The effects of an office ergonomics training and chair intervention on worker knowledge, behavior and musculoskeletal risk

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Abstract

A large-scale field intervention study was undertaken to examine the effects of office ergonomics training coupled with a highly adjustable chair on office workers’ knowledge and musculoskeletal risks. Office workers were assigned to one of three study groups: a group receiving the training and adjustable chair ($n = 96$), a training-only group ($n = 63$), and a control group ($n = 57$). The office ergonomics training program was created using an instructional systems design model. A pre/post-training knowledge test was administered to all those who attended the training. Body postures and workstation set-ups were observed before and after the intervention. Perceived control over the physical work environment was higher for both intervention groups as compared to workers in the control group. A significant increase in overall ergonomic knowledge was observed for the intervention groups. Both intervention groups exhibited higher level behavioral translation and had lower musculoskeletal risk than the control group.

Keywords: Office ergonomics intervention; Training; Musculoskeletal risk

1. Introduction

Work-related musculoskeletal disorders (WMSDs) among office workers are receiving growing attention. With over 45,000,000 computers in US workplaces, concerns exist about an escalation in the incidence of computer-related WMSDs (Tittiranonda et al., 1999). Studies have revealed a variety of contributing factors to musculoskeletal discomfort including: increased job demands and more hours working at a computer (e.g., Bernard et al., 1994; Faucett and Rempel, 1994), increased levels of psychological stress (e.g., Bongers et al., 1993; Carayon and Smith, 2000; Marcus and Gerr, 1996; Faucett and Rempel, 1994), and a lack of specific ergonomic features in the workstations and office buildings (e.g., Nelson and Silverstein, 1998; Sauter et al., 1990). Typically these studies are cross-sectional in design (Demure et al., 2000). Although there is a growing interest among employers to improve office workplaces, few longitudinal field studies have examined the effects of office ergonomics interventions on worker’s health and performance (Brewer et al., 2006; Buckle, 1997; National Research Council Institute of Medicine, 2001; Karsh et al., 2001). There is some evidence, however that ergonomics training (Brisson et al., 1999) in workstation and building design (e.g., Aaras et al., 2001; Hagberg et al., 1995; Lewis et al., 2002; Nelson and Silverstein, 1998; Rudakewych et al., 2001; Sauter et al., 1990) can prevent or reduce musculoskeletal and visual discomforts and symptoms in office environments.

One method for reducing the prevalence of musculoskeletal and visual symptoms is to provide specialized
ergonomics training and workstation changes. Office ergonomics training helps employees to understand proper workstation set-up and postures (e.g., Brisson et al., 1999; Bohr, 2000; Ketola et al., 2002; Lewis et al., 2002; Verbeek, 1991). Green and Briggs (1989) showed that merely providing adjustable furniture alone may not prevent the onset of overuse injury. However, a significant decrease in WMSDs has been observed when workers were given an adjustable/flexible work environment, coupled with ergonomics training (Robertson and O’Neill, 1999). Further, the provision of control over the work environment through adjustability and knowledge may enhance worker effectiveness as well as health (McLaney and Hurrell, 1988; O’Neill, 1994; Robertson and Huang, 2006).

A large-scale longitudinal field intervention study was implemented to examine the effects of office ergonomics training coupled with a highly adjustable chair on office worker’s ergonomics knowledge, computing behaviors and postures, and health and performance compared to training-only and control groups. Using the instructional system design (ISD) (Knirk and Gustafson, 1986) as a guide, we developed an office ergonomics training workshop with the goal of motivating workers to conduct self-evaluations and to reorganize and adjust their workspace. Fig. 1 shows a theory of change guiding our research model and questions (Amick et al., 2003). Participants were assigned to one of three study groups: a group receiving the adjustable chair and ergonomics training (C+T), an ergonomics training-only group (T-only), and a control group. We proposed the following hypotheses:

**Hypothesis 1.** Office ergonomics knowledge and intent to change office workstation set-ups will increase for the C+T and T-only intervention groups on pre- vs. post-intervention tests.

**Hypothesis 2.** Perceived control over the work environment will increase for the T-only group compared to a control group, with a greater increase for the C+T group as compared to the T-only and control groups.

**Hypothesis 3.** There will be a reduction in musculoskeletal risk for the T-only group as compared to the control group, with a greater reduction for the C+T groups compared to the T-only and control groups.

**Hypothesis 4.** There will be an increase in workstation rearrangement and trained computing behaviors and postures for the T-only group as compared to a control group with a greater increase for the C+T group as compared to the T-only and control groups.

2. **Methods**

2.1. **Study participants**

All participants were employees from one public sector department of revenue services whose jobs involved collecting tax revenues. Participants had access to the internet and worked in sedentary, computer-intensive jobs requiring at least 4 h per day working at an office computer and at least 6 h per day sitting in an office chair. Individuals who filed a Workers’ Compensation claim in the past 6 months were excluded. Informed consent documentation was transferred over the internet on a secure website. The Liberty Mutual Research Institute Institutional Review Board for the protection of human subjects approved the study.

2.2. **Workplace settings**

The study took place at 11 remote office locations, some being 200–300 miles away from the corporate office. Overall the architectural design of the workplaces varied but, in general, consisted of long hallways with private offices in the center of the floor and system panel individual workstations located around the perimeter. Natural lighting

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**Fig. 1.** Theory of change. This model depicts the expectation that when an office ergonomics training program is implemented, an increase in ergonomics knowledge will motivate workers to modify working postures and behaviors (e.g., break patterns, workstation set-up). The training, coupled with the chair, is expected to improve postures and behaviors that reduce musculoskeletal loads, thereby decreasing musculoskeletal symptoms and improving health. A decrease in symptoms influences job functioning and ultimately contributes to performance.
was limited for those situated closer to the center of floor and better for those near the windows. Direct glare from the windows could be controlled by window shades. The individual workstations were “L”-shaped work surfaces, with non-adjustable storage, fixed work surface heights and monitors, and minimally adjustable chairs. Some workstations had adjustable keyboard trays, mouse surfaces, and document holders.

2.3. Study design

A quasi-experimental, longitudinal field study design was employed consisting of two pre-intervention and three post-intervention measures (Campbell and Stanley, 1966). Pre-intervention measures of both outcomes and covariates of theoretical importance were assessed to control for any between-groups differences at baseline. Attempts were made to balance workload requirements and job descriptions as much as possible across the three groups. Workers were not randomly assigned to the study groups; our intent was to minimize the potential for the control group to obtain ergonomic knowledge from the other two study groups. Participants were therefore assigned to groups based on geographic separation by different supervisory units, floors, and buildings.

Over a 16-month period, participants were asked to complete five online surveys: 2 months and 1 month prior to intervention and 2, 6, and 12 months following intervention. Individual workstation assessments and body postures were observed (1 pre- and 1 post-intervention) along with two training knowledge tests (pre- and immediate post-training). Fig. 2 details the specific outcome measures that will be reported and when they were taken.

2.4. Office ergonomics training intervention: instructional system design

The ISDs approach includes six phases: analysis, design, develop, implement, evaluate, and feedback. Each of these steps are discussed below and their applicability to the design of the ergonomic training intervention for the specified study sites.

2.4.1. Analysis

Needs assessment included two steps. First, interviews were conducted by one of the authors (MMR) with the company’s corporate ergonomist, nurse practitioner, and facility manager to identify existing related office health, safety and ergonomics training programs, and to review who had been trained in the study workforce. The semi-structured interviews lasted approximately 1 h and were guided by open-ended questions that focused on identifying the training and ergonomic organizational practices, policies and procedures, the existing ergonomic and safety training programs (content, design, delivery), and the perception of employee’s knowledge level regarding office ergonomics. Second, the corporate facility manager provided a facility walk-through for one researcher (MMR) to view the company’s office spaces, workstation configurations, layout, and furniture.

2.4.2. Design

Based on the needs assessment and previous work in office ergonomics training (Robertson and O’Neill, 1999), the training goals, objectives, and procedures were defined. The training goals were to: (1) understand office ergonomic principles, (2) perform ergonomic self-evaluation of

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*Work Environment and Health (WEH) survey
** Office Ergonomics Assessment (OEA)
*** Rapid Upper Limb Assessment (RULA)

#Office ergonomics intervention consisting of ergonomics training and highly adjustable chair;
3 Groups: Group 1 = Chair + Training, Group 2 = Training-Only, Group 3 = control

Fig. 2. Study timeline and measurement periods.
workspaces, and (3) adjust and rearrange one’s own workspace. Nine instructional objectives were specified:

- recognizing WMSDs and risk factors,
- understanding the importance of varying work postures,
- knowing how to rearrange the workstation to maximize the “comfort zone”,
- recognizing and understanding visual issues in the office environment,
- reducing visual discomfort,
- understanding computing habits (rest breaks),
- knowing how to change work–rest patterns,
- being aware of the company’s existing health and ergonomic programs,
- knowing how to obtain ergonomic accessories through the company’s programs.

For each objective, appropriate presentation strategies and media were determined. Active adult learning models, which allow for a high level of interaction among the trainers and trainees (Gordon, 1994), were specified for use in the training.

2.4.3. Develop

Multi-media presentation provided for various learning modalities for the trainees. The primary media presentation included power point slides, an “Office Ergonomics Today” video, demonstrations, and pictures of various trainees’ computer workspaces. Practice sessions, performance feedback, group discussion, and problem solving activities were all used to facilitate the learning process. Each trainee used their own office chair and learned appropriate adjustments. Group exercises and breakouts were designed and consisted of having the trainees conduct ergonomic assessments of several computer workspaces and provide recommendations. Debriefing and feedback were provided by the co-facilitators. Participants were provided with an opportunity to share real-life examples and experiences related to their computer workspaces. These active learning exercises were designed to instill desired attitudes toward healthy computing, skills of how to use their workspaces, as well as transference of these skills to behaviors when the trainee returned to their workspace. We developed several training materials including: a facilitators handbook, and a computer ergonomic guidelines (“Ergo-Guidelines”) handout with recommendations and solutions. These ergonomic handouts were intended for the trainees to use for future reference.

2.4.4. Implement

The training and evaluation materials, including the pre/post-knowledge tests, were piloted with 25 office workers at another worksite. The training materials and the instructional sequence were modified to meet the training time limit of 90 min. For consistency, the same two co-facilitators, using the same training materials, delivered the training at each of the 11 participating company sites using the same training materials. Facilitators were trained ergonomists and health experts. Training lasted for 1.5 h and was introduced by a supervisor. All supervisors attended the training. Each participant was either provided with the newly adjustable chair at the workshop (group 1; Chair+Training) or came to the training with his or her existing chair (group 2; Training-only). Group 3, the control group, was trained after the study was completed as an obligation and benefit to the participating worksite.

2.4.5. Evaluate

Training’s effectiveness was evaluated based on a five level training evaluation framework (Knirk and Gustafson, 1986; Kirkpatrick, 1979): (1) baseline assessment, prior to training, (2) trainee reaction, (3) learning, (4) performance, and (5) organizational results. In Level 4, behavioral and symptom measures may be included as they are relevant to measures of effectiveness regarding ergonomic training interventions. Evaluation results for Levels 1–3, and part of Level 4 are presented. Symptom reporting and productivity results of this ergonomic intervention study are reported in Amick et al. (2003) and DeRango et al. (2003), respectively. The training effectiveness measures included: Level 1: pre-training office ergonomics knowledge tests; Level 2: trainees’ reaction to the ergonomics workshop (usefulness, value, and relevance); Level 3: pre–post office ergonomics knowledge tests; and Level 4: observed behavioral changes. All of these measures and instruments are described below.

2.4.6. Feedback

E-mail messages provided feedback to the trainees on the results of the knowledge tests and served as reminders of the office ergonomics principles. Messages were sent at 1 and 3 months post-training. These communications were coordinated by the company’s facilities manager, who spearheaded the research project. The 1-month post-training e-mail notified the trainees of the results of the course evaluation and knowledge tests highlighting the item(s) with the greatest improvements and the item(s) with the least improvement. The 3-month post-training e-mail included selected results from the post-training observed behaviors and contained reminders about working postures and tips on healthy computing habits and exercises. Also, reminders about corporate resources concerning ergonomics were given at 1 and 3 months following the training.

2.5. Office ergonomic chair

The ergonomic chair chosen for the intervention has highly adjustable design features including width telescoping armrests, dynamic back support, gliding seat depth, plus the standard ANSI VDT (1998) ergonomic chair requirements (e.g., lumbar support, seat height adjustment, waterfall seat pan front, and five-coaster base). The intent of these adjustable features is to support the ergonomic
goal of improving the worker fit to his or her office workspace (Bush and Hubbard, 1999). For a detailed description of the chair design features and functions see Amick et al. (2003).

2.6. Instrument and outcome measures

Several instruments were used in the study including: (1) Work Environment and Health (WEH) survey (Amick et al., 2003), which asks workers to report comfort, satisfaction, health, computer use, performance, and basic demographic information, (2) two observational tools; Office Environment Assessment (OEA), and Rapid Upper Limb Assessment (RULA), (3) office ergonomics knowledge tests, and (4) office ergonomics workshop evaluation.

2.6.1. Work Environment and Health (WEH) survey

Perceived control over their work environment and knowledge was measured by an objective, 18-item checklist to determine: (a) the number of adjustable features within the workspace and chair (availability of control), (b) the number of features that employees knew how to adjust (knowledge of control) within a workstation and chair, and (c) whether they had adjusted the items (exercise of control) for both the workstation and chair. Response categories were “yes”, “no”, or “don’t know”. The knowledge of adjustability score was determined by the number of features the worker knew how to adjust divided by the number of adjustable features in the workspace. The exercise adjustability score was determined by the number of features the workers had adjusted divided by the number of adjustable features in the workspace. The result was four indices representing the degree of the workers’ perception of control over their physical environment: (1) chair knowledge of adjustability, (2) chair exercise of adjustability, (3) workstation knowledge of adjustability, and (4) workstation exercise of adjustability. The total score is the summative average where a higher score indicates more knowledge and exercise of adjustability.

2.6.2. Rapid Upper Limb Assessment (RULA) observational tool

RULA was used to assess working postures and the associated muscular effort and exerting forces of computer users (McAtamney and Corlett, 1993; Lueder and Corlett, 1996). A computerized version of RULA was developed based on the RULA illustrations and scoring tables reported in Lueder and Corlett (1996) (McGorry and Chang, 2002). Four scores were generated for both the left and the right sides of the body: Score A: upper arm/wrist/wrist twist, Score B: neck, trunk, legs, Score C: Score A + muscle and force scores, Score D: Score B + muscle and force scores, Grand score: combination of Score C and Score D + weighted combination of the four subscores. The grand score is based upon the estimated risk of injury due to musculoskeletal loading. The scales range from 0 to 5 where a higher score represents more of postural load, muscular effort, and musculoskeletal risk.

2.6.3. Office Environment Assessment observational tool

The OEA is a new observational tool intended to evaluate the ergonomic configuration of the overall workspace and items within the worker’s control to change. This 39-item instrument allows for observing the impact of the ergonomic training program on the behaviors of office workers. There are 7 categorical areas: (1) work surface configuration (2 items), comfort zone and accessories (10 items), keyboard and mouse (13 items), monitor (7 items), lighting and glare (6 items), and chair features (9 items). The OEA generates two scores. First, the overall Appropriate Ergonomic Configuration (AEC) score is calculated as the percent of all items correctly configured, regardless of their adjustability. This score reflects how many items within the workspace were appropriately positioned or adjusted relative to the worker’s needs—irrespective of whether the items could be manipulated in any way by the worker. Second, the Training Outcome (TO) score is calculated as the percent of all items that could be changed and were correctly configured within the worker’s workspace. The total score is the mean percent, ranging from 0 to 1, where higher AEC and TO scores represent more appropriately adjusted/or moved items. Trained raters decided whether or not something was adjustable, moveable, or properly configured. Each participant was unobtrusively observed while they were performing representative computing postures such as keying and mousing.

2.7. Inter-rater reliability procedure

Four observers, all with backgrounds in ergonomics, were trained on the OEA and RULA observational instruments. Observers were trained by one of the authors (MMR). Training consisted of a 3.5 h workshop, including a review of the purpose, the instruments, the operational definition of terms, the basic observational techniques, and the procedural use of the instruments. First, observers individually practiced rating on a series of selected pictures of office workers in class, followed by interactive practice sessions with paired trainees in the field. Immediate performance feedback was given by the instructor. Each observer then conducted a series of assessments on the same individuals until there was 90% agreement across items and the gold standard (the instructor). This process required 5 practice assessments with the whole group of observers before the 90% agreement was reached.

After the training was completed, each observer participated in an inter-rater reliability study. Sixteen participants were randomly selected and simultaneously evaluated. Intraclass Correlation Coefficients (ICC), with observers treated as a random factor, were determined for the RULA subscores and grand scores and the OEA scores (AEC and TO). A second study was conducted
post-intervention. An ICC score of 0.70 was considered appropriate for an adequate reliability among observers.

2.8. Office ergonomics knowledge pre–post-tests

Pre- and post-training office ergonomics knowledge tests were distributed to the training intervention groups while they were assembled in the training room. These tests consisted of 17 questions assessing seven knowledge areas of office ergonomics: (1) work-related risk factors (2 items), (2) physical ergonomic features (2 items), (3) body posture (6 items), (4) workstation layout and configuration (4 items), (6) rest breaks (1 item), and (7) ergonomic practices and resources (2 items). The total number of correct items was summed for each participant, ranging from 0 to 17, with 17 being a perfect score.

The post-training knowledge test had one additional open-ended question: “What immediate changes are you going to make to your computer workstation as a result of this office ergonomics training?” Responses were content coded by two raters who first reviewed all of the comments together, identified specific themes, and then coded the responses until 100% agreement was met between them.

2.9. Office ergonomics training workshop evaluation

Workshop ratings provided by participants consisted of 17 items assessing satisfaction with the training format and objectives (6 items), the facilitators (4 items), and course materials (7 items). Responses were provided on a 4-point Likert scale from “1” (strongly agree) to “4” (strongly disagree) for 14 items and “1” (very useful) to “4” (not useful) for 3 items.

2.10. Statistical analyses

To test the pre–post-differences in mean scores for the four perceived control indices, a simple multivariate model in STATA was conducted. Multilevel analyses were completed using MLwiN 1.1 (2001) and all other analyses using STATA 7 (2000). Differences in correct responses pre-test vs. post-test overall, and between knowledge areas were tested using paired \( t \)-tests (i.e., design layout vs. body posture).

3. Results

3.1. Participation rates

For the overall study, 316 workers were invited to participate and 219 provided informed consent for a participation rate of 69.3%. Study participant demographic and workplace characteristics have been described previously: the mean age was 47; 60% of the participants were female; and nearly all participants were white or Caucasian (Amick et al., 2003). Average time spent in an office chair and computing was 5–6 h per day. Table 1 presents the breakdown by group for those who participated, completed the WEH surveys, attended the training, and were observed. The sample size for the control group was \( n = 57 \), chair + training (C + T) \( n = 96 \) and training-only (T-only) \( n = 63 \). There was no significant difference regarding the drop out rates among the groups, and there was a high level of retention (88%) (see Amick et al., 2003).

3.2. Inter-rater reliability for RULA and OEA

Tables 2 and 3 presents the calculated ICCs for each RULA subscores and grand scores, and the two OEA subscores, AEC and TO scores, respectively. The differences in the ICCs between Time 1 and Time 2 were due to the additional practice time and feedback given to the evaluators on understanding the instrument and operational definitions of items in the observational measures.

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Table 1
Number of participants by group and measurement period, who completed work environment and health surveys, training knowledge tests, and observations

<table>
<thead>
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<td>Observed OEA</td>
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<td>44</td>
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<sup>a</sup>WEH: Work Environment and Health Questionnaire (perceived control over environment questions).

<sup>b</sup>OEA: Office Ergonomics Assessment.

<sup>c</sup>RULA: Rapid Upper Limb Assessment.
3.3. Office ergonomic knowledge

3.3.1. Trainee’s reaction

Participants in the two intervention groups found the training to be beneficial as reported on the post-training evaluation questionnaire by either strongly agreeing (64%) or agreeing (36%). Trainees’ responses to the question, “Will they be able to apply this information to their job” yielded 63% strongly agreeing and 37% agreeing.

3.3.2. Trainee’s learning

Results of the pre/post-knowledge test revealed significant increases in knowledge about: overall office ergonomics ($t(143)=13.7, p<0.001$), the use of ergonomic workstation and chair features ($t(143)=7.8, p<0.001$), improvement of body postures ($t(143)=8.9, p<0.001$), company ergonomic practices and company resources ($t(143)=12.4, p<0.001$) (see Fig. 3).

3.4. Self-reported intended behavior changes: post-training test

Pertaining to self-reported intended behaviors, over 93% of the trainees responded to the open-ended question: “...What immediate changes are you going to make to your computer workstation as a result of this office ergonomics training?” Of those that responded ($n=124$), 45% indicated at least two or more changes with changes to the chair, appropriate workstation adjustments, and monitor placement the most frequently provided responses. Similarly, these responses were observed for the control group after the intervention. Fig. 4 presents trainees’ self-report of immediate workstation changes following training.

3.5. Perceived control over the work environment

Responses to the knowledge and exercise of chair adjustability questions showed a positive change for the groups receiving the training as compared to the control group, though not statistically significant ($p>0.05$). An observed positive change was noted in the responses to the knowledge of workstation adjustability questions for the chair + training (pre-intervention $M=0.70$; post-intervention $M=0.76$) and training-only groups (pre-intervention $M=0.81$; post-intervention $M=0.90$) as compared to the control group (pre-intervention $M=0.85$; post-intervention $M=0.82$). However, no significant change was found for the knowledge and exercise workstation adjustability questions.

3.6. Observed postural and behavioral changes

Selection of confounders followed a statistical analysis protocol described in Amick et al. (2003). Of the 30 covariates measured through the WEH, 10 were identified as potentially relevant to the OEA and RULA observational outcomes. These 10 were: hours spent working at office computer, repetitive hand and wrist activity, decision latitude, social support, body mass index categorization, general health, wearing of eyeglasses, age, and gender. A separate confounder selection process was conducted for each outcome modeled.

Through the covariate selection process, only repetitiveness of hand/wrist activity (0 = no repetitiveness and 6 = highly repetitive) remained in the models predicting the OEA outcomes, and no covariates remained in the models predicting the RULA grand scores.

3.6.1. Postural changes: RULA

Table 4 presents the multilevel model results. The models show that both trained intervention groups significantly improved their observed computing body postures (lower RULA scores) compared to the control group, for both the
right and left side of the body. The C+T intervention group experienced a significant improvement in computing postures post-intervention compared to the control group for the left side of the body ($\beta = -2.25; z = -7.77; p < 0.05$) and for the right side of the body ($\beta = -1.94; z = -6.23; p < 0.05$). The T-only group experienced a statistically significant improvement in computing posture post-intervention compared to the control group for the left side of the body ($\beta = -1.88; z = -5.77; p = 0.00$) and for the right side of the body ($\beta = -1.98; z = -5.73; p = 0.00$). The difference between C+T and the T-only groups for both the left and right side of the body were not statistically significant. Changes in the RULA scores for the left and right side of the body are depicted in Fig. 5.

### 3.6.2. Behavioral changes: Office Ergonomics Assessment (OEA)

The results of the multilevel model for the OEA show that the chair with training group did not experience post-intervention improvements in workstation changes for either TO ($\beta = 0.034; z = 1.35; p = 0.176$) or AEC ($\beta = 0.045; z = 1.9; p = 0.057$) as compared to the control group (see Table 4). The training-only group experienced a statistically significant improvement post-intervention in workstation changes (TO) ($\beta = 0.71; z = 2.49; p = 0.01$) and AEC ($\beta = 0.079; z = 2.97; p = 0.003$) as compared to the control group. Post hoc analysis revealed that with the removal of the covariate hand/wrist repetitiveness, the chair with training group model for TO approaches significance $p = 0.075$ compared to the control group.
The difference between chair with training group and the training-only groups for the TO and AEC scores were not statistically significant \((p > 0.05)\). The percent improvements for the OEA regarding observed behavioral changes are depicted in Fig. 6.

### 4. Discussion

This study examined the effects of an office ergonomics intervention, consisting of office ergonomics training and a highly adjustable chair, on workers knowledge, computing behaviors, postures, and risk of musculoskeletal and visual discomfort. Due to the knowledge gained following an office ergonomics intervention improved postures and computing behaviors may be observed. The trainees reported that the office ergonomics training was beneficial and that they could apply the information to their work environment. Additionally, there was an increase in office ergonomics knowledge and skills of the participants from pre- to post-intervention. Participants exhibited a large,
significant increase in knowledge about body postures, ergonomic design features, and corporate resources. Through training, these employees were encouraged to use corporate resources to achieve an ergonomic fit with their new chair as well as setting up and arranging their workstations components. Participants gained a high level of knowledge and awareness of where to go and who to contact concerning the use of corporate ergonomic resources and facility adjustments and changes. At the end of the study, the control group was trained and it is noted that the three groups did not differ significantly from one another in their average level of knowledge pre- and post-intervention (\( p < 0.05 \)).

The lack of significant results on the environmental control and adjustability control questions was surprising. However, positive changes were observed for both trained groups for all four perceived control indices. There may have been an issue of statistical power due to the varying number of adjustable items in the workstation. In some instances, participants only needed to adjust one thing in their workstation or chair.

Observational results indicate that the two trained groups exhibited a higher level of behavioral translation leading to less awkward postures and musculoskeletal loading. Trained participants were more likely to make appropriate behavioral changes to their workstation than the control group. With the participant’s increased knowledge and skills of office ergonomics, workers were more likely to ergonomically adjust their workstation, chair setup and other ergonomic accessories, thereby reducing non-neutral postures and muscular effort, as was indicated by lower RULA grand scores and improved OEA scores.

The marginal non-significant findings for the OEA for the chair with training group may be due to several issues. One is it may be due to the fact that the hand/wrist repetitiveness covariate is acting as an outcome as it showed improvement post-intervention. Second, it appears that the chair with training group started at higher OEA scores than the other two groups, thus minimizing the amount of potential change. However, the chair and training group had positive changes in the workstation arrangement and reduction in hand/wrist activity post-intervention. Moreover, this group appears to be applying the training and making appropriate changes, which may have possibly influenced the movement patterns of the hand and wrist, thus reducing the repetitive motions. These results are consistent with those of Ketola et al. (2002) showing that trained groups in office ergonomics demonstrated less musculoskeletal discomfort than the reference group. Bohr (2000) found that those who received office ergonomics education reported less pain/discomfort and psychosocial work stress following the intervention than those who did not receive education, however it was unclear whether the differences in reported pain/discomfort or psychosocial work stress were related to better work area configuration or improved worker postures.

The study results suggest that with the increased knowledge in ergonomics, positive changes in workstation configuration are associated with behavioral changes. However, this was only in the training-only intervention group, whereas the C+T group only showed significant improvements in computing work postures. These changes were translated into improved working postures, thus potentially reducing musculoskeletal risks. Furthermore, as reported elsewhere, we have observed a reduction in musculoskeletal symptom growth over the workday and visual symptoms (Menéndez et al., 2006) for the C+T group, and a reduction in average pain levels over the workday (Amick et al., 2003) for both C+T and T-only intervention groups. Given these changed computer working postures, there is the potential to reduce musculoskeletal loading which may lead to improved performance and positive return on investment (shown in our earlier work; DeRango et al., 2003).
range of covariates was measured and the risk of contamination was reduced), and the limited postural information collected due to cost, time, and intrusiveness. Also, the pre-intervention ICC’s for the observational measures were marginal. Strengths of this study are: its systematic process for training program development, “presence of a control group, high participation rate, limited loss to follow-up” the full participation of the managers and supervisors, including strong support of senior management, and its study design being longitudinal in nature with individual level measures.

5. Conclusion

Overall, our study findings suggest that due to the knowledge gained from office ergonomics training and an adjustable chair, workers were able to appropriately change and adjust their workstation and chair set-up more ergonomically and effectively. Further field intervention research is needed to support these findings and to replicate them with different office workplace designs and training programs. These findings would contribute to a knowledge base on how to optimally design workplace interventions to help create injury-free environments for office workers.

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