

Table 1. Panel C. Elbow/Lower Arm 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	
79	Dahl	Unnamed	Spread and stretch fingers as much as possible, then make a fist.	Finger flexors and extensors, finger abductors	Finger flexors and extensors, finger adductors	*	chair	no	micro	simple	l j 1 3
80	Austin	Fingers	With palms down, spread thumb and fingers as far apart as possible. Hold for count of 5. Relax. Repeat.	Wrist/finger extensors, finger abductors	Finger flexors, finger adductors	good	chair	no	micro	simple	l j
81	Sauter	Palm Push-Ups	Place tops of hands under front edge of worktable. Push up with hands (not arms) for a moment. Then place palms in similar position on top of desk and push down. Drop hands to sides and wiggle hands a bit. Rest in lap for a few seconds.	Finger extensors, wrist extensors		good	chair	no	micro	simple	k
82	Australian National University	Exercise 10	Lift arms forward, circle hands at wrist, then reverse. Drop hands to sides, repeat circling. Raise arms above head, repeat circling. Do 5 times each direction, each position.	Wrist flexors, wrist/finger extensors, forearm supinators/pronators, wrist ulnar and radial deviators, shoulder flexors, abductors and external rotators	Wrist flexors, wrist/finger extensors, forearm supinators/pronators, wrist ulnar and radial deviators, shoulder extensors, adductors and internal rotators	good	chair	highly	mini	simple	l j k 1 3 May increase joint stress in the wrist. Arm extension may actually increase neck/shoulder strain.
83	LA Times	Forearm Stretch	Bend elbow so palm is facing forward. Make fist. Bend wrist so palm surface points to floor. Turn hand so it points away from body, then straighten forearm and turn arm inward. Hold 15 seconds. Repeat 3-5 times.	Wrist/finger flexors, forearm pronators	Wrist/finger extensors, forearm supinators	fair	chair	somewhat	mini	simple	l j k 1 3
84	Australian National University	Exercise 11	Bend wrist and fingers of one hand towards palm, applying pressure with other hand. Repeat with other hand. Do 5-10 times.		Wrist extensors	fair	chair	no	mini	simple	l j
85	Sauter	Finger Curls	Holding forearms outstretched in front, bend fingers (not hands) downward and curl them into a fist. Open fist and bend fingers up slightly. Repeat once or twice. Return fingers to neutral position and stretch them apart. Drop arms and hands to sides and gently wiggle them about for a moment. Return hands to lap and rest them for a few seconds.	Finger flexors and extensors	Finger flexors and extensors	good	chair	somewhat	micro	simple	l j 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 | 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 D. Lower Back/Hip 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
86	Sauter	Back Arch	Upper cervical, thoracic and lumbar extensors, scapular adductors, elevators and upward rotators, neck flexors	Upper cervical extensors Phase II: anterior ligaments of the upper cervical, thoracic and lumbar spine	good	chair	somewhat	micro	simple	a b d f l
87	Austin	Knee Kiss	Arm flexors, shoulder extensors	Hip extensors, lower cervical and thoracic extensors and posterior ligaments of the cervical, thoracic and lumbar spine	good	chair	highly	mini	difficult	b c d e f i l m 2 4 Rolling chair potentially hazardous. Difficult to perform in most office attire, or for obese individuals.
88	Krames Comm.	Legs	Arm flexors, shoulder extensors	Hip extensors, lower cervical and thoracic extensors and posterior ligaments of the cervical, thoracic and lumbar spine	good	chair	highly	mini	difficult	b c d e f i l m 2 4 Rolling chair potentially hazardous. Difficult to perform in most office attire, or for obese individuals.
89	Austin	Back Relaxer		Thoracic and lumbar extensors, posterior ligaments of the thoracic and lumbar spine	good	chair	highly	mini	simple	b c d e 1 2 3 Awkward to perform. Rolling chair potentially hazardous. Difficult to perform in most office attire. Difficult to perform for obese or pregnant individuals.
90	Krames Comm.	Lower Back Stretch		Thoracic and lumbar extensors, posterior ligaments of the thoracic and lumbar spine	fair	chair	highly	mini	moderately difficult	b c d e 1 2 3 Awkward to perform. Rolling chair potentially dangerous (as noted in brochure). Difficult to perform for obese or pregnant individuals.
91	Lee and Walker	Bending		Phase I: Thoracic and lumbar extensors, posterior ligaments of the thoracic and lumbar spine, hip extensors and knee flexors (hamstrings) Phase II: Anterior ligaments of the lumbar spine and hip joints, trunk and hip flexors	good	work area	highly	mini	moderately difficult	b c d e 1 2 3 Awkward and difficult to perform for obese or pregnant individuals.
92	Dahl	Unnamed	Neck flexors Phase II: Lower cervical, thoracic and lumbar extensors	Phase I: Lower cervical, thoracic and lumbar extensors, scapular adductors, elevators and upward rotators, posterior ligaments of the cervical, thoracic and lumbar spine Phase II: Upper cervical flexors, anterior ligaments of the lower cervical and thoracic spine	*	chair	no	micro	simple	a b c d e 1 3
93	Joyce & Peterson	Pelvic Tilt	Phase I: Trunk flexors, hip extensors. Phase II: Trunk extensors and hip flexors	Phase I: Thoracic and lumbar extensors, and posterior ligaments of the lumbar and thoracic spine. Phase II: Hip extensors	good	chair	no	micro	simple	b c d e 4 Avoid strong pelvic tilt contractions as they may increase stress to the lumbar discs.

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- k Acute lateral epicondylitis
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Table 1. Panel D. Lower Back/Hip 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	
94	Sauter	Pelvic Tilt	Imagine you have a tail and are trying to tuck it between your legs by tilting the pelvis up. Hold 1-2 sec. Repeat a few times.	Trunk flexors and hip extensors	Posterior ligaments and extensors of the lumbar spine	good	chair	no	micro	simple	b c d e 4 Avoid strong pelvic tilt contractions as they may increase stress to the lumbar discs.
95	Joyce & Peterson	Glute Clench	Sit straight, tighten both buttock and abdominal muscles, hold for 5 seconds. Relax, then repeat 2 more times.	Trunk flexors and hip extensors		fair	chair	no	micro	simple	b c d e 4 Avoid strong pelvic tilt contractions as they may increase stress to the lumbar discs.
96	Austin	Windmill	Sit in chair. Place feet apart on the floor. Bend over and touch right hand to left foot with left arm extended up. Alternate sides repeatedly.	Anterior and posterior trunk rotators, thoracic, lumbar and hip extensors, trunk side benders	Anterior and posterior trunk rotators, thoracic, lumbar and hip extensors, trunk side benders, posterior and lateral ligaments of the thoracic and lumbar spine	good	chair	highly	mini	difficult	a b c d e f i j 1 2 3 4 Avoid rapid stretching. Difficult to perform for obese or pregnant individuals. Rolling chair potentially hazardous. Difficult to perform in most office attire.
97	Austin	Trimming the Waist	Interlace fingers behind neck. Lift right knee and touch left elbow to right knee. Alternate sides 5 times.	Hip flexors, anterior and posterior trunk extensors and rotators	Anterior and posterior trunk rotators, thoracic, lumbar and hip extensors, trunk side benders, posterior and lateral ligaments of the cervical, thoracic and lumbar spine	good	chair	highly	mini	moderately difficult	a b c d e f i j 2 3 4 Rapid stretching not recommended. Rolling chair potentially hazardous.
98	Dahl	Unnamed	Sit forward in chair. Put hands on seat behind body, extend and raise both legs. Relax.	Hip and trunk flexors, knee extensors	Hip extensors and knee flexors (hamstrings)	*	chair	somewhat	micro	moderately difficult	b c d e f i j 1 2 3 4 Hip flexors are often already tight as a result of the sedentary nature of VDT work. Rolling chair potentially hazardous.
99	Joyce & Peterson	Knee Raises	Sit upright in chair. Tighten abdominal muscles and raise knees 2 inches. Hold 3 sec. Relax. Repeat 2 times.	Hip and trunk flexors, trunk anterior and posterior rotators		good	chair	somewhat	mini	moderately difficult	b c d e f i j 3 4 Hip flexors are often already tight as a result of the sedentary nature of VDT work. Rolling chair potentially hazardous.
100	Austin	Side Stretch	Interlace fingers. Lift arms over head and press backwards as far as possible. Lean to the left, then to the right.	Trunk side benders, shoulder flexors, abductors and internal rotators, scapular adductors, elevators and upward rotators	Trunk side benders, shoulder extensors, adductors and internal rotators, posterior and lateral ligaments of the thoracic and lumbar spine	good	chair	highly	micro	simple	b c d e f i j j 1 3 4
101	Australian National University	Exercise 7	Arms by side, creep hand down thigh toward knees. Repeat on other side. Do 5-10 times.	Trunk side benders	Trunk side benders, lateral ligaments of the thoracic and lumbar spine	fair	work area	highly	mini	simple	b c d e f i 1 4 Rapid stretching not recommended.
102	Gore and Tasker	Sideways Bend	Standing with arms at sides, bend sideways so right arm goes down right leg. Return to upright and repeat on left side. Repeat 5 times each side.	Trunk side benders	Trunk side benders, lateral ligaments of the thoracic and lumbar spine	good	work area	highly	mini	simple	b c d e f i 1 4 Rapid stretching not recommended.
103	Lee and Walker	Side Bending	Bend to left as far as possible, letting left arm hang loose. Repeat on right side.	Trunk side benders	Trunk side benders, lateral ligaments of the thoracic and lumbar spine	good	work area	highly	mini	simple	b c d e f i 1 4 Rapid stretching not recommended.

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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 | 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 |

Table 1. Panel D. Lower Back/Hip 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
104	Pragler	Exercise b-4	Bend to left and stretch left arm down side. Repeat to right.	Trunk side benders	Trunk side benders, lateral ligaments of the thoracic and lumbar spine	good	work area	highly	mini	simple	b c d e l 1 4 Rapid stretching not recommended.
105	Sauter	Chair Rock	Place feet squarely on floor with hands at side of chair. Rock slowly to left, looking over right shoulder, then to the right, looking over left shoulder. Do several times.	Anterior and posterior cervical, thoracic, and lumbar rotators	Anterior and posterior cervical and thoracic and lumbar rotators, posterior and lateral ligaments of the cervical, thoracic and lumbar spine	good	chair	highly	micro	simple	a b c d 4 May produce moderate loading on cervical discs if performed with forward head posture.
106	Austin	Trunk Twists	Turn at trunk. Turn head in direction of trunk. Twist 3 times in each direction.	Anterior and posterior trunk rotators, shoulder abductors and external rotators, scapular adductors, elevators and upward rotators, neck rotators	Anterior and posterior trunk rotators, posterior and lateral ligaments of the thoracic and lumbar spine, shoulder internal rotators	good	chair	highly	micro	simple	a b c d e f i l 1 3 4 Raised arms (as shown in the brochure) produce additional loading on lumbar and thoracic discs.
107	Emanuel and Glonek	Trunk Rotations	Rotate entire upper body in a clockwise direction 3 times. Repeat counter-clockwise 3 times.	Anterior and posterior trunk rotators, trunk side benders, trunk/hip flexors and extensors	Anterior and posterior trunk rotators, trunk side benders, trunk/hip flexors, anterior and lateral ligaments of the lumbar and thoracic spine and hip joints	fair	work area	highly	micro	simple	b c d e l 1 4
108	Australian National University	Exercise 6	Place palms across the small of back, bend and arch spine. (5-10 times)	Abdominals (eccentric)	Anterior ligaments of the lumbar spine and hips, trunk and hip flexors	poor	work area	somewhat	mini	simple	b d e l
109	Gore and Tasker	Disc Reliever	Standing up straight with feet slightly apart, place hands in hollow of back. Focus eyes on a point straight ahead. Bend backwards over hands without bending knees, then straighten up. Repeat 10 times.	Abdominals (eccentric)	Anterior ligaments of the lumbar spine and hips, trunk and hip flexors	good	work area	somewhat	mini	moderately difficult	b d e l
110	Austin	Derriere Firmer	Place hands on chair, feet flat on floor, lift hips and buttocks up. Tighten buttocks and hold for 5 sec. Sit back and relax. Repeat twice.	Hip adductors/extensors, back extensors, scapular adductors, arm and shoulder extensors	Hip/trunk flexors, shoulder flexors	good	chair	highly	mini	difficult	b c d e f l 2 Arm strength limits ability to perform. Rolling chair potentially hazardous. May be difficult for obese or pregnant individuals to perform.

Key

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- i Acute inflammatory or arthritic conditions of the elbow/forearm complex
- j Hand/wrist disorders, such as carpal tunnel syndrome
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Table 1 Panel E. Knee/Lower Leg 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
111	Dahl	Unnamed		Knee extensors, anterior ligaments of the hip, hip flexors	*	work area	highly	mini	difficult	b c d e m 2 Support should be provided when performing standing portion of the exercise. Difficult to perform in most office attire, or in high-heeled shoes.
112	Australian National University	Exercise 14	Hands on hips, one foot in front of other, rock forward and backward slowly 10-20 times. Repeat with other leg.	Hip abductors and extensors, knee extensors	fair	work area	highly	mini	moderately difficult	m
113	Dahl	Unnamed	Standing, take long step forward and bend knee. Keep heel of rear foot on floor. Bend front knee joint further to lower body downward. Repeat with other leg.	Hip abductors and extensors, knee extensors	*	work area	highly	mini	moderately difficult	m 2 Support should be provided. Difficult to perform in most office attire, or in high-heeled shoes.
114	Gore and Tasker	Calf Lengthener	Stand with one leg behind the other in lunge position, keeping heel of back foot on floor, lean forward onto front leg. Hold for count of 10. Repeat 3 times per leg.	Hip abductors and extensors, knee extensors	good	work area	highly	mini	moderately difficult	m 2 Support should be provided. May be hazardous for individuals with ankle problems. Difficult to perform in most office attire, or in high-heeled shoes.
115	Australian National University	Exercise 6	With one foot in front of other, lean forward from hip, supporting arm on forward thigh. Circle free arm. Repeat other side. Do 5-10 times.	Hip abductors and extensors, knee extensors	poor	work area	highly	mini	moderately difficult	m 2 Support should be provided. Difficult to perform in most office attire, and in high-heeled shoes.
116	Australian National University	Exercise 13	Standing with hands on hips, place feet apart and rock from side to side, bending alternate knees 10-20 times.	Hip abductors and extensors, knee extensors	fair	work area	highly	mini	simple	m
117	Pragler	Exercise b-5	Walk on the spot, letting shoulders and arms hang loose.	Hip abductors and extensors, knee extensors	good	work area	somewhat	mini	simple	m
118	Dahl	Unnamed	Walk up stairs rather than using the elevator.	Hip abductors and extensors, knee extensors, hip flexors, hamstrings	*	extra-work area	no	major	simple	c d m 4
119	Pragler	Exercise b-6	Hop on left foot, then on right foot.	Plantar flexors, knee extensors, hip extensors/abductors	good	work area	highly	micro	moderately difficult	c d e m 4 Exercise creates too much impact through knees, hips and back. Difficult to perform in high-heeled shoes.
120	Emanuel and Glonek	Stretching	Stand on tip toes, extend hands as far as possible overhead. Lower arms slowly to side of body, continuing to extend arms as far as possible.	Plantar flexors, knee extensors, scapular adductors and upward rotators, shoulder flexors, abductors, and external rotators, thoracic extensors	fair	work area	highly	mini	simple	f 2 Difficult to perform in high-heeled shoes.

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| 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 E. Knee/Lower Leg 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
121	Emanuel and Glonek	Relaxing	Let arms hang loose, try to relax arms, shoulders and knees. Bounce up and down on toes for a few seconds.	Plantar flexors	good	work area	somewhat	mini	simple	2 Difficult to perform in high-heeled shoes.
122	Austin	Strengthen the Quadriceps	Bring legs straight out in front of body in L-shaped position. Hold 5 sec. Relax. Repeat.	Knee extensors, hip flexors, back flexors	good	chair	somewhat	micro	difficult	b c d e 1 2 4 Hip flexors already tight as a result of sitting for long periods. Rolling chair potentially hazardous.
123	Dahl	Unnamed	Sitting, extend one leg and flex the foot up and down. Repeat with other leg.	Ankle dorsiflexors, invertors and evertors, knee extensors	*	work area	somewhat	micro	simple	m
124	Sauter	Leg Reach and Toe Circles	While seated, hold onto chair and raise and extend one leg out in front. Draw a couple of circles in the air with foot, using toe as pointer. Slowly bend knee and bring it about one third of way toward chest. Extend leg again and relax. Repeat exercise with each leg several times.	Ankle dorsiflexors, invertors and evertors, knee extensors	good	chair	highly	mini	simple	b c d e m 4 May be difficult to perform by obese or pregnant individuals. Difficult to perform in most office attire.
125	Joyce & Peterson	Legs/Ankles/Feet	While sitting, slowly rotate each foot from ankle three times in one direction, then three times in the other. Point toes downward as far as possible. Hold three seconds. Then point toes straight up and hold three seconds. Repeat three times.	Ankle dorsiflexors, invertors and evertors	good	work area	no	mini	simple	
126	Fragler	Exercise a-5	Sitting in chair, lift right leg, hold out straight, then move foot up and down from ankle 10 times. Circle foot to right 10 times, then to left 10 times. Repeat with left leg.	Ankle dorsiflexors, invertors and evertors, knee extensors	good	chair	no	mini	simple	
127	Sauter	Foot Presses	Sitting erect in chair, press down alternately with ball and heel of right foot several times. Repeat with other foot.	Ankle dorsiflexors, plantar flexors	good	chair	no	micro	simple	

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A review of physical exercises for VDT operators

Table 2. Proportion of exercises, by body part, falling within each of the useability assessment categories.

	Specificity of Instructions			Location			Conspicuousness			Time Requirement			Ease of Performance		
	Good	Fair	Poor	Chair	Work Area	Extra Work Area	No	Somewhat	Highly	Micro	Mini	Major	Simple	Mod. Difficult	Difficult
Neck	0.61	0.35	0.04	0.92	0.08	0.00	0.24	0.68	0.08	0.52	0.48	0.00	1.00	0.00	0.00
Shoulder	0.56	0.38	0.05	0.95	0.05	0.00	0.02	0.52	0.45	0.64	0.36	0.00	0.95	0.02	0.02
Elbow/Lower Arm	0.53	0.33	0.13	1.00	0.00	0.00	0.28	0.61	0.11	0.61	0.39	0.00	1.00	0.00	0.00
Lower Back/Hip	0.78	0.17	0.04	0.68	0.32	0.00	0.16	0.20	0.64	0.40	0.60	0.00	0.60	0.24	0.16
Knee/Lower Leg	0.69	0.23	0.08	0.24	0.71	0.06	0.24	0.24	0.53	0.24	0.71	0.06	0.59	0.29	0.12
All Exercises	0.63	0.31	0.06	0.80	0.19	0.01	0.16	0.46	0.38	0.51	0.48	0.01	0.85	0.09	0.06

all are suitable for performance at the workstation, or even in the workplace. Each exercise was categorized according to the location most suitable for performance. Three categories were utilized: chair, work area and extra-work area.

- **Chair** The exercise can be performed while seated at the workstation.
- **Work area** The exercise can be performed in close proximity to the workstation.
- **Extra-work area** The exercise does not lend itself to performance at the work area due to the required postures, or the inappropriateness of work attire for such an activity.

Conspicuousness This dimension is important because it addresses the issues of modesty and fear of embarrassment. Highly conspicuous exercises may be less likely to be accepted by VDT users, or may not be performed as instructed. Three categories were defined: highly conspicuous, somewhat conspicuous, or not conspicuous.

- **Highly conspicuous** Potentially embarrassing to the user or dramatically different from routine movements.
- **Somewhat conspicuous** Somewhat obvious to others, but socially acceptable and not embarrassing because of the similarity to common movements (eg, spontaneous stretch associated with fatigue).
- **Not conspicuous** Neither obvious nor embarrassing.

Time requirement/disruption of the work process The exercises varied in the amount of time required to

perform them, or in the degree to which they could interrupt work. Excessive or repeated disruption of work may interfere with the work rhythm and impair performance, leading to lack of acceptance by employers or individual VDT users. Three categories were defined: microbreaks, minibreaks and major breaks.

- **Microbreak** Very short break required (ie, less than 10–15 s), entailing no significant interruption of work.
- **Minibreak** A break of less than 1–2 min in duration is required; interruption of the work task is usually necessary.
- **Major break** The exercises can be performed only during a formal break from the task/work area lasting several minutes or more.

Ease of learning and performance This dimension refers to the complexity of the exercises, a factor also potentially affecting acceptance and performance of the exercise routine by VDT users. Three rating categories were defined: simple, moderately difficult, or difficult.

Physiotherapeutic assessment

The potential for three types of problems was considered in the analysis of each exercise. The 'Comments' column in Table 1 notes limitations pertinent to these issues (see also Table 3)

Aggravation of pre-existing health conditions Some medical conditions (eg, acute low back pain) may be aggravated by exercise or may limit performance of an

Table 3. Proportion of exercises, by body part, falling within each of the physiotherapeutic assessment categories.

	Reprods physical stresses of VDT work	Stretches over-stretched structures	Places additional loads on discs	Poses one or more safety hazards	Health contra-indications
Neck	0.36	0.44	0.40	0.00	0.72
Shoulder	0.45	0.50	0.05	0.07	0.93
Elbow/Lower Arm	0.39	0.33	0.00	0.00	1.00
Lower Back/Hip	0.60	0.40	0.68	0.36	1.00
Knee/Lower Leg	0.06	0.00	0.23	0.41	0.82
All Exercises	0.40	0.38	0.26	0.15	0.90

exercise. These conditions are noted in the 'Comments' column of Table 1.

Replication/exacerbation of physical stresses associated with the task Some exercises reproduce or exacerbate postural or biomechanical demands of the job. Examples are exercises which stretch spinal muscles and ligaments already overstretched as a result of sitting for long periods in a fixed spinal posture, or wrist hyperextension-flexion exercises which may exacerbate the physical demands of keyboard work.

Safety/therapeutic/performance issues Exercises were also analysed for their potential to create a safety hazard when performed in an office setting (eg. use of mobile office furniture as props), or by certain populations of users (eg. obese or pregnant individuals). Additionally, it was noted when an exercise would be awkward or impossible to perform in typical women's office attire (eg. dress or skirt; high heels).

The usability of physiotherapeutic-safety judgments were arrived at by consensus among the authors. The authors first performed the evaluations individually, then met as a group to resolve any differences. (Each author's area of expertise is as follows: K Lee, biomechanics; N Swanson and S Sauter, office ergonomics; R Wickstrom, biomechanics and physical therapy (RPT); A Waikar, biomechanics; M. Mangum, exercise physiology.)

Results

Nature of the exercises

The exercises were rather unevenly distributed among the classified body parts: neck ($n = 25$), shoulder ($n = 42$), elbow/lower arm ($n = 18$), lower back/hip ($n = 25$) and knee/lower leg ($n = 17$). For the most part, the underlying objectives of the evaluated exercises were to relax or stretch chronically tense muscles, to increase flexibility or mobility, and to improve circulation.

Usability and physiotherapeutic assessments

Below is a summary of the usability and physiotherapeutic ratings for the exercises, organized according to targeted body part. The specific rating of each of the 127 exercises on all usability and physiotherapeutic dimensions is presented in Table 1. Tables 2 and 3 give the proportion of exercises receiving each rating within each usability/physiotherapeutic dimension (also organized according to targeted body part).

Implicit in our evaluation is the assumption that those exercises that are least conspicuous, disruptive and most easily performed (preferably at the work station) are most likely to be adopted in a typical office workplace. Our assessment of the utility of these exercises may vary somewhat depending upon employers' willingness to set aside special breaks and places for individual or group exercises by workers. However, even then, some workers may not perform the exercises because of embarrassment or difficulty in performance.

Neck exercises (Table 1, panel A)

Usability assessment There are 25 neck and upper-back exercises designed to offset problems that are very common to VDT operation such as stiffness or soreness associated with long-term shoulder retraction during data entry tasks. All exercises can be performed easily. 61% had good instructions, and all but two (1, 18) can be performed while seated. Approximately half (52%) of the exercises can be performed without significant disruption of the work routine, and most (92%) were judged to be fairly inconspicuous (ie, mimicked natural movements).

Physiotherapeutic assessment Some of the exercises may be somewhat uncomfortable or difficult to perform by individuals with acute neck pain, degenerative disc disease, osteoporosis, etc. Over one third (36%) of the exercises reproduced the physical stresses of VDT work, most further stretching muscles and ligaments which were already overstretched owing to sitting in a flexed spinal posture for long periods of time. Additionally, over one third (40%) of the exercises may place additional loads on already loaded cervical and thoracic discs.

Shoulder exercises (Table 1, panel B)

Usability assessment There are 42 shoulder exercises designed to stretch and relieve tension in the upper back and to enhance the range of motion of the shoulders. Over half (56%) of the exercises have good instructions and all but two exercises (38, 48) can be performed while seated. However, one third (36%) of the exercises are somewhat disruptive of work since they require several minutes to perform, and nearly half (45%) of the exercises were judged to be highly conspicuous. All but two exercises (43, 62) are simple to perform.

Physiotherapeutic assessment Most (88%) of the shoulder exercises may be contraindicated for individuals with acute inflammatory or arthritic conditions of the shoulder (see, for example, Figure 1 (a)). Nearly half (45%) of the exercises reproduce some of the physical stresses of VDT work, primarily in further stretching chronically stretched structures. Three exercises (46-48), all of which require the use of a chair as a prop, pose potential safety hazards because the required exercise movements may cause the chair to roll, or to tip backwards.

Elbow/lower arm exercises (Table 1, panel C)

Usability assessment There are 18 elbow/lower arm exercises, many designed to enhance the flexibility of the fingers and wrists. About half (53%) have good instructions, all can be performed while seated, and many (61%) can be performed without significant disruption of the work routine since they require only a few seconds to perform. Most (89%) of the exercises are inconspicuous or only moderately conspicuous. None are difficult to perform.

Physiotherapeutic assessment Most (83%) of the exercises may be problematic for individuals with hand/wrist disorders owing to the extreme postural angles

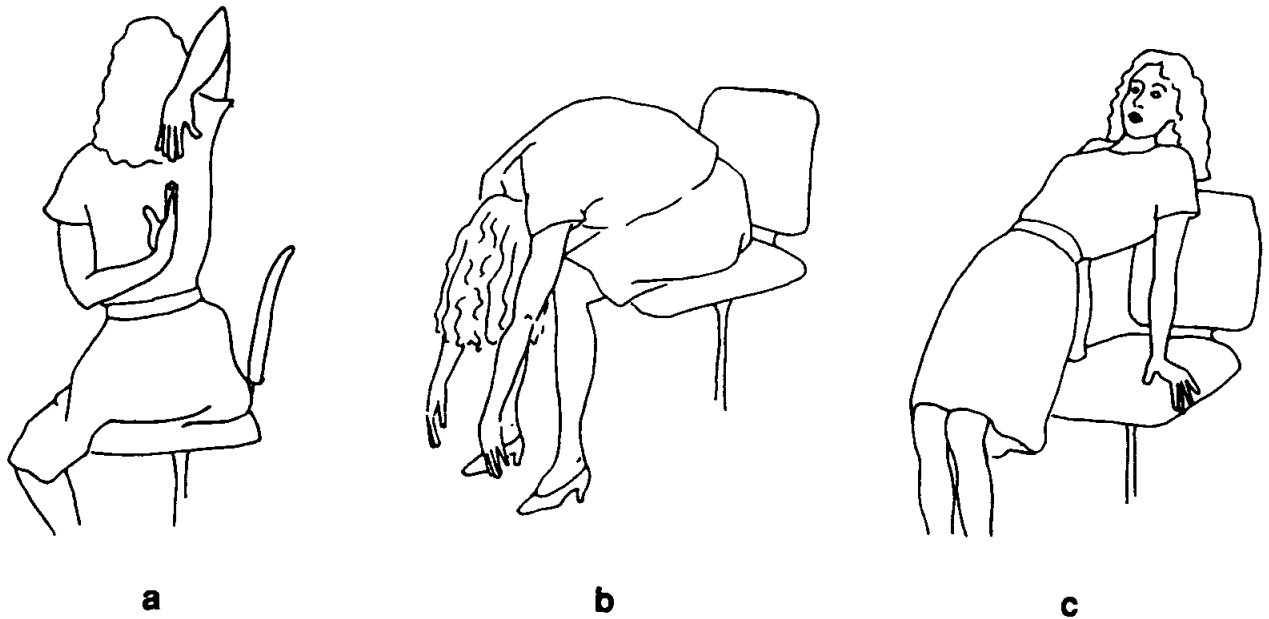


Figure 1 Examples of exercises which (a) had the potential to exacerbate existing health conditions, (b) replicated the stresses of VDT work, or (c) posed potential safety hazards

created in the performance of the exercises. For example, exercises 72–74 require that the wrist of one arm be manually hyperextended with the other hand. Additionally, most of the exercises may be contraindicated for individuals with arthritic conditions of the hands and wrist, and several others (76, 77, 81–83) may be contraindicated for those with lateral epicondylitis or inflammatory conditions of the shoulder. Additionally, three exercises (76, 77, 82) involve static arm extensions of some duration which may actually exacerbate the neck/shoulder strain arising from VDT work.

Lower back/hip exercises (Table 1, panel D)

Usability assessment There are 25 lower back/hip exercises designed mainly to stretch the muscles that act directly on the vertebral column (eg, the erector spinae), and also muscles that act as prime movers elsewhere, but impact on the vertebral column and lower back (eg, the hamstrings). The majority (78%) of the exercises had good instructions. However, many are potentially disruptive owing to time and posture requirements (standing, upper body movement). Nearly two thirds (60%) required a break of several minutes to perform, and 64% were judged to be highly conspicuous. Only four (92–95) were inconspicuous. Over one third (40%) of the exercises are moderately difficult or difficult to perform, especially for obese people, as these exercises involve touching the toes, or lifting the legs to the chest, from a seated position.

Physiotherapeutic assessment All of the exercises may be contraindicated for individuals with low back pain, degenerative disc disease or osteoporosis, or for women in the second or third trimesters of pregnancy, as extreme flexion or extension of the lumbar region is often required. A number of the exercises (60%)

reproduce the physical stresses of VDT work, primarily in producing additional loads to the lumbar region (see Figure 1 (b)). Over one third (36%) of the exercises posed safety hazards owing to the potential for an office chair, which is used as a support, to roll while the exercise is being performed (see Figure 1 (c)). Additionally, four exercises (87–89, 96) would be difficult to perform in most women's semi-formal office attire.

Knee/lower leg exercises (Table 1, panel E)

Usability assessment There are 17 knee/lower leg exercises. The primary intent of these exercises is to stretch muscles and to offset poor circulation associated with prolonged sitting and constrained postures. Nearly three quarters (69%) of the exercises had good instructions. However, all would disrupt work to some extent since either minibreaks, a standing posture, or use of both hands is required. Over half of the exercises (53%) are highly conspicuous and 41% are moderately difficult or difficult to perform.

Physiotherapeutic assessment Over half of the exercises (64%) are contraindicated for individuals with arthritic conditions of the hips and/or knees. Additionally, exercises 111 and 113–15 create the potential for a fall if adequate support is not provided during performance, and eight exercises (111, 113–15, 119–121, 124) would be difficult or impossible to perform for individuals wearing high heels or typical women's office attire.

Discussion

In general, the results of this evaluation showed that a considerable number of exercises recommended for VDT users have some features which would facilitate their acceptance and performance in a typical office

workplace. For example, the instructions for the majority of the exercises were clear, and most of the exercises were simple to perform.

The neck and elbow/lower arm exercises had the best overall evaluations on the five usability criteria. Most had clear instructions (58%), could be performed without leaving the chair (95%), were inconspicuous, or mimicked natural body movements (91%), could be performed in a brief period of time (56%), and were simple to perform (100%). On the other hand, the majority of the lower back/hip and knee/lower leg exercises were disruptive because they were highly conspicuous (58%) and/or required interruption of the work task to perform (ie, required standing posture or several minutes to perform). The shoulder exercises were intermediate in that they were judged positively on all the usability criteria except conspicuousness. A large number of the shoulder exercises (45%) were highly conspicuous, primarily because of the arm movements required.

Surprisingly, quite a high proportion (90%) of the exercises may be contraindicated for individuals with one or more acute or chronic musculoskeletal disorders, such as osteoporosis or lower back pain. Individuals with such conditions are advised to seek medical approval before performing these exercises. Of especial concern, however, was the finding that more than a third of the exercises (40%) appeared to reproduce or exacerbate some of the physical or biomechanical demands of VDT work, and that one out of seven exercises posed one or more safety hazards. The majority of these safety hazards were posed by the lower back/hip and knee/lower leg exercises. More than half (60%) of the back/hip exercises, and nearly half (45%) of the shoulder exercises, replicated the physical demands of VDT work, primarily through further stretching of already overstretched muscles of the spine and upper back.

Because the literature shows that musculoskeletal discomfort in VDT/clerical work is particularly acute for the back, neck and shoulder regions²⁷⁻²⁹ it is especially important that exercises for these regions satisfy basic design requirements facilitating their performance in the office environment. The present findings are not very promising in this regard. Many of the shoulder and back exercises were highly conspicuous and disruptive of the work process, and thus may meet with resistance by workers. More worrying was the finding that more than a third of the back exercises appeared unsafe to perform, and a sizable number of the neck, shoulder and back exercises (36-60%) appeared to exacerbate, rather than counteract, the physical/biomechanical stresses of VDT work. Apparently, the development of many of these exercises has proceeded without sufficient appreciation for office biomechanical and safety concerns.

While usability and safety criteria should be considered when designing an exercise programme for VDT users, to be fully effective the exercises must additionally combat the full range of musculoskeletal stressors encountered in VDT work. These stressors, and thus the best combination of exercises, will vary to

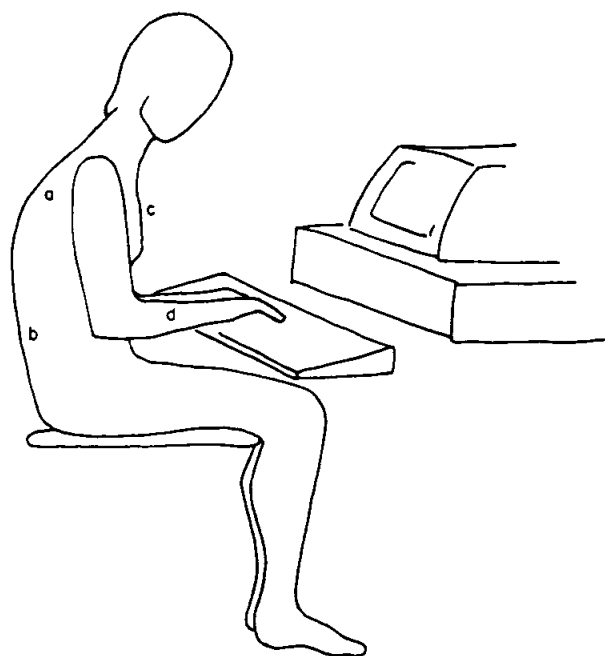


Figure 2 Muscle groups commonly requiring relaxation or activation after periods of continuous VDT work. (a) Chronically tensed scapular elevators require stretching and relaxation. (b) Spinal extensors of the lumbar, thoracic and cervical regions are overstretched and require activation. (c) Muscles of the anterior thoracic region are shortened and require stretching. (d) Forearm flexors are chronically tensed and shortened, and require stretching and relaxation

some extent according to the type of task performed. Table 1 was designed to present the results of our analysis in a manner which facilitates the selection of individual exercises for an exercise programme for VDT users. Following an analysis of the task to determine the muscles stressed by task demands, the "muscle groups" and "anatomical structures" columns of Table 1 can be consulted to select exercises to counteract these stressors. For example, Figure 2 illustrates a posture often assumed during VDT work. This posture results in chronically tensed muscles in the shoulders (ie, scapular elevators), forearms (ie, forearm flexors) and chest (ie, anterior thoracic muscles), as well as overstretched muscles of the back (ie, lumbar, thoracic and cervical regions). Table 1 can be consulted to identify exercises which stretch the chronically tensed muscles in the shoulders, forearms and chest, or contract the chronically stretched muscles of the back.

Regardless of the specific musculoskeletal stressors imposed by a particular VDT task, there are 'generic' stressors common to most VDT work (ie, constrained postures which impart static loads to the neck, back, shoulders and upper extremities, and which impair venous return from the lower extremities). To counteract these generic stressors, any exercise programme for VDT users should include the following components:

- 1 stretching of chronically shortened and tensed muscles to improve flexibility and circulation, and to reduce muscle fatigue;

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- 2 mobilization of the spine to help relieve stress on the lower back muscles and reduce compressive forces at intervertebral discs;
- 3 strengthening or contraction of chronically stretched and weakened muscles to increase resistance to fatigue and discomfort, and to promote better posture;
- 4 improvement of venous return from lower extremities.

The exercise programmes evaluated here focused primarily on the first of these components (stretching/relaxation), and often failed to address the remainder adequately. There is some evidence that strengthening exercises may be more useful than flexibility/relaxation exercises in preventing musculoskeletal discomfort in VDT users³⁰. However, such exercises are likely to be far more intrusive and demanding than flexibility or relaxation exercises, and require special employer-designated breaks and exercise areas.

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