

A Cross-Country Comparison of Short- and Long-Term Effects of an Ergonomic Intervention on Musculoskeletal Discomfort, Eyestrain and Psychosocial Stress in VDT Operators: Selected Aspects of the International Project

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Three groups of data entry female visual display terminal (VDT) workers from Norway (n = 30), Poland (n = 33) and the USA (n = 29) were compared. Before intervention, the Norwegian group reported more neck pain compared with the Polish group. The Polish group reported less shoulder pain than both the U.S. and the Norwegian groups. The clinical examination documented fewer symptoms and signs of musculoskeletal illness among the Polish participants compared with the Norwegian and the U.S. groups. After intervention, the Norwegian group reported a reduction in neck pain while the U.S. group reported a reduction in shoulder pain. The Polish group reported an increase in neck, shoulder and forearm pain at follow-up compared to after intervention. The Polish group recorded higher flexion of the upper arm at follow-up parallel with an increase of pain in the upper part of the body. Visual discomfort showed variable results in the 3 countries.

ergonomic stress musculoskeletal stress visual stress work environment computer work

1. INTRODUCTION

This paper describes the results of a cross-country comparison of the international MEPS (musculoskeletal—eyestrain—psychosocial—stress) project. Results from Poland, the USA and Norway will be presented and compared. The national teams in Norway, the USA and Poland conducted the project. The aim of the study was to evaluate short- and long term effects of an ergonomic intervention of musculoskeletal, psychosocial and visual strain of visual display terminal (VDT) routine data entry work. The studies were performed in a group of routine data entry female operators. The evaluation of musculoskeletal, visual and psychosocial factors was performed before, 1 month after and 1 year after the ergonomic interventions.

2. METHODS

The methods are described in detail in Dainoff et al. [1] (in this issue).

2.1. Demographic Variables

The data entry groups in the three countries consisted of female workers, 30 in Norway, 29 in the USA and 33 in Poland. The age of the participants is shown in Table 1.

TABLE 1. Age of the Study Population (Years)

Population	<i>M</i>	95% CI
Norwegian group	41.1	37.1–45.1
U.S. group	38.4	34.9–42.0
Polish group	32.7	30.2–35.2

Notes. CI—confidence interval.

The study population in Poland was significantly younger compared to the Norwegian and the U.S. groups. All subjects were experienced VDT workers who had been in current jobs 61 months in Norway, 122 months in the USA and 70 months in Poland (group median values).

2.2. Ergonomic Interventions

2.2.1. Norway

The Norwegian intervention consisted of ergonomic training and small adjustments in the workstations, along with eyeglasses as needed. The worksites studied had already complied with detailed ergonomic regulations specified by the company (see Aarås et al. [2] in this issue).

2.2.2. USA

The U.S. intervention was extensive. Completely new motorized sit-stand workstations, advanced ergonomic chairs, advanced completely adjustable keyboards and specially designed copyholders were provided along with eyeglasses as needed. Formal ergonomic training and onsite coaching was provided after the new equipment was installed (see Dainoff et al. [3] in this issue).

2.2.3. Poland

The Polish ergonomic intervention was preceded by a needs assessment, which was discussed with employees to seek their participation. The intervention consisted of installation of new luminaries and blinds, new chairs, repair of ventilators, and eyeglasses as needed. However, the company also insisted on installing new computer equipment on the existing workstations at the same time (see Konarska et al. [4] in this issue).

3. RESULTS

3.1. Optometry

3.1.1. Visual acuity and optometric corrections

When comparing the countries, there was a rather normal distribution of visual acuity (Table 2), with better results when both eyes were used simultaneously (binocular results), which had been anticipated. However, there was a higher visual acuity in Poland than in Norway and the USA.

When looking at the results from the prescribed correction (see Table 3), the USA demonstrates a significantly higher degree of myopia than Poland and Norway. This may contribute to an explanation of the difference in visual acuity. However, still it is unlikely that people in Poland have a higher visual acuity than people in Norway and the USA, so these results may also be a result of the different testing conditions, and they therefore show the importance of a better standardization of visual acuity testing. The recommended test method was the Snellen’s chart, and this is known to have some weaknesses in these types of comparisons, like the difference in luminance and contrast, small difference in test distance, etc.

TABLE 2. Visual Acuity in Decimal Notation. The Results Are Given as Group Mean Values. Minimum and Maximum Results Are Also Given

Country	OD (<i>M</i>)	OD (Min-Max)	OS (<i>M</i>)	OS (Min-Max)	Binocular (<i>M</i>)
Norway	1.26	0.40–1.50	1.24	0.02–1.50	1.50
Poland	1.74	1.00–2.00	1.78	0.50–2.00	1.78
USA	0.92	0.03–1.00	0.95	0.67–1.34	0.96

Notes. OD—right eye, OS—left eye.

TABLE 3. Number of Prescribed Corrections

Country	New Correction	No New Correction	Total
USA	29	0	29
Norway	10	13	23
Poland	2	26	28
Total	41	39	80

The low number of new corrections in the Polish group might be explained by the age distribution (see Table 1). All the participants in the U.S. group received new corrections (see Table 3).

In Poland very few (only 2) people got new distance corrections. The prescriptions in the USA tended to have a higher minus value than in Poland and Norway (see Table 4). This may be an

TABLE 4. Optometric Corrections, Lens Power (Spherical) Group Mean Values

Country	OD	OS
Norway	-0.16 DS	-0.22 DS
Poland	-0.28 DS	-0.33 DS
USA	-2.22 DS	-1.93 DS

Notes. OD—right eye, OS—left eye, DS—dioptr sphere.

interesting finding. The development of myopia is suspected to be connected with near work [5, 6, 7]. However, other studies do not support that VDT work leads to an increase in myopia [8, 9].

3.1.1.1. Poland. There were small values in the prescribed corrections. This indicates limited visual disorders.

The stereo acuity was 40" both as mean and median, and demonstrates almost no changes from Part I to II of the study. The amplitudes of accommodation were within normal limits for the age group: OD (right eye): 6.8 DS (dioptr sphere), OS (left eye): 7.3 DS, binocular 7.7 DS. No significant changes occurred from Part I to Part II.

3.1.1.2. USA. The values indicate than most subjects were myopic. The most hypermetropic person was +1.50 DS. Unfortunately some subjects were outside the inclusion criteria. High myopes often have a reduced visual acuity, and this might contribute to the reduced average visual acuity in the results from the USA.

Stereo acuity: 123 minutes of arc, as group mean value. This was lower than expected. There were only small changes from baseline, but there was a large range and some very low readings.

Accommodation: OD: 7.5 DS, OS: 7.3 DS, binocular: 7.6 DS. There was one change in binocular accommodation, which was peculiar. The amplitude of accommodation increased from Part I to Part II. No program of visual training was performed, so a reasonable explanation may be that this was an artifact. On the other hand, the ergonomic intervention provided a larger work surface and a newly designed copyholder. There was a corresponding significant increase in viewing distance to the screen (57.1 to 75.9 cm) and to the paper copy (51.6 to 62.6 cm) between Parts I and II. This might have had some impact on the increased amplitude of accommodation.

3.1.1.3. Norway. Here there was a change from Part I to Part II in the average spherical refraction of approximately 0.30 DS. Maximum change observed from Part I (baseline) to Part II was 0.75 DS. Visual acuity was 1.4, ranging from 0.2 to 1.5. Stereo acuity was 45" as a group mean value. Only small changes took place between Part I and Part II, and the range was from 40" to 80".

Accommodation: the plots indicated normal distribution according to age (see Aarås et al. [2] in this issue).

3.1.2. Near addition

There was a rather skewed age distribution between the three countries (see Table 1). In Poland (mean age 32.7 years) one hardly anticipated any presbyopic near addition at all. In the USA near additions were given to participants who would normally not get near additions according to standard optometric procedure [10, 11]. However, some authors advocate near additions to be given

3.1.3. Visual problems and headache

3.1.3.1. Poland. The average intensity in the past 6 months at Part II was 42.6 mm VAS (Visual Analog Scale). There was no change from Part I to Part II ($p = .64$ with large dispersion in the material). At Part III however, there was a significant reduction.

3.1.3.2. USA. The average intensity in the past 6 months at Part II was reduced significantly from Part I to Part II ($p = .009$) from approximately 36 to 23 mm VAS. At Part III, visual discomfort was down to 9.2 mm.

3.1.3.3. Norway. There was a clear tendency in the average intensity in the past 6 months towards reduction from Part I to Part II ($p = .09$) from approximately 36 to approximately 27 mm VAS. (In data dialog female and data dialog men, the reduction was significant, $p = .03$ and $p < .01$ respectively, see Aarås et al. [2] in this issue). At Part III the reduction was about 20 mm VAS (see Table 5).

TABLE 5. Average Intensity of Visual Problems in the Past 6 Months (in millimetres VAS)

Part I	USA (N = 29)	Poland (N = 33)	Norway (N = 30)
Group mean	35.8	29.8	36.1
95% CI	24.9/46.7	21.6/38.6	27.7/44.6
Part II	USA (N = 25)	Poland (N = 29)	Norway (N = 25)
Group mean	22.9	42.6	27.2
95% CI	13.0/32.9	30.9/54.3	18.0/36.2
Part III	USA (N = 26)	Poland (N = 21)	Norway (N = 23)
Group mean	9.2	29.1	19.6
95% CI	5.1/13.3	19.0/39.3	9.9/29.3

Notes. VAS—Visual Analog Scale, CI—confidence interval.

in cases of astenopic symptoms at near, even though the candidate have normal amplitudes of accommodation. The rationale behind this is that accommodation fatigue may occur after prolonged use of the accommodative effort, and that weak plus lenses for near use might benefit these patients [12]. Since this was not anticipated in the trial protocol, no cross-country analysis of the effects of near addition was made.

3.1.3.4. Discussion. The intensity of visual problems seems to have been reduced down to an acceptable level in Norway and the USA. In Poland however, we still see a higher level in visual discomfort.

Analyses considering groups with and without optometric corrections were executed for the Norwegian subjects. However, to do these analyses on a cross-country basis was very difficult because of the big differences between the countries regarding the number of subjects who got new corrections. The result would be more

likely to reflect national differences in prescription policy, than effects of the intervention per se. The combined cross-country analyses did not show any indication of relation between the outcome and explanatory variables.

However, by simple comparison of variance of the changes in visual discomfort from before to after intervention, there was a significant difference ($p = .02$) between the groups. The Norwegian and U.S. groups experienced an improvement while the Polish group experienced a worsening. There were no significant difference between the groups regarding mean intensity in headache from before to after intervention ($p = .43$) although the mean values showed an improvement in the Norwegian group, and almost no changes in the other groups.

3.1.4. Types of visual problems

Population at commencement (Part I): Norway: $n = 30$; Poland: $n = 25$; USA: $n = 29$. Fatigue was the most frequent complaint, together with stinging/itching. Blurred vision was somewhat less frequent. Undefined visual discomfort consisted of more than one complaint, and it therefore had a relatively large value (see Table 6).

TABLE 6. Number of Subjects Reporting Different Types of Visual Discomfort

Part I	Norway	Poland	USA
Fatigue	3	22	15
Itching/burning	1	20	18
Red eyes	0	15	12
Double/hazy vision	3	16	17
Undefined visual discomfort	9	21	8
Part II	Norway	Poland	USA
Fatigue	7	22	4
Itching/Burning	2	18	5
Red eyes	0	11	3
Double/hazy vision	3	12	7
Undefined visual discomfort	4	16	2

When using optometric data as direct predictors for pain, there were no significant correlations. However there were some interesting findings when analyzing some specific parameters: headache-visual discomfort ($r = .34$, $p = .0020$), pain in the neck-visual discomfort ($r = .40$, $p = .0003$).

The models are adjusted for differences between the countries.

In two earlier studies it was shown that using multifocal lenses leads to an increased trapezius load in terms of higher electromyographic (EMG) values and a reduced head angle (keeping the head more upright) compared to single vision lenses [13, 14].

The aforementioned indications support the view that the whole body posture is influenced by the vision and line of gaze. In the Norwegian part of the study there are also clear indications that it is important to perform a full eye examination and to correct errors of refraction in order to reduce the total muscle load when working at a VDT.

In Norway (as in the rest of the European Economic Community/European Free Trade Association member countries) it is the Directive 90/270 EU stating that workers who spend most of the work day in front of a VDT screen have the right to get an eye examination before work starts and at regular intervals thereafter. Further, if any "special type of correction needed", it is to be paid for by the employer [15].

In the international part of the study, the analysis was difficult to perform, mainly because of differences in the age distribution and the number of given corrections in each country. Nevertheless, the results call for an increased research effort in these important areas.

3.2. Intensity and Frequency of Pain

Measurements were taken of both the intensity and frequency of pain. Since the results were similar for both measurements, only average intensity is discussed.

Overall the Norwegian group reported more pain in the upper part of the body compared with the Polish group before intervention. The U.S. and the Norwegian groups reported a tendency to a reduction in pain at follow-up compared with before intervention while the Polish group had a tendency to suffer more pain at follow-up compared to after intervention.

3.2.1. Neck

The Norwegian group reported higher intensity of neck pain in the past 6 months compared with

the Polish group before intervention ($p = .05$) (see Figure 1). The Norwegian group reported significantly reduced intensity of neck pain comparing after with before intervention ($p = .05$) while the Polish group reported a clear tendency to increased neck pain at follow-up versus after intervention ($p = .07$). In the U.S. group only small changes were observed. At follow-up, there were no significant differences between the groups.

3.2.2. Shoulder

Both the Norwegian and the U.S. groups reported higher intensity of shoulder pain in the previous 6 months before intervention compared with the Polish group ($p = .01$) (see Figure 2). The U.S. group reported significantly lower intensity of shoulder pain after compared with before intervention ($p = .005$) while the Polish group reported significantly increased pain level comparing follow-up with after intervention ($p = .03$). At follow-up, there were no significant differences between

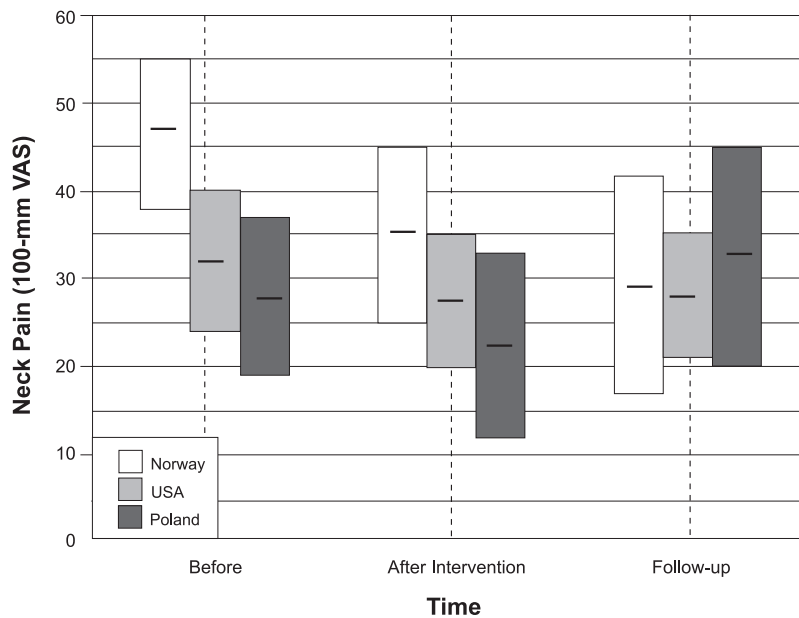


Figure 1. Intensity of neck pain in the past 6 months. Notes. VAS—Visual Analog Scale.

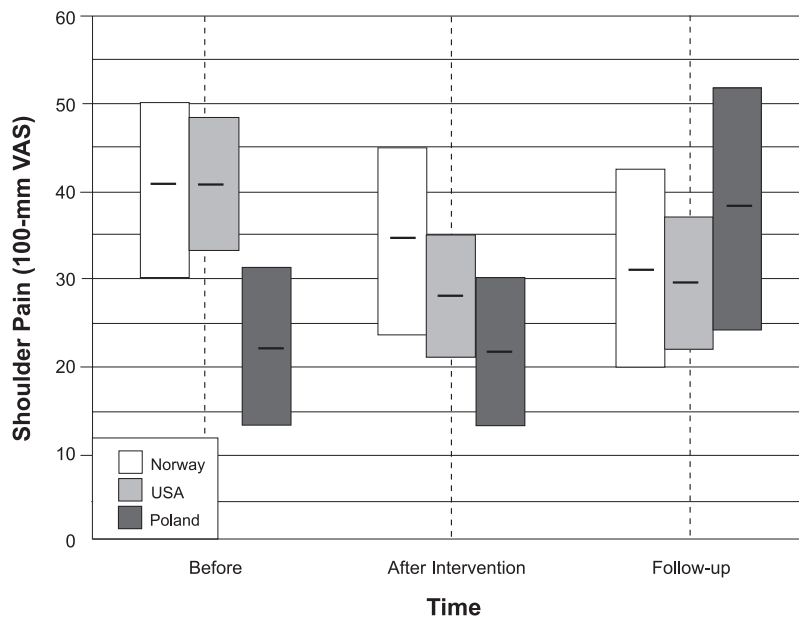


Figure 2. Intensity of shoulder pain in the past 6 months. Notes. VAS—Visual Analog Scale.

the groups. There were no significant differences regarding changes in shoulder pain between the groups before to after intervention ($p = .41$).

3.2.3. Forearm and hand

The U.S. group reported significantly higher intensity of pain in this body region for the previous 6 months compared to the Polish group ($p = .03$). No measurements were taken for the Norwegian group (see Figure 3). The U.S. group reported a significant reduction in the intensity of pain in the forearm and hand after versus before intervention ($p = .03$). At follow-up, there were no significant differences between the groups.

3.2.4. Back

The U.S. group reported higher back pain the past 6 months compared with the Norwegian and Polish groups. The U.S. group reported a significant reduction of back pain after compared with before intervention ($p = .002$) while the Norwegian group reported reduced back pain at follow up compared with after intervention ($p = .06$) (see Figure 4). Small changes in back pain were observed in the Polish groups during the study period. There were no significant changes regarding back pain between the groups before to after intervention ($p = .09$).

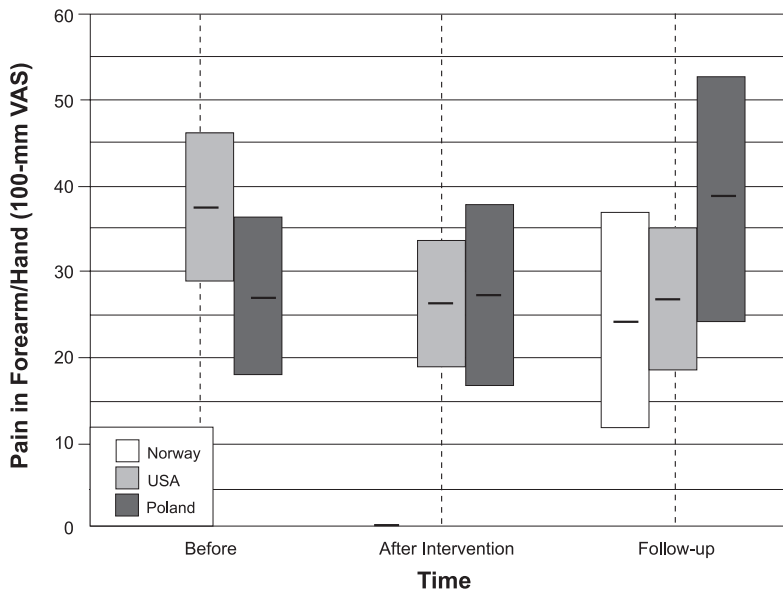


Figure 3. Intensity of pain in the forearm and hand in the past 6 months. Notes. VAS—Visual Analog Scale.

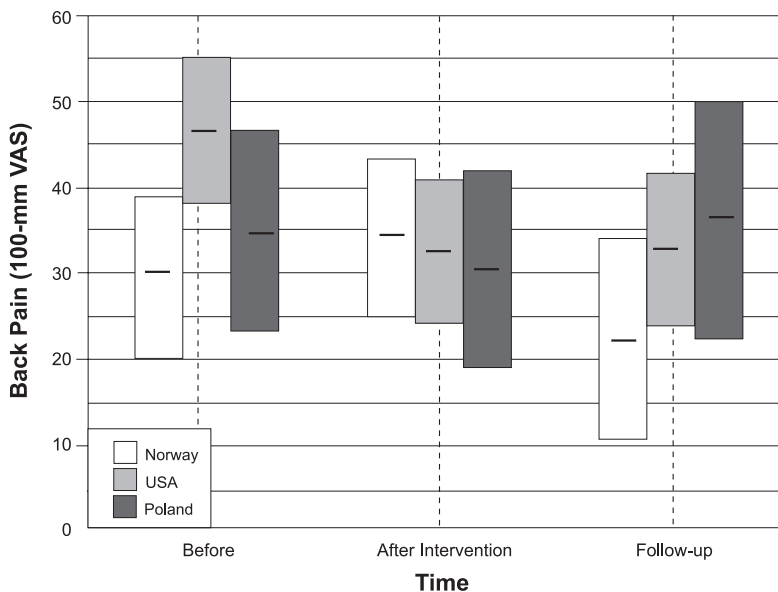


Figure 4. Intensity of back pain in the past 6 months. Notes. VAS—Visual Analog Scale.

3.2.5. Leg

Intensity of leg pain was reported significantly higher in the U.S. group compared with the Polish group before intervention ($p = .01$) (see Figure 5). The U.S. group reported a significant reduction in intensity of leg pain after versus before intervention ($p = .003$). At follow-up, there was a clear tendency that the Polish group had higher pain level compared with the U.S. group.

All three groups reported that the pain in the neck, shoulder, forearm and hand occurred most frequently during work rather than at other times of the day such as before and after work. Back pain was

reported more unrelated to work. Many participants suffered more back pain outside working hours.

3.3. Clinical Examination

3.3.1. Movement of the neck

Very few operators had a restricted range of movement of the neck regarding flexion and extension and reported pain during the same movements. Sideways movements of the neck were also normal for almost all operators. Both the Norwegian and the U.S. groups reported more pain during sideways movements of the neck compared with the Polish group before intervention (see Figure 6).

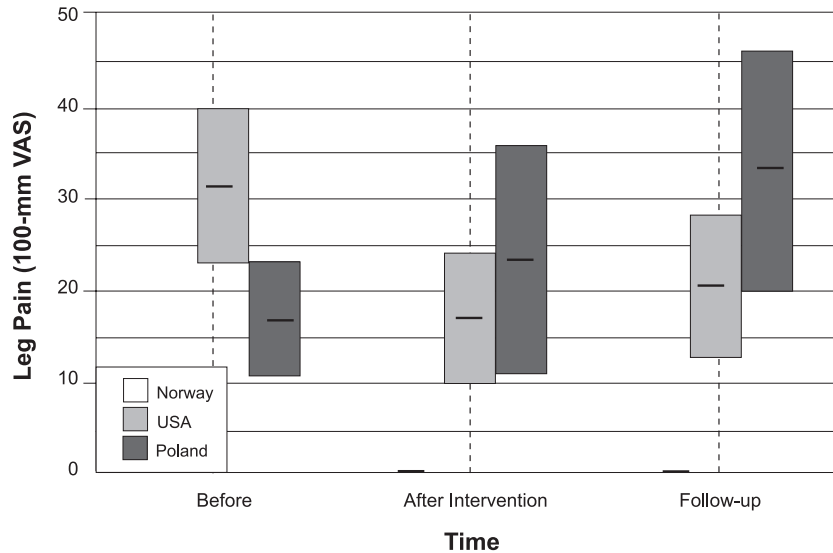


Figure 5. Intensity of leg pain in the past 6 months. Notes. VAS—Visual Analog Scale.

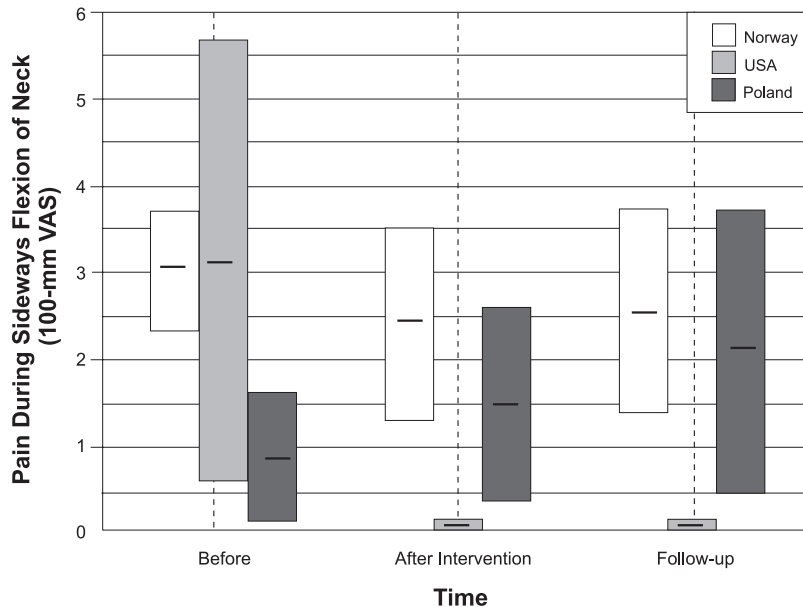


Figure 6. Intensity of pain during sideways movement of the neck. Notes. VAS—Visual Analog Scale.

The U.S. group reported a highly significant reduction in pain during sideways movement after versus before intervention ($p = .004$). Only small changes were observed in the Polish and the Norwegian groups. The U.S. group had less pain after intervention compared to the Polish and Norwegian groups.

3.3.2. Trigger points

The number of trigger points found was significantly lower in the Polish group compared with the Norwegian and U.S. groups before intervention ($p = .001$) (see Figure 7). The U.S. group had fewer trigger points after versus before intervention ($p = .001$). Only small changes were observed in the Norwegian group. The Polish and the U.S. groups had significantly fewer trigger points compared to the Norwegian group at follow-up. There was a significant change in terms of fewer trigger points in the U.S. group during the study period compared to the Norwegian group ($p = .02$).

of 28 subjects) reported tenderness in the U.S. group.

The Norwegian group reported less tenderness and pain at follow-up versus before intervention. Seven out of 23 subjects reported tenderness at follow-up versus 16 out of 30 before intervention. The corresponding numbers regarding pain during the test were 5 out of 23 versus 8 out of 30 subjects. In the U.S. group 8 out of 28 reported tenderness before intervention while no subjects reported pain at follow-up. In the Polish group only 4 out of 23 had tenderness after versus 8 out of 25 before intervention. No subjects in the Polish group had pain during the test.

3.3.4. Palpation of the attachment of *m. supraspinatus* and *m. deltoideus*

In the Norwegian group tenderness was reported by 14 subjects (out of 30) and 5 (out of 30) reported pain when the attachment was palpated with resistance against contractions of the muscles

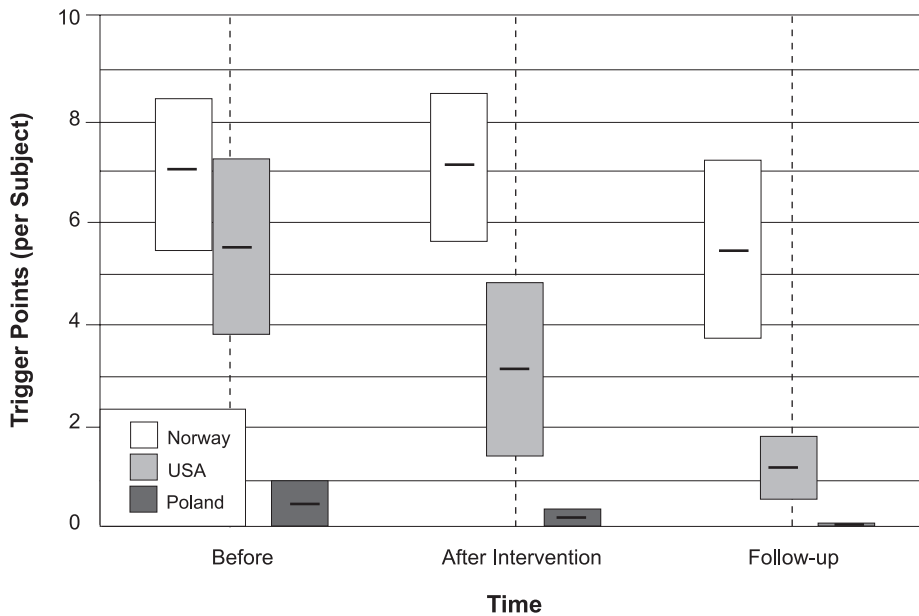


Figure 7. Number of trigger points per subject.

3.3.3. Isometric test

This test provoked more tenderness and pain in the Norwegian group compared with the Polish and the U.S. groups. Of the 30 subjects in the Norwegian group, 16 felt tenderness and 8 felt pain while only 8 subjects (out of 33 subjects) reported tenderness in the Polish group and 8 subjects (out

before intervention. In the U.S. group 8 (out of 23) subjects reported tenderness while none in the Polish group had discomfort before intervention.

In the Norwegian group tenderness was reported by 9 subjects (out of 23) while 5 subjects reported pain at follow-up. In the U.S. group the number of subjects who reported tenderness was reduced

from 8 to 3 subjects comparing before with after intervention ($p = .06$). No subjects reported pain.

3.3.5. Carpal tunnel syndrome

In the Norwegian group, 1 subject got this disease in the period after intervention. After operation no symptoms was found any longer. Before intervention 7 out of 31 operators in the Polish group suffered carpal tunnel syndrome.

3.4. EMG Measurement

The results will be analyzed in two ways. First, all three national groups will be compared at each of

taken at follow-up, the Norwegian group recorded significantly less static trapezius load compared with the other two groups.

Examining now the changes across the three phases of the study, the observed patterns were different for each of the national groups (see Table 7). Looking first at static and median loads: there were no significant differences for the Norwegian group. The U.S. group recorded a significant reduction of the static and median values comparing after versus before intervention while a significant increase was observed at follow-up versus after intervention.

The Polish group recorded an increase in static and median values comparing after versus before

TABLE 7. Summary of Statistically Significant Improvements (+) or Decrements (–) From Before and After Intervention (I to II) and Post-Intervention to One Year Follow-up (II to III)

Statistically Significant DVs	Change I to II			Change II to III		
	Poland	USA	Norway	Poland	USA	Norway
Visual problems (Table 5)	–	+	+	+		
Neck pain (Figure 1)			+			
Shoulder pain (Figure 2)		+		–		
Forearm/hand pain (Figure 3)		+				
Back pain (Figure 4)		+				+
Leg pain (Figure 5)		+		–		
Clinical exam-neck (Figure 6)						
Clinical trigger points (Figure 7)		+				
EMG static (Figure 8)		+		+	–	
EMG median (Figure 9)		+		+	–	
EMG periods below (Figure 10)			+		–	
Head and neck angle (Table 7)	–	+				

Notes. DVs—dependent variables.

the three measurement phases of the study. Second, the pattern of changes across the three phases will be considered for each of the three groups.

For measurements taken prior to intervention, both the static and the median muscle load of the right trapezius were significantly higher in the Polish group compared with the Norwegian one. However, the number of periods per minute when the trapezius load was below 1% Maximum Voluntary Contraction (MVC) did not show any significant differences among the three groups before intervention (see Figures 8, 9 and 10).

For measurements taken after intervention, significant differences between the Norwegian and Polish groups were observed for static and median right trapezius load. For measurements

intervention while a significant decrease was observed at follow-up versus after intervention

With respect to the number of periods per minute below 1%MVC, the Norwegian group showed a significant increase after compared with before intervention while in the U.S. group a reduction was observed at follow-up compared with after intervention. There were no significant changes for the Polish group.

3.5. Postural Angles

3.5.1. Head

3.5.1.1. Poland. Head flexion angle significantly increased from Part I to Part II at the 50th and 90th

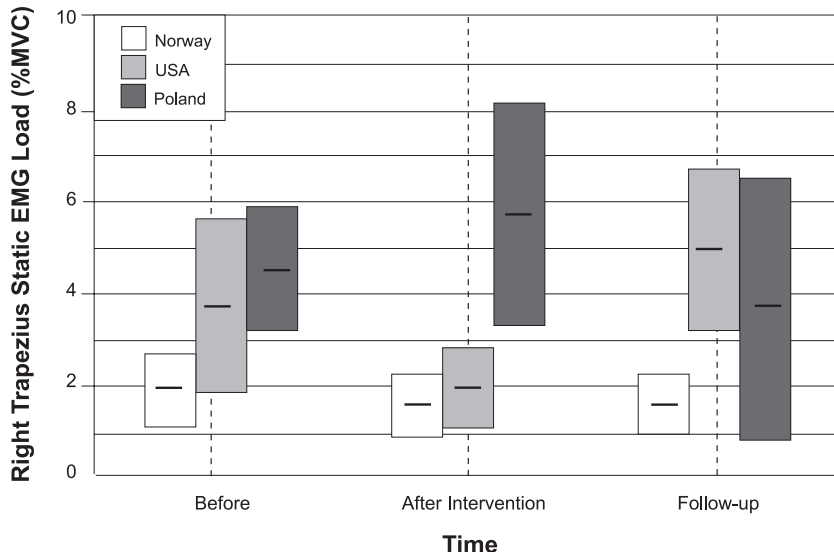


Figure 8. Right trapezius static electromyographic (EMG) load.

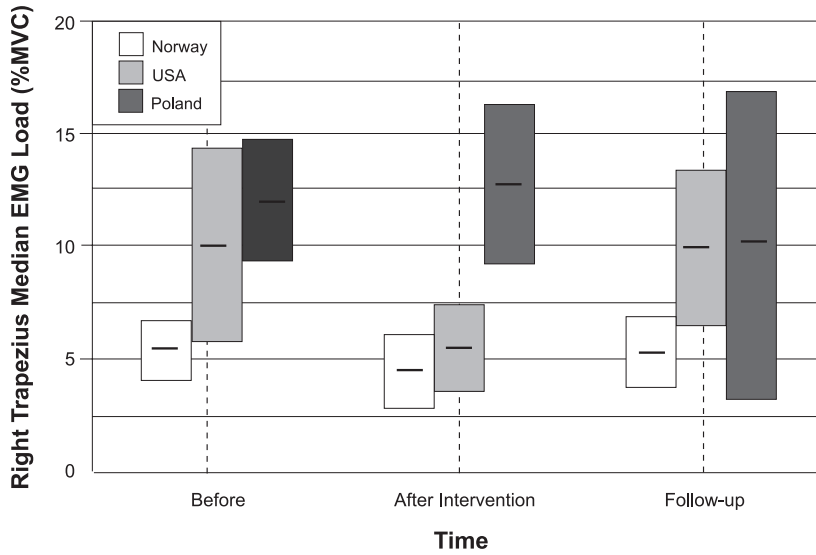


Figure 9. Right trapezius median electromyographic (EMG) load.

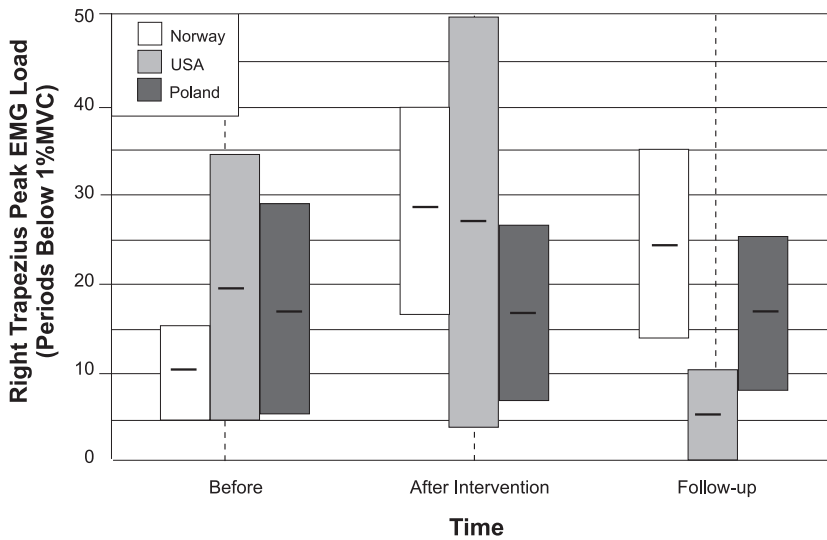


Figure 10. Right trapezius peak electromyographic (EMG) load.

percentile. (At 50th, approximately 10° from 24.8 to 34.9 and at 90th—approximately 18° from 33° to 51.3°.)

Only 2 persons changed spectacles. The back angle increased significantly at the 10th (static), 50th (mean) and 90th (peak) percentile (approximately 21° mean and 16° median).

3.5.1.2. USA. Head flexion angle significantly decreased at the 10th, 50th and 90th percentile. (At the 10th percentile approximately 6°, from 11.8° to 6°, at the 50th percentile approximately 19°, from 6° to 12.8°, and at the 90th percentile approximately 6°, from 26.5° to 19.2°) from Part I to Part II.

3.5.1.3. Norway. From Part I to Part II, the head flexion angle decreased a little at the 10th percentile, but there was almost no change at the 50th and 90th percentile. (At the 10th percentile approximately 2.1°, from 9.4° to 7.3°, at the 50th percentile approximately 1.2° from 19° to 18° and at the 90th approximately 1° from 27.5° to 28.6°) (see Table 8).

TABLE 8. Head Flexion Angles in Degrees

Part I	Norway	Poland	USA
10th percentile	9	14	11
50th percentile	19	25	19
90th percentile	28	33	26
Part II	Norway	Poland	USA
10th percentile	8	10	6
50th percentile	18	35	13
90th percentile	29	51	19

3.5.2. Arms

3.5.2.1. Flexion of the upper arm. The Norwegian and the U.S. groups had similar flexion/extension angles during VDT work. Considering the static and peak angles, i.e., the range of movements 80% of the recording time, the angles were between -3° and 12° while the Polish group had approximately 8° greater flexion.

3.5.2.2. Abduction of the upper arm. All the three groups had similar abduction, which, 80% of the time, ranged from 3° to 14°.

3.5.2.3. Flexion of the upper arm. This angle increased in the Norwegian group after intervention by approximately 5° while the U.S. and the Polish groups recorded an increase of approximately 10°.

3.5.2.4. Abduction of the upper arm. In the Norwegian and the U.S. groups the variation of the abduction was only a few degrees while in the Polish group the abduction increased approximately 15° as a mean group value. In fact the abduction of the Polish group increased even more at follow-up where the static and peak angles were 10° and 41° respectively.

3.5.3. Back

The Norwegian group seems to move their back more regarding flexion/extension compared with the Polish group. The static and peak angles were -4° and 14° versus 8° and 15° as mean group values. The corresponding values for the U.S. group were 5° and 10°. All the three groups had a symmetric position of the back during VDT work with only a few degrees' bending to each side. After intervention the Polish group bent their back to the right between 4° and 10° 80% of the recording time.

3.6. Individual Variables

Interesting differences were found regarding some of the psychosocial factors. The Polish group reported significantly more psychological problems compared to the Norwegian group ($p = .0009$) (see Figure 11). In the Norwegian data, a positive correlation between psychological problems and pain in the upper part of the body was established ($r = .38$). The U.S. group reported significantly more sleeping problems than the Norwegian group. In the U.S. data, a correlation was found between sleeping problems and psychological problems ($r = .33$). The Norwegian group described a significant higher satisfactory family situation compared to the U.S. group. The Polish group reported significantly less satisfying economical conditions compared to the Norwegian and the U.S. groups. In the Norwegian data, a negative correlation between economy and pain in the shoulder region was found, i.e., better economy meant less pain ($r = -.28, p = .05$). No significant differences were found between the three groups regarding sport and physical activity. In the Norwegian data, it was found that an increased level of sports and physical activity

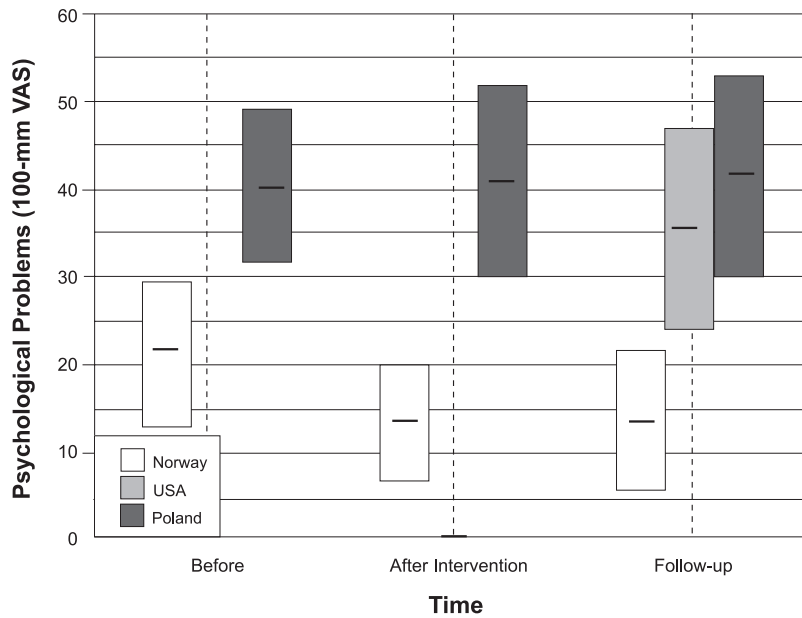


Figure 11. Psychological problems. Notes. VAS—Visual Analog Scale.

reduced the intensity and duration of pain in the upper part of the body. The strongest correlation was to the neck region ($-.60 < r < -.80$).

The feeling of tenseness, i.e., how the subjects felt subjectively to be tense, has in many studies a high correlation to pain in the upper part of the body. The Norwegian group reported a significant higher level of tenseness compared with the U.S. group. In the Norwegian data, a correlation between headache, neck and shoulder pain and the feeling of tenseness was established, strongest for neck pain ($r = .56$). In the U.S. data, a correlation was found between the feeling of tenseness and sleeping problems ($r = .46$) as well as psychological problems ($r = .43$). Psychological problems, sleeping problems, family situation, economical conditions, sport and physical activity as well as the feeling of tenseness showed no significant changes within the three groups during the study period. In addition, there were no significant differences between the three groups with regard to relative changes during same period.

3.7. Correlation Between Pain, Number of Trigger Points, Static Trapezius Load and Visual Discomfort

A clearly significant relation between the presence of trigger points and static trapezius load was found ($p = .002$). There was also an indication of

an association between neck/shoulder pains and visual discomfort ($R^2 = .19, p = .0008$). Back pain showed a weak positive relation to self realization ($R^2 = .12, p = .06$). The average intensity of neck/shoulder pain in the previous 6 months related significantly to the results of the isometric test ($p = .0001$). The average intensity of back pain in the past 6 months showed no relationship to smoking habits when considering the pain differences between the three countries ($p = .25$).

4. DISCUSSION

When comparing data in a multi-center study, it is of vital importance that the data are collected through identical methods and with identical criteria. In order to secure this, written procedures were distributed to the participating institutions. A video film was also produced, in order to better ensure not only the criteria, but also the clinical procedures to follow. This turned out to be more complicated than first expected. Not only were the clinical methods that people were used to perform somewhat different, but also there were significant differences in the professional and cultural background of the researchers that have complicated the study. This will be further discussed in the final paper in this issue, i.e., in Dainoff et al. [16].

Despite the methodological problems, the resulting summary shown in Table 8 reveals an interesting pattern. The U.S. group, which had the most extensive intervention (completely new integrated workstations plus extensive training), revealed a consistent pattern of improvement across several different types of dependent measures. The Norwegian group, which added training and adjustment to an already well-designed workplace, showed a small degree of positive changes. However, it is of some interest that the Polish group showed ambiguous results with several indications of actual decreases away from desired outcomes following the intervention. This finding is consistent with the reported observation that the professional ergonomists' goal of providing an adequate intervention was thwarted by management decisions to add new computer equipment to workstations for which such equipment was not designed. Thus, viewed from a global perspective, the international component of the MEPS study successfully tracked the differential impacts of three very different kinds of ergonomic intervention.

At the same time, it is important to attempt to describe and understand the methodological difficulties and differences across countries.

The difference in refractive error in the USA compared to Norway and Poland is not easily explained. Since this was not a main object for this study, the findings only deserve some interest. The development in visual discomfort in the past 6 months demonstrated a reduction in the USA and Norway while no such reduction was seen in Poland. This may be contributed to the general development of discomfort in Poland, and thereby support the connection between visual and body discomfort.

Further, there is an increase in the head flexion angle in Poland from commencement to Part II, clearly demonstrated at the 50th and 90th percentile. However, such an increase is not normally considered to lead to a development of musculoskeletal symptoms.

Before intervention, the Polish group reported less intensity of neck pain compared with the Norwegian group. Regarding shoulder pain the Polish group reported less pain compared to both

the U.S. and the Norwegian groups. These results were supported by clinical examination where the Polish group reported less pain during sideways movement of the neck and had fewer trigger points compared with the Norwegian and U.S. groups. Further, the isometric test provoked less tenderness and pain in the Polish and the U.S. groups than in the Norwegian one. None of the subjects in the Polish group reported tenderness when palpating the attachments of *m. supraspinatus* and *m. deltoideus* during muscle contraction compared to the Norwegian group where almost half of the subjects reported discomfort. The differences in pain intensity between the three countries are difficult to explain.

The Norwegian group reported more feeling of tenseness compared to the Polish and the U.S. groups. The feeling of tenseness correlated strongly with pain in the upper part of the body compared to the relatively weak correlation found for the other psychosocial factors, i.e., that the feeling of tenseness may have contributed to increased pain level of the Norwegian group relative to the Polish and the U.S. group. However, the Polish group reported more psychological and sleeping problems and less satisfactory family situation and economical conditions compared with the Norwegian group. Thus, these psychosocial factors might have increased the pain level in the Polish group relative to the Norwegian one. The U.S. group reported more psychological and sleeping problems and less satisfactory family situation and economic conditions compared to the Norwegian group. These factors should be expected to increase the pain level for the U.S. group.

The Polish and the U.S. groups recorded higher trapezius load compared with the Norwegian one. One reason for the difference in trapezius load may be the great difference in MVC during calibration between the Polish and the Norwegian groups. The mean group value of the MVC was 250 N and 380 microvolt in the Polish group compared with 380 N and 1028 microvolt in the Norwegian group. No indication of a relationship was found between EMG parameters and the intensity of pain in the neck and shoulder.

After intervention, the Norwegian group reported a reduction in neck pain while the U.S. group reported a reduction in shoulder pain after compared with before intervention. The Polish group reported an increase in neck, shoulder and forearm pain at follow-up compared to after intervention. No significant differences were found between the three groups at follow-up regarding neck and shoulder pain. These results were supported by the clinical examination where the U.S. group reported a significant reduction in pain during sideways movements while the Polish group reported a significant increase comparing follow-up with before intervention. Further, the Polish group had higher flexion of the upper arm at follow-up parallel with an increase in pain in the upper part of the body.

Regarding the psychological factors, no significant changes were reported within the three groups during the study. Further, no significant differences with regards to relative changes between the three groups were observed during the study period. Thus, indication of the effect of these factors should have been small regarding change in the pain level within each group during the study. The reason for the difference in pain level between the Polish and the Norwegian group is not clear. Cultural difference in experiencing pain may be one explanation. The Polish group was younger than the Norwegian one. The pain level of the Polish group increased after intervention. The reason for this result may be that the intervention was done by the engineers in the company who were not trained in ergonomics. However, at follow-up, the load in terms of EMG parameters was significantly reduced for static (10%) and median (50%) in the Polish group; perhaps indicating a successful adaptation to the new equipment. With respect to the U.S. EMG data, the increase load levels at follow-up were contradicted by most of the other measures, and could perhaps be explained by calibration errors during this phase.

5. CONCLUSION

Despite differences among the participating countries, and the methodological difficulties inherent in implementing a complex multidisciplinary research protocol by professionals with different cultural backgrounds, the overall pattern of results across the three countries is consistent with the characteristics of the ergonomic interventions carried out in each country.

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