The Effects of Education on Hand Use With Industrial Workers in Repetitive Jobs

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Eighteen subjects participated in a preliminary study to determine the effects of two types of educational programs on the hand-use patterns of industrial workers at risk for developing cumulative trauma disorder (CTD). The subjects were divided into three groups. Two groups received different educational programs and the third group served as the control. One program used a handout as the only educational tool, the other used the handout as well as a hands-on demonstration of the concepts in the handout. Pretests and posttests of the frequency of movements identified with CTD of the hand and wrist during work were administered to all subjects. Both educational programs were significantly effective in reducing the number of at-risk movements performed by workers tested 1 week after receiving the education. No significant difference was found between the two educational programs. The results of this study show that education can affect hand-use patterns, and a similar study on a larger sample is recommended.

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The incidence of cumulative trauma disorder (CTD) of the hand, wrist, and entire upper extremity is a major problem facing industry today. Once it is diagnosed, CTD can be effectively treated, but it is costly to the employer and employee in terms of workers' compensation insurance, time lost from work, and chronic disability that interferes with personal goals.

As a consultant to industry, the occupational therapist skilled in task analysis and adaptation, the biomechanics of hand use, and patient education can contribute greatly to both the employer and the employee. As in other types of programs for health maintenance or disability prevention, education is the means by which occupational therapists treat workers.

The therapist can apply to workers the procedures used with persons with rheumatoid arthritis to prevent increased deformity of diseased joints due to cumulated microtraumatic biomechanical stress. By teaching workers who are at risk for developing injury to their hands due to high repetition of microtraumatic postures and movements to work in less damaging positions, the therapist should be able to reduce the incidence of CTD. This assumption, which is also the basis for the teaching of joint protection techniques to persons with rheumatoid arthritis, has not been verified in the occupational therapy or ergonomic literature.

We thought it important, as a first step, to determine whether education actually did change habitual behavior. We developed and tested an educational program at the workplace of electronic assembly workers who do repetitive jobs and have a high incidence of CTD of the upper extremities. The concepts of the educational program, aimed at decreasing the incidence of CTD by changing the way people use their hands while they work, were derived from studies of psychomotor learning. In the present study, this type of educational program was contrasted with an exploratory, psychomotor-skills learning style used in patient education (Heringa, Lawson, & Reda, 1987). We believed that if this program were successful in promoting hand use that is less traumatizing and aggravating to the worker, the debilitating effects of CTD might be greatly reduced.

Literature Review

Musculoskeletal disorders, which include CTD, rank first in frequency of injury to workers, with nearly one half of the nation's work force being affected (Myers, Withers, & Johnson, 1984). "Chronic tendon and nerve disorders, such as carpal tunnel syndrome and tendinitis, are major causes of lost work and workers' compensation in some industries" (Armstrong, Fine, Goldstein, Lifshitz, & Silverstein, 1987, p. 830). Breakdown of the musculotendinous system, often
resulting in tendinitis, is one of the sources for CTD development. Major causes of this breakdown can be the overload or repeated use of particular muscle groups or the maintenance of constrained postures, which are required in highly repetitive and forceful jobs (Armstrong et al., 1987; Browne, Nolan, & Faithful, 1984; Habes & Putz-Anderson, 1985; Myers et al., 1984). Habes and Putz-Anderson found that high-risk jobs for development of CTD had high rates of manual repetition combined with deviated wrist postures, excessive wrist flexion or extension, overhead reaching, pinching, and grasping, and use of wrist and arm torque. The occupational groups most at risk include but are not limited to light assembly and process workers (McDermott, 1986).

The clinical features of CTD related to the neuromuscular system are tenderness, weakness, swelling, inflammation, neuromuscular fatigue, and numbness or paresthesia. These symptoms may result directly from impaired circulation and nutrition due to long-term deviated postures of the involved limb (Brand, 1979). Neuromuscular breakdown is most commonly exhibited through carpal tunnel syndrome and usually results from a person's working with the wrist deviated from the straight position. The extrinsic finger flexor tendons, which are major force-producing muscles during exertions of the hand, are displaced against the adjacent walls of the carpal tunnel, causing irritation, swelling, and impaired circulation characteristic of carpal tunnel syndrome (Armstrong & Chaffin, 1979; Smith, Sonfegard, & Anderson, 1977). Birbeck and Beer (1975) found that occupations that require light but highly repetitive movements of the fingers and wrists are likely to produce changes in the carpal canal, thus leading to carpal tunnel syndrome. Phalen (1972) found that thickening of the flexor synovialis within the carpal tunnel due to prolonged forceful grasping movements is the most common cause of carpal tunnel syndrome.

A commonality of CTDs of musculotendinous or neuromuscular origin appears to be that the way in which the hand is used to perform a task contributes to, aggravates, or causes the CTD. Armstrong et al. (1987), in their study of the relationship between ergonomics and learning, stated that "there is ample evidence that mechanical stresses and certain postures are important factors in hand and wrist tendinitis and should be considered as possible intervention routes" (p. 835). The identification of such a pattern may have prophylactic importance regarding CTD (Hadler, 1977).

A review of the literature shows that certain hand and wrist postures carry an increased risk for the onset of CTD. Armstrong et al. (1987) demonstrated the importance of repetition and force in relation to CTD in their finding that the risk for the development of tendinitis of the hand and wrist in persons who performed highly repetitive and forceful jobs was 29 times greater than for persons who performed low-repetitive and low-force jobs.

Medical and surgical treatment after development of CTD has been the norm (Berger & Fromison, 1979; Dionne, 1984b; Gelberman, Aronson, & Weisman, 1980; Kurppa, Waris, & Rokkanen, 1979). Prevention as a form of treatment for CTD has not been discussed in detail in the literature. Prevention may be the only way to reduce medical costs by reducing a person's premature aging associated with degenerative diseases (Grove, Reed, & Miller, 1979). Due to stricter federal laws by the Occupational Safety and Health Administration and higher health care expenses and insurance premiums, prevention is an important aspect of occupational health safety (Gallaher, 1979). Prevention has been used in relation to other industrial problems. Wright (1981) reported on an educational program to prevent hearing loss and noted that educated employees were more likely to be motivated to conserve their hearing than were persons who had never received information on protecting their hearing. Maples, Jacoby, Johnson, TerHarr, and Buckingham (1982) used employee training and motivational programs to reduce lead levels in the blood and urine of 35 employees who worked in an alkyl lead production facility. The program was successful, with a 40% reduction in lead levels in urine and a 24% reduction in lead levels in blood after only 12 months. From the success of this study, it was concluded that employee training and motivational programs appear to be effective methods of reducing employees' exposure to chemicals.

Practice is important in the learning of psychomotor skills. Gomez and Gomez (1987) studied nurses who were learning to take blood pressure readings. They stated that practice for learning should include all environmental conditions and constraints present when the skill will be performed, and their study involved practice in laboratory and patient care settings. They found that the nursing students who received minimal practice in taking blood pressure readings in the patient care setting performed better than those who had practiced in the laboratory. Barnes (1987) reported on studies indicating that medical students' skill in performing surgical techniques was optimally developed by supervised practice of the skill in the laboratory.

Heringa et al. (1987) used adult learning principles through structured education to increase knowl-
edge and psychomotor skills of patients who were inhaling beclomethasone dipropionate aerosol (BDA). The patients in the study were randomly assigned to an experimental or control group. In the experimental condition, the investigator used a structured educational program to teach BDA inhalation on a one-on-one basis. This condition included the use of a 10-min videotape and a flip chart to illustrate the steps necessary for correct use of the inhaler. The instructor demonstrated the use of the metered-dose inhaler using a placebo inhaler. A question-and-answer session and educational handouts were used. In addition, after seeing the instructor demonstrate the use of the inhaler, the subjects were required to demonstrate its proper use, with guidance from the instructor. The subjects in the control group received no structured, formal education but were encouraged to read the package insert if they had questions. A pretest-posttest experimental design was used to assess skill in self-administration by two independent raters using an 11-point rating scale. The results showed that the mean knowledge score increased significantly for both the experimental group and the control group, but the subjects who received the structured educational program showed a significantly greater improvement in performance than did the control group. Heringa et al. concluded that a structured educational program, provided on a one-on-one basis, improves the psychomotor skills necessary for effective self-administration of inhaled BDA.

On the basis of the results of the Heringa et al. (1987) study, we developed a preventive educational program and applied it to the problem of CTD. Our purpose was to teach employees assigned to repetitive hand-assembly jobs ways to prevent CTD by using new hand patterns.

Method

Subjects

Eighteen men and women who performed hand-insertion (electronic assembly) jobs at an AT&T plant volunteered for this study. They were selected from the population who work the first shift (7:00 a.m. to 3:00 p.m.). Seventeen of the subjects were right-hand dominant, but all used their right hand as the active hand in performing this task. The subjects’ ages ranged from 25 to 64 years. Their work experience ranged from 2 months to 15 years.

Instrumentation

A checklist adapted from Armstrong, Fonkle, Joseph, and Goldstein (1982), who recorded observations made from videotapes, was used to record the frequency of eight hand postures. Because the constraints of the work environment used in this study did not permit videotaping, a form for recording live hand use patterns was developed through the use of the principles of interval recording (Borg & Gall, 1983). The form consisted of diagrams of movements identified as traumatizing and aggravating to the musculature and connective tissue of the hand, wrist, and forearm and known to be associated with CTD. Blocks for the checking off of these movements were provided at set intervals. At the end of each 30-sec interval of a 15-min observation period, a mark was made to indicate the subject’s hand and wrist posture at that time. The final score was the total number of CTD-associated postures performed by each hand during a randomly chosen 15-min interval. The total possible score for each hand was 30.

For test-retest reliability, a Spearman rank order correlation was calculated for the combined left and right hand scores of 3 subjects. The correlation of r_s = .83, which accounted for 68% of the variance, was obtained, and the test was considered a reliable measure of hand-use patterns.

Procedure

The subjects were randomly assigned to one of three groups. The control group, Group 3, was used not only to compare the effect of treatment to no treatment but also to control for the effects of the presence of the researcher (the first author) in the work environment.

All 18 subjects were individually observed performing their jobs, and the number of movements identified with CTD was recorded for each. The intervention programs for Groups 1 and 2 were then implemented 1 week later.

The first section of each program, which was presented to Groups 1 and 2 separately, informed the subjects about repetitive trauma injury. Simple anatomy and physiology of the wrist and hand and causative factors related to hand use were discussed. A question-and-answer session followed. This first phase lasted from 30 to 45 min, depending on how the groups used the question-and-answer time. The goal of the second section for each program was the same—to change behavior in order to reduce the number of undesired motions. The method by which this goal was accomplished, however, differed for the two groups.

Members of Group 1 received a handout developed to inform workers of the potential risks of performing highly repetitive movements with their hands and wrists. This information was job specific. The handout illustrated less stressful hand and wrist postures that, if used, could reduce the incidence of repetitive trauma injury. The following principles used in this handout are supported by principles of joint
protection used with persons with rheumatoid arthritis (Pedretti, 1985; Trombly, 1989):

- Avoidance of positions of deformity, especially grasp and pinch.
- Avoidance of external and internal pressures and stress to joints in positions of deformity.
- Use of joints in their most stable anatomical and functional plane.
- Use of the strongest joint available for the job.
- Use of correct patterns of motion.
- Avoidance of prolonged use of muscles or the holding of the joints in one position for undue periods of time.

Each subject in Group 1 received the handout but was then left with the responsibility of reading the handout and practicing its concepts.

The subjects in Group 2 were also given the handout. Additionally, the instructor (the first author) discussed the concepts from the handout in detail with each subject; this was followed by a question-and-answer session. These subjects also engaged in a simulated performance of their job at a table set up for each subject, and the entire group observed each member's lesson. The subjects practiced performing their work using suggestions from the handout. This session lasted no longer than 60 min.

One week after both educational programs were completed, the posttest was completed for 17 subjects (the 18th subject went on maternity leave sooner than expected and was unable to complete the study).

### Results

The data used for analysis in this study were the total number of potentially traumatizing movements performed with the left and right hands during 15-min observation periods. The pretest and posttest scores for each hand are shown in Table 1.

To establish the equality of groups at the start of the study, the Kruskal-Wallis one-way analysis of variance (ANOVA) \((H)\) of the combined (right and left hand) pretest scores was used. Although the mean combined score for the control group was less than that of the other groups, thus indicating better hand use, no significant differences were found among the groups \((H = 4.24, df = 2, p = .2)\).

The mean scores indicated that while the control group's scores remained stable, the scores of the educated groups decreased, as predicted. The significance of the change from pretest to posttest with the use of combined difference scores (see Table 2) was tested with the Kruskal-Wallis one-way ANOVA, which indicated that this change was significantly different among the groups at the .1 level \((H = 4.99, df = 2)\). The probability level of .1 indicates a potentially significant observation (Stevens, 1986) and was chosen appropriately as a significant level in this pilot study (a significance level of .1 means that there is a 1 in 10 chance that the findings are due to chance alone). This difference was further analyzed with the use of the Mann Whitney \(U\) test, which showed significant differences between Groups 1 and 3 \((U = 5, n_1 = 6, n_3 = 6, p = .02)\) and between Groups 2 and 3 \((U = 5, n_2 = 6, n_3 = 6, p = .04)\), but not between Groups 1 and 2.

Because the left and right hands did not perform the same work duties, the data were inspected further. Separate difference scores for the left and right hands were tested across groups with the Kruskal-Wallis one-way ANOVA (see Table 2). The test results showed that there was not a significant difference among groups in the use of the left hand \((H = 1.73, df = 2, p = .5)\), although the control group's mean score is considerably less than that of Group 2. A significant difference among groups did exist, however, in use of the right hand \((H = 7.36, df = 2, p = .05)\). A Mann Whitney \(U\) test, performed to find the difference among groups, showed a significant difference in use of the right hand between Groups 1 and 3 \((U =

### Table 1

**Frequency of Traumatizing Hand-Use Patterns**

<table>
<thead>
<tr>
<th>Group</th>
<th>Pretest</th>
<th></th>
<th>Posttest</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Left Hand</td>
<td>Right Hand</td>
<td>Total</td>
<td>Left Hand</td>
</tr>
<tr>
<td>Group 1 ((n = 6))</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(M)</td>
<td>22.30</td>
<td>20.30</td>
<td>42.60</td>
<td>16.60</td>
</tr>
<tr>
<td>(SD)</td>
<td>3.98</td>
<td>4.36</td>
<td>4.50</td>
<td>1.21</td>
</tr>
<tr>
<td>Group 2 ((n = 5))</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(M)</td>
<td>23.20</td>
<td>21.40</td>
<td>44.60</td>
<td>14.40</td>
</tr>
<tr>
<td>(SD)</td>
<td>2.38</td>
<td>5.68</td>
<td>7.79</td>
<td>5.36</td>
</tr>
<tr>
<td>Group 3 ((n = 6))</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(M)</td>
<td>22.50</td>
<td>15.50</td>
<td>37.80</td>
<td>18.60</td>
</tr>
<tr>
<td>(SD)</td>
<td>4.05</td>
<td>2.50</td>
<td>2.99</td>
<td>2.12</td>
</tr>
</tbody>
</table>

*Note:* Total possible score for each hand = 30. Group 1 received the educational handout only. Group 2 received the educational handout plus hands-on demonstration. Group 3 served as the control group.
Table 2  
Pretest–Posttest Combined Difference Scores

<table>
<thead>
<tr>
<th>Group</th>
<th>Left Hand</th>
<th>Right Hand</th>
<th>Combined</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1 (n = 6)</td>
<td>5.60</td>
<td>6.60</td>
<td>12.20</td>
</tr>
<tr>
<td>SD</td>
<td>4.27</td>
<td>4.76</td>
<td>6.34</td>
</tr>
<tr>
<td>Group 2 (n = 5)</td>
<td>8.80</td>
<td>6.40</td>
<td>15.20</td>
</tr>
<tr>
<td>SD</td>
<td>7.46</td>
<td>5.22</td>
<td>11.70</td>
</tr>
<tr>
<td>Group 3 (n = 6)</td>
<td>3.80</td>
<td>-0.16</td>
<td>3.50</td>
</tr>
<tr>
<td>SD</td>
<td>5.34</td>
<td>2.58</td>
<td>8.00</td>
</tr>
</tbody>
</table>

Note: Group 1 received the educational handout only. Group 2 received the educational handout plus hands-on demonstration. Group 3 served as the control group. Positive numbers indicate decreases in traumatizing movements performed after education was implemented.

In the present study, our intention was not to recommend a better way of educating people, but rather to ensure that the educational information was actually received by at least one group. Further research is needed to determine the single best way in which to educate industrial workers.

A significant difference in scores between the left and right hands existed, although neither was emphasized by the educational program. The educational program did emphasize, however, posture or placement over dynamic movement. In the electronic assembly job done by these workers, the left and right hands perform different activities. The hand that inserts and holds the electronic components on the board assumes mostly static postures throughout the work task, while the other hand fastens the components in place using dynamic motions. All subjects in this study used their right hands to perform the dynamic aspect of this job and their left hands to place and hold the components. As already noted, the number of potentially traumatizing movements of the right hand in the educated groups was significantly reduced, whereas the number of movements in the left hand was not. Possibly, the subjects associated the education message with the voluntarily controlled active right hand more than with the automatically posturing left hand.

Conclusion

The findings of this preliminary study indicate that the number of at-risk repetitive motions performed by employees during work tasks decreases immediately following preventive educational programs. Further verification is needed for the assumption that a reduced incidence of the use of at-risk hand postures and movements results in a reduced incidence of CTD in workers or deformity in persons with rheumatoid arthritis. Additionally, further study is indicated to determine if workers permanently change their hand-use habits to less harmful patterns as a result of educational programs.

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