb the shock.
- When landing, make sure to bend your knees and hips to prevent jarring the low back and promote proper shock absorption.
- Wearing shock-absorbing shoes is indicated when performing this kind of activity with frequency.
- Keep your feet at least shoulder-width apart when coming down.
- Take mini-breaks!

### **5.5.7 Stripping Forms**

After concrete is set, the form that it was poured into is removed using a pick or crowbar. The form is then thrown out of the trench, cleaned, and stacked in a truck. When stripping forms, work surfaces can be uneven and the area can be small. One foot may be in the trench and one foot may be out of the trench. The body parts at risk of injury are the low back, hands, knees, and feet. Stripping agents lessen the amount of force necessary to strip forms.

#### Ergonomic Recommendations for Form Stripping

- Make sure the concrete is set!
- If the forms are wooden, be careful of splinters and always wear gloves.
- Be careful of awkward walking surfaces, as they can be slippery.
- Wear shoes that can grip wet and slippery surfaces.
- Ask for help if you think the surface is too slick.
- Make sure to clear all unnecessary objects out of the way.
- Make sure to bend your knees and get as close to the load as possible to reduce the risk of injury. Maintain a wide base and face your target.
- Avoid twisting when lifting, carrying, or lowering the load.
- Keep the load close to you while carrying it.
- Work in pairs while lifting and stacking forms.
- Take mini-breaks!

### **5.5.8 Flagging and Holding Signs**

Flagging requires standing for long periods of time and directing vehicles and traffic around the construction site, constantly paying attention. Dozing off can be very dangerous as traffic is constantly coming through. Thus, workers should be rotated frequently.

#### Ergonomic Recommendations for Flagging

- Train yourself to flag with each hand to prevent asymmetrical differences between both sides of the body. The shoulders and neck can become fatigued during flagging, so be sure to change hands frequently.

- Take mini-breaks and alternate with other workers every 30 minutes.
- Take a few steps when possible. Do not remain in one position or posture while flagging. Instead, periodically stretch and move around.
- Wear comfortable footwear.
- Don't lose focus! If you feel yourself "zoning out" while flagging, ask the foreman if you can take a break.
- If possible, use a handle that rests on the ground.
- Stand with the feet wide to increase balance and reduce the risk of falling into oncoming traffic.

### **5.5.9 Housekeeping**

Keeping the work site as clean as possible is key to reduce hazardous situations. All tasks become much more difficult to perform when the construction site is messy and cluttered. Make sure to have a properly arranged and clean work environment for the workers.

#### Housekeeping Tips

- Organize and allow time for clean-up every day.
- Designate "debris" areas.
- Make sure to have a schedule for periodic clean-up and maintenance.
- Remember a work area can become extremely hazardous when unkempt. Make every attempt to ensure the safety of all involved by keeping the worksite as clean and organized as possible.

## **Chapter 6. Conclusions**

Strain/sprain-related incidents are the most dominant injuries for TxDOT employees. Although muscle strengthening exercises can reduce workplace strain/sprain-related incidents, current Stretch and Flex programs involve more stretching than flexing. Thus, current Stretch and Flex programs may not be as beneficial as they could be. In addition, traditional core-strengthening exercises are performed on the ground, which may not work well for employees who work outdoors or are not dressed for being on the ground. This project designed and tested a Stretch and Flex Program (including pamphlets, posters, and video instructions) to reduce the number of strain/sprain-related incidents in TxDOT office and fieldwork employees. Also, a guidebook and posters including ergonomic recommendations were created.

Together, the guidebook and Stretch and Flex program will help TxDOT employees reduce their risk of injury through specific work-related ergonomic strategies and injury-prevention exercises designed to improve strength and flexibility. The program is expected to reduce the incidence of TxDOT strain/sprain-related incidents and substantially reduce associated costs, which have exceeded \$3.7 million over the past 5 years.



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## **Appendix A: Scripts for Field Worker and Office Worker Videos (0-6805-P2)**

### **Script for TxDOT Field Worker Video**

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Tim Fleisher will be the only speaker in this video.

#### **Pelvic Tilt**

Stand holding a neutral alignment or a comfortable position. Using your lower abdominals, pull up on the pelvis, tucking the pelvis underneath you. Use your abs to do this and not so much your gluteals. This will help to warm up and protect your low back.

#### **Hip Flexor Stretch**

Get into a lunge position and push your back hip forward. This will help to open the front of your hip and stretch your calf in the back. Remember we want to only hold these stretches for between 5 to 20 seconds.

#### **Dead Lift**

The next exercise we are going to do is called the dead lift. What we are going to do is this: Johnny is going to stand right here and he is going to hinge forward at the hips. So here is your hip right here and he is just going to come up and down trying to keep his spine as straight as possible. It's ok to let the knees bend and he's just going to go up and down. Now everything that's working is on the back of his body pretty much, with the exception of his quadriceps—that's these muscles right here on the front of his body. This is a great exercise to wake up the back his body. If you think about it, again you've been sitting a while so the front of your body has been shortened a lot but the back of your body has not gotten a lot of attention. That's the purpose of this exercise. You are just going to come up and come down right from the hip. Nice and slow and then relax...good.

#### **Static Lunges**

So this next exercise is a basic static lunge. Johnny is going to do it; he's going to start off [with his legs] about hip distance apart and he's going to go one step back. This is called a split squat stance. From here, this is going to be his basic position, and he can put his hands on his hips just to add a little bit of support, and then he's just going to drop the knee down slowly and then come up. He wants to keep his spine nice and neutral and aligned. He wants to keep his knee slightly behind his second toe. He's going to go ahead and wants to prevent hinging forward at the hip. He's going straight up and straight down. Now we want the back femur here to stay right in line with the hip and the front femur here as well. What we don't want to see is the hip drop to the side. So, if that happens, you want to use your gluteals a little bit more in the back.

### **Spine Twist**

Stand and cross your arms over your chest. Try to keep your hips forward and then rotate your spine. Excellent. If you want to increase the challenge, then just lengthen the arms out to the side. Great job!

### **Middle Back Strengthenener**

This next exercise is called the middle back strengthener. This is a very important exercise if you are working at a computer all day because you are working, you are hammering, so the muscles between the shoulder blades get long and weak. So this is a great way to get some blood flow to those muscles and to start to wake them up throughout the day. So, what you are going to do is, reach your arms up and keep them chest height and shoulder width like you are holding a foam roller. Then from there you are just going to reach the arms forward slowly and gently and then draw the shoulders back. Now this movement is isolated to the shoulder blades so you are not trying to bend your elbows and you aren't trying to move your hands closer to each other. You're moving from the shoulders; that way, you are moving from the muscles between the shoulder blades nice and strong. If you lift your arms up too much, you are going to get into and cramp that neck. So you want to relax, at chest height with the arms—so that means hands below the shoulders—and then just work in and out with the shoulder blades. It's a great exercise to do at your desk. You don't have to be standing for this so it's really nice and versatile. As I mentioned earlier, this exercise can be done from a seated position as well. Notice how the back gets nice and long [during this exercise]. [While working,] your muscles will tend to get a little weak and there will be a lack of blood flow through here while the front of your body will tend to get short. So, throughout the day this is a great exercise to do. If you [want to] go ahead and turn to the side, we will show you how it's done from a seated position. It's the same way it's done from a standing position: you're just going to reach the arms forward and then draw the shoulders back. Notice where the mobility is coming from, right here at the shoulders. Again, the important thing is to keep the tension out of the upper part of the shoulders and neck; the way you do that is put the arms at about chest height. It's going to go in and out, just drawing the shoulders back—not trying to jam them back, but rather gently mobilizing the shoulder blades on the back of the ribs. Great!

### **Shoulder Blade Lifts**

I want you to now reach your arms above your head. Good! Now move your arms up and down and try and not bend your elbows. Keep going! Great job.

### **Middle Back Extension**

So this next exercise is called a middle back extension. The purpose of this exercise again is going to be to wake up these muscles through the middle back—right through the shoulder blades and a little bit below. What you are going to do is we are going to have you cross your arms and just lift your chest up to the ceiling. It doesn't have to be aggressive. Back and forth. If you take a nice inhale as you lift that actually helps with the extension. If you find that you are going too much into the lower back, you can tuck your pelvis underneath you and then just lift the chest and come down. That will help limit the amount of lower back involvement in here. As you can see the muscles of the middle back are getting worked very nicely.

### **Side Bend Stretch**

Johnny is going to stand still and reach his arm above his head and bend to the side. This is going to be great to open up the side of his hips and ribs and arms. Great job! Try to stay facing the same way.

### **Arm Stretch**

Reach your arm over your head and bend your elbow. Pull on your elbow as you stretch your triceps. Great job, Johnny! Be careful of neck tension in this position.

### **Side Neck Stretch**

Now we are going to do a [neck] stretch. So, with stretching, you can choose the amount of time just as long as you don't go over about 20 seconds. We want to make it a rather dynamic type of stretching, so what we are going to recommend is you are going to do two stretches anywhere from between 5 and 20 seconds. What I am going to have you do, Johnny, is go ahead and grab the opposite side of your head with your hand and gently pull down. Now he's just going to hold it there and breathe. Now, these muscles tend to get a little tight, so it will be good to take a break and go ahead and stretch them out. After he's done holding for about 5 to 20 seconds, he's just going to go ahead and release and relax and then he's going to do it again—same side and just pull it over and just hold there. Now you are not trying to crank away on your neck. You don't want to pull on that neck; it's just gentle pressure more so to hold the neck in place, because the weight of your head will really help the stretch. If you want to add a little extra stretch, go ahead and reach your fingers down to the ground as you stretch over and then you can come up and relax. Good! So, you want to do both at least two times and again for 5 to 20 seconds.

This can also be done from a seated position. It's the exact same thing, so grab your head with your hand and pull over to the side and, like I said earlier, you can go ahead and reach this hand to stretch out all these muscles here. Now, a compensatory move would be to rotate the neck. So you want to make sure that you are facing the same way and just think "lengthen your neck away" as you stretch over; again, 5 to 20 seconds is plenty of time. Do at least two sets.

### **Forearm Extensor Stretch**

So, remember your extensors are on this side; if your palm is facing the ground, your extensors are on the side you see. [You'll see] the flexors if your palm is facing up. What we are going to do now is stretch the extensors. The reason we want to do that is that because, if you are hammering all day, your wrist is in an extended position while you are using your flexors, so both the flexors and the extensors tend to get tight. So, what you want to stretch the extensors now is to go ahead and turn, so that the palm faces up and then pull back with the opposite hand. Now you pull your fingers down a little bit more. Keep that arm long, so that elbow is long; you are going to get a nice stretch on those extensors that help operate your fingers. Now this is stretching the muscles across the elbow and the wrist. If we want to hit the one-joint muscles, just go ahead and bend the elbow and you can go ahead and do the same stretch. If you bend the elbow, that helps you isolate more of the one-joint muscles—but you still want the fingers to relax, pulling toward the inside of the forearm. That way you get all of the nice extensors stretched out—particularly the ones that operate your fingers.

## **Script for TxDOT Office Worker Video**

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Tim Fleisher will be the only speaker in this video

My name is Tim Fleisher; I am a Pilates instructor trainer and personal trainer. This is Rebecca and she is going to be the “body” today. She is from Atlanta, Texas. What we are going to do is we are going to introduce to you the Stretch and Flex Office Program from TxDOT. The reason we came up with this program is just to give you a few exercise programs to do throughout the day, or maybe all at once in the morning or afternoon, just to keep the joints loose and to keep the blood flow going. So these exercises could be done all at once like I said, or you could pick the ones that work for you and stand up and do them throughout the day.

### **Dynamic Leg Swing**

The first exercise we are going to do is a dynamic leg swing. Now, Rebecca is going to put both hands on her hips and she’s going to lift her leg up. Now she is just going to bring her leg back and forth nice and slow, and the axis of rotation is going to be at this point right here at the hip. What we don’t want is for her low back to get involved while she is swinging her leg back and forth. So she’s going to just gently tighten her core and swing her leg back and forth. If you go too far back, your low back is going to get involved. The way to handle that is just to limit the range of motion here at the leg. You can go ahead and put that leg down. Now if balance becomes an issue or it’s in the morning and you just aren’t ready to stand on one leg by yourself yet, you can always use your desk and do same exercise, [with the] same things going on at the hip except you have a little bit of extra support here from your desk—or you could use a bookshelf or something the appropriate height for your arm.

### **Side Leg Lift**

This next exercise is called the side leg lift. What I am going to have Rebecca do is just go ahead and bend the knee and slightly reach her leg behind. Then you are going to go out to the side, only reaching your leg as far as you can without letting the ribs and the hips come closer. This bone here is moving out to the side, then in. Here the side of the hip and the back of the hip are working gently with the abdominals and, on this support leg here, the ankle/knee and hip muscles are all working here to stabilize against this movement. You can go ahead and set your leg down. You can also, just like with the previous exercise, brace yourself on a bookcase or a desk and you can see here that she’s really reaching the leg back and then to the side.

The range of motion is not very important. It’s the posterior hip muscles and the side here involved while she reaches the leg out to the side. You can go ahead and set that leg down and relax.

### **Dead Lift**

The next exercise we are going to do is called the dead lift. What we are going to do is Rebecca is going to stand right here and she is going to hinge forward at the hips. So here is your hip right here and she is just going to come up and down trying to keep her spine as straight as possible. It’s ok to let the knees bend, and she’s just going to go up and down. Now everything that’s working is on the back of her body pretty much, with the exception of her quadriceps—that’s these muscles right here on the front of her body. This is a great exercise to wake up the back body; and if you think about it, again, you’ve been sitting a while so the front of your body has

been shortened a lot but the back of your body has not gotten a lot of attention. That's the purpose of this exercise. You are just going to come up and come down right from the hip. Nice and slow and then relax...good.

### **Static Lunges**

So this next exercise is a basic static lunge. Rebecca is going to do it; she's going to start off [with her legs] about hip distance apart and she's going to take one step back. This is called a split squat stance. From here, this is going to be her basic position, and she can put her hands on her hips just to add a little bit of support. Then she's just going to drop the knee down slowly and then come up. She wants to keep her spine nice and neutral and aligned. She wants to keep her knee slightly behind her second toe. She's going to go ahead and wants to prevent hinging forward at the hip. She's going straight up and straight down. Now we want the back femur here to stay right in line with the hip and the front femur here as well. What we don't want to see is the hip drop to the side. So, if that happens, you want to use your gluteals a little bit more in the back; if she's losing balance, she can always grab onto a desk or a bookcase or something while she does the move.

### **Middle Back Strengtheners**

This next exercise is called the middle back strengthener. This is a very important exercise if you are working at a computer all day because you are working, you are typing, so the muscles between the shoulder blades get long and weak and this is a great way to get some blood flow to those muscles and to start to wake them up throughout the day. So what you are going to do is reach your arms up and keep them chest height and shoulder width like you are holding a foam roller. Then, from there, you are just going to reach the arms forward slowly and gently and then draw the shoulders back. Now, this movement is isolated to the shoulder blades so you are not trying to bend your elbows and you aren't trying to move your hands closer to each other. You're moving from the shoulders; that way you are moving from the muscles between the shoulder blades nice and strong. If you lift your arms up too much, you are going to get into and cramp that neck. So you want to relax, chest height with the arms—so that means hands below the shoulders—and then just work in and out with the shoulder blades. It's a great exercise to do at your desk. You don't have to be standing for this, so it's really nice and versatile. As I mentioned earlier, this exercise can be done from a seated position as well. Notice how the back gets nice and long [during this exercise]. [While working,] your muscles will tend to get a little weak and there will be a lack of blood flow through here while the front of your body will tend to get short. So, throughout the day this is a great exercise to do. If you [want to] go ahead and turn to the side, we will show you how it's done from a seated position. It's the same way it's done from a standing position: you're just going to reach the arms forward and then draw the shoulders back. Notice where the mobility is coming from—right here at the shoulders—and again the important thing is to keep the tension out of the upper part of the shoulders and neck; so, the way you do that is put the arms at about chest height. It's going to go in and out, just drawing the shoulders back—not trying to jam them back, but rather gently mobilizing the shoulder blades on the back of the ribs. Great!

### **Hinge Rotation**

The next exercise we're going to have Rebecca do is called the hinge rotation. This is a great exercise to emphasize two things: rotation through the middle back and extension through the

middle back (two things that are often neglected throughout the day while sitting at a desk). So what we're going to have her do is hinge forward at the hips, just like we did on the deadlift. And then I'm going to have her round her spine a little bit...Great! So, [notice] this nice round part right through the spine here. Then she is going to take her arm and turn it in, so that her palm is facing out and then go ahead and rotate and extend her spine. Good! And I want you to notice that she is lifting her chest as she rotates, so you see the shoulder here is not able to get involved. That's the importance of having the hand in this position. We are going to lift her chest. Good! And also she's going to push into her opposite hand as well, to assist with that rotation. Great job!

If she wants to modify it...let's just say that knee problems have limited her a little bit. You can reduce the load by putting your elbow on your desk and then do the same move. So, she is going to round her spine a little to start, so go ahead and put your belly button to the spine. Good! Then, from there, she's going to lift her chest and rotate. Notice again that the shoulder cannot get involved here, so it has to be true rotation through the middle part of her back. Great, and you can relax there! Good!

### **Side Neck Stretch**

Now we are going to do a stretch. So, with stretching, you can choose the amount of time just as long as you don't go over about 20 seconds. We want to make it a rather dynamic type of stretching, so what we are going to recommend is you are going to do two stretches from anywhere between 5 to 20 seconds. What I am going to have you do, Rebecca, is go ahead and grab the opposite side of your head with your hand and gently pull down. Now she's just going to hold it there and breathe. Now, these muscles tend to get a little tight, so it will be good to take a break and go ahead and stretch them out. After she's done holding for about 5 to 20 seconds, she's just going to go ahead and release and relax, and then she's going to do it again. Same side and just pull it over and just hold there. Now, you are not trying to crank away on your neck. You don't want to pull on that neck; it's just gentle pressure more so to hold the neck in place because the weight of your head will really help to stretch. If you want to add a little extra stretch, go ahead and reach your fingers down to the ground as you stretch over and then you can come up and you can come up and relax. Good! So, you want to do both at least two times and again 5 to 20 seconds.

This can also be done from a seated position. It's the exact same thing, so grab your head with your hand and pull over to the side and, like I said earlier, you can go ahead and reach this hand to stretch out all these muscles here. Now, a compensatory move would be to rotate the neck. So, you want to make sure that you are facing the same way and just think "lengthen your neck away" as you stretch over; again, 5 to 20 seconds is plenty of time. Do at least two sets.

### **Middle Back Extension**

So this next exercise is called the middle back extension. The purpose of this exercise, again, is going to be to wake up these muscles through the middle back—right through the shoulder blades and a little bit below. What you are going to do is...cross your arms and just lift your chest up to the ceiling. It doesn't have to be aggressive. Back and forth. If you take a nice inhale as you lift, that actually helps with the extension. If you find that you are going too much into the lower back, you can tuck your pelvis underneath you and then just lift the chest and come down.

That will help limit the amount of lower back involvement in here. As you can see, the muscles of the middle back are getting worked very nicely.

### **Lat Arm Stretch**

What we are going to do is we are going to position Rebecca with her hands against the wall and she's going to step back into a pretty aggressive lunge. Now the calves can get stretched here too if you just reach your heel to the ground, so it's a nice stretch to the calf. Why not kill two birds with one stone? So, here are your lats right here, but they also attach to your arm and your rib cage, so it's a big muscle. So, to stretch the lats, you want to lift the belly and round the back. Relax the neck as much as you can. That's how you're going to go ahead and do the stretch, so bellybutton to spine while you reach the arms away.

If you tend to hyperextend the elbows or this is an uncomfortable position for your wrist, then you can put the elbows on the wall. Lean forward; relax the shoulders; round the lower part of your back—not the upper, just the lower part of the back as you walk your fingers up the wall. That's a nice lat stretch. Remember, do 2 sets of 5 to 20 seconds. Very good job.

### **Forearm Flexor Stretch**

So, this is the forearm flexor stretch. We are going to give you two variations and the reason this is important is because...well, first off, here are where your flexors are on the inside of the forearm. Sometimes if you are typing all day you, may tend to get a little medial elbow pain and this is known as golfers elbow. Just a little bit of tightness through the wrist flexors and it can lead to things like carpal-tunnel sort of nerve pain that you may have down here in the forearm. So, what you want to do is make sure these muscles are stretched throughout the day several times; you can do this seated or standing. [In] the first one, we are going to hit the superficial muscles, so that just means muscles closer to the surface. So, she's going to extend her elbow or make her arm long and then spread her fingers as she pulls them back; you just want to go to your comfort level. You don't really need to crank away on those fingers. You want to feel a nice stretch, again between 5 to 20 seconds. Now, [some of] these muscles cross the elbow and that's why we want to make the arms long, but some of them go deep and don't pass the elbow. So, to stretch those a little bit better, we are going to bring the elbow in by the side, [doing the] same exact stretch again between 5 to 20 seconds, just pulling the finger tips back. It's important to get those fingertips back—not just the palm but the fingertips as well and you're going to stretch those forearm flexors.

This is another exercise that's great to do throughout the day even when you are seated. So, what you want to do is the same thing. Extend the wrist; extend the fingers; pull back. Or you could bend the elbow and do it so you can get into those deep muscles as well. So, if you are typing, just go ahead and take a break: swing around so that your desk isn't in the way and then, again, do hold the stretch between 5 to 20 seconds.

### **Forearm Extensor Stretch**

So, remember your extensors are on this side; so if your palm is facing the ground, your extensors are on the side you see. [You'll see] the flexors if your palm is facing up. What we are going to do now is stretch the extensors. The reason we want to do that is that because if you are typing all day at your desk, your wrist is in an extended position while you are using your flexors,

so both the flexors and the extensors tend to get tight. So, what you want to [do to] stretch the extensors now is go ahead and turn so that the palm faces up and then pull back with the opposite hand. Now...pull your fingers down a little bit more. Keep that arm long so that the elbow is long; you are going to get a nice stretch on those extensors that help operate your fingers. Now, this is stretching the muscles across the elbow and the wrist. If we want to hit the one-joint muscles, just go ahead and bend the elbow and you can go ahead and do the same stretch. If you bend the elbow that helps you isolate more of the one-joint muscles, but you still want the fingers to relax, pulling toward the inside of the forearm. That way you get all of the nice extensors stretched out—particularly the ones that operate your fingers.

### **Single Leg Dead Lift**

This next exercise is called a single leg dead lift. This is one that you may or may not want to incorporate into your routine. If you responded well to the single leg work that we did earlier, then go ahead and try this if you like but...don't feel compelled to do this exercise just because it's within the Stretch and Flex program. Having said that, we are going to go ahead and try it here. So, bringing one leg to about 90 degrees, you are going to hinge forward at the hip, just like we did with the dead lift earlier. You are going to allow the knee to bend in response to the movement at the hip. The spine is going to stay relatively straight. And then, [with] the back leg working the gluteals, extend the hip back as you hinge forward. Good! Nod your head a little bit. You want to hold that nice, neutral posture the entire time as you go up and as you go down. Great; relax. Now, if you would like, you can go ahead and use the desk or whatever you have close to you that's a stable structure as you hinge the leg back. The reason you want to do that is because this is about the ankle/knee/hip in equal parts; if you have a weak link or something that is less stable, it may be a good idea to modify by having something to lean on and a support structure close by. Great; come on back. Great job!