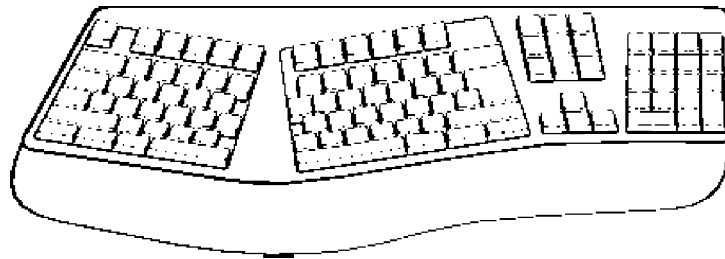
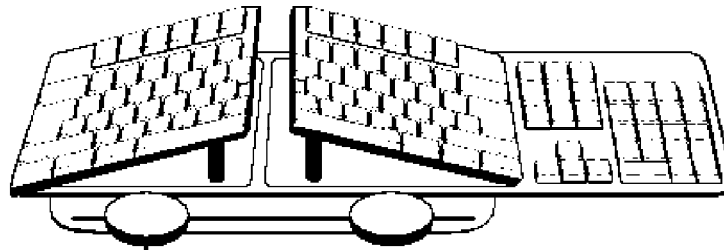




Alternative Keyboards



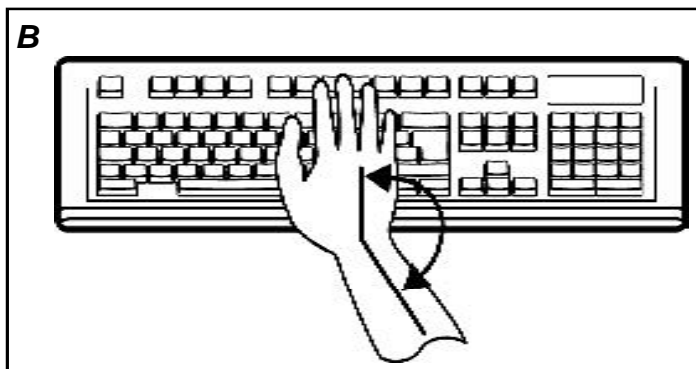
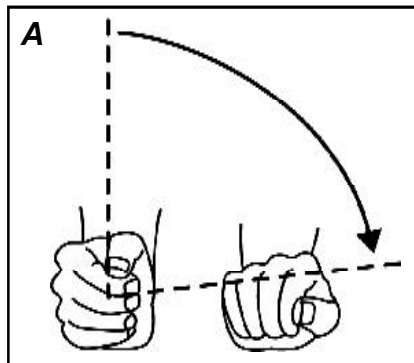
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

Purpose

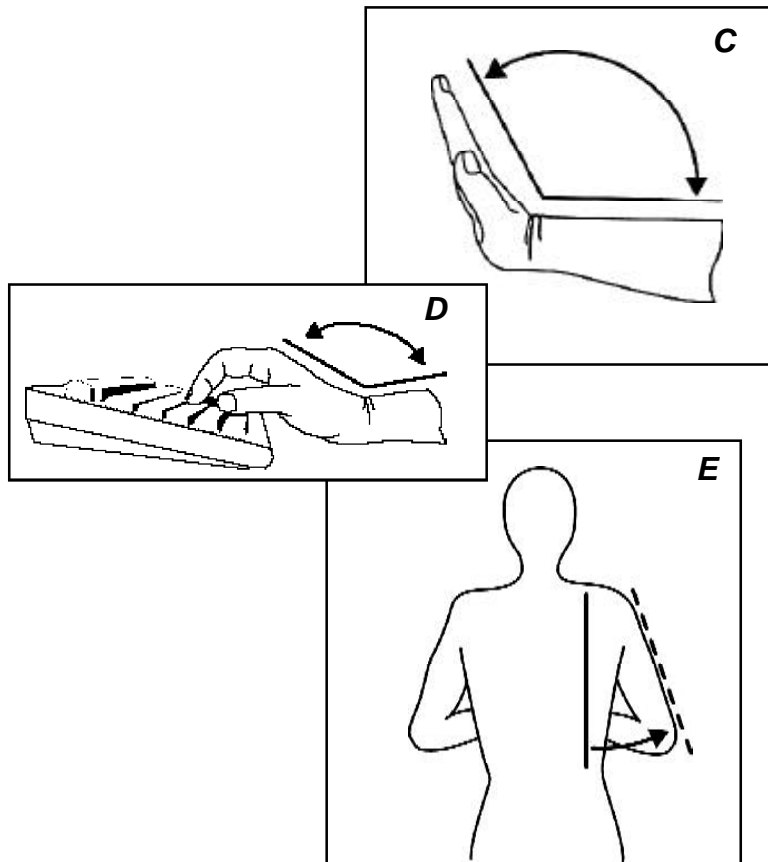
To date, there is little information to assist people interested in purchasing alternative keyboards. While the scientific evidence about whether alternative keyboards prevent musculoskeletal disorders is inconclusive at this time, this document provides basic information about common alternative keyboard designs and their effects on work posture.

Why Redesign the Keyboard?

When typing, holding the hands and wrists in a neutral work posture--where the hands are extended straight without significant bending at the wrist-- is thought to reduce the risk of musculoskeletal problems. Computer users sometimes use awkward or non-neutral work postures when working on the traditional keyboard. They rotate their forearms so that



their palms are facing the keyboard (A), and they often bend their hands outward (B) and upward (C & D). Sometimes, workers also hold their elbows slightly away from their bodies (E) while keying, particularly when the keyboard surface is too high. Alternative keyboards can help keep wrists straight as shown on the following pages.

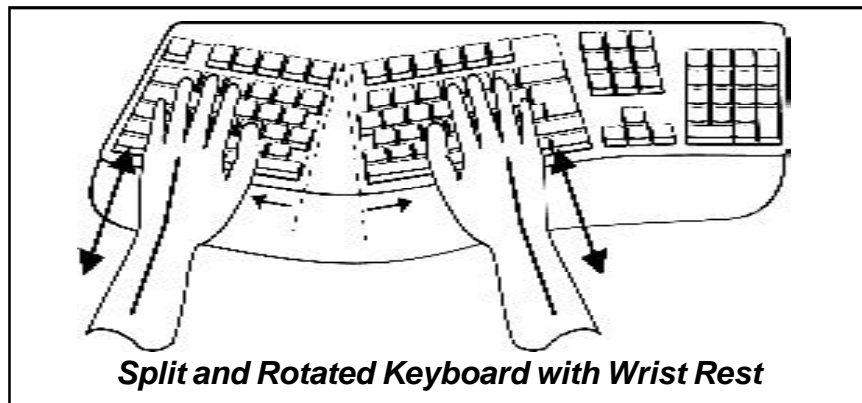


What's Different About Alternative Keyboards?

Alternative keyboards use different designs to attempt to change the user's posture. The following are some of the more common designs.

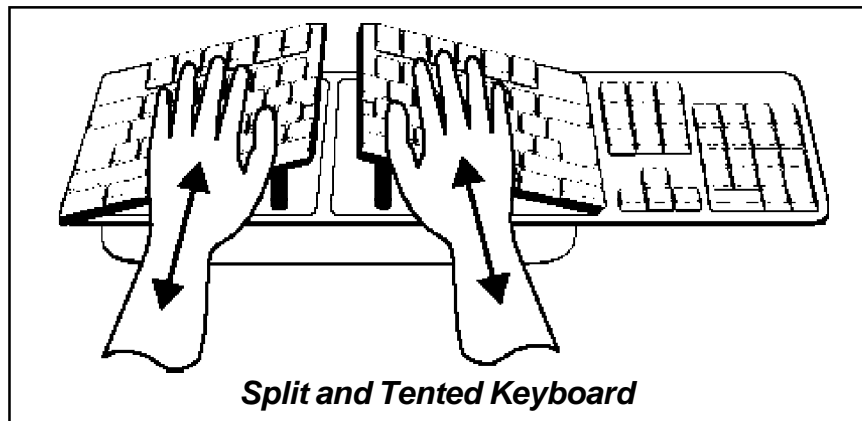
Split keyboards

Split keyboards are designed to straighten the wrist. This can be done in two ways: by increasing the distance between the right and left sides of the keyboard or by rotating each half of the keyboard so that each half is aligned with the forearm. Some alternative keyboards combine these two methods.



Tented keyboards

On tented keyboards, the two keyboard halves are tilted up like a tent. This feature is a variation of the split keyboard and reduces the rotation of the forearms.



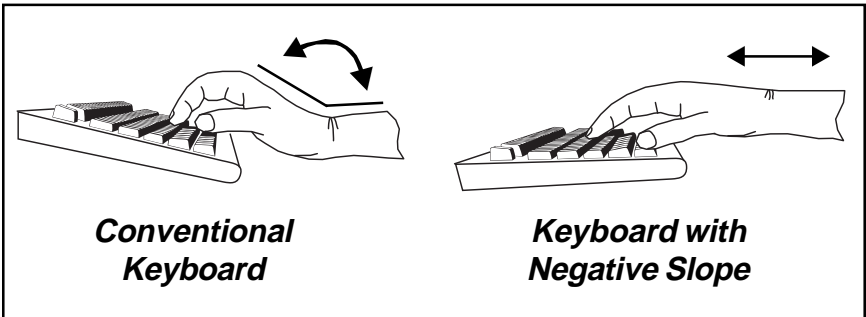
Built-in wrist or palm rests

Built-in wrist or palm rests help prevent bending the hands up by providing support that straightens the wrists. It should be noted that questions do remain about the usefulness of wrist or palm rests. For example, it is unclear whether they increase pressure on the wrists, relieve loads on shoulder and upper back muscles, or interfere with typing.

What's Different About Alternative Keyboards? (Continued)

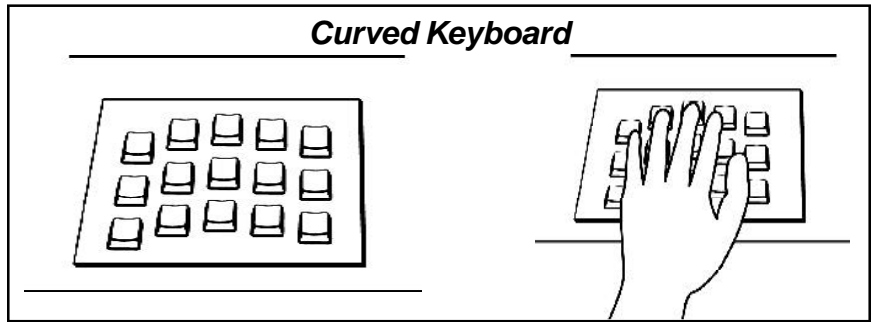
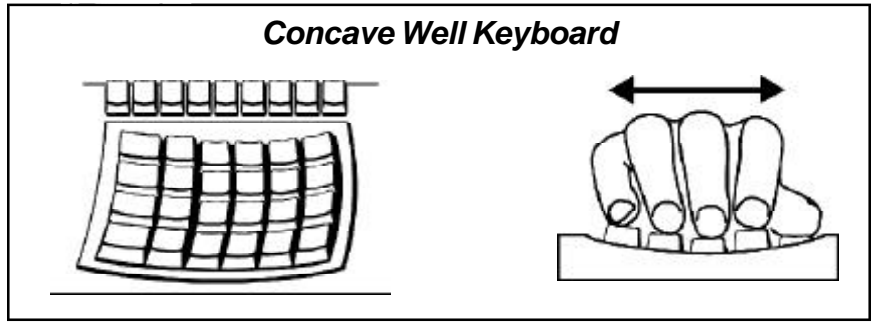
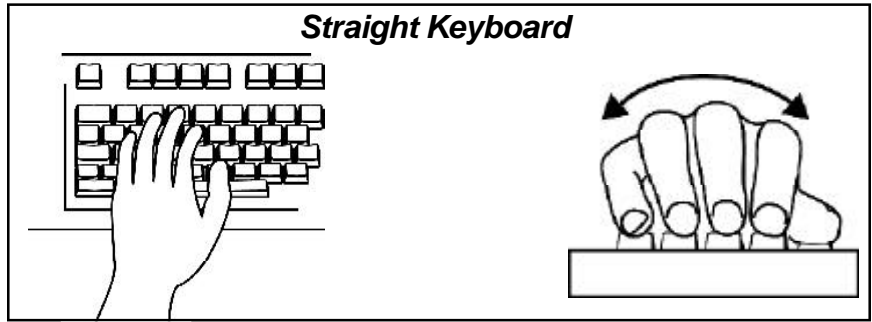
Adjustable negative slope

Keyboards with a negative slope also help prevent bending the hand too far up by allowing the user to raise the front edge of the keyboard, or to slope the keyboard backward, thus straightening the wrist.



Key position

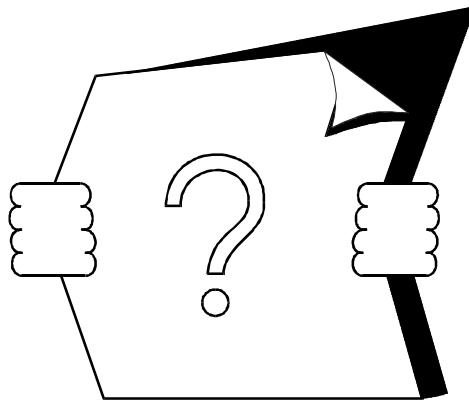
Some alternative keyboard designs have attempted to “fit” the different lengths of the fingers by curving the rows of keys or by placing the keys in concave wells. This is believed to allow the fingers to work in a more relaxed posture (see illustrations on next page).



Do Alternative Keyboards Prevent Injuries?

Alternative keyboards have been shown to promote neutral wrist posture. Yet, available research does not provide conclusive evidence that alternative keyboards reduce the risk of discomfort or injury.

Thus, further research is needed before specific keyboard features can be recommended with great confidence.



What if I Want to Use an Alternative Keyboard?

If alternative keyboards are to be used in the workplace, the following suggestions may be helpful in making purchasing decisions.

Determine whether the keyboard is compatible with existing hardware and software and whether the keyboard can accommodate other input devices, such as trackballs and mice.

Assess how the keyboard will fit with the workstation. Some alternative keyboards are extra wide, long, or high and may not fit on standard keyboard trays. Such keyboards may also prevent the tray from retracting under the work surface. Additionally, some alternative keyboards, particularly tented versions, must be placed on surfaces that are lower than those required for the conventional keyboard to achieve proper working posture.

Evaluate whether the keyboard will affect the performance of the user. Some alternative keyboard designs and adjustments make it difficult to see the

What if I Want to Use an Alternative Keyboard? (Continued)

keys. This is particularly important for users who rely on key visibility, such as “hunt and peck” typists. Also, check whether the job requires use of the numeric keypad and specialized keys, because some alternative keyboards eliminate or reconfigure these keys.

Allow users to try a keyboard on a trial basis before buying it. It would seem reasonable to try the keyboard for at least one to two weeks, since studies show that this amount of time is necessary to adapt to alternative keyboards.

Alternative keyboards are like other office equipment, furniture or accessories. Preferences will vary and one type will not “fit” everyone or every type of task. Allow users to try a number of different alternative keyboards before making decisions about which ones to buy. If a user wants to retain his or her conventional keyboard, respect that decision.

Expect frustration until users become familiar with the new keyboards. Frustration frequently results from diminished productivity as workers get used to new equipment.

Involve a specialist in the decision-making process. This specialist should have both knowledge and experience in office ergonomics. If a computer user has discomfort or musculoskeletal symptoms, a health professional should also be involved in making the decision to purchase an alternative keyboard.

Integrate a new alternative keyboard into the work process carefully. Make sure that users are trained in the appropriate use of the product, since many alternative keyboards can be used incorrectly. If the keyboard is adjustable, encourage users to change the adjustments gradually from the conventional (flat) configuration.

What Can Be Done to Prevent Musculoskeletal Injuries?

A keyboard is only one part of a computer workstation setup that may influence comfort. Other important factors include: workstation and chair adjustability; placement of equipment, accessories, and work materials; lighting; and the design and organization of work tasks.

Because computer work is highly repetitive and promotes static postures, it can cause discomfort over long periods of time. It is important to break up long sessions of keyboard work with frequent rest breaks or with other tasks that require movements different from those used to type or operate the mouse.



Keep in mind that it is essential to examine the entire work environment to determine all possible causes of discomfort. In other words, it is unlikely that changing only one workplace element, such as a keyboard, will eliminate all discomfort and disorders.

In addition, each workplace should have a comprehensive ergonomics program in place to protect all workers.

Call NIOSH at
1-800-35-NIOSH
(1-800-356-4674)

or visit the NIOSH Homepage at
<http://www.cdc.gov/niosh/homepage.html>

to receive:

- **A bibliography** on alternative keyboard research.
- Information on **implementing an ergonomics program** (request *Elements of Ergonomics Programs: A Primer Based on Workplace Evaluations of Musculoskeletal Disorders* DHHS (NIOSH) Publication No. 97-117).
- **More information** on workplace safety and health issues.

For additional information,
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Fax number: (513) 533-8573

or

visit the NIOSH Home Page on the world Wide Web at
<http://www.cdc.gov/niosh/homepage.html>

The National Institute for Occupational Safety and Health (NIOSH) is the Federal agency responsible for conducting research and making recommendations for the prevention of work-related disease and injury. The Institute is part of the Centers for Disease Control and Prevention.

A review of physical exercises recommended for VDT operators

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This paper presents an evaluation of exercises that have been recommended for the prevention of musculoskeletal discomfort among VDT/office workers. 127 individual exercises were analysed for their suitability for performance in VDT workplaces. Additionally, each exercise was judged in terms of its safety and its compliance with principles of physiotherapy. Results showed that, in the majority of cases, the prepared instructions for the exercises were satisfactory and the exercises could be readily performed at the workstation. However, over a third of the exercises were conspicuous and potentially embarrassing to perform, and half would significantly disrupt the work routine. Additionally, a number of the exercises posed potential safety hazards, exacerbated biomechanical stresses common to VDT work, or were contraindicated for persons with certain health problems. These findings suggest a need for greater attention to both the practical and the therapeutic aspects of exercises promoted for VDT users.

Keywords: Exercise; office work; musculoskeletal discomfort

Introduction

Widespread study of video display terminal (VDT) users has raised concerns regarding the potential for musculoskeletal disorders among these individuals. In a review of the literature¹, the World Health Organization found that "... musculoskeletal discomfort was commonplace during work with VDTs . . ." and that "injury from repeated stress to the musculoskeletal system is possible". In addition to the health implications, it is likely that musculoskeletal discomfort in VDT work is associated with performance impairments^{2,3}.

A review of current literature suggests that the primary emphasis for reducing musculoskeletal strain in VDT work has been on improving the workstation/environment by applying well-established ergonomic principles⁴⁻⁷. However, Winkel⁸ suggests that ergo-

nomically designed workstations are an incomplete prescription for preventing musculoskeletal discomfort in VDT work because they do not correct for a major contributory factor, namely, constrained postures. Constrained sedentary postures during VDT work may create static loading leading to muscle fatigue, impediment of circulation in the lower extremities, and stresses on joints, chronically stretched muscles and other tissues.

Winkel's contention that ergonomically designed workstations are an incomplete prescription for preventing musculoskeletal discomfort is supported by several studies showing that optimal workstation design does not eliminate the accumulation of musculoskeletal discomfort in VDT work^{9,10}. What is needed, according to Winkel, is more dynamic activity to relieve the stresses of sedentary work⁸.

This type of thinking no doubt underlies the proliferation of exercise programmes designed to reduce musculoskeletal discomfort arising from VDT work. However, there has been insufficient study of these exercise programmes, in the context of VDT/office work, to ascertain their effectiveness.

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An effective office exercise programme should satisfy two criteria. First, the exercises must be 'usable' (ie, they must be designed to maximize VDT users' ability and motivation to perform them). Second, the exercises must be sound from a physiotherapeutic/safety perspective (ie, they must effectively combat the stresses of VDT work, and performance of the exercises must not pose added safety or health risks). The purpose of this paper is not to advocate the substitution of exercises for job redesign (eg, changes in work routines which result in increased physical activity). Exercises should be regarded as a complement to, not a substitute for, improving the design of jobs to relieve the musculoskeletal stresses of VDT work.

In the present paper, we review exercises proposed for VDT users with regard to the usability and physiotherapeutic/safety criteria. For the usability assessment, it was assumed that exercises which are easy to learn, do not call undue attention to the individual, and can be easily integrated into the work routine, would be most readily utilized by VDT users. Assessments regarding physiotherapeutic value were restricted to judgements regarding potential safety or health risks associated with performance of a particular exercise because, unlike the apparent benefits of these exercises, potential risks have not been addressed.

Ultimately, the suitability of any set of exercises for office workers can be firmly established only through empirical study. The rationale behind the present review is to provide some basis for selection of exercises until empirical data emerge on their effectiveness.

Method

Identification of exercises for review

A total of 14 exercise programmes for VDT users and office workers were identified in the literature:

- 1 Austin¹¹
- 2 Australian National University¹²
- 3 Australian Occupational Health and Safety Unit¹³
- 4 Dahl¹⁴
- 5 Emanuel and Glonek¹⁵
- 6 Gore and Tasker¹⁶
- 7 Joyce and Peterson¹⁷⁻¹⁹
- 8 Krames Communication^{20,21}
- 9 Lacey²²
- 10 Lee and Humphrey²³
- 11 Lee and Waikar²⁴
- 12 *Los Angeles Times*²⁵
- 13 Pragier²⁶
- 14 Sauter *et al*¹

Two of the programmes^{15,23} were designed for microscope operators. Because both microscopy and VDT work involve sedentary work and static postures of the upper extremities and neck/shoulder region, it was presumed that the types of musculoskeletal stresses experienced would be similar.

Of the 14 exercise programmes identified, only 12 were actually evaluated. The exercise programme of Lee and Humphrey²³ was not evaluated since it is identical to that of Emanuel and Glonek¹⁵, except for

the duration of the exercises. The exercises of the Australian Occupational Safety and Health Unit¹³ were general relaxation exercises which did not target specific muscle groups.

Three sources¹⁶⁻²¹ offered multiple exercise programmes. Gore and Tasker¹⁶ offered 45 distinct exercises, organized into five separate exercise programmes (A-E). The programmes were virtually identical in terms of the musculoskeletal structures targeted. Therefore, we selected only programme A for analysis. The Joyce Institute¹⁷⁻¹⁹ has three exercise programmes whose contents overlap. Only the unique exercises in these programmes were reviewed. The same procedure was used for the review of the two programmes by Krames Communications^{20,21}. Similarly, because the majority of the Lee and Waikar²⁴ exercises were identical to those of Emanuel and Glonek¹⁵, only the Lee and Waikar exercises which did not duplicate those of Emanuel and Glonek were included in the analysis.

Exercises which did not target specific musculoskeletal structures (ie, general relaxation exercises or eye exercises) were not included in the analysis. In all, 127 separate exercises were evaluated.

Evaluation procedure Table 1 lists each of the exercises analysed, the source, the exercise instructions, and a listing of the primary muscle groups and structures recruited. (The exercise instructions provided in Table 1 were abbreviated to economize on space. Most instructions included illustrations of a model performing the exercise. The analysis of the exercises was based on the original instructions and illustrations.)

The exercises were classified according to the body part targeted: (1) neck; (2) shoulder; (3) elbow/lower arm; (4) lower back/hip; and (5) knee/lower leg. Many exercises affected muscles from more than one body part. Each of these exercises was categorized under the body part primarily affected.

After classification, each exercise was analysed along a number of dimensions which potentially influenced its usability and physiotherapeutic value. The procedures for these assessments are described below.

Usability assessment

Each exercise was evaluated along five dimensions reflecting the presumed willingness and ability of VDT users to perform them at work. These dimensions were: (1) specificity of instructions; (2) location most suitable for performance; (3) conspicuousness; (4) time requirement/disruption of the work task; and (5) ease of learning/performance. The operational definitions and rating factors used for each of the evaluation end-points are as follows.

Specificity of instructions This dimension refers to the ease with which the instructions can be understood and followed. Three rating categories were utilized: good, fair or poor.

Location most suitable for performance Because the exercises vary in their time and space requirements, not

Table 1. Panel A. Neck Exercises.

Author	Name of Exercise	Exercise Instructions	Muscle Groups Recruited	Anatomical Structures Stretched	Specif. of Instr.	Specie or Location	Conspicuous?	Time Reqmt.	Ease of Perform.	Comments
1 Australian National University	Exercise 2	1) Stand as tall as possible, then 2) relax and go loose like a rag doll. (10 to 20 times).	Lower cervical and thoracic extensors, neck flexors (phase I only)	Upper cervical extensors, anterior ligaments of the lower cervical and upper thoracic spine (phase I), cervical and thoracic extensors, scapular adductors, elevators and upward rotators, posterior ligaments of the cervical and thoracic spine (phase II)	fair	work area	highly	mini	simple	a b c d 1 3
2 Sauter	Head Nods	Nod head (not entire neck) in 'yes' motion.		Upper cervical extensor muscles, posterior ligaments of the cervical spine and facet joints	good	chair	somewhat	micro	simple	a b c 1 3
3 Gore and Tasker	The Pigeon	Standing or sitting, keep eyes looking forward. Without dropping head, pull face in to make double chin. Hold for count of 6. Repeat 10 times.	Lower cervical, thoracic and lumbar extensors, neck flexors	Upper cervical extensors, anterior ligaments of the lower cervical and upper thoracic spine	good	chair	no	mini	simple	
4 Krames Comm	Neck Glide	1) Glide head back, as far as it will go, keeping head and ears level. 2) Now glide head forward. Repeat 3 times.	Phase I: Lower cervical, thoracic and lumbar extensors, neck flexors Phase II: Upper cervical extensors and neck flexors	Phase I: Anterior ligaments of the lower cervical and thoracic spine, upper cervical extensors Phase II: Posterior ligaments of the lower cervical and thoracic spine, lower cervical and thoracic extensors	good	chair	no	micro	simple	
5 LA Times	Dorsal Glides (Turkey)	Sit up straight and pull shoulders back. Slide head straight back on neck, keeping face pointed forward (Turkey Position). Isolate movement to head and neck. Repeat slowly 5 times.	Lower cervical, thoracic and lumbar extensors, scapular adductors, elevators and upward rotators, neck flexors	Anterior ligaments of the lower cervical and thoracic spine, upper cervical extensors	good	chair	no	micro	simple	
6 Joyce & Peterson	Cable Stretch	Sit relaxed, with feet flat on floor. Imagine a cable attached to the top of the head pulling you up. Hold for count of 3; relax. Repeat 3 times.	Lower cervical, thoracic and lumbar extensors, neck flexors	Anterior ligaments of the lower cervical and thoracic spine, upper cervical extensors	good	chair	no	micro	simple	
7 Pragler	Exercise a-1	Tuck the chin in, shoulders back and "sit tall". Hold the position for a count of 3; relax.	Lower cervical, thoracic and lumbar flexors/extensors, scapular adductors, elevators and upward rotators, neck flexors	Anterior ligaments of the lower cervical and thoracic spine, upper cervical extensors	good	chair	no	micro	simple	
8 Emanuel and Glonek	Neck Rotations	Rotate head and neck 3 times clockwise and 3 times counterclockwise.		Anterior and posterior cervical and thoracic rotators, neck upper back extensors and flexors, scapular elevators, anterior, lateral and posterior ligaments of the cervical and thoracic spine	fair	chair	somewhat	micro	simple	a b c 1 3 4

The exercise instructions have been abbreviated to economize on space. Most instructions included illustrations of a model performing the exercise. The analysis of the exercises was based on the original instructions and illustrations.

Key

- 1 Exercise reproduces physical stresses of VDT work
- 2 Exercise poses one or more safety hazards
- 3 Exercise stretches already overstretched structures
- 4 Exercise places additional loads on lumbar and/or thoracic discs
- a Acute neck pain
- b Degenerative disc disease
- c Moderate to severe osteoporosis
- d Acute lower back pain
- e Second and third trimesters of pregnancy
- f Acute inflammatory or arthritic conditions of the shoulder
- i Acute inflammatory or arthritic conditions of the elbow/forearm complex
- j Hand/wrist disorders, such as carpal tunnel syndrome
- k Acute lateral epicondylitis
- l Spinal stenosis
- m Arthritic conditions of the hips and/or knees

Table 1. Panel A. Neck Exercises (cont.)

Author	Name of Exercise	Exercise Instructions	Muscle Groups Recruited	Anatomical Structures Stretched	Specif. of instr.	Space or Location	Conspicuous?	Time Reqmt.	Ease of Perform.	Comments
9	Australian National University	Exercise 5	Cervical and thoracic flexors, sidebenders, rotators, extensors	Anterior and posterior cervical and thoracic rotators, neck/upper back flexors and extensors, scapular elevators, anterior, lateral and posterior ligaments of the cervical and thoracic spine	fair	chair	somewhat	mini	simple	a b c 1 3 4
10	Dahl	Unnamed	Cervical and thoracic rotators, neck flexors	Cervical and thoracic rotators, posterior and lateral ligaments of the cervical and thoracic spine and facet joints	*	chair	somewhat	micro	simple	a b c
11	Sauter	Head Turns	Cervical and thoracic rotators, neck flexors	Cervical and thoracic rotators, posterior and lateral ligaments of the cervical and thoracic spine and facet joints	good	chair	somewhat	micro	simple	a b c
12	Krames Comm.	Head and Neck	Cervical and thoracic rotators, neck flexors	Cervical and thoracic rotators, posterior and lateral ligaments of the cervical and thoracic spine and facet joints	good	chair	somewhat	mini	simple	a b c
13	LA Times	Turkey with Rotation	Cervical and thoracic rotators, neck flexors	Cervical and thoracic rotators, posterior and lateral ligaments of the cervical and thoracic spine and facet joints	fair	chair	somewhat	micro	simple	a b c
14	Gore and Tasker	Headrest		Upper thoracic and cervical extensors and rotators, posterior and lateral ligaments of thoracic cervical spine and facet joints	good	chair	somewhat	mini	simple	a b c 1 3 4 Alternative exercise to stretch the upper cervical muscles should be chosen that does not produce extreme flexion and rotation of lower cervical and upper thoracic spine.
15	Joyce & Peterson	Neck/Head	Cervical and thoracic rotators, anterior and posterior cervical and thoracic rotators, neck flexors and extensors	Upper thoracic and cervical extensors, lateral, anterior and posterior ligaments of the thoracic and cervical spine and facet joints, cervical flexors, neck side benders, scapular elevators, anterior and posterior cervical and thoracic rotators	good	chair	somewhat	mini	simple	a b c 1 3 4
16	Austin	Neck	Anterior and posterior cervical and thoracic rotators, neck flexors and extensors	Upper thoracic and cervical extensors, lateral, anterior and posterior ligaments of the thoracic and cervical spine and facet joints, cervical flexors, neck side benders, scapular elevators, anterior and posterior cervical and thoracic rotators	good	chair	somewhat	micro	simple	a b c 1 3 4

*As the Dahl exercises were translated from Danish to English for the authors, the specificity of the instructions was not evaluated

Key

- | | | | |
|---|--|---|---|
| 1 | Exercise reproduces physical stresses of VDT work | d | Acute lower back pain |
| 2 | Exercise poses one or more safety hazards | e | Second and third trimesters of pregnancy |
| 3 | Exercise stretches already overstretched structures | f | Acute inflammatory or arthritic conditions of the shoulder |
| 4 | Exercise places additional loads on lumbar and/or thoracic discs | i | Acute inflammatory or arthritic conditions of the elbow/forearm complex |
| a | Acute neck pain | j | Hand/wrist disorders, such as carpal tunnel syndrome |
| b | Degenerative disc disease | k | Acute lateral epicondylitis |
| c | Moderate to severe osteoporosis | l | Spinal stenosis |
| | | m | Arthritic conditions of the hips and/or knees |

Table 1. Panel A. Neck Exercises (cont.)

	Author	Name of Exercise	Exercise Instructions	Muscle Groups Recruited	Anatomical Structures Stretched	Specif. of Instr.	Space or Location	Conspicuous?	Time Req'd.	Ease of Perform.	Comments
17	Australian National University	Exercise 4	Place one hand on opposite shoulder. Pull shoulder down while bending head toward other shoulder. Repeat on other side. Repeat 5-10 times.		Neck side benders, scapular elevators, lateral ligaments of the upper thoracic and cervical spine and facet joints	fair	chair	somewhat	mini	simple	a b c 3 4 Avoid rapid stretching. May produce moderate loading on cervical discs if performed in forward, flexed head posture.
18	Gore and Tasker	Tension Neck	Standing, place left hand on back of neck. Point left elbow to ceiling and keep there. Drop chin on chest and turn head to right without lifting chin. Tilt right ear to right and hold for count of 10. Relax. Repeat with right hand, turning head to left. Do 3 times each side.		Neck side benders, scapular elevators, posterior and lateral ligaments of the upper and cervical spine and facet joints	fair	work area	highly	mini	simple	a b c 3 4 Avoid rapid stretching.
19	LA Times	Upper Trapezius Stretch	Grasp seat or leg of chair with right hand to pull shoulder down slightly. Lean head to left until stretch is felt on right side of neck. Lean body to left to increase stretch. Hold 15 seconds. Repeat on other side.		Neck side benders, scapular elevators	good	chair	somewhat	mini	simple	a b c 4 Avoid rapid stretching.
20	LA Times	Levator Scapulae Stretch	Grasp seat or leg of chair with right hand to pull shoulder down slightly. Move head forward, rotate and lean to left until stretch from neck to top of shoulder blade is felt. Lean body to left to increase stretch. Hold 15 seconds. Repeat on other side.		Neck side benders, scapular elevators, posterior and lateral ligaments of the upper thoracic and cervical spine and facet joints	fair	chair	somewhat	mini	simple	a b c Avoid rapid stretching. May produce moderate loading on cervical discs if performed in forward, flexed head posture.
21	Pragler	Exercise a-3	Keeping shoulders down, bend the head over towards the shoulder to stretch the muscles of the neck. Hold that position for a count of 3, and then bring head slowly back to the center.		Neck side benders, scapular elevators, lateral ligaments of the upper thoracic and cervical spine and facet joints	poor	chair	no	micro	simple	a b c 4 Avoid rapid stretching. May produce moderate loading on cervical discs if performed in forward, flexed head posture. Enhance safety by tucking chin during side bending.
22	Sauter	Nose Drawing	Close eyes and imagine pen attached to nose. Moving head, draw a large circle. Within circle, draw a plus. Go over it several times. Draw a "X" and go over it several times. Try drawing other objects, or writing name.	Neck sidebenders, rotators, flexors and extensors	Neck sidebenders, rotators, flexors and extensors; posterior and lateral ligaments of the cervical and thoracic spine and facet joints	good	chair	somewhat	mini	simple	a b c 1 3 4
23	Dahl	Unnamed	Lift shoulders towards ears in a shrug, then relax and let them fall back.	Scapular upward rotators and adductors	Scapular downward rotators	*	chair	somewhat	micro	simple	
24	Joyce & Peterson	Shoulder Shrug	Sit straight and bring shoulders up toward ears. Hold for count of 3. Relax. Repeat twice.	Scapular upward rotators and adductors	Scapular downward rotators	good	chair	somewhat	micro	simple	
25	Joyce & Peterson	Shoulder Roll	Sit upright. Lower chin. Slowly make 3 circles with shoulders, then gradually tilt head backward. Make 3 slow circles with shoulders. Stretch upward for count of 3, and relax.	Scapular upward rotators and adductors	Scapular downward rotators cervical flexors and extensors	fair	chair	somewhat	mini	simple	a f 1 3

*As the Dahl exercises were translated from Danish to English for the authors, the specificity of the instructions was not evaluated

Key

- 1 Exercise reproduces physical stresses of VDT work
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- d Acute lower back pain
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 f Acute inflammatory or arthritic conditions of the shoulder
 i Acute inflammatory or arthritic conditions of the elbow/forearm complex
 j Hand/wrist disorders, such as carpal tunnel syndrome
 k Acute lateral epicondylitis
 l Spinal stenosis
 m Arthritic conditions of the hips and/or knees

Table 1. Panel B. Shoulder Exercises

Author	Name of Exercise	Exercise Instructions	Muscle Groups Recruited	Anatomical Structures Stretched	Specif. of Instr.	Space or Location	Conspicuous?	Time Reqmt.	Ease of Perform.	Comments	
26	Krames Comm.	Shoulders	Roll shoulders forward 5 times using wide circular motions. Then roll shoulders backward 5 times. Repeat cycle 5-10 times.	Scapular upward rotators and adductors, scapular downward rotators and shoulder abductors	Scapular downward rotators and abductors, scapular upward rotators and adductors	good	chair	somewhat	mini	simple	f 3
27	Pragier	Exercise a-6	Circle shoulders backward three times, with arms relaxed by sides.	Scapular upward rotators and adductors, scapular downward rotators and shoulder abductors	Scapular downward rotators and abductors, scapular upward rotators and adductors	good	chair	somewhat	micro	simple	f 3
28	Austin	Shoulder Roll	Slowly roll shoulders forward 5 times in circular motion. Then roll back with same circular motion.	Scapular upward rotators and adductors, scapular downward rotators and shoulder abductors	Scapular downward rotators and abductors, scapular upward rotators and adductors	good	chair	somewhat	micro	simple	f 3
29	Australian National University	Exercise 3	Circle shoulders backwards and forwards 10-20 times.	Scapular upward rotators and adductors, scapular downward rotators and shoulder abductors	Scapular downward rotators and abductors, scapular upward rotators and adductors	fair	chair	somewhat	mini	simple	f 3
30	Sauter	Shoulder Circles	With arms at sides, raise shoulders up, and rotate forward in circular motion several times. Repeat several times in backwards direction.	Scapular upward rotators and adductors, scapular downward rotators and shoulder abductors	Scapular downward rotators and abductors, scapular upward rotators and adductors	good	chair	somewhat	micro	simple	f 3
31	Emanuel and Gionek	Shoulder Rotations	Bend elbows and rotate shoulders 4 times forward and 4 times backward.	Scapular upward rotators and adductors, scapular downward rotators and shoulder abductors	Scapular downward rotators and abductors, scapular upward rotators and adductors	fair	chair	somewhat	micro	simple	f 3
32	Austin	Arm Circles	Raise arms to side with elbows straight. Slowly rotate arms in small circles, forward and backward.	Scapular upward rotators, shoulder adductors, scapular downward rotators and abductors, shoulder abductors	Scapular downward rotators and abductors, scapular upward rotators and adductors	good	chair	highly	mini	simple	f
33	Krames Comm.	Arm Circles	Raise the arms to the sides, elbows straight. Slowly rotate arms in small circles forwards, then backwards. Lower arms, then repeat 3 times.	Scapular upward rotators, shoulder adductors, scapular downward rotators and abductors, shoulder abductors	Scapular downward rotators and abductors, scapular upward rotators and adductors	good	chair	highly	mini	simple	f
34	Lacey	Upper Arms	Let arms fall to side and rotate hands in circular motion. Put arms up, interlock fingers overhead. Push arms forward, then stretch arms back, pulling ribcage up. Hold arms straight out, rotate them in circular motion. Flex upper arms as in making a muscle.	Wrist flexors, wrist/finger extensors, forearm supinators and pronators, wrist ulnar and radial deviators; shoulder flexors, external rotators, horizontal abductors and internal rotators	Wrist flexors, wrist/finger extensors, forearm supinators and pronators, wrist ulnar and radial deviators, shoulder extensors, adductors and internal rotators, external rotators and abductors	fair	chair	highly	mini	simple	f 3

*As the Dahl exercises were translated from Danish to English for the authors, the specificity of the instructions was not evaluated

Key

- 1 Exercise reproduces physical stresses of VDT work
- 2 Exercise poses one or more safety hazards
- 3 Exercise stretches already overstretched structures
- 4 Exercise places additional loads on lumbar and/or thoracic discs

- a Acute neck pain
- b Degenerative disc disease
- c Moderate to severe osteoporosis

- d Acute lower back pain
- e Second and third trimesters of pregnancy
- f Acute inflammatory or arthritic conditions of the shoulder
- i Acute inflammatory or arthritic conditions of the elbow/forearm complex
- j Hand/wrist disorders, such as carpal tunnel syndrome
- k Acute lateral epicondylitis
- l Spinal stenosis
- m Arthritic conditions of the hips and/or knees

Table 1. Panel 6. Shoulder Exercises (cont.)

Author	Name of Exercise	Exercise Instructions	Muscle Groups Recruited	Anatomical Structures Stretched	Specif. of Instr.	Space or Location	Conspicuous?	Time Reqmt.	Ease of Perform.	Comments	
35	Dahl	Unnamed	Sit forward in chair. Slump forward, straighten up and arch back, raise arms as high above head as possible, then slump forward again.	Phase II: Cervical, thoracic and lumbar extensors, scapular adductors, elevators and upward rotators, shoulder flexors and external rotators	Phase I: Shoulder extensors and internal rotators, posterior ligaments of the cervical, thoracic and lumbar spine. Phase II: Cervical, thoracic and lumbar flexors, scapular adductors, elevators and upward rotators	*	chair	highly	micro	simple	a b c d e 13
36	Pragler	Exercise b-7	Push one arm up toward ceiling with hand stretched out. Repeat with other arm.	Scapular adductors and upward rotators; shoulder flexors and abductors, thoracic extensors and external rotators	Shoulder extensors and adductors	good	chair	highly	micro	simple	f
37	Krames Comm.	Reaching High	Raise arms over head, stretching as high as possible. Then bring arms back down. Rest a moment. Repeat 2 times.	Scapular adductors and upward rotators, shoulder flexors and abductors, thoracic extensors	Shoulder extensors, adductors and internal rotators	good	chair	highly	micro	simple	f
38	Gore and Tasker	Reach for the Sky	Standing, stretch arms above head and hold for count of 6. Drop arms. Repeat 5 times.	Scapular adductors and upward rotators, shoulder flexors and abductors, thoracic extensors	Shoulder extensors, adductors and internal rotators	good	work area	highly	mini	simple	f
39	Austin	Reach	Slowly raise arms and draw stomach in. Let arms drop. Repeat twice.	Scapular adductors and upward rotators, shoulder flexors and abductors, thoracic extensors, abdominal flexors	Shoulder extensors, adductors and internal rotators	fair	chair	highly	mini	simple	f
40	Sauter	Arm Stretch	Stretch left arm over head, and right arm towards floor. Hold for several moments. Repeat several times, then reverse arms and repeat.	Scapular adductors and downward and upward rotators, shoulder flexors and abductors, thoracic extensors, neck rotators and flexors	Shoulder extensors and adductors, trunk lateral flexors	good	chair	highly	mini	simple	a b c 1134
41	LA Times	Windmills	Bring head into Turkey Position (see exercise 5), with arms at sides. Point one thumb forward, one thumb back. With arms straight, move them in direction thumbs are pointing. Repeat, moving arms in opposite direction. Do 3-5 times.	Scapular adductors, downward and upward rotators, shoulder flexors, abductors, external rotators, extensors, adductors and internal rotators, elbow extensors, forearm supinators and pronators, thoracic extensors	Scapular downward and upward rotators, shoulder extensors, adductors, internal rotators, flexors, abductors and external rotators, elbow flexors, forearm pronators and supinators	fair	chair	highly	micro	simple	a 113
42	Australian National University	Exercise 1	With arms bent across chest, push elbows back while stretching head up. Repeat 7-15 times.	Scapular adductors, upward rotators, shoulder vertical and horizontal abductors, external rotators		poor	chair	somewhat	mini	simple	

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Key

- | | | | |
|---|--|---|---|
| 1 | Exercise reproduces physical stresses of VDT work | d | Acute lower back pain |
| 2 | Exercise poses one or more safety hazards | e | Second and third trimesters of pregnancy |
| 3 | Exercise stretches already overstretched structures | f | Acute inflammatory or arthritic conditions of the shoulder |
| 4 | Exercise places additional loads on lumbar and/or thoracic discs | i | Acute inflammatory or arthritic conditions of the elbow/forearm complex |
| a | Acute neck pain | j | Hand/wrist disorders, such as carpal tunnel syndrome |
| b | Degenerative disc disease | k | Acute lateral epicondylitis |
| c | Moderate to severe osteoporosis | l | Spinal stenosis |
| | | m | Arthritic conditions of the hips and/or knees |

Table 1. Panel B. Shoulder Exercises (cont.).

Author	Name of Exercise	Exercise Instructions	Muscle Groups Recruited	Anatomical Structures Stretched	Specif. of Instr.	Space or Location	Conspicuous?	Time Reqmt.	Ease of Perform.	Comments	
43	Austin	Shoulder Stretch	Bring right hand to upper back from above. Bring left hand to upper back from below and hook fingers of two hands. Repeat on other side.	Scapular adductors, downward and upward rotators, shoulder flexors, abductors, external rotators, extensors, adductors and internal rotators, elbow flexors, thoracic extensors	Scapular downward and upward rotators, shoulder extensors, adductors, internal rotators, flexors, abductors and external rotators	fair	chair	highly	micro	difficult	f j 3
44	Joyce & Peterson	Arm Rotation	Extend arms straight ahead at shoulder level. Rotate them so the back of the hands face and touch each other. Hold to count of 3. Then rotate hands so palms face upward with sides of hands touching. Hold to count of 3. Repeat 2 more times.	Shoulder external rotators, flexors, shoulder internal rotators, forearm supinators and pronators	Shoulder internal rotators, external rotators, forearm pronators and supinators	fair	chair	highly	micro	simple	f k 1 3 Arm extension may actually increase neck/shoulder strain.
45	Joyce & Peterson	Give Me Five	Hold arms straight out in front. Make fist. Slowly point knuckles to floor. Hold for count of 3. Slowly straighten out fingers. Then point fingers toward ceiling and hold for count of 3. Repeat 3 times.	Shoulder external rotators, flexors and abductors, scapular adductors and upward rotators, thoracic extensors, finger flexors, wrist and finger extensors	Shoulder internal rotators, extensors and adductors, scapular downward rotators, wrist extensors	good	chair	somewhat	mini	simple	f j 3 Arm extension may actually increase neck/shoulder strain
46	Gore and Tasker	Fall Back	Sitting up straight, raise arms above head and clasp hands together. Looking forward, let arms and shoulders fall backwards over back of chair. Hold for slow count of 10. Relax. Repeat 3 times.	Shoulder flexors and abductors, scapular adductors and upward rotators	Shoulder extensors and adductors, anterior ligaments of the thoracic spine and facet joints	good	chair	somewhat	mini	simple	b c d e f 2 Potential for chair tipping backwards.
47	Dahl	Unnamed	Sit forward in chair. Raise arms above head and bend backward over back support.	Shoulder flexors and abductors, scapular adductors and upward rotators	Shoulder extensors and adductors, anterior ligaments of the thoracic spine and facet joints, cervical flexors	*	chair	somewhat	micro	simple	b c d e f 2 Potential for chair tipping backwards.
48	Gore and Tasker	Forwards Lean	Standing, push chair against desk. Stand about 1 meter behind chair, place hands on back of chair while keeping elbows straight, drop head forward between arms while keeping back straight. Hold for count of 10. Relax. Repeat 5 times.	Shoulder flexors and abductors, scapular adductors and upward rotators	Shoulder extensors and adductors, hip extensors/knee flexors (hamstrings), lumbar extensors, posterior ligaments of the lumbar spine and facet joints, cervical extensors	fair	work area	highly	mini	simple	a b c d e 1 2 3 4 Rolling chair potentially dangerous.
49	Krames Comm.	Upper Back Stretch	Raise hands to shoulders. Using the arms push shoulders back. Keep elbows down. Hold for 15 seconds. Repeat 3 times.	Scapular adductors, upward rotators, shoulder vertical and horizontal abductors, external rotators	Scapular abductors, downward rotators, shoulder internal rotators and horizontal adductors	fair	chair	somewhat	mini	simple	f
50	Austin	For your Arms	Bend elbows, keeping arms parallel to floor, fingers in front of chest. Push arms way out to sides with arms straight. Repeat 5 times.	Scapular adductors, upward rotators, shoulder vertical and horizontal abductors	Scapular abductors, downward rotators, shoulder internal rotators and horizontal adductors	poor	chair	highly	micro	simple	f

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| 1 Exercise reproduces physical stresses of VDT work | d Acute lower back pain |
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| 3 Exercise stretches already overstretched structures | f Acute inflammatory or arthritic conditions of the shoulder |
| 4 Exercise places additional loads on lumbar and/or thoracic discs | j Acute inflammatory or arthritic conditions of the elbow/forearm complex |
| | j Hand/wrist disorders, such as carpal tunnel syndrome |
| | k Acute lateral epicondylitis |
| a Acute neck pain | l Spinal stenosis |
| b Degenerative disc disease | m Arthritic conditions of the hips and/or knees |
| c Moderate to severe osteoporosis | |

Table 1. Panel B. Shoulder Exercises (cont.)

	Author	Name of Exercise	Exercise Instructions	Muscle Groups Recruited	Anatomical Structures Stretched	Specif. of Instr.	Space or Location	Conspicuous?	Time Reqmt.	Ease of Perform.	Comments
51	Joyce & Peterson	Trapezius Squeeze	Raise arms up and to the sides, with palms facing out. Squeeze shoulder blades together and hold 3 sec. Relax. Repeat 2 more times.	Scapular adductors, upward rotators, shoulder vertical and horizontal abductors, external rotators	Scapular abductors, downward rotators, shoulder internal rotators and horizontal adductors	good	chair	highly	micro	simple	f
52	LA Times	Shoulder Blade	Bring head into Turkey Position (see exercise 5). Hold arms up, elbows bent, with palms facing forward at shoulder height. Pull hands back as if to touch little fingers together. Repeat 3-5 times.	Scapular adductors, upward rotators, shoulder vertical and horizontal abductors, external rotators	Scapular abductors, downward rotators, shoulder internal rotators and horizontal adductors	fair	chair	somewhat	micro	simple	f
53	Joyce & Peterson	Executive Stretch	Lock hands behind head and bring elbows back. Lean back in chair, stretching and arching spine. Hold to count of 3. Relax. Repeat twice.	Scapular adductors, upward rotators, shoulder vertical and horizontal abductors, external rotators, cervical and thoracic extensors	Scapular abductors, downward rotators, shoulder internal rotators and horizontal adductors	good	chair	somewhat	mini	simple	a d f
54	Pragler	Exercise a-2	Hands behind head, tuck chin in and push the back of the head into the hands. Hold that position for a count of 3; relax.	Scapular adductors, upward rotators, shoulder vertical and horizontal abductors, external rotators, cervical and thoracic extensors	Scapular abductors, downward rotators, shoulder internal rotators and horizontal adductors	fair	chair	somewhat	micro	simple	a f
55	Austin	Pectoral Stretch	Grasp hands behind neck and press elbows as far back as possible. Relax. Repeat.	Scapular adductors, upward rotators, shoulder vertical and horizontal abductors, external rotators, cervical and thoracic extensors	Scapular abductors, downward rotators, shoulder internal rotators and horizontal adductors	good	chair	somewhat	micro	simple	a f
56	Dahl	Unnamed	Interlace fingers, turn palms forward, raise arms above head, lower them behind the neck, then down in front of the body again.	Scapular adductors, upward rotators, shoulder flexors and abductors, arm extensors, cervical and thoracic extensors	Scapular abductors, downward rotators, shoulder internal rotators, horizontal and vertical adductors, extensors and internal rotators, scapular adductors, downward rotators	*	chair	somewhat	micro	simple	f j 13
57	Pragler	Exercise b-2	Rotate both shoulders backwards, keeping arms relaxed by sides.	Scapular upward rotators and adductors	Scapular downward rotators	good	chair	somewhat	micro	simple	
58	Pragler	Exercise b-3	Clap hands in front of body, keeping elbows bent and tucked in by sides.	Shoulder external rotators, scapular adductors, downward rotators	Shoulder internal rotators, scapular upward rotators	good	chair	highly	micro	simple	f
59	Gore and Tasker	Triangle	With arms by sides, turn palms outward and move arms backward as far as possible. Hold for count of 10. Relax. Repeat 3 times.	Shoulder external rotators, scapular adductors, downward rotators, horizontal adductor	Shoulder internal rotators, scapular upward rotators, anterior chestwall	good	chair	somewhat	mini	simple	f 3
60	Pragler	Exercise b-1	Pull shoulders back, arms at sides. Hold for count of 3.	Cervical and thoracic extensors, scapular adductors, elevators and upward rotators	Anterior ligaments of the lower thoracic spine, anterior chestwall	good	chair	no	micro	simple	

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Key

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2 Exercise poses one or more safety hazards

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4 Exercise places additional loads on lumbar and/or thoracic discs

a Acute neck pain

b Degenerative disc disease

c Moderate to severe osteoporosis

d Acute lower back pain

e Second and third trimesters of pregnancy

f Acute inflammatory or arthritic conditions of the shoulder

i Acute inflammatory or arthritic conditions of the elbow/forearm complex

j Hand/wrist disorders, such as carpal tunnel syndrome

k Acute lateral epicondylitis

l Spinal stenosis

m Arthritic conditions of the hips and/or knees

Table 1. Panel B. Shoulder Exercises (cont.)

Author	Name of Exercise	Exercise Instructions	Muscle Groups Recruited	Anatomical Structures Stretched	Specif. of Instr.	Space or Location	Conspicuous?	Time Reqmt.	Ease of Perform.	Comments
61	Sauter Upper Arm Relaxer	Slowly open and spread arms to sides as when stretching and yawning. Fold arms back toward body tightly. Repeat a few times.	Shoulder external rotators, scapular adductors, downward rotators, shoulder internal rotators, scapular abductors, horizontal abductors and adductors	Shoulder internal and external rotators, scapular upward rotators	fair	chair	somewhat	micro	simple	f 3
62	Pragier Exercise a-4	Bring arms over the back of the chair with the hands clasped. Stretch arms down towards the floor. Hold for a count of 3 then relax.	Scapular adductors, downward rotators	Scapular upward rotators	fair	chair	somewhat	micro	moderately difficult	d f
63	Sauter Shoulder Blade Pinch	Move forward slightly in chair. Place hands on edges of chair behind buttocks and try to touch elbows together behind back. Relax and repeat a few times.	Scapular adductors, downward rotators	Scapular upward rotators and abductors	good	chair	somewhat	micro	simple	d f
64	Pragier Exercise b-8	Push arm forward at shoulder height with the hand stretched out. Repeat with the other arm.	Scapular adductors and downward rotators, shoulder extensors, elbow flexors, wrist extensors, scapular abductors and upward rotators, shoulder flexors, elbow extensors	Scapular abductors and upward rotators, shoulder flexors, elbow extensors, wrist flexors, scapular adductors and downward rotators, elbow flexors	fair	chair	highly	micro	simple	f 1 3
65	Austin Upper Back Stretch	Sit with hands on shoulders. Try to cross elbows in front. Relax. Repeat.	Scapular abductors, shoulder horizontal adductors, and external rotators	Scapular adductors, shoulder horizontal abductors and internal rotators	good	chair	highly	micro	simple	f 1 3
66	Austin Middle-Upper Back Stretch	Hold right arm just above elbow with left hand. Gently pull elbow toward left shoulder. Hold 5 seconds. Repeat other side.	Scapular abductors, shoulder horizontal adductors	Scapular adductors, shoulder horizontal abductors	good	chair	somewhat	micro	simple	f 1 3
67	Austin Hug Yourself	Cross arms in front of chest and reach fingertips towards shoulder blades.	Scapular abductors, shoulder horizontal adductors	Scapular adductors, shoulder horizontal abductors	fair	chair	highly	micro	simple	f 1 3

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Table 1. Panel C. Elbow/Lower Arm Exercises.

Author	Name of Exercise	Exercise Instructions	Muscle Groups Recruited	Anatomical Structures Stretched	Specif. of Instr.	Space or Location	Conspicuous?	Time Reqmt.	Ease of Perform.	Comments
68	Gore and Tasker	Eiffel Tower		Finger flexors, anterior ligaments of the MP joints, finger adductors	poor	chair	somewhat	mini	simple	1
69	Australian National University	Exercise 12	Shoulder flexors, abductors and external rotators	Finger flexors, anterior ligaments of the finger joints, shoulder extensors, adductors and internal rotators	good	chair	highly	mini	simple	1
70	Gore and Tasker	Palm Press		Finger flexors, anterior ligaments of the finger joints	fair	chair	somewhat	micro	simple	1
71	Dahl	Unnamed		Finger flexors, anterior ligaments of the finger joints	*	chair	somewhat	micro	simple	1
72	Austin	Wrist Flex		Finger flexors, anterior ligaments of the finger joints	fair	chair	somewhat	micro	simple	1
73	Krames Comm.	Wrist Flex		Finger flexors, anterior ligaments of the finger joints	good	chair	somewhat	micro	simple	1
74	Dahl	Unnamed		Finger flexors, anterior ligaments of the finger joints	*	chair	no	micro	simple	1
75	Joyce & Peterson	Thumb Stretch		Thumb flexors and adductors	fair	chair	somewhat	mini	simple	1
76	Krames Comm.	Wrist	Wrist/finger extensors, shoulder flexors	Wrist extensors and flexors	poor	chair	somewhat	micro	simple	1 1 3 Arm extension may actually increase neck/shoulder strain.
77	Australian National University	Exercise 9	Finger flexors and extensors, shoulder flexors	Finger flexors and extensors	good	chair	somewhat	mini	simple	1 1 Arm extension may actually increase neck/shoulder strain.
78	Krames Comm.	Finger Fan	Finger flexors and extensors, finger abductors	Finger flexors and extensors, finger adductors	good	chair	somewhat	micro	simple	1 1 3

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Key

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| 2 Exercise poses one or more safety hazards | e Second and third trimesters of pregnancy |
| 3 Exercise stretches already overstretched structures | f Acute inflammatory or arthritic conditions of the shoulder |
| 4 Exercise places additional loads on lumbar and/or thoracic discs | i Acute inflammatory or arthritic conditions of the elbow/forearm complex |
| | j Hand/wrist disorders, such as carpal tunnel syndrome |
| a Acute neck pain | k Acute lateral epicondylitis |
| b Degenerative disc disease | l Spinal stenosis |
| c Moderate to severe osteoporosis | m Arthritic conditions of the hips and/or knees |