
Effectiveness of Workplace Rehabilitation Interventions in the Treatment of Work-related Upper Extremity Disorders: A Systematic Review

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ABSTRACT: The purpose of this systematic review was to evaluate the available evidence on workplace rehabilitation interventions for work-related upper extremity disorders (WRUEDs). The literature search identified a total of 811 abstracts from Medline, Cumulative Index to Nursing and Allied Health Literature (CINAHL), and EMBASE databases. The abstracts were independently assessed by four reviewers and 53 full-text articles were identified. Twenty-one studies were then randomly allocated to two pairs of reviewers. Using a 24-item critical appraisal form, the reviewers evaluated the articles for quality and level of evidence. During this process, an additional 13 articles were discarded, resulting in eight studies. The effectiveness of these studies was limited by small sample sizes, lack of standardized outcome measures, and inadequate reporting of interventions and results. The findings of this review indicate that the evidence for workplace interventions for WRUEDs has not been established. This systematic review provides a rigorous analysis of workplace interventions for WRUEDs and emphasizes the need for further research in this area.

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Work-related upper extremity disorders (WRUEDs) are becoming an increasingly prominent cause of disability in working populations.^{1,2} These disorders encompass a wide variety of conditions such as tenosynovitis, epicondylitis, and cumulative trauma disorders.³ The increasing prominence of these disorders in hand therapy caseloads and the concern over effective treatment management were evident in a research needs survey of practicing hand therapists.⁴ A recent practice analysis of hand therapy also indicated that cumulative trauma disorders was one of the most common occurring conditions treated by hand therapists.^{5,6}

The impact of WRUEDs include changes in the employment and earnings for injured workers, adverse effects on productivity and competitiveness, and other economic costs.⁷ Workers with these disorders may suffer from persistent pain, loss of

function, and work disability. The complex nature of these injuries suggests that workplace rehabilitation interventions are a crucial aspect of treatment management. With the increasing prevalence of WRUEDs, concern has been raised with respect to how to manage these injuries at the workplace. As the number of workers afflicted with these disorders increases, so does the need for effective workplace interventions.

Although the primary goal in the rehabilitation of workers with WRUEDs is to return injured workers to work in a safe and timely manner, the ultimate goal is to try to ensure that these individuals stay at work. The need to maintain injured workers at the workplace and to return them to their preinjury employment is paramount. Worksite interventions may include applying ergonomic modifications to the workplace to decrease the repetitiveness, force, and awkward postures of the upper extremity associated with work activities.⁸ Job accommodations such as modified work, including light duty, graded work exposure, and work trials, are important in return to work.⁹ Studies^{9,10} have shown that

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modified work facilitates return to work and can reduce recurrence.¹¹ The benefits of workplace interventions include a decrease lost and restricted workdays due to injuries, decreased absenteeism, reduced workers' compensation and health care costs, increase in productivity, and improvement in employee morale.⁸

In general, worksite rehabilitation interventions enable injured workers to carry out their employment duties.^{8,9} These approaches should facilitate the injured workers' earlier return to work, enhance their quality of life, and reduce the costs of these injuries. Given these circumstances, we identified the need for a systematic review of the literature to examine workplace interventions that may be effective in the treatment of WRUEDs. The purpose of this systematic review was to evaluate the available evidence on workplace rehabilitation interventions for WRUEDs.

METHODS

The reviewers consisted of three physical therapists and one occupational therapist. The two physical therapists and the one occupational therapist had mainly academic and research expertise in work-related musculoskeletal injuries, whereas the third physical therapist had clinical expertise in these injuries.

Inclusion and Exclusion Criteria for Selection of Articles

For this systematic review, the inclusion and exclusion criteria were met if the study had the following characteristics: 1) The intervention was given at the workplace. 2) The population consisted of individuals with WRUEDs (patients with neck and upper extremity disorders were included and patients with only neck disorders were excluded). 3) The intervention involved treatment (not prevention). Ergonomic modifications and worksite analysis were considered to be workplace interventions rather than prevention because they were treatments that were given to the injured workers. 4) The study was published in English. 5) The study involved primary research on one or more patient groups (i.e., case studies were excluded).

Literature Search

Literature searches of Medline, the Cumulative Index to Nursing and Allied Health Literature (CINAHL), and EMBASE computerized databases were conducted from January 1982 to May 2003. The key terms that were used for the searches were: hand, wrist, elbow, shoulder, upper extremity, upper limb, posture, wellness, ergonomics, exercise, accommo-

modation, occupational therapy, physical therapy, occupational rehabilitation, vocational, treatment, intervention, workplace, occupation, employer, worksite, industry, cumulative trauma disorders, repetitive strain injury, rotator cuff, lateral epicondylitis, carpal tunnel, and tendonitis.

From these searches, 296, 144, and 371 articles were retrieved from the Medline, CINAHL, and EMBASE databases, respectively, resulting in a total of 811 abstracts to be reviewed. To determine whether a study should be included, these abstracts were independently assessed by four reviewers. If there was any doubt as to whether the study met the eligibility criteria, the full article was retrieved and read independently by the reviewers. Disagreements were discussed in a consensus meeting.

Of the 811 hits, 53 full-text articles were identified. The most common reasons for exclusion at this stage were: 1) the article was not a primary study, 2) the intervention did not take place at the workplace, 3) the study did not address the upper extremity, and 4) the intervention involved prevention and not treatment. References from the retrieved articles were screened (citation tracking) by the reviewers. Twenty-one studies were then randomly allocated to two pairs of reviewers. That is, two reviewers independently evaluated nine papers, whereas the other two evaluators independently reviewed 12 studies.

Quality Assessment

Each study was independently evaluated by two pairs of reviewers using the Evaluation Guidelines for Rating the Quality of an Intervention Study Form.¹² This form describes 24 specific research design elements of studies. A value of 2 is the best score and indicates a high-quality approach to this element of research design. A score of 1 represents fair quality, whereas 0 represents poor quality or unmet criteria. Specific descriptors of these elements are found in the introductory article of this issue. The articles also were assessed with regard to the level of evidence.¹³ Consensus between the two reviewers as to the methodologic quality and the level of evidence of the identified studies was reached. If consensus could not be reached, a third reviewer independently evaluated the article until agreement was determined. During this process, an additional 12 studies were discarded because on a more detailed review it was found that they did not meet the eligibility criteria. The most common reasons for exclusion were that the intervention did not occur at the workplace and the population did not have a WRUED.

RESULTS

Eight studies met the inclusion and exclusion criteria and are summarized in [Table 1](#). The quality

TABLE 1. Evidence of Workplace Rehabilitation Interventions in the Treatment of Work-related Upper Extremity Disorders (WRUEDs)

<i>Study</i>	<i>Subjects</i>	<i>Interoventions</i>	<i>Evaluations</i>	<i>Results</i>	<i>Comments</i>	<i>Level</i>
Exercises Vasseljen et al. ¹⁴	33 workers with neck and shoulder pain	Randomized controlled trial Group 1:12 subjects received individual physical therapy outside workplace; group 2:12 subjects received group exercise at workplace; group 3: nine subjects received physical therapy outside workplace	Pain ratings with the visual analog scale pre-post electromyography trigger points	Decreased pain and perceived tension in all three groups	There was no control group	2b
In-House/Worksite Physical Therapy Grayzel et al. ¹⁵	152 employees with upper extremity problems	Cohort study 16 in-house physical therapy patients vs. 136 outside physical therapy patients	Program evaluated at one year	Mean lost time for in-house physical therapy was 140 days and 489 days for those treated outside; cost savings (\$221 vs. \$1216/case)		3b
Worksite Analysis Hanson et al. ¹⁶	43 employees with WRUEDs	Cohort study Group 1:14 hospital employees; group 2:15 university employees; group 3:14 university employees (control group) Subjects were given questionnaires regarding their injury, treatment, functional status, and pain level	Demographics/ worksite questionnaire Modified Functional Status Scale (MFSS) Pain scale	Less absenteeism and greater modified work days for employees undergoing worksite analysis No significant differences among groups on MFSS and pain scale	Psychometric properties of MFSS were not examined	3b
Nurse Case Managers' Training on Accommodations Lincoln et al. ¹⁷	101 claimants with compensable lost time	Randomized controlled trial 101 claimants randomized to 53 nurse case managers with Integrated Case Management (ICM) training on workplace accommodation and 48 nurse case managers without ICM training (control group)	Workplace accommodations by nurse case managers	Claimants from trained nurses had 1.5 times more accommodations recommended and implemented although rates of implementation were the same		1b
Shaw et al. ¹⁸	53 claimants with compensable lost time	Case series Nurse case managers were trained on workplace accommodations	Workplace accommodations by nurse case managers	Claimants from trained nurses had 1.4 times more accommodations recommended and implemented	There was no control group	4
Ergonomic Keyboard Modifications Rempel et al. ¹⁹	20 computer users with WRUEDs	Randomized controlled trial Group 1: keyboard A or group 2: keyboard B	12 weeks of keyboard use	Between six and 12 weeks, keyboard A users had reduction in pain; over 12 weeks, keyboard A Users had increase in Phalen's test time		2b
Tittiranonda et al. ²⁰	80 computer users with WRUEDs	Randomized controlled trial Group 1: Apple keyboard; group 2: Comfort keyboard; group 3: Microsoft keyboard; group 4: placebo	24 weeks of keyboard use	Significant improvement in pain and function for group 1: Microsoft keyboard users		2b
Rest and Exercise Breaks van den Heuvel et al. ²¹	268 computer users with neck and upper extremity complaints	Cohort study 97 subjects stimulated to take breaks; 81 subjects stimulated to exercise during breaks; 90 subjects in control group	Eight weeks of computer use Self-reported perceived overall recovery from complaints, severity of complaints, and sick leave	Increased frequency of recovery, less deterioration and higher productivity in intervention groups	There were no additional effects from performing exercises during the breaks	3b

This table describes the studies evaluating treatment effectiveness for workplace rehabilitation interventions for WRUEDs.

of the studies, using the evaluation guidelines by MacDermid,¹² are displayed in Table 2. Because a score of 2 represents the best score for each element of the research design, the highest total score that an article can achieve is 48. Of the eight articles that met the inclusion/exclusion criteria, five studies^{14,17,19,20,21} achieved a score of at least 32 or higher, indicating fair quality of research findings.

The workplace interventions that were identified in the eight studies (Table 1) included: 1) exercises; 2) in-house/worksites physical therapy; 3) worksite analysis; 4) nurse case managers' training on accommodations; and 5) ergonomic modifications with regard to a) keyboard designs and b) rest and exercise breaks. These studies are discussed subsequently under these headings.

Exercises

One trial¹⁴ was located that evaluated exercises as a workplace intervention for WRUEDs. Vasseljen et al.¹⁴ examined the use of either individual physical therapy outside the workplace versus group exercises in the workplace to decrease pain and perceived tension in workers experiencing neck and shoulder pain. Twenty-four female office workers were randomized to receive either individual physical therapy ($n = 12$) or group exercise ($n = 12$). In addition, nine female patients were recruited to form a third group. Individualized physical therapy, at a local clinic, consisted of one-hour sessions two times per week for ten treatments, which included massage, strength and flexibility exercises, stretching, and weight training with passive mobilization as needed. Ergonomic principles and a home program also were included. The group exercise group was performed at the workplace for 30 minutes three times per week over six weeks and included a published exercise regime with four arm exercises performed with 1.1-kg dumb bells in both hands. Each exercise was performed for ten repetitions. Participants in the group exercise group were provided with similar information on ergonomics and home exercises as was given to the individualized physical therapy group. The third group of nine patients, who were followed outside of the study, received an average of 12 (range, 8–17) treatments. All groups reported a significant improvement in pain and perceived general tension as measured by the visual analog pain scale, self-reported general tension, and trigger point sensitivity. Six-month follow-up questionnaires indicated that all groups showed a marked reduction in pain ($p < .05$) and perceived general tension ($p < .05$). A sustained improvement in pain levels was seen for both groups with a larger improvement for the group receiving individual physical therapy ($p < .01$). The findings indicate that both individualized physical therapy and group exercises are

effective in pain reduction, and individualized physical therapy showed a larger decrease in pain for patients with neck and shoulder complaints. However, the results of this study are limited because it was only one study, had a small sample size, and lacked a control group.

In-house/Worksite Physical Therapy

One cohort study¹⁵ was found that evaluated in-house (at the worksite) physical therapy versus outside (at the clinic) physical therapy in the workplace treatment of WRUEDs. Grayzel et al.¹⁵ examined the use of in-house physical therapy versus outside physical therapy for patients with musculoskeletal problems to determine if the time lost from work was reduced. The patients in the study included 41 in-house cases (16 cases had upper extremity problems) and 413 outside physical therapy cases (136 cases had upper extremity problems). In-house physical therapy included exercise, tubing, exercise putty, ultrasound, thermal modalities, stationary bicycle, and treadmill. A description of outside physical therapy treatment was not provided. After one year, the mean loss of work time for the in-house patients was 140 days compared with 489 days for outside physical therapy. The average expenses per outside physical therapy was \$1,216 compared with the in-house physical therapy cost of \$995, representing a saving of \$221 per case in direct medical costs. Although the findings seem to demonstrate that in-house physical therapy is effective in reducing time lost from work and medical costs, the results are questionable because this was only one study, there were no data to show whether the patients in the two groups were similar in terms of severity and duration of their injuries, the sample size was small, and a description of outside physical therapy treatment was not provided.

Worksite Analysis

Hanson et al.¹⁶ investigated whether individuals with WRUEDs in hospital and university settings who received worksite analysis would have less lost workdays than individuals who did not receive worksite analysis. Participants were divided into the following three groups: group 1 consisted of 14 hospital employees who received worksite analysis; group 2 included 15 university employees who underwent work site analysis; and group 3 included 14 university employees who did not have any worksite analysis. Over the one-year trial period, the employees were given questionnaires regarding their injury, treatment, functional status, and pain level. The results showed that there was less absenteeism and greater modified workdays with those individuals undergoing worksite analysis. Although these

TABLE 2. Quality of Workplace Rehabilitation Intervention Studies in the Treatment of Work-related Upper Extremity Disorders (WRUEDs)

Author/Year	Literature Review	Study Design							Subjects				Inter-vention			Outcome			Analysis				Recommen-dations	Total		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23		24	
Vasseljen et al. ¹⁴	2	1	2	2	2	1	1	0	1	2	0	1	2	1	0	1	1	2	2	0	2	2	2	2	2	32
Grayzel et al. ¹⁵	0	1	2	1	0	1	0	0	0	0	0	0	1	1	0	0	2	2	1	1	0	2	1	2	2	20
Hanson et al. ¹⁶	2	2	1	1	0	1	1	0	2	2	0	0	2	0	2	1	1	1	2	0	0	0	0	0	0	21
Lincoln et al. ¹⁷	2	2	2	2	2	1	1	0	1	1	1	1	2	2	2	2	1	1	2	2	2	2	2	2	2	39
Shaw et al. ¹⁸	2	2	0	1	1	0	0	0	1	0	0	0	1	1	1	2	1	1	1	1	1	0	0	0	1	18
Rempel et al. ¹⁹	2	2	2	2	2	2	2	2	2	2	0	1	2	2	2	2	2	2	2	0	2	2	2	2	2	43
Tittiranonda et al. ²⁰	2	2	2	2	2	1	2	2	2	2	0	0	2	1	2	2	2	2	2	0	2	2	2	2	2	40
van den Heuvel et al. ²¹	2	2	2	2	2	1	1	1	2	2	2	1	2	0	2	1	1	0	2	2	2	2	1	2	37	

This table describes the design elements for 24 specific aspects of research design for the studies appraised. A score of 2 is the best score and indicates a high-quality approach to this element of research design. A score of 1 indicates only fair quality of research design and a 0 is poor quality. The specific descriptors of these elements are discussed in the MacDermid article in this issue.

findings suggest that worksite analysis is important in reducing absence from work, the results are questionable because this was only one study, it was underpowered, and there was a low response rate (46%) for hospital employees.

Nurse Case Managers' Training on Accommodations

Two studies^{17,18} on nurse case managers' training on accommodations were located. Lincoln et al.¹⁷ determined the effects of a two-day education program for nurse case managers on workplace accommodation within a workers' compensation health care delivery system. The education program emphasized an Integrated Case Management (ICM) approach, which included training in conducting an ergonomic assessment, using ergonomic evaluations as the basis for implementing workplace accommodations, and training claimants in a problem-solving approach to reduce barriers to return to work. The control group of nurse case managers did not receive training and followed the standard workers' compensation protocol regarding ergonomic procedures and problem-solving strategies. After the training, 101 claimants with compensable WRUEDs were randomly assigned to 53 nurse case managers who had ICM training and 48 nurse case managers without training. A total of 208 accommodations were recommended among the 101 claimants and 155 were implemented (75%). Claimants of the ICM nurses received 50% more recommendations for accommodations in comparison to claimants in the control group and were nearly twice as likely to receive three or more recommendations for accommodations. Trained nurses were more likely to recommend accommodations involving workstation layout, computer-related improvements, furnishings, accessories, and lifting/carrying aids, whereas untrained nurses were more likely to suggest light duty and lifting restrictions.

Shaw et al.¹⁸ described the ICM approach with 53 workers with WRUEDs who were a subgroup of the 101 workers discussed previously in the Lincoln

et al.¹⁷ study. The workers who received the ICM intervention by the 65 trained nurse case managers were 1.4 times more likely to have the accommodations implemented than with the non-ICM approach. They also found that the use of the Job Requirements and Physical Demands scale, which is a self-reported measure of ergonomic exposure, was a factor in contributing to more frequent accommodations in the ICM group. The findings of these two studies suggest that training nurse case managers in the ICM approach was associated with a change in practice behavior regarding accommodations. However, incomplete data, lack of statistical analyses, and the absence of a control group, particularly in the Shaw et al. study, limits us from drawing definitive conclusions about ICM training of nurse case managers.

Ergonomic Modifications

Keyboard designs Two studies^{19,20} were found on the role of keyboard designs in workplace interventions for WRUEDs. In the Rempel et al.¹⁹ study, 20 computer users with hand paresthesias were matched and randomly assigned to keyboard A (*n* = 10) or B (*n* = 10). The two keyboards were of conventional layout and differed in keyswitch design. After 12 weeks, the subjects who were assigned to keyboard A experienced a decrease in hand pain between six and 12 weeks when compared with keyboard B subjects (*p* = 0.05). They also demonstrated an improvement in the Phalen test time (right hand: *p* = 0.006; left hand: *p* = 0.06). Keyboard assignment had no effect on hand function or median nerve latency.

Tittiranonda et al.²⁰ randomized 80 computer users with carpal tunnel syndrome and/or tendonitis into one of the following four keyboard groups (20 subjects in each group): Apple, Comfort, Microsoft, and placebo. Compared with placebo, subjects in the Microsoft group and, to a lesser extent, those in the Apple group demonstrated improvement in pain severity and hand function after six months of

keyboard use. The findings from these studies suggest that keyboard users may experience a reduction in hand pain after several months of using alternative geometry keyboards; however, these studies are limited by small sample sizes.

Rest and exercise breaks Only one study²¹ was retrieved that evaluated rest and exercise breaks for computer users in the workplace treatment of WRUEDs. In a randomized controlled trial, Van den Heuvel²² examined the effects of rest breaks alone ($n = 97$), the combination of rest and exercise breaks ($n = 81$), and a control group ($n = 90$) among computer users with neck and upper limb complaints. Computer use was recorded online and the software program stimulated the intervention groups regarding when to take the breaks. There was an increased frequency of recovery from symptoms in the intervention groups (55% vs. 34% in the control group) and less reporting of deterioration and higher productivity in the intervention groups (4% vs. 20% in the control group). There were no additional effects from performing physical exercises during these breaks. Although these findings may demonstrate that the use of a software program stimulating computer users to take regular breaks may contribute to perceived recovery from neck and upper limb complaints, the results are limited by the use of unstandardized outcome measures and the fact that the participants may have shown favorable effects because of the presence of the intervention. This is known as intervention bias. That is, the use of the software program may have appeased the computer users merely because their complaints were being paid attention to and consequently they recovered.

DISCUSSION

The findings of this systematic review indicate that the evidence is insufficient to identify effective workplace rehabilitation interventions for WRUEDs. Only eight appropriate studies were identified, limiting our ability to make recommendations. Although there were some positive findings, the design of the studies affected the reliability of the results. The flaws included: 1) small sample sizes, 2) lack of standardized outcome measures and statistical analyses, 3) inadequate reporting of the interventions and results, and 4) failure to include a control group.

Limitations of the Review

This review used both the Sackett's levels of evidence¹³ and the Evaluation Guidelines for Rating the Quality of an Intervention Study Form¹²; however, it is possible that these assessment methods

may be overly rigorous given the difficulties of performing workplace interventions. Although the reliability of the quality guidelines¹² has not been formally evaluated, we used consensus to determine the final grades for the quality of all of the items and the levels of evidence. The reviewers noted difficulty in retrieving the information from the studies and in evaluating the quality because the articles were missing information and the descriptions of the subjects and methods often were unclear. Another concern is that the psychometric properties of many of the outcome measures are unknown because they were developed by the investigators. Further studies need to be conducted to determine the reliability and validity of the quality guidelines,¹² and to develop and psychometrically test outcome measures that can be used in effectiveness studies on workplace rehabilitation interventions for WRUEDs.

Future Research

This systematic review revealed a need for further research on workplace interventions for WRUEDs. The positive findings of some of the studies^{14,17,19-21} should be confirmed by future research that includes randomized controlled trial designs, adequate power, standardized outcome measures, and appropriate statistical analyses. Such studies are necessary to advance our understanding of the effectiveness of workplace interventions for WRUEDs. The following specific recommendations are made:

1. There is a need to conduct a practice survey to determine the interventions currently used in workplaces so that future studies could be more comprehensive in their scope.
2. There is a need to develop a set of core outcome measures that would include disability, work limitations, days lost from work, costs, and impact on quality of life. This should be performed through a consensus process. Until such time as this can be accomplished, the following viable options are suggested: a) WRUEDs disability—the DASH²² with the optional work module can be used; b) work limitation—the Work Limitation Scale²³ can be included; c) lost work time—the total number of days lost from regular work duties can be determined; d) costs—the costs to both employers and injured workers, when possible, can be calculated; and e) quality of life—the SF-36²⁴ can be used.
3. There is a need to test the psychometric properties of outcome measures that are available in this area.
4. Because workplace studies seem to be inherently difficult to conduct, methodologies that may assist workplaces in conducting such trials need to be further developed. Investigators should seek

collaboration with epidemiologists and statisticians with expertise in this area so that techniques such as complex statistical modeling and cluster randomization/analyses can be used to maximize the validity of conducted studies.

5. Future studies should clearly describe the interventions and study designs. Given the level of complexity of interventions and the page limitations imposed in publications, authors may consider greater use of appendices, and so on, which may be available to readers in electronic format.

Hand therapists frequently make recommendations to injured workers and employers on exercise, ergonomics, and work modifications. In many instances, the therapists are unable to evaluate the results of their recommendations because there is no formal follow-up of the workers. Therefore, the therapists rely on the evidence from the literature to make and support their recommendations. Although this review provided support for some workplace interventions for WRUEDs, much has been left unaddressed. For example, understanding the proper role of rest and exercise during work hours is more complicated than providing exercise recommendations to injured workers who are not working. Studies also are needed to address the multifactorial nature of WRUEDs through the measurement of multiple outcomes and the evaluation of the effectiveness of the overall program and their individual components.

CONCLUSION

This systematic review on the role of workplace interventions for WRUEDs has shown that the evidence is inadequate in scope and inconsistent in quality. Although the evidence may be poor, it tends to favor a positive impact for several workplace interventions such as ergonomic modifications in keyboard designs and rest and exercise breaks, nurse case managers' training on accommodations, and exercise programs. Conclusive treatment recommendations cannot be made at this time due to the low number and quality of the available studies. Given the increasing extent to which hand therapists are required to deal with these challenging and costly disorders, they should assume a leadership role in defining and evaluating the effectiveness of workplace rehabilitation interventions for WRUEDs.

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