Effectiveness of a library ergonomics training program

Lu Yuan[1], Gregory Culberson[1]
[1]Computer Science & Industrial Technology, Southeastern Louisiana University

Abstract This study evaluated the effectiveness of a library ergonomics training program. The training was aimed at teaching librarians to apply sound ergonomics principles in their daily work activities and to evaluate and adjust their own workstations, with an ultimate goal of reducing musculoskeletal symptoms. The pre- and post- training ergonomics knowledge tests were distributed to the 39 subjects that participated in the project. In addition, work environment and health questionnaires were administered to the subjects before and 2 months after the program to examine changes in self-reported musculoskeletal symptoms, computer workstation configuration, and other pertinent activities. The results of ergonomics knowledge tests indicate statistically significant improvement of librarians' understanding of ergonomics principles. There are also statistically significant positive changes in the questionnaire responses to the four specific questions: "break/rest every 2 hours", "hand/wrist positions", "handle more than 50 lbs", and "bend or twist at the waist to handle objects". The changes in other categories of the questionnaire, including the presence and severity of musculoskeletal symptoms and perceived control over the work environment, were not statistically significant; however, there was a trend toward positive improvement. Overall, the study findings accomplish the training program's objective of assisting librarians to improve ergonomics in the workplace and to reduce musculoskeletal symptoms. The results of this study provide necessary foundation for an integrated participatory approach to reduce ergonomic injuries for librarians.

INTRODUCTION

Technological advancement has shaped the work environment in libraries dramatically since the 1990s. Intensive or long-term use of computers and other electronic tools has become more and more popular in all public service areas and technical operations, particularly cataloguing. This has caused librarians to use awkward postures of the head, neck, and upper extremities and to endure increased pressures on the soft tissues against external workstation surfaces. On the other hand, librarians are still involved in extensive and repetitive handling of books, boxes, and other materials, where they usually have to exert excessive strength during different activities and maintain sustained static posture during prolonged holding (Thibodeau and Melamut, 1995).

Both these typical aspects of library work expose librarians to a relatively wider range and higher level of ergonomic hazards than "standard" office-type work does, as they have produced enormous risk and stress on librarians (Chao, 2001). In addition, the increased job demands and psychological stress have aggravated musculoskeletal discomfort. Consequently, work-related hand, wrist, arm, and back injuries have become a major concern for librarians. For example, Mansfield and Armstrong (1997) reported that the average yearly numbers of injuries and traumatic musculoskeletal disorders (MSDs) at the Library of Congress whose yearly average was 4917 staff during 1991-1995, are 229 and 47, respectively. These injuries and disorders have caused an average yearly $946,284 workers' compensation cost during that five-year span. In the present study, librarians working in the East Baton Rouge Parish Main Library have filed many complaints about their work environment. There are 5 carpel tunnel related injuries over the last two years.

It seems there is a great need to address ergonomic issues within the library environment. Although there is a growing body of literature discussing ergonomics and libraries found in books, journals, and internet sources, there is currently no systematic process to determine needs and evaluate interventions (Tepper, 1996). Rather, the majority of relevant ergonomic research focuses on the examination of hazards in the "standard" office environment. Libraries spend a great amount of time planning the hardware and software implementations of electronic information services, but the human factors and ergonomics are often overlooked (Thibodeau and Melamut, 1995). Thus, it is imperative to educate both management and the workforce on the concepts and principles of ergonomics, identify ergonomic risk factors, and implement sound ergonomics program.

One method for introducing and implementing ergonomics is to use the concept of participatory ergonomics, which originated from discussions between Drs. Kageyu Noro and Kazutaka Kogi in Singapore in 1983 (Imada, 1991). Such an approach maximizes the active involvement of workers in implementing ergonomic knowledge, procedures and changes with the intention of improving working conditions, safety, productivity, quality, morale and/or comfort (Vink and Wilson, 2003; Wilson, 1995).

As part of the participatory ergonomics approach, a comprehensive training module on library ergonomics was developed to teach librarians to apply sound ergonomics principles in their daily work activities and to evaluate and adjust their own workstations, with an ultimate goal of reducing musculoskeletal symptoms.

The primary objective of this study was to evaluate the effectiveness of the library ergonomics training program. The results of this study provide preliminary findings of the overall participatory approach to reduce ergonomic injuries for librarians.

METHODS

Overview of methods

The study was conducted at the East Baton Rouge Parish Main Library, whose employees work for the City-Parish Department of Public Works of Baton Rouge. The City of Baton Rouge Risk Management Division approached the researchers with a plan to provide ergonomics training to all Public Works employees working for the East Baton Rouge Parish Libraries. A walk-through in the East Baton Rouge Parish Main Library was made in summer 2009, where the management personnel exhibited strong interest in and support for both the ergonomics training and the expanded ergonomics research project. All employees from different divisions of the Main Library were invited to participate in this project.

Before participants took the ergonomics training, an initial meeting was held where the research procedures were explained. The subjects were scheduled to take two-hour ergonomics training and complete both pre- and post- training ergonomics knowledge tests. Also, they would complete the work environment and health questionnaire before the ergonomics training and 2 months after the training. Participants signed the informed consent form if they agreed to participate. The research procedures have been approved by the Southeastern Louisiana University Institutional Review Board.

The training program

The training program was developed by the researcher, a senior ergonomist who has ten-year experiences in the ergonomics field, based on references from a variety of sources, including OSHA (Occupational Safety and Health Administration) Computer Workstation eTools (OSHA, 2003), NIOSH (National Institute for Occupational Safety and Health) Ergonomics Guidelines for Manual Material Handling (NIOSH, 2007), and Oregon-OSHA Introduction to the Ergonomics of Manual Material Handling (OROSHA, 2006), etc. Since different divisions of the Main Library use different work schedules, the researcher taught multiple sessions to accommodate participants' schedules and needs. Handouts containing the course material and exercise were distributed and discussed during each session to ensure a consistent delivery of information.

The training program combines text, graphics, color illustrations, and simulation exercises to provide a fully interactive learning environment. Given that the typical library work constitutes activities of both office computer use and manual material handling, the main topics for the ergonomics training include: Introduction to Ergonomics, Understanding MSDs, Ergonomics of Computer Use, Manual Material Handling, and Principles of Ergonomics.

The ergonomics knowledge test questions were drafted to reflect those five modules. There were a total of 11 questions containing 25 fill-in-the-blank challenges; with each one is worth 4 points. The post-training test had one additional open-ended question: "What immediate changes are you going to make to your computer workstation and/or manual material handling activities as a result of this library ergonomics training?"

Work environment and health questionnaire

The NIOSH Symptom Survey questionnaire has been widely used for the purpose of workplace ergonomics studies (Baron et al., 1996; Lewis et al., 2001). Thus, it was used to develop questionnaire for this study. The questionnaire had 6 sections, eliciting the following information: 1) demographic information including age, gender, work history, job title, and employment status; 2) musculoskeletal symptom presence and severity in different body parts including eye, neck, shoulder/upper arm, elbow/forearm, wrist/hand, upper back, lower back, hip/buttock, knee/leg, and ankle/foot; 3) workstation posture, especially the head and upper extremities; 4) manual material handling experience; 5) perceived control over the work environment, specifically the physical adjustability; and 6) other non-work-related activities.

There are four responses for the presence and severity of musculoskeletal symptoms, respectively. Those responses are in an increasing order where the first one means "never" or "light", and the last one denotes "daily" or "severe". The change in response between the pre- and post- training questionnaire was classified as "improved", "worsened", or "no change". For instance, if the response on the pre-training questionnaire was "daily" and the response on the post- one was either "occasionally" or "never", the case was classified as "improved". If the change was in the opposite direction, such a case was coded as "worsened".

The responses for sections 3, 4, and 5 of the questionnaire varied depending upon the specifics of the questions. Overall, more neutral and relaxed workstation postures, reduced manual material handling activities, and increased control of the work pace and environment, were classified as "improved" cases based on the common ergonomics principles.

Data analysis

Differences in the average scores of pre- and post- training ergonomics knowledge tests were examined using paired t-tests. Changes in the responses of work environment and health questionnaire, especially the presence and severity of musculoskeletal symptoms, workstation postures, manual material handling experience, and perceived control of the work, were calculated and then summed across librarians to

determine the proportion of subjects' responses in each of the three classifications ("improved", "worsened", or "no change"). A McNemar non-parametric test was used to evaluate the statistical significance of the observed changes ("improved" vs. "worsened").

Data were analyzed using PASW (also known as SPSS) Statistics 18.0. In each of the two tests described above, the level of significance required to reject the null hypotheses was established at $p < 0.05$.

RESULTS

Demographics of the study population

Thirty nine employees representing nine different divisions participated in the study. The demographic characteristics of participants are shown in Table 1. There were 28 females and 11 males. The average age for the sample population was 43.3 years (range 22 to 72). The subjects have been in their profession for an average of 13.2 years (range 0.4 to 45 years), and they have been working in the East Baton Rouge Parish Main Library for an average of 10.0 years (range 0.3 to 36 years). The majority of subjects are full-time employees (89.7% of the total), and the top two job titles that the subjects hold are Librarian Technician/Assistant (41.0%) and Librarian (30.8%).

Table 1. Demographic characteristics of the study population

Demographic characteristics	Subcategories	Number (% of total subjects)
Gender	Female	28 (71.8%)
	Male	11 (28.2%)
Age	21-30 years	12 (30.8%)
	31-40 years	8 (20.5%)
	41-50 years	3 (7.7%)
	51-60 years	13 (33.3%)
	60+ years	3 (7.7%)
Job Title	Librarian	12 (30.8%)
	Library Technician	16 (41.0%)
	Accountant	2 (5.1%)
	Clerical Specialist	3 (7.7%)
	Computer Specialist	2 (5.1%)
	Page	2 (5.1%)
	Director/Supervisor	2 (5.1%)
Division	Technical Services	5 (12.8%)
	Computer Services	3 (7.7%)
	Business Office	3 (7.7%)
	Branch Division	4 (10.3%)
	Children's Services	4 (10.3%)
	Young Adult	1 (2.6%)
	Circulation	10 (25.6%)
	Reference	8 (20.5%)
	Public Relations	1 (2.6%)
Employment Status	Full-time	35 (89.7%)
	Part-time	4 (10.3%)

Pre- and post- training ergonomics knowledge tests

The average pre-test score was 37.6 (of 100 points), whereas the average post-test score was 76.3. The mean increase was 38.7. The t value of 11.9 (df = 38) was significant at $p < 0.0001$. Thirty four of the 39 subjects have answered the open-ended question in the post-test, of which the most common answers include adjusting monitor and chair height, and removing clutter from desk, etc.

Work environment and health questionnaire responses

The numbers (proportions) of changes in subjects' overall health rating for the three categories of "improved", "worsened", or "no change" were 6 (15%), 10 (26%), and 23 (59%). The χ^2 value for the McNemar test was 0.56, which did not show a significant difference between "improved" and "worsened" responses ($p = 0.45$).

Changes in the presence and severity of musculoskeletal symptoms are shown in Tables 2 and 3, respectively. There were no statistically significant changes in either the presence or severity of symptoms between the pre- and 2-month-post-training questionnaires. However, net changes ("improved percent" minus "worsened percent") were in the direction of improvement for the majority of symptoms.

Table 2. Results of McNemar test for changes in presence of musculoskeletal symptoms 2 months after the library ergonomics training

Body part	Improved percent (N)	No change percent (N)	Worsened percent (N)	χ^2 (p value)
Eye	15% (6)	67% (26)	18% (7)	0.00 (1)
Neck	28% (11)	64% (25)	8% (3)	3.50 (0.06)
Shoulder/Upper Arm	23% (9)	56% (22)	21% (8)	0.00 (1)
Elbow/Forearm	20% (8)	67% (26)	13% (5)	0.31 (0.58)
Wrist/Hand	21% (8)	56% (22)	23% (9)	0.00 (1)
Upper Back	23% (9)	59% (23)	18% (7)	0.06 (0.80)
Lower Back	28% (11)	57% (22)	15% (6)	0.94 (0.33)
Hip/Buttock	15% (6)	64% (25)	21% (8)	0.07 (0.79)
Knee/Leg	23% (9)	62% (24)	15% (6)	0.27 (0.61)
Ankle/Foot	23% (9)	56% (22)	21% (8)	0.00 (1)

Table 3. Results of McNemar test for changes in severity of musculoskeletal symptoms 2 months after the library ergonomics training

Body part	Improved percent (N)	No change percent (N)	Worsened percent (N)	χ^2 (p value)
Eye	18% (7)	67% (26)	15% (6)	0.00 (1)
Neck	38% (15)	44% (17)	18% (7)	2.23 (0.14)
Shoulder/Upper Arm	31% (12)	51% (20)	18% (7)	0.84 (0.36)
Elbow/Forearm	20% (8)	67% (26)	13% (5)	0.31 (0.58)
Wrist/Hand	33% (13)	49% (19)	18% (7)	1.25 (0.26)
Upper Back	28% (11)	54% (21)	18% (7)	0.50 (0.48)
Lower Back	36% (14)	46% (18)	18% (7)	1.71 (0.19)
Hip/Buttock	20% (8)	59% (23)	21% (8)	0.06 (0.80)
Knee/Leg	23% (9)	51% (20)	26% (10)	0.00 (1)
Ankle/Foot	28% (11)	44% (17)	28% (11)	0.05 (0.83)

Table 4 shows changes in computer workstation activities and configuration. All of these results except for "hand position on keyboard" show positive changes, of which the improvements on "break/rest every 2 hours" and "hand/wrist positions" were statistically significant.

Changes in manual material handling experience are illustrated in Table 5. Of all the positive changes, there were statistically significant improvements in the categories of "handle more than 50 lbs" and "bend or twist at the waist to handle objects".

Table 4. Results of McNemar test for changes in computer workstation 2 months after the library ergonomics training

Variable	Improved percent (N)	No change percent (N)	Worsened percent (N)	χ^2 (p value)
Hours at computer per day	13% (5)	82% (32)	5% (2)	0.57 (0.45)
Break/rest every 2 hours	38% (15)	57% (22)	5% (2)	**8.47(0.004)**
Head position	21% (8)	74% (29)	5% (2)	2.50 (0.11)
Hand and wrist positions	41% (16)	46% (18)	13% (5)	**4.76 (0.03)**
Arm position	28% (11)	59% (23)	13% (5)	1.56 (0.21)
Hand position on keyboard	5% (2)	90% (35)	5% (2)	0.25 (0.62)

Table 5. Results of McNemar test for changes in manual material handling 2 months after the library ergonomics training

Variable	Improved percent (N)	No change percent (N)	Worsened percent (N)	χ^2 (p value)
Handle more than 50 lbs	31% (12)	67% (26)	2% (1)	**7.69(0.006)**
Handle large objects that cannot be held close to the body	36% (14)	51% (20)	13% (5)	3.37 (0.07)
Repetition	23% (9)	67% (26)	10% (4)	1.23 (0.27)
Lift above shoulder	33% (13)	54% (21)	13% (5)	2.72 (0.1)
Bend or twist at the waist to handle objects	41% (16)	54% (21)	5% (2)	**9.39(0.002)**
Use mechanical aids to handle objects	23% (9)	62% (24)	15% (6)	0.27 (0.61)

Finally, Table 6 shows changes in perceived control over the work environment. Overall, subjects tended to work in a slower pace and less repetitively; also, they have adjusted workstation and chair more frequently. On the other hand, there have been positive changes in the supervisor's willingness to listen to work-related problems.

Table 6. Results of McNemar test for changes in perceived control over the work environment 2 months after the library ergonomics training

Variable	Improved percent (N)	No change percent (N)	Worsened percent (N)	χ^2 (p value)
Job requires to work very fast	33% (13)	46% (18)	21% (8)	0.76 (0.38)
Job requires to work repetitively	26% (10)	64% (25)	10% (4)	1.79 (0.18)
Frequency of adjusting workstation and chair	28% (11)	49% (19)	23% (9)	0.05 (0.82)
Supervisor willing to listen to work-related problems	38% (11)	54% (21)	18% (7)	0.50 (0.48)

DISCUSSIONS

The present study evaluated the effectiveness of a library ergonomics training program through comparing the pre- and post- training ergonomics knowledge tests and work environment and health questionnaire responses. The results of ergonomics knowledge tests indicate significant improvement of librarians' understanding of ergonomics principles, whereas the questionnaire responses have shown positive changes in the majority of musculoskeletal symptom presence and severity, computer workstation, manual material handling, and perceived control over the work environment. Overall, the study findings accomplish the training program's objective of assisting librarians to improve ergonomics in the workplace and to reduce musculoskeletal symptoms. The results of this study provide necessary foundation for all other research activities of a participatory approach to reduce ergonomic injuries for librarians.

Since the post-training questionnaire was handed out two months after the training, this study only measured its short-term effect on changes in subjects' work behavior and health status. As 13 subjects have reported medical care for existing symptoms, it was not surprised to not see significant changes in the short-term effects that participating in this project could improve the subjects' health conditions. On the other hand, the responses in "other non-work-related activities" indicate that approximately half of the subjects had prolonged use of home computer, did heavy housework such as painting and mowing, and attended fitness program regularly. All these activities could produce confounding effect in the work-relatedness of musculoskeletal symptoms.

The improvement in subjects' computer usage and other work activities and experience indicates the application of ergonomics principles into their daily work life. Although the training tests only examined the subjects' knowledge of ergonomics, it would be surmised that because of the improving knowledge which could be demonstrated by the increasing test scores, subjects tended to apply ergonomics more often during their regular work activities.

The evaluation of library ergonomics training has not been conducted significantly in previous research; however, there have been a few publications depicting office ergonomics program evaluation (Bohr, 2000; Harrington and Walker, 2004; Lewis et al., 2001; Rizzo et al, 1997; Robertson et al. 2009). Our findings are consistent with the results of those studies in general, although the study design and time span for questionnaire distribution are quite different. Since this study is only the first part of a year-long participatory ergonomics project, other research approaches including observation, focus group discussion, ergonomics brochure distribution, and hardware intervention, have been applied to collect more quantitative and qualitative data about the library work.

Additionally, another round of work environment and health questionnaire has been distributed about 8 months after the training. A preliminary analysis indicated the similar results when comparing these questionnaire responses with those before the ergonomics training. The present study provides invaluable baseline information about the ergonomic issues in the library environment, beyond which further research effort is warranted to improve the effectiveness of the library ergonomics program.

ACKNOWLEDGMENTS

The authors thank the East Baton Rouge Parish Main Library employees who participated in the research activities. We appreciate the support from City of Baton Rouge Risk Management Division. This study was funded by the NIOSH Southwest Center for Occupational and Environmental Health (SWCOEH) Pilot Projects Research Training Program (Grant 3T42OH008421-0552). The contents in this article are solely the responsibility of the authors and do not necessarily represent the official views of NIOSH.

REFERENCES

Baron S, Hales T, Hurrell J. Evaluation of symptom surveys for occupational musculoskeletal disorders. Am J Ind Med 1996; 29: 609-17.

Bohr PC. Efficacy of office ergonomics education. J Occup Rehabil 2000; 10: 243-55.

Chao SJ. Library ergonomics in literature: a selected annotated bibliography. Collection Building 2001; 20: 165-75.

Harrington SS, Walker BL. The effects of ergonomics training on the knowledge, attitudes, and practices of teleworkers. J Saf Res 2004; 35: 13-22.

Imada AS. The rationale and tools of participatory ergonomics. In: Noro K, Imada AS, eds. Participatory Ergonomics. London: Taylor & Francis, 1991; 30-49.

Lewis RJ, Fogleman M, Deeb J, Crandall E, Agopsowicz D. Effectiveness of a VDT ergonomics training program. Int J Ind Ergon 2001; 27: 119-31.

Mansfield JA, Armstrong TJ. Library of Congress workplace ergonomics program. Am Ind Hyg Assoc J 1997; 58: 138-44.

NIOSH. Ergonomics Guidelines for Manual Material Handling. http://www.cdc.gov/niosh/docs/2007-131/pdfs/2007-131.pdf (accessed on August 24, 2010)

Oregon-OSHA. Introduction to the Ergonomics of Manual Material Handling. http://www.orosha.org/pdf/workshops/206w.pdf (accessed on August 24, 2010)

OSHA. Computer Workstation eTools. http://www.osha.gov/SLTC/etools/computerworkstations (accessed on August 24, 2010)

Rizzo TH, Pelletier KR, Chikamoto, Y. Reducing risk factors for cumulative trauma disorders (CTDs): the impact of preventive ergonomic training on knowledge, intentions, and practices related to computer use. Am J Health Promot 1997; 11: 250-53.

Robertson M, Amick III BC, DeRango K, Rooney T, Bazzani L, Harrist R, Moore A. The effects of an office ergonomics training and chair intervention on worker knowledge, behavior and musculoskeletal risk. Appl Ergon 2009; 40: 124-35.

Tepper D. Participatory ergonomics in a university library. Master's Thesis, Connell University, 1996.

Thibodeau PL, Melamut SJ. Ergonomics in the electronic library. Bull Med Libr Assoc 1995; 83: 322-9.

Vink P, Wilson JR. Participatory ergonomics. In: Proceedings of the XVth Triennial Congress of the International Ergonomics Association and The 7th Joint conference of the Ergonomics Society of Korea/Japan Ergonomics Society, 'Ergonomics in the Digital Age', Seoul, Korea: August 24-29, 2003.

Wilson JR. Ergonomics and participation. In: Wilson JR, Corlett EN, eds. Evaluation of Human Work: A Practical Ergonomics Methodology, 2nd ed. London: Taylor and Francis, 1995; 1071-96.