OPNAV 5216/144A (Rev. 8-81)
S/N 0107-LF-052-2320

DEPARTMENT OF THE NAVY

Memorandum

5040
NREAD

DATE: 29 Sep 87

FROM: Director, Natural Resources and Environmental Affairs Division

TO: Base Forester
Wildlife Manager

SUBJ: INDUSTRIAL HYGIENE NOISE LEVEL SURVEY OF NATURAL RESOURCES AND ENVIRONMENTAL AFFAIRS DIVISION

Encl: (1) PMU, NAVHOSP ltr 6260.3a 371/87-340-3a of 21 Sep 87

1. As per the enclosure, please implement recommendations as requested.

Julian I Wooten

JULIAN I. WOOTEN

Copy for Charlie & Peter

I'll need short memo to C + P to present PMU recommendation for action.

Jack

(1) Attached is forwarded for ~~info~~/action.

2. Please initial, or comment, and return all papers to this office.

3. Your file copy.

B. C. Elton
By direction

"LET'S THINK OF A FEW REASONS
WHY IT CAN BE DONE"

ASSISTANT CHIEF OF STAFF, FACILITIES
HEADQUARTERS, MARINE CORPS BASE

DATE 9/24/87

TO:

BASE MAINT O	DIR, FAMILY HOUSING
PUBLIC WORKS O	DIR, BACHELOR HOUSING
COMM-ELECT O	BASE FIRE CHIEF
DIR., NAT. RESOURCES & ENV. AFFAIRS	

ATTN: Mr Wooten

1. Attached is forwarded for ~~info~~/action.

2. Please initial, or comment, and return all papers to this office.

3. Your file copy.

B W Elton
By dir

"LET'S THINK OF A FEW REASONS
WHY IT CAN BE DONE"

MCBCL 5216/21 (REV. 04-85)

JdW copy to Charles & Peter for action. 9-29-87

DEPARTMENT OF THE NAVY
NAVAL HOSPITAL
CAMP LEJEUNE, NORTH CAROLINA 28542-5008

IN REPLY REFER TO
6260.3a
371/87-340-3a
21 Sep 87

From: Commanding Officer
To: Commanding General, Marine Corps Base, Camp Lejeune, NC 28542 (Attn: AC/S Facilities)

Subj: INDUSTRIAL HYGIENE NOISE LEVEL SURVEY OF NATURAL RESOURCES AND ENVIRONMENTAL AFFAIRS DIVISION

Ref: (a) CO, NHCLNC ltr 6260.3a/371/87-152-3a dtd 29 Jun 87
(b) BO 6260.4A
(c) OPNAVINST 5100.23B

Encl: (1) Noise Level Data Sheets for 17 Aug 87/11 Sep 87

1. Introduction. A noise level survey was conducted at Bldg 1103, Forestry and Fish/Wildlife, Natural Resources and Environmental Affairs Division (NREAD) on 17 August 1987 and 11 September 1987. Results of the survey are contained in enclosure (1) and are submitted as an addendum to reference (a). Mr. Don Patton, (Environmental Health Technician) of the Industrial Hygiene Branch, Occupational Health and Preventive Medicine Department conducted the survey.

2. Equipment. This survey was accomplished using a Quest Sound Level Meter (SLM), Type II, Model 215, Serial No. M5080043. A Quest Calibrator, Model CA-12B, Serial No. U5080049, was used to calibrate the SLM before and after the survey each day. Electro-acoustical calibration of the SLM and calibrator was completed on 12 June 1987.

3. Findings. Enclosure (1) contains the noise levels of the various pieces of equipment used in Forestry and Fish/Wildlife, NREAD. Those items which generate noise levels in excess of 84 dBA are considered noise hazardous and hearing protection must be worn when the equipment is in operation, as required by reference (b).

4. Comments/Recommendations

a. When noise hazardous equipment is in operation, all personnel working within the hazardous radius, indicated in enclosure (1), are required to wear hearing protection.

b. Reference (c) requires that noise hazardous equipment and areas be labeled with hazardous noise decals, SN 0105-LF-212-6020 and/or 0105-LF-206-2605. Labeling was evident on most equipment.

c. The high noise level during operation of the truck, J-20, 800X264 could be reduced by replacing existing mud/snow tread tires with tires with an all-terrain tread pattern.

d. References (b) and (c) also require that personnel occupationally exposed to hazardous noise be given a one hour course of instruction in hearing conservation and appropriate refresher training annually thereafter. This training is available through the Hearing Conservation Branch, Bldg. 65 at extension 2767.


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SEP 23 1987

Subj: INDUSTRIAL HYGIENE NOISE LEVEL SURVEY OF NATURAL RESOURCES AND ENVIRONMENTAL AFFAIRS DIVISION

e. All personnel exposed to noise levels exceeding 84 dBA should be placed in or remain in the Hearing Conservation Annual Surveillance Program (HCASP). Since exposure time is so variable, further hazardous noise evaluations (dosimetry) will be performed in the future to provide personal data. These dosimetry results will be utilized to identify which individuals need to remain in the HCASP.

5. For additional assistance or information, contact Mr. Don Patton at extension 2707.

for M. P. GENTRY
By direction

Copy to:
Base Safety
Director, NREAD
Occupational Health Clinic

DATE 17 Aug 87/11 Sep 87

RECORDED BY D. R. PATTON

SIGNATURE D R Patton

COMMAND Marine Corps Base

BLDG/SHOP Bldg 1103 NREAD
Forestry and Fish/Wildlife

☒ MEASUREMENT TAKEN AT OPERATOR'S EAR

☒ CALIBRATIONS PRIOR TO AND AFTER SURVEY 1 DB

☒ INITIAL SURVEY ☐ RESURVEY ☐ OTHER

INSTRUMENTATION

	BLM	MIKE	CALIBRATOR
MFR	Quest		Quest
MOD	215		CA12B
SER	M5080043		U5080049
CAL	12 Jun 87		12 Jun 87

MEAS TAKEN: ☐ INDOORS ☒ OUTDOORS

WINDSCREEN: ☐ USED ☒ NOT USED

WIND: TEMP N/A PRES N/A

SOUND LEVEL DATA

LOCATION	EXP. TIME	NO. EXP.	TYPE NOISE	METER ACTION	DBA	DBC	LABEL Required	H/P TYPE	HAZ RAD (FT)
Forestry									
Generator, Honda GX140 Ser. 1728741	Variable	7	SS	S	71	76	No	N	N/A
Chainsaw, Echo Model 302S	"	7	SS	S	109	109	Yes	P&M	20'
Chainsaw, Echo Model 290 EVL	"	7	SS	S	106	108	Yes	P&M	20'
Chainsaw, Homelite Model SXL	"	7	SS	S	110	112	Yes	P&M	20'
Weedeater, Echo Ser. 0005492	"	7	SS	S	98	102	Yes	M	15'
Truck, J-20 4WD 800X264	"	7							
Windows open	"		SS	S	92	101	Yes	M	N/A
Windows closed	"		SS	S	85	96	Yes	M	N/A
Grinder, Milwaukee Mod. 6095	"	7	SS	S	96	94	Yes	M	10'
Fire Pump Forester B/S 5 hp	"	7	SS	S	88	83	Yes	M	4'
Fire pump Berkeley Ser # 7-733391	"	7	SS	S	100	106	Yes	M	12'
Wildlife									
Chainsaw, Homelite Ser #3D3220155	"	3	SS	S	106	108	Yes	P&M	20'
Chainsaw, Homelite Ser #3129276	"	3	SS	S	114	115	Yes	P&M	50'

NOTE TYPE NOISE - STEADY STATE (SS), INTERMITTENT (INT), IMPACT (IMP) Encl (1)
METER RESPONSE - ENTER 'F' FOR FAST, 'S' FOR SLOW
HEARING PROTECTION - PLUGS (P), MUFFS (M), PLUGS AND MUFFS (P&M), NONE (N)

SOUND LEVEL DATA						PROTECTION REQUIRED (ie: dBA L			
LOCATION	EXP TIME	No EXP	TYPE NOISE	METER ACTION	DBA	DBC	LABEL Required	H/P Type	HAZ (FT)
Wildlife (cont)									
Chainsaw, Echo Ser #0069426	Variable	3	SS	S	105	106	Yes	P&M	20'
Weedeater, echo Mod. SRM 200	"	3	SS	S	97	99	Yes	M	20'
Brush Cutter, HoffCo. Ser # 0019137	"	3	SS	S	95	97	Yes	M	15'

NOTES: *Range of levels noted by /; i.e., 102/109. At operator work stations, measure at ear level.*
METER ACTION: Enter F for fast meter action and S for slow meter action.

REMARKS *(i.e., Area and equipment posted, hearing protection in use, etc.)*

ASSISTANT CHIEF OF STAFF, FACILITIES
HEADQUARTERS, MARINE CORPS BASE

DATE 7-10-87

TO:

BASE MAINT O
PUBLIC WORKS O
~~COMM-ELECT O~~
DIR., NAT. RESOURCES & ENV. AFFAIRS
DIR, FAMILY HOUSING
DIR, BACHELOR HOUSING
BASE FIRE CHIEF

ATTN: Mr Wotten

(1) Attached is forwarded for ~~info~~/action.

Tmplate
File

2. Please initial, or comment, and return all papers to this office.
Copy to each Branch 20 July 87
with instruction

J dW

3. Your file copy.

By dir

"LET'S THINK OF A FEW REASONS
WHY IT CAN BE DONE"

MCBCL 5216/21 (REV. 04-85)

DEPARTMENT OF THE NAVY
NAVAL HOSPITAL
CAMP LEJEUNE, NORTH CAROLINA 28542-5008

IN REPLY REFER TO
6260.3a
371/87-152-3a
29 Jun 87

From: Commanding Officer
To: Commanding General, Marine Corps Base, Camp Lejeune, NC 28542 (ATTN: AC/S Facilities Dept.)

Subj: INDUSTRIAL HYGIENE SURVEY OF NATURAL RESOURCES AND ENVIRONMENTAL AFFAIRS DEPARTMENT

REF: (a) MCO 5100.8E
(b) OPNAVINST 5100.23B

Encl: (1) Baseline Industrial Hygiene Survey Report, Natural Resources and Environmental Affairs Department, Base Facilities, Camp Lejeune, NC (19 March, 30 April, And 18,20,21 May 1987)

1. By references (a) and (b), subject survey of the Natural Resources and Environmental Affairs Department (NREAD) was performed by Mr. Jeffery Jones (Industrial Hygienist) of the Occupational Health and Preventive Medicine Department, Industrial Hygiene Branch, on 19 March, 30 April, and 18, 20, 21 May 1987. On these days, a "walk-through" survey of the department's work spaces was conducted. In the future, additional hazard evaluations will be performed and these results will be forwarded as addendums to the baseline survey report.

2. The survey summary and findings/recommendations are given in enclosure (1). The summary contains the significant survey results and a Risk Assessment Code (RAC) summary for survey deficiencies.

3. The survey report contains an evaluation of the worksites and work practices found in the NREAD. This evaluation is based upon work process information, hazardous materials used in these processes, and control measures. The deficiencies are assigned a number, a RAC, and an appropriate corrective action.

4. The assistance from Mr. M. Martin and other personnel in performing this survey is greatly appreciated. Contact Mr. J. Jones at extension 2707 for assistance or information on this survey.

M. P. GENTRY
By direction

Copy to:
Director, NREAD
Base Safety

Baseline Industrial Hygiene Survey Report
Natural Resources and Environmental Affairs Department
Base Facilities,
Camp Lejeune, North Carolina
19 March, 30 April and 18,20,21 May, 1987

Occupational Health and Preventive Medicine Department
Naval Hospital
Camp Lejeune, North Carolina 28542

Encl (1)

I. References

(a) MCO 5100.8E
(b) OPNAVINST 5100.23B
(c) DOD 6055.5-M
(d) BO 6260.5
(e) BO 6260.4A
(f) BO 6240.5A
(g) BO 11090.1B
(h) MCO 5100.25
(i) MCO 6200.1D
(j) ANSI Z358.1=1981
(k) 29 CFR 1910.120
(l) 29 CFR 1910.134
(m) 29 CFR 1910.141
(n) 29 CFR 1910.1200

II. Summary

A. By references (a) and (b), the Industrial Hygiene Branch, Occupational Health and Preventive Medicine Department performed a baseline survey of the NREAD to review workplace operations identify/evaluate potential hazards, and recommend control measures for these hazards where necessary. The significant findings from this survey are:

1. A complete baseline noise survey of applicable equipment used by department personnel will be conducted in the future. As soon as the noise data is obtained, report(s) will be forwarded as addendum(s) to this survey.

2. All Hazardous Material Inventory Sheet Listings along with the Material Safety Data Sheets for each product noted will be reviewed by the Industrial Hygiene Branch. If any problems are determined, addendum reports will be forwarded as necessary.

3. By reference (h) and (n), a complete Hazardous Communication Program for each section of the NREAD should be implemented.

4. A Hearing Conservation Program should be implemented for personnel exposed to hazardous noise levels in accordance with reference (e).

5. A Respiratory Protection Program should be implemented for personnel who are provided with respirators in accordance with reference (d).

6. A survey will be conducted on ventilation hoods at the labatory as soon as the results are obtained and evaluated, a report will be forwarded as an addendum to this report.

B. References (a) and (b) discuss the use of hazard risk

assessment codes (RAC) as guidelines for the abatement of deficiencies. A summary of the RAC for Occupational Health deficiencies identified in this survey is given below:

		RAC
1	Critical	0
2	Serious	3
3	Moderate	7
4	Minor	0
5	Negligible	0
	Total	10

III. Findings

A. Workplace: Administration Section of Natural Resources Environmental Affairs Department (Bldg. 1103)

1. Process Description: Two civilian (1 male, 1 female) personnel perform general office duties in the Management of the NREAD. Duties include: typing, computer opeation/word processing filing, copying, reception, correspondence review/routing, and departmental management.

2. Evaluation:

a. Noise. Hazardous noise levels may be created by the typewriter/printer used with the word processor approximately thirty minutes, three days a week. The typewriter/printer will be included in the noise survey of the Department. Personnel should be provided hearing protection if requested.

b. Office supplies. Office personnel use "white-out", "magic markers", and are responsible for changing the toner cartridge in the copier. Exposures during these activities present no occupational health hazards due to short-term and infrequent use.

c. Cleaning Supplies. Secretary uses cleaning supplies such as glass cleaner and furniture polish infrequently and for short periods. Weekly cleaning is done by Base Maintenance personnel. No occupational health hazards are expected from NREAD personnel's exposure to these materials.

3. Deficiencies/Medical Surveillance: None

4. Comments/Recommendations:

a. Attachment (A) provides guidelines for the proper design of computer workstations used in the office. Please review this material and contact the Occupational Health and Preventive Medicine Department, Industrial Hygiene Branch, if additional information or assistance is needed.

b. Recommendations on noise exposure will be included as a part of the noise survey report.

B. Workplace: Environmentalist Branch (Bldg. 1103)

1. Process Description: Nine civilian (6 males, 3 females) personnel are responsible for the environmental monitoring and management of potable and waste water, solid and hazardous waste, spill response, environmental impact accessment, and soil erosion and sediment control.

2. Evaluation:

a. Spill Response. Personnel are called at times of oil or chemical spills to assume the role of the On-Scene-Coordinator (OSC) in accordance with reference (g). During spill response, personnel may be exposed to chemical or physical agents at short term and limited exposures. These are times that proper personal protection equipment may be needed i.e. hearing protection for noise, respirator protection for air contaminants, or gloves for skin contact of irritants.

b. Field Inspections. Personnel also perform field inspections to assure labels on hazardous waste materials are properly completed and materials are properly contained before sending to DRMO. Exposure to chemical and physical agents which may occur during these inspections are short term and limited. Personnel should be provided with personal protection equipment such as hearing protection, gloves, and respirators.

3. Deficiencies:

No	Reference	RAC	Corrective Action
152.1	9 CFR 1910.120	3	Establish a safety and health program for personnel who respond to chemical spills.

4. Medical Surveillence: By references (k) and (l), personnel should receive pre-placement medical exams for chemical spill response and respiratory protection use.

5. Comments/Recommendations: Personnel should be provided with and/or have access to personal protection equipment when conducting field inspections and responding to hazardous chemical spills in accordance with reference (k).

C. Workplace: Forestry Branch (Bldg. 1103)

1. Process Description: Eleven civilian (10 males, 1 female) personnel are responsible for timber management and protection, forest fire detection, prevention, and surveillance; and some general office duties i.e. typing, filing, copying, computer operation/word processing.

2. Evaluation:

a. Heat Stress. During the summer months, personnel are exposed to potential heat stress situations while performing duties outside. Recommendations given in reference (h) should be observed to prevent occurances of this type.

b. Noise. Personnel use hazardous noise producing equipment e.g. chainsaws, generators, weed eaters, water pumps. This equipment will be included in the noise survey of the Department. Recommendations will be given as part of the survey report.

c. Personal Protection Equipment. Personnel are provided with hard hats, protective/snake boots, NOMEX gear, fire tent, "emergency escape mask", and chainsaw chaps; none of which contain asbestos material. This equipment is provided for protection during forest fires and other field duties.

d. Flammable Materials. Personnel conduct controlled burning operations using a mixture of diesel fuel and gasoline which creates heavy smoke at times. Also, aerosal spray paints are used for tree marking. These jobs are done outside in the open, no occupational health hazards are expected as long as personnel continue to use personal protection equipment and handle these materials properly i.e. no spraying paints into the wind when sprays can be inhaled, use glove and goggles.

3. Deficiences:

No	Reference	RAC	Corrective Action
152.2	29 CFR 1910.134	2	Use of the non NIOSH approved "emergency escape mask" should be discontinued. A NIOSH approved compatible respirator should be used.
152.3	29 CFR 1910.1200 MCO 5100.25	3	Ensure personnel receive hazardous material training as part of the department's Hazard

			Communication Program.
152.4	29 CFR 1910.1200	3	Obtain and retain MSDS on all hazardous materials used by Forestry personnel.

4. Medical Surveillance: By references (c) and (h), personnel should receive pre-placement medical exams for heat.

5. Comments/Recommendations:

a. Reference (h) should be used as a source document for heat stress training of personnel.

b. Recommendations on noise exposure will be included as part of the survey report.

c. Attachment (A) provides guidelines for the proper design of computer workstations. Please review this material and contact the Industrial Hygiene Branch if additional information or assistance is needed.

D. Workplace: Fire Towers #1 - Hubert, #2 - Sneads Ferry, and #3 - Combat Town

1. Process Description: One or two civilian (both male) personnel perform forest fire surveillance in any one of the three fire towers during the fire seasons of the year (Hubert Tower was surveyed).

2. Evaluation:

a. Heights. To reach the observation room at the top of each tower, personnel must climb stairs at heights of 86 feet and greater. The steps on the stairs are metal and could become slippery when wet. They are also steep which could also lead to a slipping hazard.

b. Noise. Hazardous noise at various levels are created when low flying jets and helicopters pass overhead and when armored vehicles pass below. This site will not be included in the noise survey due to personnel's short term and infrequent exposure to noise of this type.

3. Deficiencies: None

4. Medical Surveillance: Personnel who man the towers receive annual medical exams for fireman.

5. Comments/Recommendations: No "walk-through" was performed at the other towers because only one tower is occupied at any one time and basicly the same activities go on at each tower.

E. Workplace: Fish and Wildlife Branch (Bldg. 1103)

1. Process Description: One military (male) and three civilian personnel (all male) work with wildlife management, control and protection of wildlife and archaeological/historical resources, and conservation of fish and wildlife.

2. Evaluation:

a. Noise. Hazardous noise levels may be created by equipment used by personnel. This equipment will be included in the noise survey of the department and an evaluation will be made when the survey has been completed.

b. Heat Stress. During the summer months heat stress is a major problem due to the amount of work that is done outside in the forest and around the rivers and ponds. Consult recommendations given in reference (h) to prevent any possible occurance.

c. Herbicide/Seed germinator/Formaldehyde/Paint. A herbicide is used for weed control. Clover seeds with a chemical germinator are planted for seed food ploting. Formaldehyde is used to preserve organ specimens from wildlife. Trees are marked by brush painting a ring around them to indicate indangered species sites. Lead chromate in the tree marking paints and formaldehyde are human carcinogen and suspect human carcinogen respectively. The use of these materials should be discontinued and/or substituted if possible. 3M 9920 "single-use" respirators are provided for protection against dust during seed food ploting operation.

3. Deficiencies:

No	Reference	RAC	Corrective Action
152.5	29 CFR 1910.1200 MCO 5100.25	3	Ensure personnel receive hazardous material training as part of the department's Hazard Communication Program
152.6	29 CFR 1910.1200	3	Obtain and retain MSDS on all hazardous materials used by fish and wildlife personnel.
152.7	29 CFR 1910.134	2	A written respirator program should be established for respirators provided

for personal use.

4. Medical Surveillance. By reference (c), (d) and (h); personnel should receive pre-placement medical exams for heat, formaldehyde, and respiratory protection.

5. Comments/Recommendations:

a. Reference (h) should be used as a source document for heat stress training of division personnel.

b. Recommendations on noise exposure will be included as part of the survey report.

c. If substitutes cannot be made for the paints and formaldehyde, personnel should be provided with and required to use gloves, goggles, and respirators.

F. Workplace: Environmental Chemistry and Microbiology Lab (Bldg. 65)

1. Process Description: Four civilian (2 males, 2 females) personnel are responsible for conducting laboratory analysis to monitor water, waste water, and indentify hazardous waste. The lab is also involved with the PCB Program and responds to hazardous material spills. Personnel perform general office type duties e.g. typing and filing.

2. Evaluation:

a. Chemicals. Various chemicals are used in conducting approximately 51 different laboratory analysis. The written procedures have instructions which include safety and health precautions on the correct use and handling of these chemicals to reduce or prevent exposure. In the future, the Material Safety Data Sheets on these chemicals will be evaluated and air sampling will be conducted to evaluate personnel exposure to various chemicals. Report(s) on results will be forwarded as addendums to this survey. Personnel should handle these chemicals in accordance with the precautions and use adequate personal protection equipment when handling.

b. Ventilation. A ventilation survey on the hoods in the lab will be conducted in the future. As soon as the data is obtained a report will be forwarded as an addendum to this report.

c. Cleaning Supplies. One day per week during "field day" of the lab, personnel use cleaning supplies such as: glass cleaner, bacterial creme cleanser, floor wax, and deodorants. Care should be taken to avoid mixing these compounds and personnel should wear gloves and goggles to prevent possible eye and skin irritation.

d. Personal Protection Equipment. Personnel have access to and are provided with disposible coveralls, hoods, foot covers, gloves, aprons, half-mask respirators, and chemical splash goggles for use in the lab, on spill response, when obtaining PCB samples, and other lab and field procedures.

e. Office Supplies. Personnel use inks and white-out which pose no occupational health hazard based on present information.

f. Freon. The liquid form of freon 113 (1,1,2-trichloro-1,2,2-trifluoroethane) is used in the oil and grease analysis. Small amounts are used and the analyses are conducted under a lab hood. Therefore, the possibility of freon creating an oxygen deficient atmosphere is unlikely. Continue to use it under the hood with gloves to protect the skin from contact.

3. Deficiencies:

No	Reference	RAC	Corrective Action
152.8	29 CFR 1910.1200 MCO 5100.25	3	Ensure personnel receive hazardous material training as part of the department's Hazard Communication Program.
152.9	29 CFR 1910.1200	3	Obtain and retain MSDS on all hazardous materials used by EC and M Lab personnel.
152.10	29 CFR 1910.134	2	A written respirator program should be established for personnel use.

4. Medical Surveillance: By reference (c) and (d), personnel should receive pre-placement medical exams for chemical spill response; respiratory protection use, and freon 113.

5. Comments/Recommendations:

a. Refrigerators used for hazardous materials should be labeled "NOT FOR FOOD". The one used for food items should be labeled "FOOD ONLY" in accordance with reference (m).

b. All hazardous material waste in the lab should be turned over to DRMO for disposal. If chemical products/ materials are infrequently used; they should be turned into Supply for possible re-use.

c. The eye wash/shower units in the lab should be maintained in accordance with reference (j).

d. Recommendations on the noise and ventilation surveys will be included as part of the addendum report on this survey.

e. Contact Insect Vector Control for the correct use and handling of pesticides used by lab personnel.

Am. Ind. Hyg. Assoc. J. 44(6):437-446 (1983)

Working Posture and Musculoskeletal Problems of Video Display Terminal Operators — Review and Reappraisal

ROBERT ARNDT, Ph.D.
Department of Preventive Medicine, University of Wisconsin, Madison, WI 53706

In order to minimize the stresses on the musculoskeletal system, attempts have been made to develop design guidelines for video display terminal workstations. Evaluations of VDT workstations reveal that many of the health problems experienced by operators might be attributed to awkward postures caused by lack of consideration of these guidelines. In other cases, it may be a matter of specific individuals not fitting "average" workstations. This has led to an increasing emphasis on designing adjustable workstations which can be adapted to the individual worker's needs. Even when guidelines are followed and workstations are adjusted to fit individuals, a variety of postural complaints may arise. One of the most important contributing factors is the constraint which is typically placed on the posture of the VDT operator. Many tasks lead to prolonged static positioning of the back, neck, arms and legs; producing rapid fatigue and increasing the risk of chronic problems. Another factor which must be considered is the effect of repetitive motion patterns which could lead to disorders in the muscles, tendons, nerves and joints. Finally, the effects of job pressures must not be overlooked as a potential contributing factor in postural complaints.

Introduction

Numerous reports of postural problems among VDT operators are available.[1-11] Problems range from complaints of discomfort, to pain and medical disability. The most frequent sources of complaints are the back, neck and shoulders. Less frequent complaints concern the arms, wrists, hands and occasionally the legs.

The occupational causes of many of these problems have been recognized and studied in the past, but the introduction of the video display terminal has led to increasing numbers of complaints and renewed interest. Part of the increased concern about health problems can be attributed to the sheer magnitude of the number of people working at VDT's. It was estimated that more than 7 million Americans already worked at VDT's in 1979.[12] In view of the accelerating trend toward office automation and information processing, the current number is certainly much higher.

All of the postural problems attributed to VDT's are not necessarily unique. Similar problems have been associated with other clerical tasks[13-18] and a variety of industrial jobs.[15 17,19,20] A limited number of studies have compared postural complaints of VDT users with those of nonusers. While several researchers[1,5,10] have reported a higher incidence of problems among VDT users, others have found very few differences.[4,6,8,9,11] Other studies have found that the frequency and type of problems are more closely related to the nature of the VDT task than to the use of VDT's *per se*.[1,5,9,10] These studies are summarized in Table I.

While it is clear that postural problems and musculoskeletal complaints are not limited to VDT work, it can be concluded that the unique characteristics of VDT equipment, workstations and tasks must be considered as additional contributing factors. Examples of these characteristics are the vertical orientation of the screen, increased space requirements, and limited mobility of equipment. In addition, the introduction of VDT equipment has in many cases accelerated the trend toward more simplified and repetitive tasks which may lead to greater postural constraints.

Working Position and Workstation Design

Any working position places a load on the musculoskeletal system. Discomfort, fatigue, pain and disability are affected by the amount, duration and distribution of the load. While the amount of effort required to maintain the various postures involved in VDT work depends upon the position of the trunk, the limbs and the head, the maximum capacity of the musculoskeletal system is ordinarily not approached, even in the most extreme positions. However, such jobs often involve prolonged periods of constrained posture characterized by static loading of muscles. Under such conditions blood circulation may be reduced, preventing the proper supply of nutrients to the muscles and removal of muscle activity by-products, leading to rapid fatigue and pain. If these conditions persist on a daily basis, the result may be chronic problems often including the joints and tendons.[17] To avoid such problems, the workstation must be designed to minimize muscular loading. To avoid the long term effects of static loading, relief in the form of movement or variations in posture must be provided.

One of the most frequently mentioned sources of postural problems is the improper design of workstations and equipment.[1,2,4-8,10] These design inadequacies cause workers to adopt awkward and inefficient working postures that lead to discomfort, pain, and eventually chronic health problems. A number of specific design inadequacies which could cause problems have been identified (Figure 1).

Guidelines and Recommendations

One of the most difficult of these problems in most VDT workstations is the position of the operator in relation to the work table, display and keyboard. Numerous guidelines and

ATTACHMENT (A)

TABLE I
Results of Studies Related to Musculoskeletal Problems Among VDT Operators and Related Occupations

Occupations	Results	Reference
Professional and clerical VDT operators, control group	Clerical VDT operators reported more problems (back, arms, neck, hands and shoulders) than either professional VDT users or controls.	1
VDT operators	Neck, shoulder and back pain increased during the work day.	3
VDT operators (programmers, supervisors, secretaries, clerks, data entry, word processors) Matched control group not using VDT's (except programmers)	VDT users consistently reported higher (but non-significant) number of neck, shoulder and back problems. No differences between VDT and controls for hand-arm problems. Data entry VDT operators reported more hand-arm problems than other VDT users, which were not related to amount of time using VDT's.	4
VDT operators (data entry, conversational) Controls (typists traditional office work)	Data entry VDT operators reported more neck, shoulder and arm problems. Conversational VDT typists, operators and typists reported same number of problems. Traditional office workers reported fewest problems.	5
VDT operators (copy typists, clerical workers, programmers, editors)	Complaints of neck and back problems depended upon type of work. Complaints were highest among copy typists. Controlling for the type of task, the number of complaints were not much different than non-VDT workers.	6
VDT operators (editors) Controls	Both groups reported neck problems, but no significant differences were found between VDT users and controls on any reported musculoskeletal problems.	8
VDT operators (data acquisition, dialogue)	More frequent complaints by data acquisition operators related to neck, shoulder and back pains.	9
VDT operators (input, creative, editors, conversational) Controls	Muscular discomfort in arms, neck and shoulders reported more frequently by input and creative operators.	10
VDT operators (telephone operators) Controls (telephone operators)	No differences between VDT and non-VDT workers when groups were age-matched.	11
Accounting machine operators, saleswomen	More complaints about hand and arm problems for machine operators. No differences found between operators and saleswomen for neck, shoulder or back problems.	13
Cash register operators, office machine operators, other workers	Cash register operators had more low back, shoulder, arm, neck, wrist, hand and finger pain.	14
Telegraphists	Adverse postures were usually associated with symptoms in hands, arms, neck and shoulders.	18

standards have been developed, specifying dimensions considered to be appropriate for equipment and workplace arrangements. Some of the more common recommendations are illustrated in Figure 2.

Critical reviews of these standards and guidelines indicate that there is not always complete agreement on recommended dimensions[22,23] and that many are based upon extrapolations from earlier office and industrial workstation guidelines, often without supporting data.[23] In fact, there appears to be very little research data available concerning relationships between VDT workstation design and postural complaints. Most of these guidelines are, therefore, based on anthropometric data, biomechanical principles, observations, and previously accepted guidelines for the design of workstations. Until further research results become available, these guidelines will in most cases continue to provide the best available information concerning desirable workplace dimensions. More importantly, these guidelines serve

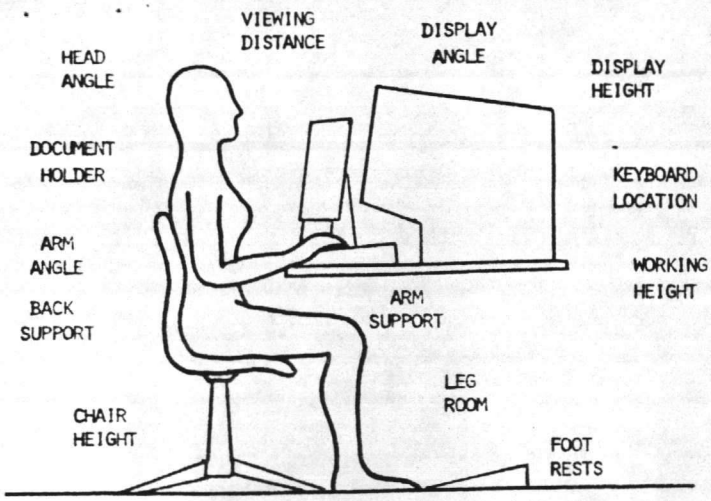


Figure 1 — Factors which may affect musculoskeletal complaints.

the purpose of drawing attention to what are probably the most critical variables to consider when musculoskeletal complaints exist. This approach is taken in the following discussion.

The interface between the operator and the VDT workstation occurs at three points: (1) the hand and keyboard (and in some cases other materials), (2) the body and chair, and (3) the eyes and screen (or other documents). When these relationships are not properly established, awkward and stressful postures usually occur.

Keyboard Location

Keyboard height is usually determined by the available work table and in most cases is not adjustable to any significant degree. Keyboard position is, therefore, a logical starting point for an analysis of working position. Numerous studies have shown that chair height is highly correlated with keyboard height, more so than any other relationship such as viewing angle.[5,24-26] According to most recommendations, the chair height should be adjusted so that the forearms are approximately parallel to the floor. This recommendation is apparently based on several early (nonkeyboard) studies which reported that performance,[15,27] discomfort[27] and energy expenditure[15] were minimized at this height. Observations and studies reveal that this is seldom the case at VDT keyboards, however.[5,25,26,28] In almost all cases, the forearms are raised between 5° and 30°.[5,26,28] This has suggested to many that the tables are too high. Studies which have included measurements of table heights have indeed found that tables are much higher than the recommended level of 720-760 mm.[5,29,30] This finding, along with the correlations between keyboard height and chair height, and the fact that chairs were completely adjustable within a range allowing operators to select horizontal forearm positions, strongly suggests that operators prefer such a forearm position (*i.e.*, elbows lower than hands). Thus, operators adjust their chairs in relation to keyboard height, but select heights which result in forearm angles between 5° and 30°. This position is illustrated in Figure 3. It is not clear whether this preference is based upon performance or comfort criteria. At least one study has reported fewer hand and arm complaints among operators working at higher keyboards, although the authors suggested that this finding reflected the fact that those operators rested their arms more frequently.

In another study it was reported that telephone operators lowered their chairs in order to rest their arms. This resulted in forearm angles between 5°-35° with very few complaints of arm or hand discomfort.[28] Another possible determinant of arm angle may be the keyboard angle. Keyboards are typically angled 5-20 degrees. If the forearm angle matches the keyboard angle, the biomechanics of arm movements are simplified and wrist flexions and extension are reduced. An early study involving a simple manual task, reported that performance at an angle of 12° was superior to that at either 0° or 18°.[31] Another study reported that operators who could adjust keyboard angles, selected angles between 14° and 25° with a mean of 18°.[26] Thus, keyboard angle may be critical in the selection of a preferred forearm angle and consequently may affect the relationship between table and chair heights. While this variation in task requirements may account for the difference between observed and recommended working positions, it is in fact, not inconsistent with studies which apparently, form the basis for most guidelines. The studies which suggested that working height should be slightly below elbow height on the basis of performance, metabolism and comfort actually, reported very small differences (*e.g.*, 2-6%).[15,27] These results are also not inconsistent with electromyographic studies. The single published study involving measurements of muscle activity in the arms during typing reported that no differences in muscular activity were found for keyboards located at elbow height and those which were higher.[32]

These studies suggest that there is little or no empirical evidence supporting the recommendation that the forearms be positioned parallel to the floor. At the same time, the preponderance of evidence suggests that the preferred arm position is one in which the hands are higher than the elbow. This certainly has implications for the proper selection of table and chair heights, and possibly keyboard angles. Furthermore, these studies would suggest that the

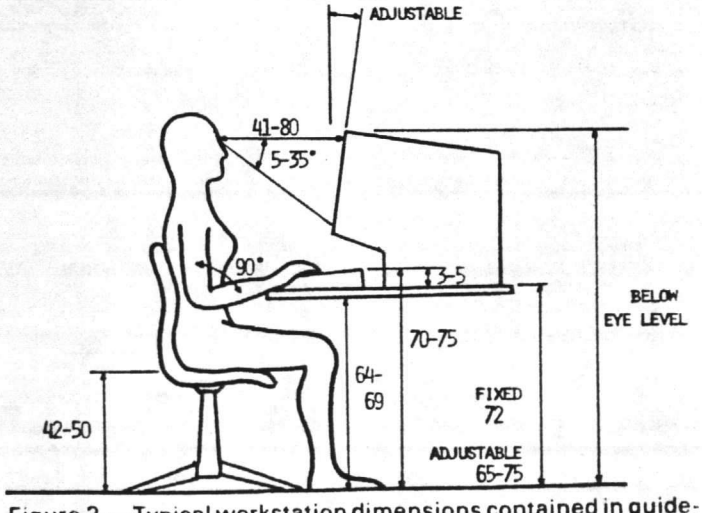


Figure 2 — Typical workstation dimensions contained in guidelines, standards, and recommendations.[6,22] Some values may disagree since the figures represent the range of dimensions included in various sources. All measurements are centimeters.

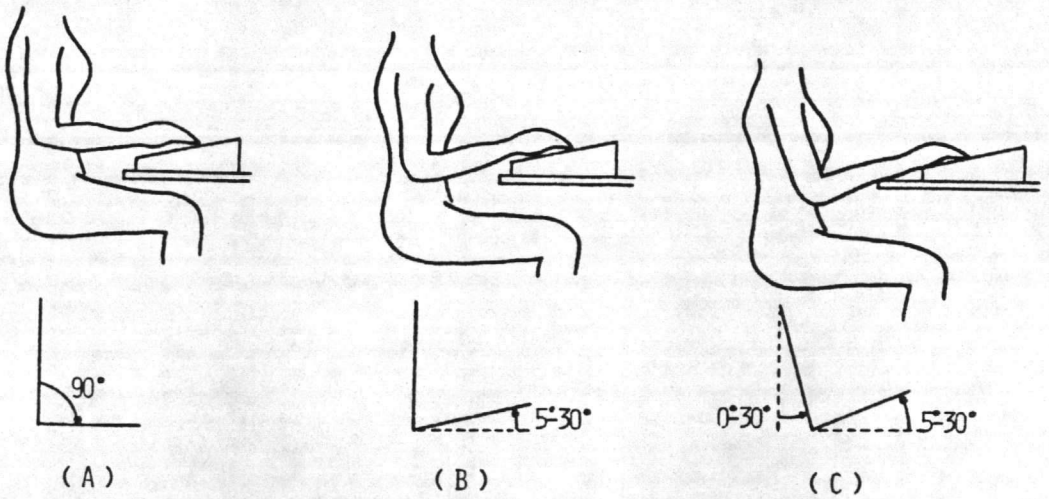


Figure 3 — Arm position in relation to keyboard: (A) generally recommended arm angle at 90°, forearm horizontal; (B) typical observed arm position,[5,28] forearm elevated 5°-30°; (C) typical observed arm position,[5,28] upper arm abducted up to 30°, forearm elevated 5-30°, arm resting.

opportunity to rest the hands and arms might be more important than the actual forearm position and that a more important cause of upper extremity discomfort might be the fatigue and pain involved in holding the arms in a fixed position. Since certain jobs (*e.g.*, data entry) offer less opportunity to rest the arms, future recommendations should also take into account the type of work being performed.

The distance of the keyboard from the operator will also affect comfort. The farther an operator must reach, the greater the load on muscles and tendons of the arms, shoulders and back. The most restful position for the upper arms is straight down. Extending the arm forward by as little as 4 inches can accelerate the time to reach fatigue by a factor of 2, and an extension of 8 inches can result in substantial fatigue in less than 10 minutes.[33] Arm or elbow rests extend these times considerably.[33] Inadequate leg room may cause the operator to sit too far from the keyboard and increase the required reaching distance. Keyboards which are attached to displays may also make it difficult to simultaneously achieve comfortable arm positions and viewing distances.

Additional problems related to working height occur when other tasks are involved. For example, a comfortable height for keying will often not be a comfortable height for writing. In many cases workstations with several different working heights may be desirable.

With a fixed keyboard height, taller workers will find it necessary to lower chairs while shorter workers will have to raise their chairs. In order to prevent excessive pressure on the underside of the thighs, footrests must be provided for shorter workers. These should be adjustable, movable, and large enough to allow the operator freedom of movement and variations of position. The preferred alternative is to provide adjustable work tables or a selection of tables with different fixed heights.

Chair Design

Consideration must also be given to the design of the chair itself. Poorly designed chairs can be a significant source of operator discomfort.[34] At least one study has found that perceived chair discomfort is one of the best predictors of musculoskeletal complaints.[4] High back chairs are preferred by workers in many cases,[5,35] and can, if correctly designed, provide proper lumbar support while sitting in an upright position. The high backrest allows the operator to occasionally lean back, resting the back muscles and relieving pressure on the lumbar discs.[36,37] The types and ranges of adjustments available should be considered in the selection of chairs. The more difficult it is to make adjustments, the less likely it is that they will be made. Chairs equipped with pneumatic cylinders may prove beneficial for this reason.

Display Screen Position

Proper positions for the display screen, source documents, and other materials must also be determined. Complaints concerning pain and discomfort in the neck muscles are frequent enough to suggest that the position and attitude of the head must be carefully considered.[1-3,5,6,9,10,14] A number of studies have reported relationships between head angle and the frequency of reported musculoskeletal complaints.[4,5,10] An early study (not involving VDT's) reported that the most comfortable viewing angle was one which placed the line of sight between 32° and 44° below the horizontal.[38] These researchers reported that about half of this angle was due to bending the head forward, and half was due to lowering the eyes. Another study found that fatigue increased dramatically if the head was tilted more than 30°, and that muscular fatigue (with cramping and intermittent "hot" pain) occurred in about 3 hours with a 45° head tilt and in 2 hours with a 60° head tilt.[33] Most recommendations for VDT screen positions are consistent with these findings although possibly over restrictive. In order to obtain suitable eye-screen relations simultaneously with arm-keyboard relations, it is often necessary to adjust each separately. This would require separation of the keyboard and display in many cases as well as work tables which allow individual adjustments for each.

Document Placement

Observations of many VDT tasks suggest that a more important source of stress on the neck muscles may be the improper

placement of source documents. Documents placed flat on the table will generally cause the operator to lean forward and extend the neck. In many cases the head will also have to be turned to view the documents. Most of these problems can be prevented through the proper placement of documents and the use of special holders. The type of task will determine the most appropriate location. If the majority of work involves the source document it may be advantageous to place the document in front of the operator and the display off to the side. Several new terminal tables have accommodations for document placement below the VDT screen.

Operators who must look at the keyboard may have particular difficulty with neck problems since an angle of sight approximately 60° below the horizontal is required. Because the keyboard cannot reasonably be moved to any extent without creating other problems, the only solution is to try to reduce the amount of time spent viewing the keyboard. Additional operator training and the selection of well-arranged keyboards may be helpful in this respect.

In many tasks, the operator must have room to spread out reference materials, computer printouts, or other materials. Standard desks, typewriter tables, and some adjustable workstations do not provide such space because of limited table space, restricted movement of the chair or inadequate leg room. As a result, the operator will be observed twisting, leaning and reaching much of the time.

Display Considerations

Finally, the visual quality of the display and the environment must be considered. The best efforts to provide a well-designed workstation may be negated by difficulties in seeing the display. The poor quality of the image on the screen (*i.e.*, size, clarity, contrast and brightness) may cause the operator to lean forward in order to see more clearly. It is also not unusual to observe operators leaning forward, sitting off to the side, or slouching down in their chairs in order to avoid reflections on the screen or overhead lights which shine directly in their eyes. The selection of higher quality displays, proper illumination controls, and adjustable screens are thus important considerations for meeting postural as well as visual requirements of VDT work.

Working Position and Work Tasks

There is evidence that the type of tasks being performed may be as important if not more important than the design of the workstation, or even whether a VDT is being used. It has been shown that both the average working position and the degree of variability in the posture of VDT operators are dependent upon the type of task.[39] As has already been indicated, many VDT studies have found that the type and number of musculoskeletal complaints are also dependent upon the nature of the work being performed.[1,5,6,9,10] The obvious fact is that both the design of the workstation and the type of tasks being performed must be considered in the evaluation of working posture. The type and duration of the different tasks involved in a job determine how much time will be spent at more or less physically stressful tasks and consequently what the likelihood of developing various problems will be. The type and organization of tasks will determine how much time will be spent keying, looking at the screen, looking at documents, and performing other non-VDT work, as well as the degree of postural constraint involved in the job.

All of these considerations lead to the conclusion that no single workstation layout will be optimal for all jobs. This fact provides one of the strongest arguments against the development of rigid standards (in contrast to guidelines) which must be applied to all VDT workstations. While standards probably provide a greater incentive to implement design changes, and are easier to enforce, the unequivocal application of many of the existing guidelines or recommendations could be of questionable value in some cases. Some examples are presented below.

1. Most guidelines for workstation dimensions do not take into account the amount of time spent at different tasks. This is especially important when a conflict between different health considerations exist. For example, it has been reported in two cases that higher worktables offered more opportunities to rest the arms.[5,28] The distribution of time spent viewing documents and the display will also determine the optimal position of each. The amount of time spent keying versus reading or writing will determine the proper location for the keyboard.
2. The frequently recommended secretarial chair, with a small backrest, may be inappropriate when the freedom of arm movement necessary to perform other tasks is not required. In contrast, a high backrest provides better support when operators find it desirable and possible to lean back occasionally. A number of manufacturers already offer chairs with high but narrow backrests which do not restrict arm movements. The most desirable types and ranges of adjustment for chairs will also depend upon the task and the type of use. Greater ranges and types of adjustment are much more important in jobs which require operators to sit for long periods of time, or in those cases in which a number of different operators might use the same chair. In both of these situations, the ease of adjustment will also be important.
3. The flexibility and adjustability of worktables also depend on the type of use. Tables used by a single person may only have to be adjusted once. If more than one person must use a terminal station (*e.g.*, different shifts) easy adjustability becomes more important. As an alternative, worktables of different heights may be made available so that operators can select a comfortable workstation.

Working Posture and Personal Attributes

The health, attitudes, habits and motivation of individual workers can adversely affect the posture assumed at a workstation. Existing musculoskeletal and visual disabilities may place severe restrictions on the working position of the operator. For example, operators who are experiencing neck

pain may be unable to tilt their heads at all, or those with back pain may require special chairs.

Visual deficiencies cause a number of frequently observed problems. Near-sighted operators (myopics) may have to lean forward to see clearly since the display usually cannot be moved closer to the eyes in the same manner that hard copy can. Presbyopia, which occurs to some extent in nearly all individuals over the age of 40, also causes special problems. This reduction in the ability to focus the eye (accommodation) for near vision is usually corrected with reading glasses, bifocals or trifocals. If the lenses are prescribed to allow clear vision at a normal reading distance of about 33 cm, the VDT operator will have to lean forward since most screens are located at distances in excess of 50 cm. Furthermore, if the range of accommodation is severely restricted the individual will have to maintain a fixed head position, accelerating the rate of fatigue. Static positioning of the head will also occur with bifocals or trifocals since only a small portion of the spectacles provide clear vision at a given distance. Bifocal wearers can usually be easily recognized by the backward tilt of their heads. Special working glasses are often helpful but not always acceptable to operators since everything beyond the screen may be blurred.

Most VDT operators have not been adequately trained and educated concerning the way to properly adjust equipment or the advantages of proper adjustment. For operators, the short-term consideration for performing work in the easiest way generally takes precedence over performing the work in the healthiest way. These two criteria are often not compatible. There is a tendency, for example, for operators to place documents where they can be easily manipulated which may make them hard to read. As work pressure increases, so also does the conflict between efficiency and health. Workers will often forego regular rest breaks in order to complete work more quickly, expecially when certain production standards must be met. Failure to take breaks at regular intervals reduces the effectiveness of the rest period as a method of preventing fatigue.

Job Design, Administrative Procedures, and Working Posture

Video display terminals frequently signify the automation of offices. Simplification of work, machine pacing, increased work loads, production standards, and even wage incentive plans are frequently introduced in order to increase productivity and provide returns on equipment investments. As a result, more time is spent at the same task and at the same workstation. Opportunities for periodic breaks, provided by non-VDT tasks such as obtaining information, making copies, communicating with others, and transmitting information, may be reduced considerably since many of these functions can now be performed at the terminal. As a result, greater and greater postural constraints are imposed on VDT operators. Increased work paces and high productivity obligations lead to even greater tension in postural muscles and further immobilization.[7,32,40]

In order to overcome these difficulties, careful consideration must be given to the design of jobs and the scheduling of regular rest breaks. While some recommendations for scheduling of breaks have been proposed,[12] none are backed up by substantive data. All that can be said with certainty is that as the VDT work becomes more intensive, more breaks will be required. Whenever possible, non-VDT tasks should be interspersed through the day in order to avoid prolonged intensive periods at the video display terminal. In some situations, stand-up workstations which operators can use periodically, may be a successful way to reduce postural fatigue.[28]

In order to maximize the effectiveness of the adjustable features of VDT's, tables and chairs, operators should be thoroughly familiarized with proper adjustment procedures. Furthermore, the problems associated with improper and constrained postures should be explained to operators. Finally, management must provide assurances that adequate time will be allowed to make such adjustments and that equipment will be properly maintained, or improved if necessary.

Repetitive Motion Injuries

A variety of problems, generally referred to as repetitive motion disorders, may occur in conjunction with other musculoskeletal complaints. It has long been recognized that repetitive motion of the fingers, hands and arms may lead to disorders such as tendinitis, tenosynovitis, carpal tunnel syndrome, myositis, bursitis and ganglion cysts.[41-43]

Unaccustomed repetitive motion patterns are especially likely to result in such disorders, placing new workers or those returning from leave at particularly high risk. The position of the arms, wrists and hands also play an important role. For example, flexion, extension and deviations at the wrist joint tend to increase pressure on the median nerve in the carpal tunnel.

The repetitive motion patterns involved in keying operations have been associated with such disorders.[13,18,41,44-46] It is not unusual for some operators to perform at rates exceeding 12 000 keystrokes per hour. Since keying is typically not equally distributed over the ten fingers, certain tendons may bear a majority of the load. In addition, some operators may flex and extend their wrists with each keystroke. Poor workstation arrangements may cause operators to continuously hold their hands in awkward positions, increasing the risk of injury.[5,18,47] Each finger and wrist flexion causes stretching and movement of the flexor tendons which pass through the wrist close to the median nerve, making the wrist an especially likely site of problems. Many of these disorders can be temporarily disabling.

Prevention and control of these problems can be accomplished in several ways. First, special attention must be given to the position of the hands and arms in order to reduce deviations of the hands as much as possible. Attention should be given to the selection of arm or handrests which do not contribute to deviations of the wrists. Secondly, the repetitiveness of work can be reduced through "enlargement" of jobs or rotation to less repetitious jobs. Thirdly, periodic rest breaks may delay or counteract the effects of the repetitive stress. Finally, careful attention should be given to early signs of problems such as discomfort, numbness, tingling and soreness. Repetitive motion disorders are

generally progressive, and these early signs should be considered as indicators of more serious and potentially disabling injuries.[45] Temporarily placing these workers on less repetitive tasks may prevent further injury, and often leads to complete recovery.

Stress Reactions

Finally, the potential effects of stress as a contributing factor in muscular complaints must not be overlooked. Several studies have revealed correlations between stress complaints and musculoskeletal symptoms.[1,6] This should not be unexpected, since the natural autonomic response to stress involves tensing of the muscles. Working under stressful conditions can lead to a constant state of muscular tension. A common complaint of workers experiencing stress is tension in the neck muscles, which leads to headaches. In view of the earlier discussion concerning working positions which place a load on the neck muscles, it becomes easier to see why this group of muscles is so often a source of discomfort and complaints. The combination of these effects often make it difficult to isolate the real causes of postural complaints.

Some of the characteristics of VDT work which have been associated with job stress include: lack of control imposed by machine pacing, "unfriendly" systems, software features which restrict acceptable procedures, excessive monitoring of work output, repetitious and monotonous work, and unrealistic work standards.[1,4,6,48-50]

A Problem Solving Approach

From the foregoing discussion, it is evident that complaints and medical complications related to working postures at video display terminals do occur. Many of the causes of these problems can be clearly identified while others are obscured by the lack of adequate research, the variability of different task and postural requirements, and the interaction of various factors.

The proper and efficient solution to such problems must be preceded by a complete systems analysis of the equipment, environment, demands of the job, and needs of individual workers. It should not be expected that strict adherence to published guidelines, recommendations or standards will automatically eliminate complaints of discomfort and pain, or disabilities. The perfunctory application of such recommendations may lead to unnecessary costs and unsatisfactory results.

Information Gathering

The first step involved in arriving at a reasonable approach to reducing the incidence of postural complaints is the collection of accurate and detailed information concerning the nature, frequency, seriousness and possible causes of problems. This will include: (1) obtaining information from operators through surveys or interviews, (2) observing workstation characteristics and environmental conditions, and (3) analyzing task requirements.

(1) *Operator surveys and interviews.* Certain types of information must be collected directly from operators. The first includes information related to the type of musculoskeletal problems experienced. This information should be collected in such a way that assessments can be made concerning the type of problems occurring, their frequency, and their seriousness. It will be helpful if problems can be qualified as fatigue, discomfort, pain or disability. One of the most useful techniques for gathering such information is to administer brief surveys listing various sites of problems (*e.g.*, neck, shoulders, back, *etc.*) along with some means of qualifying the seriousness of the symptoms. This can be accomplished by providing a diagram of the body and asking workers to indicate the areas in which they experience problems. Each worker can also be asked to indicate whether he or she would describe the problem as pain, discomfort or fatigue. The most reliable method of obtaining accurate information may be to ask the operator to indicate only those problems which he or she is experiencing at the time the survey is being completed. By administering the same form on several occasions (*e.g.*, beginning of the week and end of the week, or beginning of the day and end of the day) detailed incidence data can be obtained which not only indicates the frequency of problems, but also the degree to which the work is contributing to the problem. This type of survey can be completed by most workers in less than 5 minutes. This technique has been used in at least one VDT study.[7] In some cases it may be helpful to supplement the collected data with information from medical records.

The second type of information which should be collected from individual operators concerns the nature of problems related to equipment and the work environment. This survey might include a list of potential problems, and ask operators to indicate the extent to which they find each to be bothersome. Items to include would be such things as table height, display height, workspace, chair design, glare, *etc.* When certain adjustments are possible, operators should also be asked if they make those adjustments and whether they are difficult to make.

At some point, information must also be gathered concerning the individuals. In different situations, the following information might be useful: age, sex, height, experience, job classification, working hours, and use of eyeglasses.

Once potential problem areas have been identified, a number of operators should be interviewed. The purpose of these interviews is to allow workers to provide more detailed information and offer suggestions concerning the problems which have been identified.

While it is desirable to include everyone in the survey, in some cases it may be necessary to select a representable sample. Care should be exercised in generalizing from results obtained for one type of job or in one department, however. In some cases it may also be useful to include a control group of non-VDT workers in order to determine whether the problems encountered are unique for VDT operators.

(2) *Workplace observations.* A great deal of information concerning problems and potential solutions can be gathered by directly observing the worksite. Listed below are some of the more useful types of data to collect:

1. working postures
2. workstation dimensions
3. ranges of adjustment
4. type of equipment, chairs and tables
5. workspace
6. workstation arrangement including placement of display, keyboard and source documents
7. environmental conditions.

It may be useful to develop a checklist or use one already available[6] in order to carry out these observations systematically.

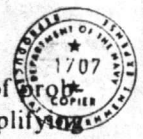
(3) *Task analysis.* In many cases the problems being experienced will be directly related to the type of task being performed. In order to identify important factors, it will be necessary to analyze the requirements of different jobs and describe the tasks involved. This will involve determining what is required and how it is done. Attention should be given to how much time is spent at the VDT; how much time the operator spends viewing the screen, keyboard, and source documents; the nature of non-VDT tasks; and the type of work (*i.e.*, editing, data entry, data retrieval, conversation, *etc.*). Since the present workstation may restrict the way in which the job is being performed, care should be taken to distinguish between how the job is done and how it should be done.

Implementing Corrective Measures

Correcting problems that have been identified should also be carried out systematically. Corrective measures should always be implemented first on a trial basis. This will allow time to determine whether the new equipment or modification does in fact eliminate the problem, as well whether it creates any new problems. This approach also allows operators to take an active part in evaluation of the change, which will aid in acceptance should it eventually be implemented. The natural resistance to change can also be overcome to a great degree by involving workers in decisions and explaining the reasons for making changes.

There are many different products on the market which may help eliminate problems. The claim by manufacturers that their equipment is adjustable or "ergonomically designed" should not, however, be the sole criterion for selection. Tables will vary in terms of range and ease of adjustment, available workspace, leg room, quality and cost. Chairs will vary in terms of adjustability, ease of adjustment, type of backrest, size of seat pan, angle of backrest, durability, maintenance, fabric, cost and most importantly, comfort. Selection should be based upon the data collected concerning musculoskeletal problems, equipment problems, observations and task requirements. Existing guidelines and recommendations can be used at this stage to aid in determining feasible solutions.

The financial and time costs involved in performing a thorough analysis of needs will be minimal as compared to the expenditure for equipment. When the costs associated with potential mistakes are also considered, the advantages become even more obvious. While the task may initially appear formidable, the first steps (collecting information from workers) will usually reveal that a limited number of problems can be isolated for further study, thereby simplifying procedures tremendously.



Implications for Equipment Designers

While the development of new specially designed VDT workstations and chairs have definitely been beneficial to VDT operators, it is apparent that additional research is necessary before clear relationships between specific design characteristics and features, postural complaints, and productivity can be established. The additional adjustment dimensions and the adaptability to individual workers must generally be considered positively, but the full advantage of such features must still be established.

Equipment designers and manufacturers will find it more and more necessary to go beyond meeting basic guidelines and recommendations. More attention will have to be given to what users need-rather than what they have been told they need. More attention must also be given to the tasks involved so that equipment is not only adaptable to the anthropometry of individuals but also to their jobs. A variety of designs will, therefore, be necessary.

Finally, designers and manufacturers must expect and be prepared for changing demands resulting from:

1. greater attention on the part of users to task demands in the selection of equipment
2. modification of existing guidelines and recommendations based upon research relating postural complaints to specific design features
3. user evaluations of costs versus benefits of certain design features
4. changes in the design of jobs
5. technological advances in VDT equipment design.

Summary

A variety of musculoskeletal problems related to working posture have been recognized, and many of these problems can be associated with adverse working postures resulting from poorly designed workstations. Present guidelines and recommendations for workstation design are based primarily on anthropometric and biomechanical considerations, however, observations and recent research cast doubt on the vaildity and usefulness of some of these recommendations. More research is necessary to determine how working posture and musculoskeletal problems are related to workstation design. In order to establish the most appropriate design considerations, more attention will have to be given to the work tasks, workers preferences, and the degree of postural constraint involved in individual jobs. Ultimately, the reduction of musculoskeletal problems among VDT operators, as well as other workers, will depend not only upon consideration of workstation designs, but also the physical demands (*e.g.*, repetitiveness, postural constraints) and psychological demands (*e.g.*, productivity pressures) of the job. Jobs must be designed to fit the physical, behavioral and psychological limitations as well as the anthropometric and biomechanical characteristics of workers.

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