Evaluation of Two Preventive Interventions for Reducing Musculoskeletal Complaints in Operators of Video Display Terminals

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Background and Purpose

The purpose of this study was to evaluate the efficacy of a preventive ergonomic intervention, which was provided by physical therapists, on spinal and upper-extremity work-related posture and symptom complaints of workers who use video display terminals (VDT).

Subjects

Two hundred employees who spent at least 20 hours per week at a VDT were randomly divided into 2 groups. Group E received the ergonomic intervention and an informative brochure, and group I received only the brochure.

Methods

Both groups were evaluated at the beginning of the study and at a follow-up 5 months later. The following tools were used: a pain drawing and the Rapid Entire Body Assessment (REBA) method to assess spinal and upper-extremity work-related posture.

Results

Group E had a lower REBA score and reduced lower back, neck, and shoulder symptoms compared with group I.

Discussion and Conclusion

The results suggest that a personalized preventive ergonomic intervention can improve spinal and upper-extremity work-related posture and musculoskeletal symptoms for workers who use VDTs.

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The presence of musculoskeletal disorders is a widespread problem among the operators of video display terminals (VDTs).[1–3] The particular characteristics that promote the onset of these disorders are repetitive movements, sustained postures, and incorrect work positions. Prolonged sitting in incorrect, fixed positions increases the biomechanical stress on the back, neck, shoulders, and upper limbs. Sustained non-neutral postures during computer use, such as neck rotation and shoulder abduction, are defined as risk factors leading to the onset of symptoms in the neck and shoulder areas.[4]

Studies conducted by the National Institute for Occupational Safety and Health (NIOSH) demonstrated that more than 75% of workers who use a VDT have reported occasional discomfort of the back, neck, and shoulders.[5,6] In a subsequent study by NIOSH, 20% to 25% of 1,000 workers who use a VDT reported constant discomfort in the upper back area.[7] In an investigation of 512 workers who use a VDT, Bodek[8] found that the most frequent disorders were neck and shoulder pain (reported by 64% of workers), backache (52%), pain in the arms and legs (28%), and swelling in joints and muscles (12%). Further problems, such as hand cramps (14.1%), numb or inflamed wrists (10.6%), and diminished sensitivity in wrists and fingers (5%), also were reported.[8]

Webster and Snook[9,10] estimated workers' compensation for upper-extremity cumulative trauma disorder and low back pain to be around $8,070 for each upper limb and $8,321 for backache. According to a study conducted by the Ergonomic Program at AT&T's Bell Labs, the average cost to ergonomically modify a single workstation is about $316.[11] Comparing this figure with the $8,000 estimated by Webster and Snook[7] as the probable compensation necessary to pay for each musculoskeletal disorder, the economic importance of investing in preventive measures becomes clear.

Golaszewski et al[12] affirmed that, for each dollar spent on prevention, $3.40 is earned in worker productivity. At the 1-year follow-up of an ergonomic intervention involving adjustments to work organization, Ong[13] found a reduction in musculoskeletal disorders. Oxenburgh[14] observed that neck and shoulder discomfort exist even when working in an ergonomically correct position. Winkel and Oxenburgh[15] suggested that this discomfort is due to the limited number of postures available when sitting at a computer. With an appropriate ergonomic intervention based on the use of armrests, the postural load diminished[16] as did physical discomfort[17] and neck pain.[18] An incorrectly placed keyboard has been associated with the onset of wrist and hand disorders[2,19–23] and neck pain.[24] This observation is supported by previous studies, which demonstrated an association between increased discomfort in the wrist or hand and non-neutral positions of the wrist or hand.[7,25,26]

The purpose of our study was to evaluate the effectiveness of a personalized ergonomic intervention provided by physical therapists, combined with an educational activity, in influencing spinal and upper-extremity work-related posture and musculoskeletal disorders mainly in the wrist, hand, shoulders, neck, and low back of workers who use VDTs.

Materials and Method

Participants

The study population—composed of administrative personnel of the town hall of Forlì, Italy—consisted of 400 employees who used VDTs for at least 20 hours a week. The participants, all of whom performed the same tasks, worked in 2 separate buildings. In order to avoid possible contamination, we randomly assigned 100 participants from the first building to group E (which received an ergonomic intervention plus an informative brochure) and randomly assigned 100 participants from the second building to group I (which received only the brochure).

The remaining 200 participants, who worked in both buildings, virtually represented a "naturalistic control group" (no intervention); however, this control group could not actually provide evidence to support or refute the use of either intervention to reduce symptoms of VDT use, due to the very probable contamination. The working environment of both groups of workers complied with the pertinent Italian legislation[27] and, therefore, did not differ in temperature, lighting, office width, humidity, and noise. The randomization (without replacement) was performed by extracting pieces of paper, each reporting a number associated with a participant.

Procedure

The study had a duration of 6 months. Upon obtaining written, informed consent from the participants, measurements for 2 different outcomes were obtained from both groups: (1) spinal and upper-extremity work-related posture and (2) physical discomfort. The measurements were taken 2 weeks before the intervention and at a follow-up examination after 5 months by 2 different health care professionals who were unaware of the group assignments. Demographic characteristics and work-related data (work experience, number and duration of daily breaks, and hours of VDT use per day) were obtained using a specifically designed questionnaire.

At the beginning of the intervention, both groups were provided with the same informative brochure, which was based on the relevant Italian legislation[27,28] and on scientific evidence dealing with the main musculoskeletal complaints resulting from VDT use.[29–32] The brochure provided the criteria for an ergonomic workplace and the benefit of "micro breaks." In addition to the brochure, participants from group E also received the advice and supervision of a physical therapist for the ergonomic adjustment of their workstation. The physical therapist, an expert in ergonomics, evaluated the posture of each participant while performing his or her daily tasks.

On the basis of the correct reference parameters[27–32] and on the nature of the tasks performed by the worker, the physical therapist provided adjustments and alterations to the existing furniture and equipment by modifying chair and desk height; backrest inclination; screen height, inclination, and orientation; mouse location; and keyboard inclination and location. In only a few cases, participants were provided with new chairs when the old ones were not adjustable. The ergonomic intervention by the physical therapist took 2 weeks, approximately 30 minutes for each operator. During the following 5 months, the therapist carried out his supervision and consultation twice a month, spending approximately 5 to 10 minutes with each operator. In addition, workers were furnished with a lumbar cushion that functions as a physiological support for the lumbar region, a gel mouse pad with ergonomic wrist support, and, depending on individual needs, a foot rest and a paper mount. The Figure reports the study's timeline.

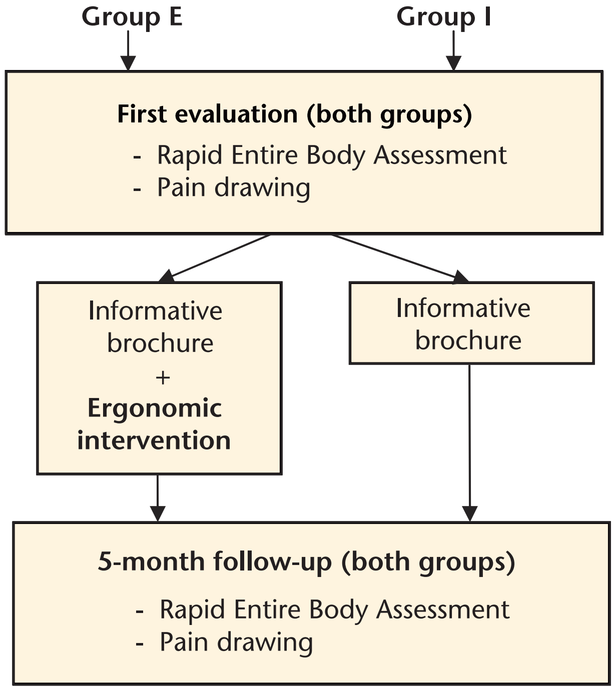

Figure.
Summary diagram of the activities of the 2 groups.

Measurements

Spinal and upper-extremity work-related posture was assessed using the Rapid Entire Body Assessment (REBA) method. The REBA method, which is based on the rapid upper body assessment (RULA) system,[33] is one of the postural measurement systems developed by ergonomists. We preferred to use the REBA method because the RULA system focuses mainly on the upper limbs and, therefore, is not suitable for assessing low back posture. Moreover, the REBA method analyzes the whole body and is ideal for static postures (eg, computer workplaces).

The REBA method analyzes posture by measuring the articular angles and by observing the load or force and repetitiveness of movements and the frequency of position changes. The postures of the neck, trunk, upper and lower arms, legs, and wrists are grouped into ranges. Each posture range, relative to the anatomical regions evaluated, is associated with a score corresponding to values that get progressively higher as the distance from the segment's neutral position increases. Score A is the sum of the posture scores for the trunk, neck, and legs and the Load/Force score, whereas score B is the sum of the posture scores for the upper arms, lower arms, and wrists and the coupling score for each hand. The REBA score is obtained by entering score A and score B and by adding them to the Activity score (Appendix).[34,35]

An analysis of the interobserver reliability of body part coding of more than 600 different postures from the health care, manufacturing, and electricity industries was conducted by a group of 14 health care professionals (occupational therapists, physical therapists, nurses, and ergonomists). The results obtained, omitting the upper arm categories, had an agreement rate ranging between 62% and 85%.[35] To our knowledge, studies that describe the construct, discriminant, or predictive validity of the REBA method have not been reported. As a measure of spinal and upper-extremity work-related posture, however, we believe that the REBA method has substantial face validity. Given the array of postures that we included in our study, we also believe that the REBA has sufficient content validity for our purposes. However, as with many areas of investigation in rehabilitation science, the limits of the measurement instrument require caution in the interpretation of results.

Each operator was photographed while performing daily tasks by a third health care professional who also was unaware of group assignments on sagittal (left and right side) and coronal (front and back) planes. The camera was positioned 1 m above the floor, about 3 m from the operator. As required by the REBA method, the photographs were used to calculate the values of the articular angles by placing a goniometer directly on the images.

Physical discomfort was evaluated using a pain drawing to identify the location and severity of symptoms. The pain drawing sketch is a body silhouette that is filled out by using various symbols that represent different types of pain modes such as stabbing and burning. The participants were instructed to describe the intensity and quality of their pain in each of these areas by markings with 7 pain mode symbols. Several studies on the validity and reproducibility of pain drawings have been published. It has been asserted that the instrument is valid, reproducible, and stable over time[36] and has low interrater variation.[37,38] Symptoms described by participants were divided into 4 categories: shoulders, wrist and hand, neck, and low back.

Data Analysis

Continuous data are expressed as mean ± standard deviation. A skewness-kurtosis test was used to test the normal distribution of values. For non-normal distributions, 2-sample tests were performed using the Wilcoxon rank-sum test. Categorical variables were assessed using the Fisher exact test. Data analysis was conducted following the "intent to treat" approach, so that all participants were analyzed according to the group to which they were initially assigned.

The "worst case scenario" was chosen as way of dealing with missing data. For the dichotomous outcome, we assumed that all dropouts in group E did not improve and that all of those in group I improved, when symptomatic. As for the REBA scores of dropouts, we presumed that all dropouts in group E did not improve (ie, maintaining the baseline REBA score) and that all of those in group I improved (ie, reaching the best value obtained in their group). To compare the chance of improving versus worsening, a logistic regression model (adjusted for age, sex, and body mass index [BMI], without forward or backward selection) was used for each specific area examined. Odds ratios (OR) and 95% confidence intervals (CI) were calculated as measures of association. The OR is a measure of effect size used to assess the risk of a particular outcome if a certain factor (or exposure) is present. Stata 8.0 SE software* was used for all analyses, with significance set at $P<.05$.

Results

Of the 200 participants selected for the study, 99 from group E and 97 from group I participated in the 5-month follow-up. The 4 participants lost at the follow-up phase were absent because of illness or injury or maternity leave and not for vacation. The demographic characteristics of group I and group E were very similar for sex, age, height, BMI, length of employment, and details of work duties (number of daily breaks and daily VDT use) (Tab. 1). Before the intervention, the REBA score, as well as score A and score B, were similar for both groups; at follow-up, however, the values of group E were significantly lower than those of group I (Tab. 2). The values of group I at follow-up did not change with respect to baseline values (Tab. 2). This means that, after intervention, the posture of the trunk, head, and lower limbs (score A) and that of the shoulders, elbows, and wrists (score B) were significantly improved in the participants from group E compared with the participants from group I.

When comparing the proportions of participants describing bodily symptoms before treatment, a greater amount of discomfort, although not significant, was found in group E for all the different anatomical regions examined (Tab. 2). A significant reduction was found when comparing the symptoms described by participants in group E before and after the intervention (Tab. 2), specifically for the shoulders (P=.020), neck (P=.005), and low back (P=.008). No significant differences were found in these areas in group I. As expected, on the basis of the low number of missing data (only 4), missing data subanalysis performed according to "worst case scenario" approach showed superimposable results (data not shown).

Table 3 shows the proportion of participants with or without symptoms according to pain drawing, before and after the intervention, with respect to each anatomical region. It shows the improvement in shoulder disorders (improvement in group E=15.2%, group I=4.1%) and low back disorders (group E=28.3%, group I=18.6%; deterioration in group E=2.0%, group I=12.4%). Table 4 shows the logistic regression

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Table 1.
Comparison Between the Two Groups Concerning Work and Individual Characteristics Before Intervention[a]

Variables	Group E (n=100)	Group I (n=100)	P
Sex (%)			.755[b]
Male	30	28	
Female	70	72	
Age (y)	44.8±6.8	43.7±8.4	.348[c]
Height (cm)	167.4±9.3	166.7±8.1	.878[c]
Weight (kg)	66.8±13.2	66.0±14.8	.361[c]
BMI (kg/m²)	23.7±3.1	23.6±3.9	.365[c]
Work experience (y)	16.0±9.3	14.1±10.2	.091[c]
No of breaks/d	2.9±1.7	2.6±1.3	.292[c]
Single break duration (min)	25.3±13.6	23.4±13.2	.192[c]
VDT use/d (hr)	4.7±1.3	4.6±1.4	.510[c]

[a] Group E received an ergonomic intervention and an informative brochure. Group I received only the brochure. All data are reported as mean±SD, except where indicated. BMI=body mass index, VDT=video display terminal.
[b] χ^2 test.
[c] Wilcoxon rank sum test.

models (adjusted for age, sex and BMI) regarding participants whose symptoms improved versus participants whose symptoms worsened for each region. All 4 models show an increased chance of improvement for group E with respect to group I; however, it was significant only for low back disorders (OR=9.4; 95% CI=1.8–49.2).

Discussion

Our results point to the importance of an ergonomic intervention performed by a physical therapist in combination with an associated ergonomic educational program in improving posture and preventing musculoskeletal disorders as opposed to an ergonomic educational program alone. The ergonomic intervention in group E proved to be decisive in improving spinal and upper-extremity work-related posture, as evaluated with the REBA method, and in the reduction of musculoskeletal complaints, mainly in the shoulders, neck, and low back (Tab. 2).

The importance of the brochure lies in making workers aware of the risks associated with sustained sitting postures associated with VDT use and of the importance of a preventive ergonomic intervention in their workplace. Although the informative brochure that was given to workers from group E may have strengthened the effectiveness of the ergonomic intervention by making workers conscious of the importance of the ad-

Table 2.
Comparison Between Group I (Informative Brochure Only) and Group E (Ergonomic Intervention and Informative Brochure) Before and After Intervention

	Before Intervention		After Intervention		Change After Intervention[a]		
	Group I (n=100)	Group E (n=100)	Group I (n=97)	Group E (n=99)	Group I (n=97)	Group E (n=99)	P
REBA[b] (mean±SD)							
REBA score	4.8±1.1	4.9±1.2	4.9±1.3	3.6±0.9	0.10±1.43	−1.24±1.22	.000[c]
Score A	2.7±1.1	2.8±1.2	2.8±1.1	1.8±0.8	0.04±1.39	−0.97±1.26	.000[c]
Score B	2.6±1.1	2.8±1.1	2.8±1.3	1.7±0.9	0.19±1.38	−1.11±1.35	.000[c]
Pain symptoms present, n (%)							
Shoulder	8 (8.0)	17 (17.0)	5 (5.2)	5 (5.1)	−2	−12	.020[d]
Wrist/hand	11 (11.0)	17 (17.0)	12 (12.4)	12 (12.1)	2	−5	.292[d]
Neck	46 (46.0)	54 (54.0)	40 (41.2)	40 (40.4)	−4	−13	.005[d]
Low back	42 (42.0)	51 (51.0)	35 (36.1)	25 (25.3)	−6	−26	.008[d]

[a] Change after intervention was calculated only for respondents at follow-up.
[b] REBA=Rapid Entire Body Assessment.
[c] Wilcoxon rank sum test.
[d] Fisher exact test.

Table 3.
Proportion of Participants With or Without Symptoms Before and After the Intervention by Anatomical Region

Symptoms Before Intervention		Symptoms at Follow-up			
		Group E (n=99)		Group I (n=97)	
		No, n (%)	Yes, n (%)	No, n (%)	Yes, n (%)
Shoulder disorders	No, n (%)	79 (79.8)	3 (3.0)	88 (90.7)	2 (2.1)
	Yes, n (%)	15 (15.2)	2 (2.0)	4 (4.1)	3 (3.1)
Wrist/hand disorders	No, n (%)	79 (79.8)	3 (3.0)	79 (81.4)	8 (8.2)
	Yes, n (%)	8 (8.1)	9 (9.1)	6 (6.2)	4 (4.1)
Neck disorders	No, n (%)	39 (39.4)	7 (7.1)	43 (44.3)	10 (10.3)
	Yes, n (%)	20 (20.2)	33 (33.3)	14 (14.4)	30 (30.9)
Low back disorders	No, n (%)	46 (46.5)	2 (2.0)	44 (45.4)	12 (12.4)
	Yes, n (%)	28 (28.3)	23 (23.2)	18 (18.6)	23 (23.7)

justments provided by the physical therapist, the informative brochure alone proved insufficient to make workers in group I adjust their workstations by themselves. Participants from group I did not change their posture according to the ergonomic criteria in the brochure they received; indeed, they appeared to be reticent in modifying their usual workstation arrangements without the guidance, supervision, and explanation of a professional. This is demonstrated by the slight increase in the REBA score for group I (Tab. 2).

Symptoms in the low back, neck, and shoulders showed the most improvement. This finding is in accordance with the findings of Ketola et al,[39] who found a decrease in musculoskeletal discomfort in the shoulder, neck, and upper back areas in the experimental group after an ergonomic intervention with an associated ergonomic educational program compared with the reference group. Moreover, the experimental group had a higher increase in the ergonomic level—assessed on a scale from 4 (poor) to 10 (excellent) by 2 experts in ergonomics by means of videorecordings of the workers' daily tasks (mean of the ratings)—than the reference group.[39]

The higher odds of improvement in low back disorders in group E with respect to group I can be explained as a positive effect of lumbar cushions, which were provided to all participants of group E, in preventing and resolving low back disorders. Contrary to what we expected, we found no significant reduction in wrist or hand disorders in workers from group E, who had been provided with wrist-support mouse pads. Similar unexpected results were obtained by Lassen et al,[40] who found, after a 1-year follow-up study of 6,943 computer users, that computer work activity or ergonomic conditions did not influence the prognosis of "severe" elbow, forearm, and wrist or hand pain among computer users. Our study differs from those mentioned above in that each ergonomic intervention was personalized and appropriately studied and proposed by a physical therapist on the basis of personal tasks, needs, and symptoms.

The strength of this study is that the 2 groups were comparable with respect to baseline demographic characteristics and occupational factors. Moreover, a possible interaction between the 2 groups can be excluded because they worked in separate buildings. A limiting factor of the study is that the photographs, which were used to calculate the values of the articular angles as required by the REBA method, represent a moment in time and do not describe the whole range of postures and movements of workers during a workday.

Table 4.
Results of the Four Logistic Regression Models (Adjusted for Age, Sex and Body Mass Index) Showing the Odds of Improvement for Group E Compared With Group I for Each Anatomical Region[a]

	Coefficients	Odds Ratio	95% Confidence Interval	*P*
Shoulder	1.1	2.9	0.3–27.4	.352
Wrist/hand	1.7	5.6	0.7–45.9	.109
Neck	0.8	2.2	0.6–8.4	.242
Low back	2.2	9.4	1.8–49.2	.008[a]

[a] Significance was set at $P<.05$

Conclusion

Among our study population, participants who received an ergonomic intervention along with an ergonomic educational program had a significant improvement in spinal and upper-extremity work-related posture and musculoskeletal disorders, mainly in the low back, neck, and shoulders, compared with participants who received only the ergonomic educational program. Workstations were modified by the physical therapist on the basis of individual tasks and needs—mainly adjusting chair and desk heights; backrest inclination; screen height, inclination, and orientation; mouse location; and keyboard inclination and location as well as furnishing a lumbar cushion and a gel mouse pad with an ergonomic wrist support. These ergonomic modifications produced a change in the posture and movements of the head, neck, arm, and back toward more neutral postures and contributing to the statistically significant reduction of musculoskeletal disorders observed for the low back, neck and shoulders.

Based on our results, we assert the importance of a personalized ergonomic intervention coupled with an ergonomic educational program both in improving spinal and upper-extremity work-related posture and in reducing musculoskeletal disorders. Further studies are needed to evaluate whether such a decrease would justify the continuing presence of a physical therapist in the work environment. Considering the growing use of VDTs in the workplace, this study highlights the importance of making workers and managers more aware of preventive measures. We intend to perform further follow-up evaluations (1, 2, and 5 years) involving both the control group and the experimental group, in order to assess the long-term effects of the intervention.

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Appendix.

Rapid Entire Body Assessment (REBA) Method

Table A			**Table B**			
Posture/Range	**Score**	**Total**	**Posture/Range**	**Score**	**Total: Left and Right**	
Trunk			**Upper Arms (Shoulders)**		**L**	**R**
Upright	1	If back is twisted or tilted to side: +1	Flexion: 0°–20° Extension: 0°–20°	1	Arm abducted/ rotated: +1 Shoulder raised: +1 Arm supported: −1	
Flexion: 0°–20° Extension: 0°–20°	2		Flexion: 20°–45° Extension: >20°	2		
Flexion: 20°–60° Extension: >20°	3		Flexion: 45°–90°	3		
Flexion: >60°	4		Flexion: >90°	4		
Neck			**Lower Arms (Elbows)**		**L**	**R**
Flexion: 0°–20°	1	If neck is twisted or tilted to side: +1	Flexion: 60°–100°	1	No adjustments	
Flexion: >20° Extension: >20°	2		Flexion: <60° Flexion: >100°	2		
Legs (Knees)			**Wrists**		**L**	**R**
Flexion: 30°–60°	1	Bilateral weight bearing; walk; sit: +1	Flexion: 0°–15° Extension: 0°–15°	1	Wrist deviated/ twisted: +1	
Flexion: >60°	2	Unilateral weight bearing; unstable: +2	Flexion: >15° Extension: >15°	2		
Score from Table A			**Score from Table B**		**L**	**R**
Load/Force			**Coupling**		**L**	**R**
<5 kg <11 lb	0	Shock or rapid buildup: +1	Good	0	No adjustments	
5–10 kg 11–22 lb	1		Fair	1		
>10 kg >22 lb	2		Poor	2		
Score A (Table A + Load/Force Score)			Unacceptable	3	Left	Right
Activity			**Score B** **(Table B + Coupling Score)**		**L**	**R**
One or more body parts are static for longer than 1 min		+1	**Score C** **(Score A + Score B)**		**L**	**R**
Repeat small range motions, more than 4 per minute		+1				
Rapid large changes in posture or unstable base		+1	**REBA Score** **(Score C + Activity Score)**		**L**	**R**