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Can a More Neutral Position of the Forearm When Operating a Computer Mouse Reduce the Pain Level for Visual Display Unit Operators? A Prospective Epidemiological Intervention Study: Part II

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The aim of this study was to investigate if participants with pain experience reduced pain development when using a mouse allowing a more neutral position of the wrist (Anir) compared with development of pain using a traditional mouse. The study population consisted of 67 participants with mean intensity of pain of approximately 50 mm on a 100-mm Visual Analog Scale (VAS). The total group was randomly divided into 1 intervention group and 1 control group. The study was performed as a prospective parallel group study. VAS was used to assess the average level of pain in the musculoskeletal system during a 6-month period.

An earlier article on this study found that after using the Anir mouse for 6 months, a significant reduction was reported in neck pain (48.9 to 33.9). Corresponding data for other areas of the upper extremities were shoulder (54.1 to 31.8), forearm (52.9 to 32.8), and wrist and hand (42.5 to 22.3), respectively (Aarås, Ro, & Thoresen, 1999). The control group using the traditional mouse reported no significant changes in pain level. This article describes the results after giving an identical intervention to

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the control group. After 6 months, the former control group reported a significant reduction in average pain for the following body areas: shoulder, M = 48.0 (CI = 32.5–63.5) to M = 28.7 (CI = 18.7–38.8); forearm, M = 45.6 (CI = 30.8–60.4) to M = 15.6 (CI = 5.5–25.7); and wrist and hand, M = 34.8 (CI = 20.1–49.5) to M = 15.8 (6.4–25.2). Neck pain was marginally significantly reduced, M = 39.4 (CI = 25.2–53.6) to M = 27.4 (CI = 15.2–39.6), p = .07. The group getting the initial intervention did not report any significant changes in any of the body areas from 6 to 12 months after the study period; that is, the reduction in pain level obtained still existed. The results from this study indicate clearly the importance of using a more neutral position of the forearm when using a computer mouse.

Laboratory tests on performance measures (speed and accuracy) showed that the Anir mouse falls well within the range of performance measures associated with already existing commercially available input devices.

1. INTRODUCTION

The number of workers and their time using a visual display unit (VDU) is steadily increasing. In Sweden, more than 55% of the workforce used VDUs in 1997. Further, 25% used VDUs more than 50% of their work time (Wigaeus-Hjelm, 1999). In the Netherlands, The European Foundation of Living and Working Conditions (1996) reported that more than 2.5 million people worked with computers more than 4 hr each day. In Finland, 57% of the women and 55% of men used VDUs in their work in 1996 (Ketola, Häkkänen, Toivonen, Takala, & Viikari-Juntura, 1999). Brisson, Montreuil, and Punnett (1997) reported that office workers who are intensive users of VDUs represent 15% of the entire working population in Canada. Women comprise about 80% of all office workers in this country.

Punnett and Bergqvist (1997), in their review of epidemiological studies of VDU work, found that VDU work indicated higher risk of neck, shoulder, arm, wrist, and hand musculoskeletal illness compared with non-VDU work. VDU work seems to be more static than non-VDU work. A decrease in variability of muscle activity was found when comparing VDU work with non-VDU office work (Wærsted & Westgaard, 1997). The underlying mechanism that causes discomfort and pain in the musculoskeletal system is scarcely known. According to Hägg (1991), long-lasting activity of single muscle fibers may overload their capacity and start the process of damage, with pain as an end result. Läbuli, Schnoz, Weiss, and Krueger (1999) hypothesized that interactions between individual muscle activation patterns and certain repetitive tasks may cause overloading of the involved muscles.

2. AIMS OF THE STUDY

This study investigates if participants with pain have a reduction in pain development when using a mouse that allows a more neutral position of the forearm and wrist (Anir) compared with development of pain using a traditional mouse with a more pronated forearm. In addition, it investigates whether there were any differ-

ences in performance. Functionally, the Anir mouse is identical to traditional mice. The main feature of the Anir mouse is that it can be operated with an almost neutral position of the forearm and wrist (see Figure 1).

3. DESIGN OF THE STUDY

The study was performed as a prospective parallel group study with two groups of VDU workers. Sixty-seven participants were randomly divided into one intervention group and one control group. The mean age of the intervention group was 43.3 years (*SD* = 8.1), with a range of 29 to 61 years. The mean age for the control group was 43.7 years (*SD* = 11.3), with a range of 25 to 60 years. Their work was software engineering, bookkeeping, and secretarial work. To fulfill the inclusion criteria, the participants were required to have pain intensity of at least 25 mm on a 100-mm Visual Analog Scale (VAS). Further, the participants were required to have used a traditional mouse for at least 2 years and at least 2 hr per day. No intervention regarding lighting, optometric correction, work table, or chair should have occurred in the last 6 months before the start of the study for any of the participants. All workstations and chairs were height-adjustable for sitting work in both the intervention and control groups. Further, all participants were allowed to support their forearms on the table top. Those who were included reported pain intensity of approximately 50 mm on the VAS regarding neck, shoulder, and forearm pain in both the intervention and control groups. The study design and participant population were described in more detail by Aarås, Ro, and Thoresen (1999). After 6 months, an identical intervention was also carried out in the control group.

FIGURE 1 The Anir mouse.

4. METHODS AND PROCEDURES

4.1. Questionnaire

Questionnaires regarding demographic data, sick leave, visual conditions and discomfort, headache, musculoskeletal pain, and organizational and psychosocial factors were described by Aarås et al. (1999). Confounding factors such as visual and ergonomic conditions as well as organizational and psychosocial factors were collected to keep track of any changes during the study period. These questionnaires were used at commencement and after 6 and 12 months. The endpoints for average intensity of pain the last month or the last 6 months were *none* to *unbearable.* The end points for lighting, glare, and visual discomfort were *very bad* to *very good, very much glare* to *no glare,* and *none* to *very much,* respectively. The endpoints for organizational and psychosocial factors are shown in Table 1.

Table 1: Endpoints for Organizational and Psychosocial Factors

	Endpoints	
Factors	*0 mm*	*100 mm*
The same work tasks every day	Nearly all	Almost none
Determine which tasks you shall undertake from day to day	No, not at all	Completely
Determine the amount of work from day to day	No	Complete
Opportunity to take unscheduled short breaks	Never	Always
Opportunity to make job contacts	Scarcely at all	Very much
Opportunity to learn something new	Scarcely at all	Very much
Opportunity to increase job skills	Scarcely at all	Very much
Opportunity of full utilization of ability	Scarcely at all	Very much
Opportunity to contact your immediate superior	Never	Always
How much of the day you feel genuinely satisfied with your job	Never	Always
Does the VDU increase stimulation at work	Increases stimulation	Reduces stimulation
Other tasks more physically demanding	More physically demanding	Less physically demanding
Other tasks more stressful	More stressful	Less stressful
Other tasks more mentally stimulating	More mentally stimulating	More tedious
Sole provider of the household or share burden with others	Sole	A lot of support
Person(s) you can rely on and get help from	None	Yes, several
Person in your home needing extra physical effort	No	Yes, to a high extent
Person in your home needing extra psychological support	No	Yes, to a high extent
The housework from day to day	Easy	Difficult
Daily journey to work	Unacceptable (stressful, tiring, takes too long)	Quite satisfying
Time to own disposal before and after work	None	A lot of time
Subjective feeling of tenseness	Never	Very often
Sports or physical activity	None	Very much

In addition, after 12 months, Aarås interviewed participants about when they first were aware of discomfort or pain in the upper part of the body. To support their memory, data from their medical records were used to inform them of the first time they consulted the medical department for pain. Each participant tried to estimate the level of pain on the 100-mm VAS when pain started and the level of pain between the start of pain and 6 months before the start of the study. Location of pain was also reported. Pain was related to when the participant started to use the keyboard and mouse.

4.2. Clinical Examination

A clinical examination was carried out on the control group after 6 and 12 months from the start of the study. The examination consisted of a general observation of the musculoskeletal system; palpating of the trigger and tender points in the upper part of the body; measuring the pressure of these points when pain radiated from the point or serious pain occurred (Sheon, Maskowitz, & Goldberg, 1982); measuring the range of passive movements of the neck and head in terms of flexion and extension, sideways flexion, and rotation; and reporting pain during these movements on the VAS. Special tests for inflammatory joint conditions in the cervical spine, disc degeneration or prolapse, and thoracic outlet syndrome were performed (see Appendix).

In the shoulder region, the acromioclavicular joint, sternoclavicular joint, and glenohumeral joint were examined. In the latter joint, signs of capsulitis, bursitis, and tendonitis were focused on. Palpation of tendon attachments to supraspinatus and deltoid was performed with relaxed muscles and against active resistance during the muscle contraction. Tenderness or pain when palpating the tendon attachment was recorded as positive. Endurance tests of the neck and shoulder consisted of lifting the shoulders with the upper arms hanging relaxed beside the body for 1 min. If the participant felt tender or experienced continuous pain for more than 1 min after cessation of the test, the results were classified as positive. In the elbow region, tests for epicondylitis, pronator teres, supinator syndrome, tenosynovitis for tendons of the wrist flexors and extensors, and nerve entrapment were performed. Symptoms of carpal tunnel syndrome and tests for signs of this disorder were performed.

4.3. Dropout Routine

A separate statistical analysis was carried out to see if the results would be influenced by the participants who dropped out during the study period. Particularly informative are dropouts whose reason for dropping out is connected to the use of the Anir mouse. Their most serious pain at the start or after 6 months of the study was selected. These values for different body parts were prolonged to 12 months. The statistical analysis was repeated and the results were compared with the original analysis.

4.4. Statistical Methods

For estimation of the location parameters in assumed continuously distributed variables, means and medians are used. As an index of dispersion, 95% confidence intervals for the mean are used. For calculation of the confidence intervals for the means, the Student procedure is used. The two groups are compared after 12 months, adjusted for the baseline value by analysis of covariance. Changes within each group are analyzed by paired *t* tests. The groups are compared with regard to changes in the categorical variable by a Mantel–Haenszel test. All tests are performed two-tailed, and *p* values less than .05 are considered significant.

4.5. Performance Assessment Using Fitts's Law

Fitts's Law provides a widely accepted conceptual model within which to evaluate human psychomotor performance. Since the original formulation by Fitts (1954), there have been hundreds of studies using this formulation, and it has been widely adopted as an evaluation tool in human–computer interaction (MacKenzie, 1992).

In a typical Fitts's Law procedure, the speed and accuracy of a movement from a starting point to a target (which varies in width, *W*) and distance or amplitude (*A*) are measured. The index of difficulty [defined as log2 (2*A*/*W*)] when regressed against movement time explains large proportions of variance in such times. Thus, the standard formulation of Fitts's Law is as follows:

$$MT = B + m^{*}(\log_2 (2A/W)) \tag{1}$$

Using a Fitts's Law procedure, Langolf, Chaffin, and Foulke (1978) found that the performance involving larger muscles will result in reduced speed (expressed as an increase in the slope of the Fitts's Law function relating movement time to index of difficulty).

It is to be expected that the different configuration of the two input devices (a Microsoft mouse and the Anir mouse) would involve different patterns of muscle use in positioning actions. Moving the vertical Anir mouse should require relatively greater involvement of larger forearm muscles, whereas the standard mouse should require relatively greater involvement of smaller finger muscles. Consequently, we would predict, following Langolf et al. (1978), that the slope of the Fitts's Law function should be greater for the vertical mouse.

In this study speed and accuracy were assessed by the use of a standardized Fitts's Law procedure devised by MacKenzie (1992). In this procedure, time to move the mouse from the center of the screen to a predefined target and errors associated with precise location of the target have been measured. Target size, distance, and location with respect to the center of the screen have been systematically manipulated. The Fitts's Law procedure was utilized under two different display mode conditions (click and point vs. click and drag).

Both tasks involved moving the mouse from an initial position in the center of the screen to a target circle. The target size (diameter) and distance and angle of

movement from start point were systematically varied. There were four sizes, four distances, and eight angles resulting in 128 trials in a single session.

Experiments 1 and 2

In Experiment 1, the participant clicked on the start point, and then moved the mouse to the target and clicked again. In Experiment 2, the participant was required to drag from the start point to the target. Participants were 10 undergraduate students at Miami University with some exposure to ergonomics and experience using a mouse. In each experiment, each participant performed 16 sessions over a 2-day period. On each day, a participant would complete a group of four sessions (which took about 45-min), then take a 15-min break, and then complete a second group of four sessions. The type of mouse alternated between groups of four sessions in a counterbalanced fashion. Four of the participants experienced the order MAAM; the other six experienced the order AMMA (where A = Anir mouse and M = Microsoft mouse). Each participant completed 2,048 individual trials. If the participant missed the target, a beep was heard, but the trial was not repeated. Participants were instructed to keep their error rates within the region of 10%.

Experiment 3

To provide some additional context for the observed performance differences, a third experiment was carried out. This study was identical to Experiment 1, except that a third pointing device was added. This device was a small thumb-operated trackball (Logitech Trackman Marble). In this case, only 3 participants were utilized. Each completed eight sessions using each of the three devices. Devices were presented in (incomplete) counterbalanced order. The point-and-click mode of operation was utilized.

5. RESULTS

5.1. Health Outcomes

The following results are a summary of the first part of this study (Aarås et al., 1999). Regarding pain intensity and frequency assessed on VAS, the intervention group reported significant improvements for the wrist and hand, forearm, shoulder, and neck ($p \leq .009$) after intervention but in the control group only small changes were observed ($p \geq .24$), as shown in Figures 2 through 5. Significant differences were also found between the intervention group and the control group after intervention for pain in the same body areas. The frequency of pain and the intensity of pain in the last month were very similar to the intensity of pain in the last 6 months; therefore only the latter parameter is discussed. Total duration of pain in the last 6 months was also significantly improved for the shoulder and forearm in the intervention group, but no such changes were observed in the control group.

After 6 months an identical intervention was also carried out in the control group, allowing them to work with a more neutral forearm position when using the Anir mouse. The intervention group continued to work with the forearm in a neutral position when using the Anir mouse. This article describes the results of the study period from 6 to 12 months.

Neck Pain

In the former control group, a clear reduction in neck pain from 6 to 12 months was observed, $M = 39.4$ ($CI = 25.2–53.6$) to $M = 27.4$ ($CI = 15.2–39.6$) as mean with 95% confidence intervals ($p = .07$). In the former intervention group no significant changes were observed, $M = 32.4$ ($CI = 22.6–42.3$) to $M = 24.3$ ($CI = 15.7–33$), $p = .11$. (This group had reported already a significant reduction of pain intensity in the period from commencement to 6 months of the study. See Figure 2.) After 12 months, there was no longer any significant difference between the groups. The frequency of neck pain in the last month was significantly reduced in the former control group, $M = 40.9$ ($CI = 24.3–57.6$) to $M = 25.8$ ($CI = 13.8–37.8$), $p = .04$ comparing levels after 6 and 12 months. The former intervention group reported no significant change, $M = 29$ ($CI = 20–38.1$) to $M = 29.8$ ($CI = 18.2–41.5$), $p = .90$.

Shoulder Pain

After 12 months the former control group reported a significant reduction in intensity of pain in the last 6 months compared with the intensity after the previous 6 months, $M = 48$ ($CI = 32.5–63.5$) versus $M = 28.7$ ($CI = 18.7–38.8$), $p = .008$, whereas the former intervention group reported no significant change, $M = 26.8$ ($CI = 17–36.5$) versus $M = 25.4$ ($CI = 15.4–35.5$), $p = .78$ (see Figure 3). After 12 months of

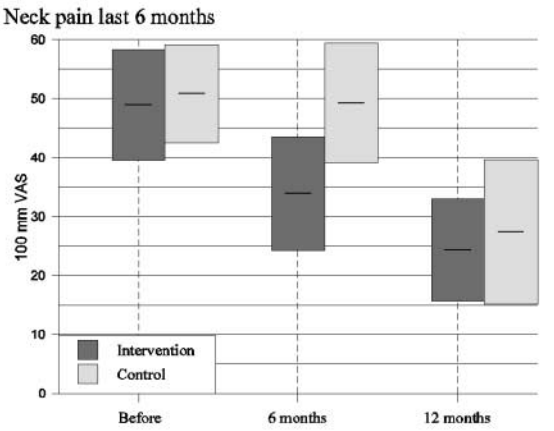

FIGURE 2 The intensity of neck pain over the last 6 months. Values are given as a group mean with a 95% confidence interval.

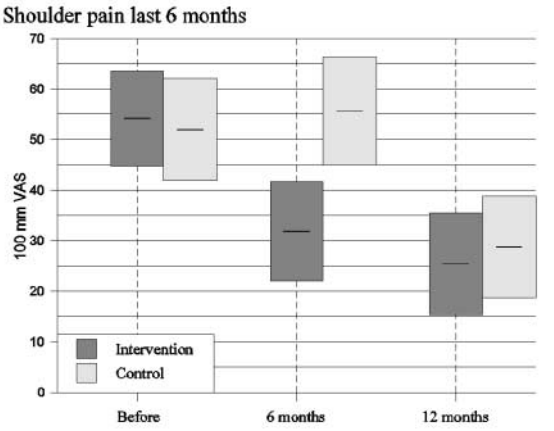

FIGURE 3 The intensity of shoulder pain over the last 6 months. Values are given as a group mean with a 95% confidence interval.

the study, no significant difference was found between the groups. Frequency of pain in the last month was also significantly reduced in the former control group, $M = 54.6$ ($CI = 37.7–71.5$) to $M = 31.5$ ($CI = 17.8–45.3$), $p = .004$, whereas no significant change was observed in the former intervention group, $M = 24.3$ ($CI = 14.1–34.6$) to $M = 26.4$ ($CI = 14.1–38.8$), $p = .76$.

Forearm Pain

After 12 months, a significant reduction of intensity of forearm pain in the last 6 months was reported in the former control group, $M = 45.6$ ($CI = 30.8–60.4$) to $M = 15.6$ ($CI = 5.5–25.7$), $p < .001$, whereas no significant change was found in the former intervention group, $M = 31.9$ ($CI = 21.6–42.3$) to $M = 22.7$ ($CI = 13.1–31.9$), $p = .09$ (see Figure 4). After 12 months, no significant difference in forearm pain was found between the groups. Further, the frequency of forearm pain was significantly reduced over the last month in the former control group, $M = 46.5$ ($CI = 30–63$) to $M = 15.2$ ($CI = 5–25.5$), $p = .001$, whereas no such change was found in the former intervention group, $M = 31.7$ ($CI = 20.9–42.5$) to $M = 27.6$ ($CI = 16.1–39.1$), $p = .46$.

Pain in the Wrist and Hand

After 12 months, the former control group reported a significant reduction in intensity of pain, $M = 34.8$ ($CI = 20.1–49.5$) to $M = 15.8$ ($CI = 6.4–25.2$), $p = .005$, whereas no significant change was observed in the former intervention group, $M = 19.9$ ($CI = 12.2–27.6$) to $M = 20.3$ ($CI = 11.1–29.4$), $p = .90$ (see Figure 5). After 12 months, no significant difference in wrist and hand pain was observed between the groups. The frequency of pain was also significantly reduced in the former control group, $M = 35.7$ ($CI = 20.6–50.8$) to $M = 15.5$ ($CI = 5.8–25.2$), $p = .006$, whereas no such

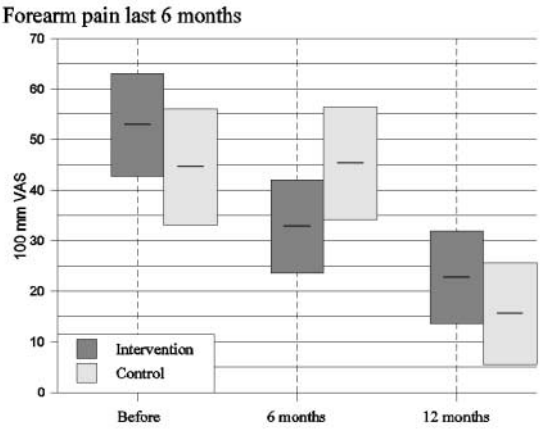

FIGURE 4 The intensity of forearm pain over the last 6 months. Values are given as a group mean with a 95% confidence interval.

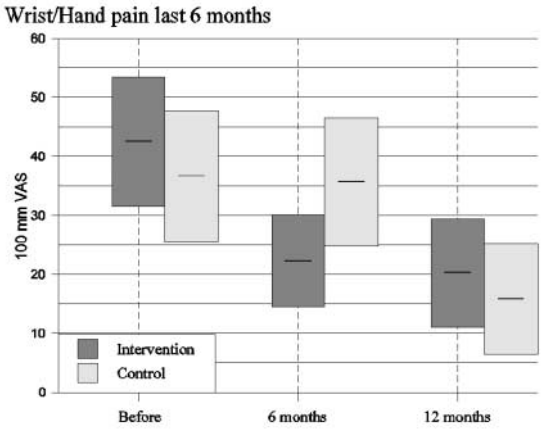

FIGURE 5 The intensity of hand and wrist pain over the last 6 months. Values are given as a group mean with a 95% confidence interval.

change was observed in the former intervention group, $M = 23.7$ ($CI = 13.2–34.1$) to $M = 22.1$ ($CI = 12.1–32.1$), $p = .70$.

Headaches

No significant changes were observed regarding headaches either in the former control group or in the former intervention group when comparing the study period

between 6 and 12 months. For the former control group the intensity of headaches was $M = 28.4$ ($CI = 17.8–39.0$) versus $M = 27.4$ ($CI = 15.6–39.1$), respectively, $p = .81$. Corresponding values for the former intervention group were $M = 30.6$ ($CI = 22.9–38.4$) versus $M = 29.0$ ($CI = 20.3–37.8$), $p = .74$ (see Figure 6). After 12 months, no significant difference was found between the two groups. The frequency of headaches in the last month did not show any significant changes in the two groups.

Musculoskeletal Sick Leave

In the former control group, sick leave due to musculoskeletal illness in the last 6 months showed a reduction from $M = 3.1$ ($CI = 0–9.1$) days to $M = 0$ ($CI = 0–0$) comparing the last 6 months with the previous 6 months. In the former intervention group, no significant change was observed, and corresponding values were $M = 0$ ($CI = 0–0$) to $M = 1.1$ (0–2.7). (See Figure 7.)

Clinical Examination

A clinical examination was performed in the former control group. The procedure of the examination and the specific tests for clinical signs are described in detail in the Appendix. Clinical signs of myalgia in the neck and shoulder were found to be reduced in terms of the number of tender or trigger points, $M = 3$ ($CI = 1.8–4.2$) to $M = 1.5$ ($CI = 0.8–2.3$), $p = .03$, comparing the clinical examination at 6 months with that at 12 months after the start of the study (see Table 2). Further support for these results was found in terms of a tendency to increase pressure before radiating pain from the trigger points, $M = 15.4$ kg ($CI = 12.8–18$) to $M = 25.6$ kg ($CI = 16.2–35$), $p = .07$. Pain during flexion and sideways flexion of the cervical column was significantly reduced. For flexion, $M = 11.9$ ($CI = 6.4–17.5$) to $M = 1.1$ ($CI = –0.5–2.6$) mm

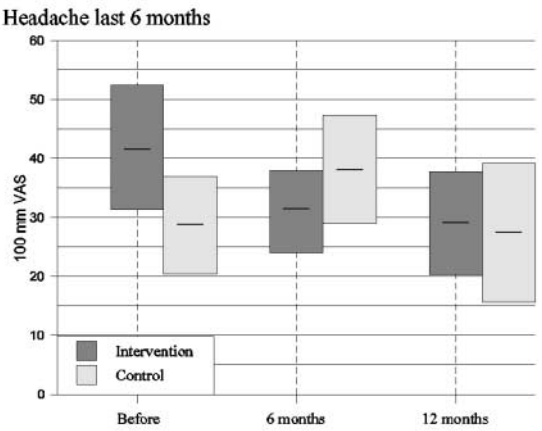

FIGURE 6 The intensity of headache pain over the last 6 months. Values are given as a group mean with a 95% confidence interval.

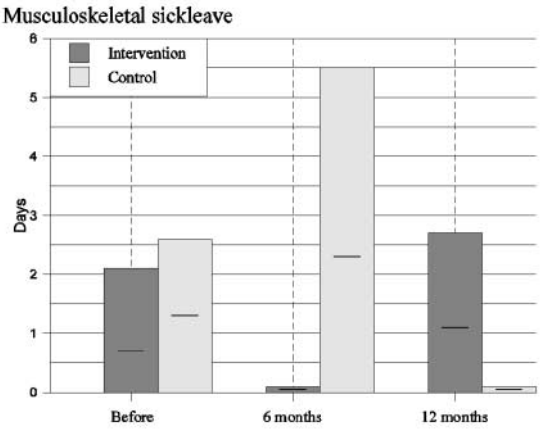

FIGURE 7 Musculoskeletal sick leave. Values are given as a group mean with a 95% confidence interval.

Table 2: Clinical Examination

	Before Intervention		*After Intervention*		
Test	*M*	*CI*	*M*	*CI*	*p Value*
Number of trigger or tender points	3.0	1.8–4.2	1.5	0.8–2.3	.03
Pressure (kg)	15.4	12.8–18.0	25.6	16.2–35.0	.07
Mobility of cervical column					
Flexion (degrees)	63.0	60.0–66.0	60.0	57.0–63.0	.08
Pain during flexion	11.9	6.4–17.5	1.1	–0.5–2.6	.002
Extension (degrees)	55.0	50.0–61.0	53.0	49.0–57.0	.18
Pain during extension	18.8	6.1–31.5	6.9	1.2–12.7	.11
Sideway flexion (degrees)	36.0	33.0–40.0	45.0	40.0–50.0	.001
Pain during sideway flexion	15.5	7.7–23.2	6.2	1.3–11.1	.03
Rotation (degrees)	69.0	65.0–72.0	77.0	72.0–82.0	.01
Pain during rotation	7.7	1.2–14.2	4.0	0.3–7.7	.27

Note. Values are given as means with 95% confidence interval.

VAS (p = .002). Corresponding values for sideways flexion were M = 15.5 (CI = 7.7–23.2) to M = 6.2 (CI = 1.3–11.1), p = .03.

Signs of inflammatory joint conditions in the cervical spine were reduced in terms of pain during flexion and sideways flexion (see Table 3). Such symptoms and signs are pain in the head, neck, or arm that is aggravated by movement, relieved by rest, and provoked by overpressure as well as reduced range of movements. These signs were found in 8 participants of 15 before intervention compared with 1 participant of 15 after intervention. Tendonitis of the glenohumeral joint was found only in 1 participant before and none after intervention. No sign of liga-

ment strain from osteoarthritis was found regarding acromioclavicular or sternoclavicular joints. No sign of capsulitis of the glenohumeral joint was found. All participants had no pathological mobility of the joint; that is, none suffered from capsulitis of the joint. Signs of lateral epicondylitis were greatly reduced from 10 participants before intervention to none after intervention. A small change was also found regarding medical epicondylitis. Three participants had such a diagnosis before versus none after intervention. One participant reported pain on resisted elbow extension, a sign of tendonitis, before intervention versus no pain after.

The endurance test showed reduced symptoms after intervention, as only 5 participants reported tenderness after intervention, whereas 3 reported pain and 8 reported tenderness before intervention (see Table 4). Only 2 participants reported tenderness with palpation of the tendon attachments of supraspinatus and deltoid muscles before and 1 reported tenderness after intervention.

Signs of tenosynovitis of extensor muscles of the forearm and wrist were reported by 9 participants before intervention, whereas none had such signs after intervention. Carpal tunnel syndrome was diagnosed in 1 participant before intervention. The surgery was successful and at 12-month follow-up, there was no sign of carpal tunnel syndrome. No one reported pain from the radioulnar joint with supination or pronation with overpressure. There were no certain signs of median nerve entrapment in the pronator teres or entrapment of radial nerve within the supinator muscles. No musculocutaneous nerve entrapment was found. Only 1

Table 3: Clinical Examination

	Before Intervention		*After Intervention*	
Symptoms and Signs	*Yes*	*No*	*Yes*	*No*
Signs of inflammatory joint condition of main cervical spine	8	7	1	14
Signs of tendonitis and bursitis of the glenohumeral joint	1	12	0	14
Lateral epicondylitis of the elbow	10	5	0	15
Medical epicondylitis of the elbow	3	12	0	15
Posterior overload syndrome	1	14	0	15

Table 4: Clinical Examination

	Before Intervention			*After Intervention*		
	Pain	*Tenderness*	*Normal*	*Pain*	*Tenderness*	*Normal*
Endurance test	3	8	4	0	5	10
Palpation of tendon attachment without resistance	0	1	14	0	1	14
Palpation of tendon attachment with resistance	0	2	13	0	1	14

participant used pain killers daily before intervention, whereas none needed such frequent treatment after intervention. One participant had gotten physiotherapy before intervention, whereas 2 received such treatment after intervention ($p = .56$).

5.2. Confounding Factors

Visual Discomfort, General Lighting Conditions, and Glare Problems

There was a tendency toward reduced visual discomfort in both groups. Only the former control group reported a significant reduction when comparing the data at 12 months with the previous 6-month period of the study ($p = .007$). No significant changes were observed regarding lighting and glare conditions in this period (see Table 5). Further, no significant differences were found comparing the two groups regarding lighting and glare problems and the intensity and frequency of visual discomfort after 12 months. In addition, both groups reported the visual conditions at home to be approximately equal to the visual conditions at work.

VDU Work

Regarding total time using the VDU and mouse at work and at home, no significant differences were found within the two groups comparing the period from 6 to 12 months with the previous 6-month period or between the groups after 12 months of study (see Table 6). Further, no significant differences were found within or between the groups regarding duration of continuous VDU work before a break. The workplace at home was assessed to be worse than that at work. However, there were no significant differences either within or between the two groups.

Organizational and Psychosocial Factors at Work

The workers' control and decision latitude showed no significant differences within the groups comparing the last 6 months with the previous 6-month period (see Table 7).There were no significant changes in job satisfaction due to the deter-

Table 5: Lighting and Glare Conditions at Work

	Intervention Group				*Control Group*			
	Before		*After*		*Before*		*After*	
	M	*CI*	*M*	*CI*	*M*	*CI*	*M*	*CI*
Lighting condition	71.1	63.6–78.5	74.2	66.7–81.7	72.4	64.7–80.2	75.4	67.4–83.4
Glare condition	62.0	52.0–72.0	71.6	61.7–81.5	64.5	52.4–76.6	72.9	62.4–83.4
Visual discomfort								
Intensity	36.9	28.1–45.8	30.4	21.6–39.2	47.4	35.6–59.1	30.7	20.1–41.4
Frequency	36.8	26.9–46.8	32.2	22.5–41.9	36.3	27.0–45.6	25.1	15.3–34.9

Note: Values are given as means with 95% confidence intervals.

Table 6: Total Time Using the VDU and the Mouse at Work and at Home

	Intervention Group				*Control Group*			
	Before		*After*		*Before*		*After*	
	M	*CI*	*M*	*CI*	*M*	*CI*	*M*	*CI*
VDU experience (years)	13.9	12.4–15.3	12.9	11.4–14.4	12.4	10.9–14.0	12.1	10.5–13.7
Mouse use (years)	7.6	6.3–8.9	7.4	6.4–8.4	7.9	6.6–9.2	8.3	6.8–9.8
Working (hr/week)	41.7	40.1–43.2	42.6	40.8–44.3	41.3	39.4–43.2	41.8	37.6–46.1
VDU use at work (hr/day)	5.2	4.6–5.8	5.6	4.5–5.6	5.6	4.9–6.4	5.7	5.0–6.4
VDU use at home (hr/day)	0.6	0.3–0.8	0.7	0.4–0.9	0.9	0.6–1.2	0.9	0.5–1.2
Mouse use at work (hr/day)	4.3	3.5–5.0	4.4	3.8–5.0	5.1	4.2–6.0	5.2	4.4–5.9
Mouse use at home (hr/day)	0.6	0.3–0.8	0.6	0.4–0.9	0.9	0.6–1.2	0.9	0.5–1.2
Continuous VDU work before break (min)	57.3	45.4–69.2	53.0	42.2–63.7	41.8	28.4–55.2	51.7	36.8–66.6

Note: Values are given as means with 95% confidence interval.

mination of the amount of work the VDU workers do from day to day. This was true within the group and between groups.

Other Tasks in Addition to VDU Work

Other tasks were compared to VDU work regarding physical demands, mental stimulation, and stressfulness. No significant differences were found within the two groups comparing the period from 6 to 12 months with the previous 6-month period (see Table 8). The former intervention group experienced the other tasks as more stressful after 12 months compared with the control group ($p = .04$). Correction was made in the statistical analysis for the difference between the group at commencement.

Work-Related Conditions of the Life Situation

Social support and cooperation at home as well as stressful conditions at home and the daily journey to work are important confounding factors for health outcome. These factors were not significantly different within the group comparing the period from 6 to 12 months with the previous 6-month period (see Table 9).

Individual Factors

Sports and physical activity were practiced to the same extent in the two groups before and after intervention (see Table 10). For the subjective feeling of tenseness,

Table 7: Organizational and Psychosocial Factors at Work

	Intervention Group				*Control Group*			
	Before		*After*		*Before*		*After*	
	M	*CI*	*M*	*CI*	*M*	*CI*	*M*	*CI*
The same work tasks every day	47.7	39.9–55.5	52.8	44.0–61.7	46.1	34.9–57.2	42.3	31.3–53.2
Determine which tasks you will undertake from day to day	56.5	48.0–65.0	60.9	52.8–69.1	59.3	48.5–70.0	66.1	57.1–75.0
Determine the amount of work from day to day	47.7	37.1–58.3	53.5	43.4–63.5	51.5	39.2–63.7	58.5	46.7–70.3
Opportunity to take unscheduled short breaks	79.3	71.2–87.3	83.5	78.3–88.7	81.4	71.5–91.2	86.4	82.2–90.7
Opportunity to make job contacts	70.3	61.8–78.9	76.2	69.7–82.7	81.7	74.3–89.1	82.3	75.8–88.8
Opportunity to increase job skills	59.4	50.2–68.7	59.4	48.8–70.0	67.1	57.3–76.8	63.9	52.3–75.6
Opportunity of full utilization of ability	55.2	45.4–65.1	52.6	42.3–62.9	69.4	62.0–76.8	64.4	54.0–74.7
Opportunity to contact your immediate superior	67.5	60.2–74.8	68.3	60.9–75.7	66.9	55.0–78.8	68.6	59.5–77.8
How much of the working day you feel genuinely satisfied with your job	59.5	51.6–67.3	60.7	52.7–68.6	64.9	57.4–72.4	64.7	56.5–73.0
Does the VDU increase stimulation at work	37.0	30.5–43.6	37.9	31.4–44.5	46.4	36.2–56.7	43.2	34.1–52.4
Opportunity to learn something new	58.9	48.1–69.6	60.6	49.5–71.6	64.1	52.6–75.6	62.7	51.2–74.3

Note: Values are given as means with 95% confidence interval.

no significant changes were reported comparing the period from 6 to 12 months with the previous 6-month period within the groups. After 12 months, the former intervention group reported significantly less feeling of tenseness compared to the former control group ($p = .03$). Correction is made in the statistical analysis for the difference between the groups at commencement by analysis of covariance.

Table 8: Other Tasks in Addition to VDU Work

	Intervention Group				*Control Group*			
	Before		*After*		*Before*		*After*	
	M	*CI*	*M*	*CI*	*M*	*CI*	*M*	*CI*
Other tasks more physically demanding	56.7	50.0–63.4	57.4	49.5–65.3	55.7	45.5–65.9	55.6	45.4–65.7
Other tasks more stressful	48.1	41.0–55.3	42.4	35.8–49.1	63.3	53.9–72.6	58.8	52.1–65.5
Other tasks more mentally stimulating	52.8	45.3–60.3	46.1	37.5–54.7	41.1	32.9–49.2	43.2	35.5–50.9

Note: Values are given as means with 95% confidence interval.

Table 9: Work-Related Conditions of the Life Situation

	Intervention Group				*Control Group*			
	Before		*After*		*Before*		*After*	
	M	*CI*	*M*	*CI*	*M*	*CI*	*M*	*CI*
Sole provider of the household or share burden with others	55.0	42.6–69.0	54.7	42.1–67.3	50.9	34.0–67.9	51.9	37.5–66.3
Person(s) you can rely on and get help from	77.7	70.5–84.9	73.3	64.1–82.6	70.8	63.0–78.5	69.3	61.5–77.1
Person in your home needing extra physical efforts	10.5	4.0–17.1	15.4	5.6–25.1	12.1	3.9–20.2	16.2	5.7–26.6
Person in your home needing extra psychological support	18.9	8.5–29.4	20.9	9.8–31.9	17.5	5.9–29.2	15.8	5.5–26.2
The housework from day to day (easy/difficult)	36.6	27.3–49.9	27.7	19.6–35.7	39.7	26.7–52.7	33.1	22.1–44.1
Stressful daily journey to work	68.3	57.4–79.3	68.8	57.9–79.7	80.2	73.0–87.3	79.6	73.3–87.9
Time to own disposal before and after work	47.7	35.5–59.9	49.5	38.1–60.8	50.2	36.9–63.5	47.5	34.3–60.8

Note: Values are given as means with 95% confidence interval.

Table 10: Individual Factors

	Intervention Group				*Control Group*			
	Before		*After*		*Before*		*After*	
	M	*CI*	*M*	*CI*	*M*	*CI*	*M*	*CI*
Subjective feeling of tenseness	53.4	44.3–62.6	50.9	41.0–60.7	64.2	52.7–75.8	59.7	50.1–69.3
Sports/physical activity	47.1	37.1–57.0	45.6	35.4–55.8	42.5	29.1–56.0	47.4	35.1–59.6

Note: Values are given as means with 95% confidence interval.

Table 11: Dropouts

Reason	*Intervention Group*	*Control Group*
Could not use Anir mouse because the participant was left-handed and a left-handed mouse was not available at that time	—	3
Could not use Anir mouse due to wrist fracture	—	1
Could not use Anir mouse due to Macintosh operation	—	1
Preferred the traditional mouse	2	4
Left job at Alcatel STK (work abroad or job terminated)	3	6
Had other work tasks with no mouse use	—	1

Dropouts

In the study period from 6 to 12 months, 16 participants dropped out of the former control group and only 5 participants dropped out of the former intervention group. Reasons for dropout are given in Table 11. Four participants in the former control group and 2 participants in the former intervention group withdrew from the study for reasons related to the Anir mouse; that is, informative dropouts. The reasons for the other dropouts were not connected to the tested mouse. The results regarding health outcomes (neck pain; shoulder pain; and pain in the forearm, wrist, and hand) were prolonged for the 4 informative dropouts in the former control group. The results of these analyses established that the conclusion made in the study does not change in any way due to the dropouts. The reduction of pain from 6 months to 12 months was higher when the dropouts were included in the analysis. That means that the informative dropouts are not the reason for the difference in pain level from 6 to 12 months in the former control group.

Pain Development Before the Start of the Study

There was a clear increasing development of intensity of pain in all body areas from the time the participants first were aware of discomfort or pain to the start of the study (see Table 12). Further, a majority of the participants were aware of their

pain after starting to work with the mouse. The number of years with discomfort or pain for the former intervention group was *M* = 5.4 (*CI* = 4–6.7). The corresponding value for the former control group was *M* = 6.3 (*CI* = 4.1–8.5). The median values were *M* = 5.5 for the former intervention group and *M* = 4 for the control group. The number of years using a mouse was *M* = 7.6 (*CI* = 6.3–8.9) for the former intervention group. For the former control group, the corresponding value was *M* = 8.8 (*CI* = 6.4–11.2). That means that the majority of the participants got their discomfort or pain after starting to use the mouse.

Performance Assessment Using Fitts's Law

Experiments 1 and 2. With respect to overall speed, the Microsoft mouse was slightly faster in both experiments. In Experiment 1 (point and click), the mean movement time—averaged across index of difficulty—for correct responses was 1157.38 msec for the Anir mouse and 992.97 msec for the Microsoft mouse. The difference between the two was 164.41 msec, or between .1 and .2 sec. The corresponding standard errors of the mean were 4.7 msec and 3.74 msec.

In Experiment 2 (drag), the mean movement time for correct responses for the Anir mouse was 1176.89 msec, compared with 1018.63 msec for the Microsoft mouse. The difference was 158.26 msec. Standard errors of the mean were 4.94 msec and 3.97 msec.

The size of the mean difference and standard errors are remarkably similar between the two experiments. It can be argued that this difference, although statistically significant, is of limited practical significance because there is a considerable overlap between the two patterns of movement times. This can be illustrated in Figure 8, which is a box plot representing the overall differences in movement times between the two mice for Experiment 1.

The comparable figure for Experiment 2 looks identical. The boxes in each plot represent 50% of the movement times for the mouse (the Anir mouse is on the left). The horizontal line within the box represents the median response time. The distance between the top and bottom of each box is a measure of variability called the

Table 12: Discomfort in the Upper Part of the Body

	Intervention Group						*Control Group*					
	1		*2*		*3*		*1*		*2*		*3*	
Test	*M*	*CI*	*M*	*CI*	*M*	*CI*	*M*	*CI*	*M*	*CI*	*M*	*CI*
Neck	30.9	19–43	39.1	27–51	48.9	39–58	21.7	8–35	28.9	12–46	50.8	42–59
Shoulder	35.6	24–47	44.8	34–56	54.1	45–64	31.6	17–46	34.5	19–50	51.9	42–62
Forearm	27.3	13–42	40.6	28–53	52.9	43–63	21.8	4–39	32.1	14–50	44.6	33–56
Wrist/hand	22.8	9–37	28.5	15–42	42.5	31–54	2.8	–3–9	14.3	0–29	36.7	25–48

Note: Values are given as means with 95% confidence interval. 1 = first time participants were aware of discomfort or pain; 2 = the discomfort or pain between the first awareness of pain (1) and until 6 months before the intervention (3); 3 = the discomfort or pain in the 6-month period before the intervention.

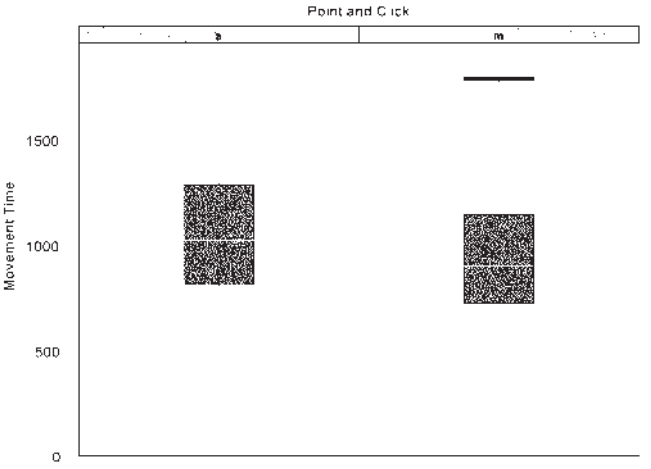

FIGURE 8 Movement time in Experiment 1.

Table 13: Fitts's Law Constants

Test	*B*	*m*
Anir-Point	309.74	255.28
Microsoft-Point	347.79	196.95
Anir-Drag	202.20	286.10
Microsoft-Drag	201.01	238.24

semi-interquartile range (SIQ). The bracketed stems above and below the boxes include ±1.5 times the SIQ. The vast majority of the data fall between these brackets. Examining Figure 8, we can see that although the median movement time for the Microsoft mouse is slightly lower, the boxes show a considerable overlap between response times between the two mice. At the same time, the variability is slightly greater for the Anir mouse. The overall error rates were close to the 10% the participants were requested to maintain. (If we had asked them to achieve lower error rates, the movement time would predictably have increased proportionately.) In Experiment 1, the Anir error rate was 11.7%, compared with 9.2% for the Microsoft mouse. This difference was not significant. In Experiment 2, the Anir error rate was 10.18% compared with 7.71% for the Microsoft mouse. This difference approached statistical significance. However, in each case, the actual difference in error percentages between mice is approximately the same (2.5%).

With respect to Fitts's Law, slopes and intercepts for best-fitting lines to Equation 1 for both experiments are seen in Table 13. It appears that the prediction of Langolf et al. (1978) is confirmed. For both experiments, the slope is greater for the Anir than for the Microsoft mouse by approximately the same amount (52 and 59).

In addition, for the drag task, slopes for both mice are greater than for the point-and-click task. This is what would be expected, because slightly greater muscle effort should be exerted while dragging. Hence, the Fitts's Law procedure appears to be a sensitive method of detecting differences in styles of muscle use in operating a mouse.

At the same time, it seems clear that the performance cost of using the Anir mouse in terms of reduced speed and accuracy is small compared with the total range of variability exhibited in mouse use. This small cost can be weighed against the considerable benefit in fatigue and strain reduction seen in the same Anir–Microsoft comparison produced by the work of Aarås and Ro (1997) and in these field data.

Experiment 3. The results of this additional study indicated that, although movement times for the vertical mouse remained slower than for the standard mouse, movement times for the trackball were slower still, by almost exactly the same amount. Mean movement times (in msec) were Microsoft = 1355.29, Anir = 1693.64, and trackball = 2092.43. Corresponding standard errors of the mean were 34.12, 26.91, and 42.16. The difference between mean movement times for the Anir mouse and the Microsoft mouse was 338 msec; the difference for the ANIR mouse and the trackball was 399 msec.

Interestingly, in this experiment, the overall error rate was 5.7, considerably lower than that in Experiments 1 and 2. There was a significant difference among devices with respect to error rates, $\chi^2(2, N = 7465) = 56.3$, $p < .01$. Observed error rates for each of the devices were Microsoft = 3.58%, Anir = 5.11%, and trackball = 8.40%. The difference between error rates for the Anir mouse and the Microsoft mouse was 1.53%; for the Anir mouse and the trackball, it was 3.29%.

The fact that the trackball was both slower and less accurate than the newly designed vertical mouse provides some important contextual information regarding the previous findings. Specifically, we can argue that this newly designed vertical mouse falls well within the range of performance measures (speed and accuracy) associated with already existing commercially available input devices.

6. DISCUSSION

The two groups using the Anir mouse, which allowed them to work with a more neutral position of the forearm, reported significant reduction of intensity and frequency of pain in the upper part of the body. Further, the former intervention group reported no increase in intensity of pain in the upper part of the body 1 year after intervention. The reason for this reduction in pain may be explained by the lower muscle load in the extensors of the forearm when using the Anir mouse when compared with the traditional one (Aarås & Ro, 1997). However, other features of the design may also be of crucial importance. During the design of the Anir mouse, even small modifications had a great impact on the muscle load of the forearm extensors.

The findings of reduced pain reported in this study are supported by a clinical examination of the former control group before and after intervention. Clinical ex-

amination may support and give additional information on the participants' experience of pain. Musculoskeletal illnesses, including tendonitis, myalgia, and myotendonitis, are often clinically associated with muscle tenderness, spasm, hardening, and sore spots when palpating the muscle. However, there is a considerable subjective confounding component in such clinical examination (Waris et al.,1977). It is difficult to confirm local tenderness at a tendon and its attachments as sign of tendonitis. More objective signs of such illness are local swelling of a tendon and crepitation during movements of the tendon within the sheath. Loss of passive movement in joints, together with painful movement, may be measured in a more accurate way. With this limitation of the clinical examination in mind, the number of trigger points was reduced after as compared with before intervention. Movements of the neck were seldom restricted, although 50% (8 of 15) participants reported pain during movement of the cervical spine, particularly provoked by overpressure during active muscle contraction before, whereas 1 participant reported such pain after intervention (see Tables 2 and 3). More discomfort and pain before versus after intervention was supported by the fact that more participants reported pain and tenderness after the endurance test before compared with after the intervention. Lateral epicondylitis in the elbow was greatly reduced after compared with before intervention, in none versus 10 participants. Thus, before intervention, a substantial number of the participants reported and showed symptoms and signs of musculoskeletal illness in the upper part of the body, although many reported low levels of intensity. In fact, such clinical symptoms and signs were found without exception for those who reported pain during work in the period of examination. Furthermore, these tests showed that those who suffered musculoskeletal illness had a reduced ability to tolerate physical load on the musculoskeletal system.

Punnett and Bergqvist (1997), in their review of epidemiological studies of VDU work, found many factors associated with musculoskeletal discomfort in the neck, shoulder, forearm, and wrist and hand. Confounding factors such as visual and ergonomic conditions and organizational and psychosocial factors did not change during the period from 6 to 12 months of the study, except for a significant reduction of visual discomfort in the former control group. Visual discomfort has been found to correlate to musculoskeletal illness in the neck and shoulder (Aarås, Horgen, Bjørset, Ro, & Thoresen, 1998). In the former control group, reduced visual discomfort was reported. Such reduction may have contributed to reduced pain in the neck and shoulder. No ergonomic changes to tables and chairs were performed during the study period. The reason for this was that an extensive ergonomic improvement of the work tables and chairs was carried out 5 to 6 years earlier in the company. Several studies have documented a relation between pain in the upper extremities and the time an operator uses the keyboard and mouse (Punnett & Bergqvist, 1997). No significant differences were found regarding these variables within the groups during the study period. The validity of reported pain intensity and when the pain reoccurred may be low. However, almost all participants had visited the medical department for their pain, which increased the accuracy of these two reported parameters, particularly the point in time when the pain started. In this study, the pain intensity increased from the time the participants

were aware of their pain to the start of the study. These results may indicate that musculoskeletal illness is a cumulative traumatic disorder.

7. CONCLUSION

This study has shown that a more neutral position of the forearm and wrist and hand when using the Anir mouse significantly reduced pain in the neck, shoulder, forearm, and wrist and hand for VDU workers who experienced pain in these areas. For one group, this significant reduction has now lasted for 1 year. Primary prevention is of utmost importance, because when musculoskeletal illness has reached a chronic state, it seems very difficult to cure, even if the most important risk factors are reduced to a minimum (Berg & Torell, 1988). Regarding the performance measures (speed and accuracy), the Anir mouse falls well within the range of performance measures associated with already existing commercially available input devices.

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APPENDIX: CLINICAL EXAMINATION

1. Musculoskeletal tender or trigger points.
   Number of tender/trigger points: _____
   Pressure: _____ kg
2. Neck mobility:
   a. No. of degrees of flexion: _____ degrees
   b. Amount of pain during flexion
   |_____|
   None Unbearable
   c. No. of degrees of extension: _____ degrees
   d. Amount of pain during extension
   |_____|
   None Unbearable
   e. No. of degrees sideways flexion: _____ degrees
   f. Amount of pain during sideways flexion
   |_____|
   None Unbearable
   g. No. of degrees rotation: _____ degrees
   h. Degree of pain during rotation
   |_____|
   None Unbearable
3. Cervical spine
   3.1. Inflammatory joint conditions
   a: No ☐ b: Yes ☐
   Symptoms:
   - Pain in the head, neck, or arm that is aggravated by movement, relieved by rest, provoked by overpressure in all directions.
   - Paresthesia.
   - Morning stiffness.

Signs:

- Loss of full range of movements in the capsular pattern, particularly limitation of extension, and rotation being chiefly limited toward the painful side.

3.2. Disc degeneration/prolapse

a: No ☐ b: Yes ☐

Symptoms:

- Severe arm pain that is aggravated on coughing, sneezing, or any increase in intra-abdominal pressure, usually increasing during the day and relieved by rest, although finding a comfortable position may be a problem.
- Marked morning stiffness.

Signs:

- Marked muscle spasm, loss of extension and rotation range. Loss of sensation over dermatome, muscle weakness and wasting may be detectable, reflexes diminished or absent.

Test of prolapse:

- Cervical extension sustained for 3 min may elicit neurological symptoms (Elvey test).
- Extension, sideways bending to the painful side and rotation to the opposite side (Spurlings test).

3.3. Thoracic outlet syndrome (Causes: cervical rib, costoclavicular syndrome, scaline syndromes, pectoralis minor syndrome, and costal syndrome—neurological, neurovascular, or vascular syndromes)

Symptoms:

- Presence of neurovascular disturbance in absence of neck joint dysfunction indicates this syndrome.
- Neurovascular symptoms provoked by arm activity, especially overhead.
- Elongated trapezius and scalene muscles "dropped shoulder" load the brachial plexus (costoclavicular syndrome).
- Symptoms increase or are brought on by carrying.

Signs:

- Dropped shoulder girdle in presence of arm hypertrophy. Wasting of the ulnar intrinsic muscles without weakness.

Tests:

- Pratt test of costoclavicular syndrome. Hyperabduction test (AER): Abduction and external rotation of the upper arm (hands in the surrender position) stretching the brachial plexus. The test should be held for 3 min. Hand clenching increases the symptoms.
- Bracing the shoulders back and downwards triggers the symptoms (Waris test).
- Adson's maneuver for testing vascular compromise—checking the persistence of the homolateral radial pulse by extending cervical column and rotating toward the painful arm.
- Cervical rib test: x-ray.

4. The shoulder region

This region includes

4.1 Acromioclavicular joint (ligament strain, osteoarthritis).

a: No ☐ b: Yes ☐

4.2 Sternoclavicular joint (ligament strain).

a: No ☐ b: Yes ☐

4.3 Glenohumeral joint (capsulitis, bursitis, and tendonitis).

a: No ☐ b: Yes ☐

Symptoms:

- Pain over deltoid muscle, worse at night, morning stiffness. Severe pain aggravated by movement and aching or dull at rest.

Signs:

- Lateral rotation limitation is gross compared with abduction and medial rotation. Overpressure provokes and limits all movements. Resisted active movement is painful as well as passive stretching and palpation of the tendon.

Tests:

- Supraspinatus tendon and bursa: resisted static abduction (Low painful arc from 60°–100°).
- Subscapularis tendon: pain over front of the shoulder joint on resisted static medial rotation.
- Infraspinatus tendon: pain provoked by resisted static lateral rotation.
- Long head of biceps: Shoulder pain provoked by abduction (in pronation) and by lateral rotation. Pain provoked by flexion of the upper arm. Resisted static supination (Yergason's test).

4.4 Neck and shoulder area

4.4.1. Isometric test and endurance test

a: Normal ☐ b: Tender or stiff ☐ c: Pain ☐

4.4.2. Palpation of tendon attachment without resistance

a: Not tender ☐ b: Tender ☐

4.4.3. Palpation of tendon attachment with resistance

a: Not tender ☐ b: Tender ☐

4.4.4. Mobility in the shoulder joint

a: Normal ☐ b: Pathological ☐

5. Elbow region

5.1 Lateral epicondylitis

a: No ☐ b: Yes ☐

Test:

- Pain on static wrist extension (+ resisted static finger extension).

5.2 Medial epicondylitis.

a: No ☐ b: Yes ☐

Test:

- Pain on resisted wrist flexion, ulnar deviation and pronation in elbow extension. Pain on resisted pronation or flexion.

5.3 Posterior overload syndrome (extension overload, tendonitis, and bursitis)

a: No ☐ b: Yes ☐

Test of triceps:

- Pain on resisted elbow extension.

5.4 Superior radioulnar joint

a: No ☐ b: Yes ☐

Test:

- Pain on supination and pronation with overpressure.

5.5 Pronator teres syndrome (entrapment of the median nerve in the pronator teres)

a: No ☐ b: Yes ☐

Test:

- Pain on resisted pronation and wrist flexion (Cabrera and Mc Cue)

5.6 Supinator syndrome (Entrapment of radial nerve within the supinator muscle)

a: No ☐ b: Yes ☐

Test:

- Pain with resisted static supination with wrist in radial deviation.

5.7 Musculocutaneous nerve entrapment

a: No ☐ b: Yes ☐

Test:

- Palpation of anterior elbow provokes symptoms.

6. Forearm, wrist, and hand region

6.1 Osteoarthris (carpometacarpal joint and finger joint); subluxations, instabilities, synovitis and strains

a: No ☐ b: Yes ☐

6.2 Inferior radioulnar joint

a: No ☐ b: Yes ☐

Sign:

- Loss of full pronation. Pain by anterior–posterior glides in full supination.

6.3 Radiocarpal joint

a: No ☐ b: Yes ☐

Test:

- Loss of extension and supination.

6.4 Carpal joints

a: No ☐ b: Yes ☐

Test:

- Pain limiting wrist extension to 5° to 10°.

6.5 Tenosynovitis: tendons of wrist flexors and extensors, abductor pollicis longus and extensor pollicis brevis (De Quervain's syndrome), tendonitis and peritendonitis crepitans, stenosing tendosynovitis "trigger finger"

a: No ☐ b: Yes ☐

Test:

- Flexor tendons: pain only on resisted finger flexion.
- Radial extension tendons: pain on resisted wrist extension with abduction.
- Medial extensor tendons: pain on resisted wrist extension with adduction.
- De Quervain's tenosynovitis: pain on resisted thumb extension and abduction.

6.6 Ulnar nerve compression at the wrist (hypothenar hammer syndrome)

a: No ☐ b: Yes ☐

6.7 Carpal tunnel syndrome

Symptoms:

6.7.1 Do you experience any symptoms in the area innervated by the median nerves?

a: No ☐ b: Yes ☐

6.7.2 Are the symptoms more severe at particular times?

a: No ☐ b: Yes ☐

6.7.3 Do symptoms awaken you at night or in early morning hours?

a: No ☐ b: Yes ☐

6.7.4 Do symptoms occur premenstrually?

a: No ☐ b: Yes ☐

6.7.5 Do symptoms occur during pregnancy?

a: No ☐ b: Yes ☐

6.7.6 Do you experience any loss of dexterity?

a: No ☐ b: Yes ☐

6.7.7 Do you often drop things?

a: No ☐ b: Yes ☐

6.7.8 Do you feel a clumsiness when using your hands?

a: No ☐ b: Yes ☐

6.7.9 Do you fell stiffness on flexion of the fingers?

a: No ☐ b: Yes ☐

Signs:

6.7.10 Is there sensory impairment in the area innervated by the median nerve (paresthesia, numbness, or pain)?

a: No ☐ b: Yes ☐

6.7.11 Is there motor impairment in the area innervated by the median nerve (wasting or atrophy or both)?

a: No ☐ b: Yes ☐

6.7.12 Phalen's sign: _____ sec

a: Negative ☐ b: Positive ☐

Phalen's sign: The test is performed by holding the wrists in complete flexion for 30 to 60 sec. A positive result is recorded if numbness and paresthesia in the median nerve distribution are reproduced or exaggerated.

6.7.13 Flick test

a: Negative ☐ b: Positive ☐

Flick sign: What do you actually do with your hand(s) when the symptoms are at their worst? A positive result is recorded if the participant makes a flicking motion with his or her hand(s), similar to that of shaking down a clinical thermometer.

7. Use of pain killers:

a: None or minimal ☐ b: 1–2 times per week ☐

c: 3–6 times per week ☐ d: Daily ☐

8. Have received physiotherapeutic treatment last month

a: No ☐ b: Yes ☐

9. Smoking

|_____|

No Heavily