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Reducing ergonomic injuries for librarians using a participatory approach

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ABSTRACT

This study utilized a participatory ergonomics approach to examine the ergonomic hazards and reduce musculoskeletal symptoms for librarians in the East Baton Rouge Parish Main Library. A variety of research activities were conducted, including: ergonomics training and tests, observations, work environment and health questionnaires, and focus group discussions. A total of 39 employees from 9 different divisions in the Library participated in the study. The results of pre- and post-training ergonomics knowledge tests indicate significant improvement of librarians' understanding of ergonomics principles. The questionnaire responses for both 2-month-post- and 8-month-post- ergonomics training compared against those before the training have shown positive improvements in ratings of the presence and severity of a majority of the musculoskeletal symptoms, the design of computer workstations and manual material handling tasks, as well as perceived control over the work environment. With the identification of ergonomic hazards through RULA (Rapid Upper Limb Assessment) and REBA (Rapid Entire Body Assessment) observations as well as focus group discussions, the study findings accomplished the project's overall objective of assisting librarians with improvement of ergonomics in the workplace. The results of this study provide a necessary foundation for future long-term study of participatory ergonomics to reduce musculoskeletal injuries and disorders for librarians.

Relevance to industry: Library work entails prolonged use of computers and other electronic tools, as well as repetitive handling of books, boxes, and other materials, which has exposed librarians to a significant risk of developing musculoskeletal injuries and disorders. A participatory ergonomics approach might be effective in improving librarians' understanding and application of ergonomics principles, and subsequently reducing musculoskeletal symptoms.

1. Introduction

Technological advancement has shaped the work environment in libraries dramatically since the 1990s (Chao, 2001). 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 cataloging. 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 of 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). Bryant (1993) estimated that eight out of every 100 Library of Congress employees suffer work-related injuries caused by repeated physical stress, outdated workstation design, poor materials-handling techniques, along with the lack of employee training programs. Mansfield and Armstrong (1997) reported that among a yearly average of 4917 staff at the Library of Congress during 1991–1995, the average yearly numbers of injuries and traumatic musculoskeletal disorders (MSDs) are 229 and 47, respectively. These injuries and disorders have caused an average annual workers' compensation cost of $946,284 during that five-year span. Laberge (2000) found a high incidence of symptoms of MSDs in a sample of 406 respondents

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from Québec public libraries in Canada, 90% of whom had experienced symptoms in the course of the previous year.

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 (Bellemare et al., 2006; Osquei-Zadeh et al., 2012; Summer, 1996; Wick and Woodford, 2006), there is currently no systematic process to determine needs and evaluate interventions (Tepper, 1996). Rather, the majority of relevant ergonomic research either centers on the evaluation of ergonomic risks for library users or only investigates the setup of computer workstation for the librarians. Libraries spend a great amount of time planning the hardware and software implementations of electronic information services, but human factors and ergonomics are often overlooked (Thibodeau and Melamut, 1995). Thus, it is imperative to explore effective and efficient research methodologies to identify, analyze, and control ergonomic hazards during library work.

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). As the word "participatory" indicates, this specific concept constitutes the use of participative techniques and various forms of participation in the workplace (Vink and Wilson, 2003). Wilson (1995) defined participatory ergonomics as "the involvement of people in planning and controlling a significant amount of their own work activities, with sufficient knowledge and power to influence both processes and outcomes in order to achieve desirable goals." 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.

The participatory ergonomics approach has been applied in a wide range of industries, including: construction, health care, manufacturing, military, production and processing plants, and transportation (de Jong and Vink, 2002; de Looze et al., 2001; Evanoff et al., 1999; Hallbeck et al., 2010; Halpern and Dawson, 1997; Laitinen et al., 1998; Moore and Garg, 1998; Rice et al., 2002). The reported benefits include: enhanced performance and reductions in work-related health problems, an improvement of work organizational climate and industrial relations, increased job satisfaction and decreased work-related stress, etc. (Brown, 1993; Haims and Carayon, 1998; Imada, 2000; Lanoie and Tavenas, 1996; Maciel, 1998; Vink et al., 2008).

Several research studies have been conducted to examine and explain the etiology and principles of participatory ergonomics. The framework of and typical methods used in such a technique have been explored by many researchers (Haines and Wilson, 1998; Haines et al., 2002; Hignett et al., 2005; Jatczak, 2008; Kuorinka, 1997; McNeese et al., 1995; Wilson, 1995). Haines et al. (2002) presented and validated a framework for participatory ergonomics by introducing the nine dimensions in participatory ergonomics. Hignett et al. (2005) later ranked those dimensions highlighting the importance of workers, with the top two relating to consultation in decision-making and involvement of workers at all levels in an organization. They also placed the permanence of the ergonomics input as the lowest order, suggesting that ergonomic input is project-specific rather than a permanent organizational role. Common tools that have been used in participatory work groups include: round-robin questionnaires, cause-and-effect diagrams, brainstorming, mock-ups, observations, and checklists.

The objective of the present study was to utilize a participatory ergonomics approach to reduce musculoskeletal symptoms for librarians in the East Baton Rouge Parish Main Library. Specifically, the study was designed to: provide training on the basic concepts and principles of ergonomics to librarians; identify the ergonomic hazards associated with typical library work; and introduce and then apply the participatory ergonomics approach to mitigate the ergonomic hazards within the library environment. The following hypotheses were proposed:

Hypothesis 1 Librarians' knowledge of ergonomics will increase after ergonomics training which is indicated by the comparison of post- vs. pre-test scores.

Hypothesis 2 Librarians' utilization of ergonomics principles will improve after completion of this participatory ergonomics project.

Hypothesis 3 There will be a reduction of musculoskeletal symptoms after the project is complete.

2. Methods

Fig. 1 illustrates a simplified diagram outlining the participatory ergonomics process used in this study. It should be noted that *evaluation* is one of the most crucial elements involved in the entire research process.

2.1. Preparation/start up

2.1.1. Establishing management support and employee buy-in

Employees of the East Baton Rouge Parish Main Library work for the City-Parish Department of Public Works of Baton Rouge. The City of Baton Rouge Risk Management Division approached the researcher with a plan to provide ergonomics training to all Public Works employees working for the East Baton Rouge Parish Library (EBRPL), which is comprised of a Main Library and 13 community or regional branch libraries, and several bookmobiles (EBRPL, 2015). A walk-through in the East Baton Rouge Parish Main Library was made in the summer of 2009. The management personnel exhibited strong interest in and support for both the ergonomics training and this expanded ergonomics research study. There were approximately 100 employees in the Main Library when the study was conducted and all of them were invited to participate in this project. The targeted number of participants was 50.

The recruitment of study participants started with an initial meeting where the research procedures were explained. Employees that were interested in participating in the study would take the ergonomics training at a scheduled time inside the Library and complete both pre- and post-training ergonomics knowledge tests. Also, they would complete the work environment and health questionnaire before the ergonomics training, 2 months after the training, and 8 months after. They would be observed in the workplace when performing their normal work duties, so that ergonomic hazards could be noted. Finally, they might be invited to participate in the focus group discussion as employee representatives. Participants signed the informed consent form if they agreed to participate. The researcher performed all of the research activities, with help from a research assistant on recording the ergonomics training and focus group discussion notes and entering the questionnaire responses into a computer. The research procedures were approved by the Southeastern Louisiana University Institutional Review Board.

2.1.2. Ergonomics training

The training program was developed by the researcher, a senior ergonomist who has more than ten-year experiences in the ergonomics field, based on references from a variety of sources, including: OSHA (Occupational Safety and Health Administration)

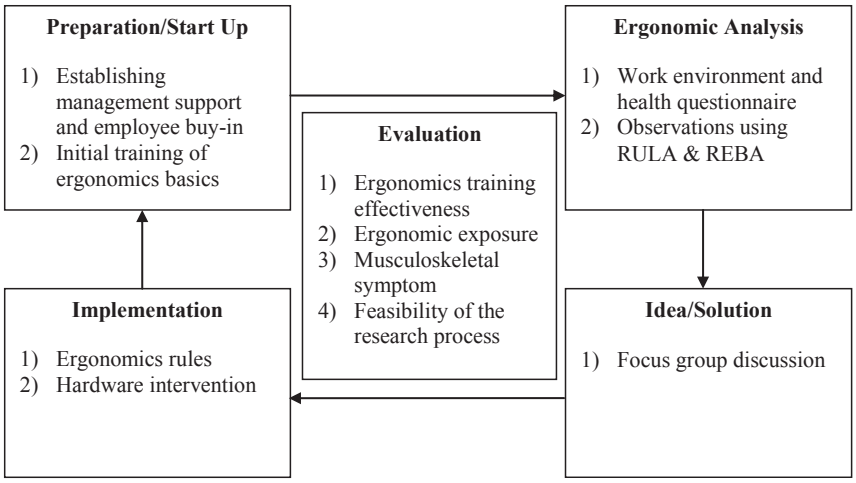

Fig. 1. A simplified diagram of the participatory ergonomics process in this study.

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 (OR-OSHA, 2006). Since different divisions of the Main Library use different work schedules, the researcher taught a total of 7 sessions between August 2010 and October 2010 to accommodate participants' schedules and needs. Each session lasted about 2 h and consisted of 3–10 trainees. 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 typical library work constitutes activities of both office computer use and manual material handling, the main topics for the ergonomics training included: 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 worth 4 points. Typical questions included: definition of ergonomics, examples of occupational risk factors for MSDs, computer monitor setup requirements, features for an ergonomic chair, examples of manual material handling activities, safe lifting guidelines, and general principles of ergonomics. The pre- and post-training tests were the same, except that 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?"

2.2. Ergonomic analysis

2.2.1. 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 the questionnaire for this study, which employed six sections to elicit 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 possible responses for questions on both the presence and severity of musculoskeletal symptoms. 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 3–5 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 common ergonomics principles.

2.2.2. Observations using RULA & REBA

RULA (Rapid Upper Limb Assessment) was used to assess working postures and required muscle use and force exertion for the library work at a desk (Lueder and Corlett, 1996; McAtamney and Corlett, 1993). Four scores were first generated for both the left and right sides of the body: Score A – Upper Limb Posture Score including upper arm, lower arm, wrist, and wrist twist; Score B – Neck, Trunk, and Legs Posture Score; Score C – Score A + Muscle Use + Force Score; and Score D – Score B + Muscle Use + Force Score. The Grand Total Score was then generated by combining Score C and Score D. This grand score indicates a relevant action level based on the estimated risk of injury due to musculoskeletal loading. There are four action levels where a higher level represents a higher risk and indicates that investigation and change are required sooner.

For the manual material handling activities during library work, REBA (Rapid Entire Body Assessment) was used to estimate the risks of entire-body injuries and disorders (Hignett and McAtamney, 2000). Similarly to RULA, REBA also uses a scoring system: Score A – Neck, Trunk, and Legs Posture Score + Load/Force Score; Score B – Upper Arm/Shoulder, Lower Arm/Elbow, and Wrist Posture Score + Coupling Score; and Score C – Score

A + Score B. The final REBA Score is determined by adding an Activity Score to Score C, which denotes a certain action level responsible for the estimated risk level. REBA has five action levels where a higher level indicates a higher risk level and requires more and further assessment.

A total of approximately 20 h of RULA and REBA observations were conducted by the researcher on samples of the library work before the ergonomics training (10 h in total), 2 months after the training (5 h), and 8 months after (5 h). These samples reflected the study participants' normal work duties and they were observed by convenience with an attempt to ensure that all tasks/activities were observed adequately. Typical library work tasks/activities that were observed by RULA include: labeling, stamping, and lining books and cataloging books in the Technical Service Department; answering phone calls in the Reference Division; checking in/out books in the Circulation Division; and by REBA include: unloading boxes of books and other materials and categorizing in the Shipping/Handling Office of the Circulation Division. At a minimum, two subjects were observed for each task/activity. Each observation required approximately five to ten minutes to record, and the total time spent for each department/division was approximately two to four hours. There are many different types of workstations in different departments/divisions; yet, for the same department/division, many of the librarians shared the same workstation, e.g., librarians in the Reference Division rotated their customer service work every one hour. On the other hand, employees of the same department/division used a similar work method, e.g., employees in the Shipping/Handling Office of the Circulation Division worked together to handle books and other materials. These characteristics seemed to indicate that the variations in these typical tasks/activities among the librarians were not high, although it was assumed that the RULA/REBA scores would vary.

2.3. Idea/solution

2.3.1. Focus group discussion

Focus group interviews and/or meetings have been employed in many participatory ergonomics research projects (Pehkonen et al., 2009). This technique uses a scripted brainstorming method to solicit questions and answers from a group of people representing a wide range of employment. In this study, the employee representatives from different divisions in the Library were invited to participate in the focus group discussion. During the one-hour meeting, the attendees were asked questions about their work activities, safety and health concerns, ergonomic exposures, hazard control, and opinions on the feasibility of the study.

2.4. Implementation

2.4.1. Ergonomics rules

Based on the previous steps of the research process where ergonomic hazards and risk factors have been identified and assessed through ergonomics training, the work environment and health questionnaires, observations, and focus group discussions, the researcher explored some handy posters or brochures illustrating ergonomics rules through consultation with the Barbre Ergonomics Consulting and Training (2011) and Experteyes (2011). Permission has been granted to distribute three ergonomics brochures including Stretches (from Barbre Ergonomics), and Workstation Ergonomics and Manual Handling and Storage (from Experteyes) to the study participants. It should be noted that these brochures, unfortunately, were not distributed to the study participants before the one-year study was over. Instead, Library Management had already made plans before the end of the present study to purchase the license of these brochures and distribute them to the entire workforce in the East Baton Rouge Parish Library.

2.4.2. Hardware intervention

It was expected that better ergonomically-designed equipment, typically an ergonomic chair, would be recommended through both observations and focus group discussions. The upper management of the Library under study was supportive regarding expenses for reasonable requests. However, since the Library was in a process of getting a new building at the end of this study, the Director has preferred to make investments for ergonomic workstations at a later stage.

2.5. Evaluation

Evaluation of the study included both comparison of intermediate effects before and after the participatory ergonomics intervention and examination of the feasibility of the participatory approach. The effects of the intervention were measured through pre-post-differences in mean scores for the ergonomics training test, work environment and health questionnaire, and RULA and REBA observations.

The feasibility of the research process was assessed by focus group discussions and satisfaction surveys. In order to assess feasibility at the end of the focus group discussions, the attendees were asked such questions as general opinions about the process, benefits of the project, difficulties with the approach, and barriers in the implementation. To measure the success of the intervention, a survey was distributed to the study participants at the end of the intervention phase. Satisfaction with the arrangements of the project, flow of information, implemented changes, support from the management, and support from researcher was evaluated on a five-point scale (1 = very dissatisfied, 2 = fairly dissatisfied, 3 = undecided, 4 = fairly satisfied, 5 = very satisfied).

2.6. 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 on the 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") for comparisons of two-month-post- vs. pre-training, eight-month-post- vs. pre-training, and eight-month-post- vs. two-month-post- training, respectively. The one-way ANOVA was used to examine the differences in the average RULA and REBA scores at different stages of the research process, including before ergonomics training, 2 months after the training, and 8 months after. The focus group discussion notes were analyzed qualitatively, whereas descriptive statistics was presented to summarize the satisfaction survey results.

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

3. Results

3.1. Demographics of the study population

Thirty-nine employees representing nine different divisions participated in the study. The demographic characteristics of the 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 22–72). The subjects have been in their profession for an average of 13.2 years (range 0.4–45 years), and they have been working in the East Baton Rouge Parish Main Library for an average of 10.0 years (range 0.3–36 years). The majority of subjects were full-time employees (89.7% of the total), and the two most common job titles that the subjects hold are Librarian Technician/Assistant (41.0%) and Librarian (30.8%). None of the participants worked on the night shift.

Six of the 39 subjects did not return their 8-month-post-training questionnaires, which made the total number of questionnaire responses for this round to be 33. Among those 6 subjects, one person had retired after completing the 2-month-post-training questionnaire, 2 employees had moved to other branch libraries, and the other 3 people could not be located.

3.2. 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 (significant at $p < 0.001$), which indicated that Hypothesis 1 should be accepted. Thirty-four of the 39 subjects answered the open-ended question in the post-test. The most common answers include adjusting the monitor and chair height, and removing clutter from the desk.

3.3. Work environment and health questionnaire

3.3.1. Two-month-post-vs. pre-

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 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 h" ($p < 0.001$) and "hand/wrist positions" ($p = 0.03$) were significant.

Changes in manual material handling experience are illustrated in Table 5. Of all the positive changes, there were significant improvements in the categories of "handle objects weighing more than 50 lbs" ($p < 0.001$) and "bend or twist at the waist to handle objects" ($p < 0.001$).

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

3.3.2. Eight-month-post-vs. pre-

Subjects reported more "improved" changes 11 (33%) than "worsened" ones 8 (24%) in the overall health rating eight months after the training. The χ^2 value for the McNemar test was 0.21, which did not show a significant difference between "improved" and "worsened" responses ($p = 0.65$).

There were significant positive changes in the questionnaire responses to three specific questions: "break/rest every 2 h" ($p < 0.001$), "hand/wrist positions" ($p < 0.01$), and "supervisor's willingness to listen to work-related problems" ($p < 0.001$). The changes in other categories of the questionnaire were not statistically significant; however, there was a trend toward positive improvement.

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/Assistant	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%)

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
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 h	38% (15)	57% (22)	5% (2)	**8.47 (<0.001)**
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)

These bold values indicate statistical significance of comparisons between “improved percent” and “worsened percent”.

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 objects weighing more than 50 lbs	31% (12)	67% (26)	2% (1)	**7.69 (<0.001)**
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 (<0.001)**
Use mechanical aids to handle objects	23% (9)	62% (24)	15% (6)	0.27 (0.61)

These bold values indicate statistical significance of comparisons between “improved percent” and “worsened percent”.

3.3.3. Eight-month-post-vs. two-month-post-

There were 10 (30%) “improved” and 4 (12%) “worsened” changes, respectively, in subjects' overall health rating between eight-month-post- and two-month-post- training questionnaire responses. However, this difference was not statistically significant ($\chi^2 = 1.79$, $p = 0.18$).

The net changes in the ratings of the presence and severity of musculoskeletal symptoms tended to fluctuate, and there were

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)

negative net changes in the manual material handling experience. Yet, positive improvements were shown in the category of computer workstation postures and adjustability. Also, it was reported that supervisors were more willing to listen to work-related problems and the improvement was significant ($p = 0.04$).

Overall, these comparisons of work environment and health questionnaire responses seemed to indicate that Hypotheses 2 and 3 could be accepted in general.

3.4. RULA and REBA

The RULA and REBA score averages (SDs) for the typical library work tasks/activities that were observed before the ergonomics training are presented in Table 7. "Labeling, stamping, and lining books" yielded the highest RULA score averages of 4.2 (1.3), which required "further investigation, change may be needed" according to the RULA worksheet.

On the other hand, the highest REBA score averages occurred when "unloading boxes of books and other materials," which represented "medium risk, further investigation, change soon" according to the REBA worksheet. During the unloading task, three boxes were stacked one on top of another. These boxes were placed either on the table or on a cart which were both at approximately waist height. The REBA score for the task conducted on the top box was the highest (11) and the lowest (4) for the task conducted on the bottom box.

The study did not find any statistically significant differences in the average RULA and REBA scores for the tasks/activities that were observed before and after the ergonomics training. Overall, some typical ergonomic hazards/issues were identified and these include: awkward postures of neck and upper extremities during computer usage and back during material handling, inadequate leg room under desk and work space on desk, improper postures of neck and shoulder and simultaneous computer typing when answering phone calls, and extreme overload on Mondays especially for the Shipping/Handling Office, etc.

3.5. Focus group discussion

Twelve subjects from 7 different divisions participated in a total of 3 focus group meetings in February 2011. The important things learned from these meetings include: 1) Heavy lifting, repetition, and sitting at computer for a long period of time are common activities for librarians; 2) There are also health concerns, e.g., customers might be sick and books might also contain viruses and bacteria; 3) Ergonomic furniture should be in place; and 4) Participation in the project was beneficial, and a workstation model during the ergonomics training and ergonomics posters/brochures afterwards would help even more.

3.6. Satisfaction survey

Approximately 85–94% of the subjects felt satisfied or very satisfied with arrangements of project, flow of information, and support from researchers (Table 8). Only half of the subjects were satisfied with the implemented changes and about 27% of the subjects were not very satisfied with support from management; however, there was a general consensus among the majority of those people that they understood that management was waiting to make the investment of ergonomic workstation for the new building that would be breaking ground soon.

4. Discussion

The present study utilized a participatory ergonomics approach consisting of ergonomics training, observations, work environment and health questionnaires, focus group discussions to improve ergonomics in the workplace and to reduce musculoskeletal symptoms for librarians in the East Baton Rouge Parish Main Library. The results of the ergonomics knowledge tests indicated significant improvement of the librarians' understanding of ergonomics principles. The questionnaire responses for both 2-month-post- and 8-month-post-ergonomics training compared against those before the training have shown positive improvements in ratings of the presence and severity of a majority of the musculoskeletal symptoms, the design of computer workstations and manual material handling tasks, as well as perceived control over the work environment. With the identification of ergonomic hazards through RULA and REBA observations as well as focus group discussions, the study findings accomplished the project's overall objective of enhancing ergonomics in the library environment.

A total of 39 employees from 9 divisions in the Main Library participated in the study. The number of participants was below what was originally planned; however, the subjects represented a broad spectrum of employment positions in the Library. Since there is no gold standard on the sample size for the participatory approach, it is challenging to study the impact of such a small sample size. Nevertheless, the ultimate goal of participatory ergonomics is that employees at all levels in an organization should be actively involved and be able to make their own decisions (Hignett et al., 2005). From this standpoint, the more subjects involved in a participatory research study, the better the results will be.

Since the post-training questionnaires were handed out both two months and eight months after the training, this study only measured the short-term effects on changes in subjects' work behavior and health status. There are some positive net changes in the presence and severity of musculoskeletal symptoms of major body parts when comparing subjects' responses two months and eight months after the training with those before training, respectively. Yet, the comparison of the responses in between two-

Table 7
RULA and REBA score averages (SDs) for library work tasks/activities observed before the ergonomics training was conducted in this study.

Division	Task/activity	RULA score average (SD)
Technical Services	Labeling, stamping, and lining books	4.2 (1.3)
	Cataloging books	3.1 (0.9)
Reference	Answering phone calls	3.3 (1.5)
	Using computer	3.4 (1.1)
Circulation	Checking in/out books	2.5 (0.6)
Division	Task/activity	REBA score average (SD)
Shipping/Handling Office of the Circulation Division	Unloading boxes of books and other materials	6.1 (2.1)
	Categorizing books/materials	3.8 (1.3)

Table 8
Statistics of satisfaction survey ($n = 33$).

Questions		1	2	3	4	5	NA
Arrangements of project	Ergonomics training	3.0%	0.0%	9.1%	51.5%	36.4%	0.0%
	Questionnaire	3.0%	0.0%	12.1%	60.6%	24.2%	0.0%
	Observation	3.0%	0.0%	9.1%	51.5%	36.4%	0.0%
	Focus group discussion	3.0%	0.0%	6.1%	48.5%	39.4%	3.0%
Flow of information		3.0%	0.0%	12.1%	48.5%	36.4%	0.0%
Implemented changes		9.1%	0.0%	33.3%	27.3%	24.2%	6.1%
Support from management		9.1%	3.0%	15.2%	42.4%	30.3%	0.0%
Support from researchers		3.0%	0.0%	3.0%	42.4%	51.5%	0.0%

Note: 1 = very dissatisfied, 2 = fairly dissatisfied, 3 = undecided, 4 = fairly satisfied, 5 = very satisfied, NA = not applicable.

month-post- and eight-month-post-training did not show a one-way pattern at all.

The percentage of “no change” was high in general, which might have indicated that participation in this project did not have significant influence on reducing the subjects' musculoskeletal symptoms. Thirteen subjects reported medical care for existing symptoms; therefore, it was not surprising to see such a high prevalence of “no change.” On the other hand, the responses in “other non-work-related activities” indicated that 25 of the 39 subjects had prolonged use of a home computer, which included browsing the Internet and playing games. In addition, 19 subjects had hand-intensive hobbies such as woodworking, knitting, and gardening. All of these activities have been well studied and considered to cause or contribute to musculoskeletal symptoms (Bernard, 1997).

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 could be surmised that because of the improving knowledge which could be demonstrated by the increasing test scores, subjects tended to apply ergonomics principles more often during their regular work activities.

It should be noted that the pre- and post-training ergonomics knowledge tests did not employ psychometric measures; rather, they consisted of objective questions aimed at examining the participants' understanding of ergonomics principles. The participants were asked about “facts” that they were taught during the ergonomics training, and the tests were scored based on if the answers were correct/appropriate or not. As researchers have determined validity as one of the important psychometric properties to evaluate the quality of a measurement tool (Coluci, 2012; Polit and Hungler, 1995; Tyson and Connell, 2009), psychometrically robust and feasible measures have been utilized in those studies that used pre-post experimental design (Mani et al., 2010; Wu et al., 2007). No standardized psychometric measures for the ergonomics knowledge test have been developed yet. Therefore, it would be imperative to explore this in a future study to continuously improve the validity and reliability of such a test.

The observational data by RULA and REBA, however, could not confirm any statistically significant improvements in subjects' workstation posture and behavior. The researcher felt part of the reason might be that no hardware intervention, primarily installation of the ergonomic workstation, had been implemented, as the Library was waiting on the new building that it would get in the near future. Also, the distribution of ergonomic brochures was delayed as the management of the Library would like to purchase the license of these brochures and expand the distribution to all of their employees (approximately 500) working in the Library system. It would be interesting to see if there were any significant differences should the new building be in place, which might indicate the necessity and importance of a follow-up study to continuously helping the librarians improve ergonomics in their new work environment.

In the present study, the focus group meetings provided a legitimate opportunity for the subjects to actively participate in the study and discuss the workplace issues and changes. For example, the ergonomic brochures reflected what the focus group meeting attendees would like to have. They have also contributed to the reductions in some musculoskeletal symptoms as well as ergonomic exposures, as indicated by the comparisons between the work environment and health questionnaire responses 8 months after the ergonomics training and before the training. Yet, not every subject was able to attend the focus group discussion, not to mention being competent enough to get involved in the design of the study. The ultimate goal of a participatory ergonomics approach is to achieve a state where the employees make decisions by themselves (Hignett et al., 2005). However, there should and must be multiple stages accomplished before reaching that goal.

The management's decision on not considering any significant changes until the new building is in place might also indirectly explain the less satisfaction ratings on support from management in the subjects' exit survey at the end of the project. This has also hindered the implementation of recommended interventions as well as the evaluation of their effectiveness in the workplace, which should be noted as a major shortcoming of the present study. Nevertheless, the 8-month-post-training questionnaire results indicate that the research participants felt their supervisors were more willing to listen to their work-related problems. In fact, the management was in the process of selecting and testing a variety of chairs that shall be purchased for different workstations and public service areas for the new building. Based on the conversation with the librarians during the focus group discussions and other casual occasions, it seemed that the majority of librarians understood the management's situation and have been anxiously waiting for the completion of the new building.

The evaluation of library ergonomics training has not been conducted in previous research studies; however, there have been a few publications depicting office and VDT (Video Display Terminal) ergonomics training evaluation (Bohr, 2000; Ketola et al., 2002; Lewis et al., 2001; Rizzo et al., 1997; Robertson et al., 2009). Bohr (2000) investigated the efficacy of worker education programs in preventing musculoskeletal injuries in a population of reservation center employees who spend the majority of their workdays using the computer. Participants were randomly assigned to one of three study groups (control, traditional education, or participatory education). Self-report surveys and observational checklists were utilized to collect data prior to the intervention and at approximately 3, 6, and 12 months post intervention. Those who received education reported less pain/discomfort and psychosocial work stress following the intervention than those who did not receive education. There was no indication that the differences in reported pain/

discomfort or psychosocial work stress were related to better work area configuration or improved worker postures. Those workers in the participatory education intervention group reported a significantly better perception of their health status than those in the control group or the traditional education group. However, there was no evidence if the method of intervention was solely responsible for the higher rating. The present study did not assign the participants into different groups; but, it also used self-report questionnaires and observational techniques, and had a similar finding that the participatory approach seemed to be effective.

The Ketola et al. (2002) study evaluated the efficacy of the participatory ergonomic approach and education on musculoskeletal discomfort and strain, as well as on the prevalence of pain in visual display unit (VDU) work. The subjects were allocated into three groups (intensive ergonomics, ergonomic education, reference) using stratified random sampling. The evaluation involved questionnaires, a diary of discomfort, measurements of workload, and an ergonomic rating of the workstations. The assessments were made 2 weeks before the intervention and after 2 and 10 months of follow-up. The intensive ergonomics and the education groups showed less musculoskeletal discomfort than the reference group in the 2-month follow-up. However, long-term effects on discomfort, strain, or pain were not found in the 10-month follow-up. After the intervention the ergonomic level was distinctly higher in the intensive ergonomic group than in the education or reference group. Based on these findings, the authors concluded that, in attempts to improve the physical ergonomics of VDU workstations, the best result would be achieved with cooperative planning in which both workers and practitioners are actively involved. This is in line with the objective of participatory ergonomics, which could be verified by the findings of the present study as well. The two studies also shared some similar results in the comparisons of musculoskeletal discomfort before and after ergonomic education, although the follow-up time was different.

Rizzo et al. (1997) administered two forms of workstation ergonomics training, both self-directed and instructor-directed, to office workers. Questionnaires were used to measure knowledge of applying ergonomics in the workplace and the adoption of ergonomic "habits" before and after attending the training program. Ergonomic habits included, but were not limited to: the adoption of appropriate ergonomic behaviors and workstation setups. The results indicated no significant difference in either knowledge or habits of the two training groups, as measured before and after the intervention. However, there was a statistically significant difference in these two groups when compared to a control group that did not receive the training. The present study used within-subject design, which is different from the Rizzo et al. (1997) study. But, both studies employed questionnaires to measure application of ergonomics in the workplace.

Robertson et al. (2009) examined 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: training and adjustable chair, training-only, and control. 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 using RULA and OEA (Office Ergonomics Assessment) 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. The present study did not have a control group, but it used many similar research methods as this study did. As both studies indicated the effectiveness of ergonomics training, the Robertson (et al., 2009) study also demonstrated the importance of chair intervention.

In particular, Lewis et al. (2001) evaluated the effectiveness of a VDT training program through comparing the 170 participants' responses to a musculoskeletal symptom questionnaire before and one year after the program. The results indicated statistically significant positive changes in two workstation configuration variables (head and mouse position). There were statistically significant improvements observed in the severity of symptoms. The presence of symptoms did not show a statistically significant reduction; however, there was a trend toward a reduction in frequency. The results suggest the program was effective in changing reported workstation configuration/posture, which resulted in a reduction of symptom severity over the period of the study. The present study did not have a control group receiving no training, which used a similar one-group pre-test-post-test design as the Lewis et al. (2001) study did. Both studies shared the same results in demonstrating the effectiveness of ergonomics training to reduce musculoskeletal symptoms.

Library work is quite unique in that it not only consists of traditional office-type work, but also entails various material handling activities. Because the study used the one-group pre-test-post-test design, it seemed impossible to draw strong causal inferences due to the inability to rule out alternative explanations with certainty (Cook and Campbell, 1979). For example, some study participants switched their department/division within the Library and as a result might have different types of work; others might have constantly changed their work schedules as long as they could fulfill their obligations. The field observations also indicated that younger males were more likely doing most of the heavy material handling activities and older females tended to have more customer service type of work including answering phone calls and guiding the customers. All of these findings could suggest that alternative explanations could not be ruled out in terms of the work-relatedness of the musculoskeletal symptoms in the present study.

The present study also contributed to the knowledge of participatory ergonomics. There are many publications on the study of the effectiveness of participatory ergonomics, but the quality of those papers is relatively low. Hignett et al. (2005) pointed out "often a lack of quality evaluation." Rivilis et al. (2008) agreed and summarized that "the main reason for not finding full support for participatory ergonomics is the low number of methodologically sound studies currently available in the literature." Hence, the challenge still remains to improve the quality of studies examining the health impacts of participatory ergonomics interventions and strengthening the evidence base for ergonomic practitioners and policy makers interested in promoting participatory ergonomics interventions (Rivilis et al., 2008). Although the present study only examined the effectiveness of the participatory ergonomics approach within a relatively short period of time after the intervention, the study results have provided a basis for future long-term study of participatory ergonomics to reduce musculoskeletal injuries and disorders for librarians.

5. Conclusion

Overall, the study findings accomplish the project's objective of assisting librarians to improve ergonomics in the workplace and to reduce musculoskeletal symptoms in a short term. 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.

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References

Barbre Ergonomics Consulting and Training. www.barbre-ergonomics.com (last accessed 01.01.14.).
Baron, S., Hales, T., Hurrell, J., 1996. Evaluation of symptom surveys for occupational musculoskeletal disorders. Am. J. Ind. Med. 29, 609–617.
Bellemare, M., Trudel, L., Ledoux, É., Montreuil, S., Marier, M., Laberge, M., Vincent, P., 2006. Allowing for MSD prevention during facilities planning for a public service: an a posteriori analysis of 10 library design projects. Int. J. Occup. Saf. Ergon. 12, 387–397.
Bernard, B.P., 1997. Musculoskeletal Disorders and Workplace Factors: a Critical Review of Epidemiologic Evidence for Work-related Musculoskeletal Disorders of the Neck, Upper Extremity, and Low Back. Department of Health and Human Services, National Institute for Occupational Safety and Health, Cincinnati, OH.
Bohr, P.C., 2000. Efficacy of office ergonomics education. J. Occup. Rehabil. 10, 243–255.
Brown Jr., O., 1993. On the relationship between participatory ergonomics, performance and productivity in organizational systems. In: Marras, W., Karwowski, W., Smith, J., Pacholski, L. (Eds.), The Ergonomics of Manual Work. Taylor and Francis, London, pp. 495–498.
Bryant, B., 1993. Ergonomics: LC workers risk injury. Library of Congress gazette 19 Nov. In: MARVAL [database online]. Available from: gopher://marvel.loc.gov/11/employee/health/ergonomics.
Chao, S.J., 2001. Library ergonomics in literature: a selected annotated bibliography. Collect. Build. 20, 165–175.
Cook, T.D., Campbell, D.T., 1979. Quasi-Experimentation: Design and Analysis Issues for Field Settings. Houghton Mifflin Co., Boston.
Coluci, M.Z.O., 2012. Measurement instruments for ergonomics surveys - methodological guidelines. In: Nunes, I.L. (Ed.), Ergonomics - a Systems Approach. InTech. Available from: http://www.intechopen.com/books/ergonomics-a-systems-approach/measurement-instruments-for-ergonomics-surveys-methodological-guidelines.
de Jong, A.M., Vink, P., 2002. Participatory ergonomics applied in installation work. Appl. Ergon. 33, 439–448.
de Looze, M.P., Urlings, I.J.M., Vink, P., van Rhijn, J.W., Miedema, M.C., Bronkhorst, R.E., van der Grinten, M.P., 2001. Towards successful physical stress reducing products: an evaluation of seven cases. Appl. Ergon. 32, 525–534.
EBRPL. http://www.ebrpl.com/aboutus.html (last accessed 01.01.15.).
Evanoff, B.A., Bohr, P.C., Wolf, L.D., 1999. Effects of a participatory ergonomics team among hospital orderlies. Am. J. Ind. Med. 35, 358–365.
Experteyes. http://www.experteyes.com.au/ (last accessed 01.01.14.).
Haims, M.C., Carayon, P., 1998. Theory and practice for the implementation of 'in-house', continuous improvement participatory ergonomic programs. Appl. Ergon. 29, 461–472.
Haines, H.M., Wilson, J.R., 1998. Development of a Framework for Participatory Ergonomics. Health and Safety Executive. Contract Research Report 174/1998. HSE Books, London.
Haines, H.M., Wilson, J.R., Vink, P., Koningsveld, E., 2002. Validating a framework for participatory ergonomics. Ergonomics 45, 309–327.
Hallbeck, M.S., Bosch, T., van Rhijn, G., Krause, F., de Looze, M.P., Vink, P., 2010. A tool for early workstation design for small and medium enterprises evaluated in five cases. Hum. Fact. Ergon. Manuf. 20, 300–315.
Halpern, C.A., Dawson, K.D., 1997. Design and implementation of a participatory ergonomics program for machine sewing tasks. Int. J. Ind. Ergon. 20, 429–440.
Hignett, S., McAtamney, L., 2000. Rapid entire body assessment: REBA. Appl. Ergon. 30, 201–205.
Hignett, S., Wilson, J.R., Morris, W., 2005. Finding ergonomic solutions - participatory approaches. Occup. Med. 55, 200–207.
Imada, A.S., 1991. The rationale and tools of participatory ergonomics. In: Noro, K., Imada, A.S. (Eds.), Participatory Ergonomics. Taylor & Francis, London, pp. 30–49.
Imada, A.S., 2000. Participatory ergonomics: a strategy for creating human-centred work. J. Sci. Labour 76, 25–31.
Jatczak, M., 2008. Key Factors for Successful Implementation of a Participatory Ergonomics Program. Master's Thesis. University of Wisconsin Whitewater.
Ketola, M., Toivonen, R., Häkkänen, M., Luukkonen, R., Takala, E.-P., Viikari-Juntura, E., The Expert Group in Ergonomics, 2002. Effects of ergonomic intervention in work with video display units. Scand. J. Work. Environ. Health 28, 18–24.
Kuorinka, I., 1997. Tools and means of implementing participatory ergonomics. Int. J. Ind. Ergon. 19, 267–270.
Laberge, M., 2000. Enquête exploratoire: problèmes musculo-squelettiques, accidents et conditions de travail chez les commis de bibliothèque. Association for Occupational Health and Safety in the Municipal Affairs Sector (APSAM), Montréal, Qué., Canada.
Laitinen, H., Saari, J., Kivistö, M., Rasa, P.-L., 1998. Improving physical and psychosocial working conditions through a participatory ergonomic process a before-after study at an engineering workshop. Int. J. Ind. Ergon. 21, 35–45.
Lanoie, P., Tavenas, S., 1996. Costs and benefits of preventing workplace accidents: the case of participatory ergonomics. Saf. Sci. 24, 181–196.
Lewis, R.J., Fogleman, M., Deeb, J., Crandall, E., Agopsowicz, D., 2001. Effectiveness of a VDT ergonomics training program. Int. J. Ind. Ergon. 27, 119–131.
Lueder, R., Corlett, E.N., 1996. A proposed RULA for computer users. In: Proceedings of the Ergonomics Summer Workshop. UC Berkeley Center for Occupational & Environmental Health Continuing Education Program.
Maciel, R., 1998. Participatory ergonomics and organizational change - a manual for musculoskeletal diseases of the upper limbs. Int. J. Ind. Ergon. 22, 319–325.
Mani, R., Milosavljevic, S., Sullivan, S.J., 2010. The effect of occupational whole-body vibration on standing balance: a systematic review. Int. J. Ind. Ergon. 40, 698–709.
Mansfield, J.A., Armstrong, T.J., 1997. Library of Congress workplace ergonomics program. Am. Ind. Hyg. Assoc. J. 58, 138–144.
McAtamney, L., Corlett, E.N., 1993. RULA: a survey method for the investigation of work-related upper limb disorders. Appl. Ergon. 24, 45–57.
McNeese, M.D., Zaff, B.S., Citera, M., Brown, C.E., Whitaker, R., 1995. AKADAM: eliciting user knowledge to support participatory ergonomics. Int. J. Ind. Ergon. 15, 345–363.
Moore, J.S., Garg, A., 1998. The effectiveness of participatory ergonomics in the read meat packing industry: evaluation of a corporation. Int. J. Ind. Ergon. 21, 47–58.
NIOSH. Ergonomics Guidelines for Manual Material Handling. http://www.cdc.gov/niosh/docs/2007-131/pdfs/2007-131.pdf (last accessed 01.01.14.).
Oregon-OSHA. Introduction to the eErgonomics of Manual Material Handling. http://www.osha.oregon.gov/ppt/materials/206w.ppt (last accessed 01.01.14.)
OSHA. Computer Workstation eTools. http://www.osha.gov/SLTC/etools/computerworkstations (last accessed 01.01.14.).
Osquei-Zadeh, R., Ghamari, J., Abedi, M., Shiri, H., 2012. Ergonomic and anthropometric consideration for library furniture in an Iranian public university. Int. J. Occup. Environ. Med. 3, 19–26.
Pehkonen, I., Takala, E.-P., Ketola, R., Viikari-Juntura, E., Leino-Arjas, P., Hopsu, L., Virtanen, T., Haukka, E., Holtari-Leino, M., Nykyri, E., Riihimäki, H., 2009. Evaluation of a participatory ergonomic intervention process in kitchen work. Appl. Ergon. 40, 115–123.
Polit, D.F., Hungler, B.P., 1995. Fundamentals of Nursing Research, third ed. Artes Médicas, Porto Alegre.
Rice, V.J.B., Pekarek, D., Connolly, V., King, I., Mickelson, S., 2002. Participatory ergonomics: determining control 'buy-in' of US Army cadre. Work 18, 191–203.
Rivilis, I., van Eerd, D., Cullen, K., Cole, D.C., Irvin, E., Tyson, J., Mahood, Q., 2008. Effectiveness of participatory ergonomic interventions on health outcomes: a systematic review. Appl. Ergon. 39, 342–358.
Rizzo, T.H., Pelletier, K.R., Chikamoto, Y., 1997. 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. 11, 250–253.
Robertson, M., Amick III, B.C., DeRango, K., Rooney, T., Bazzani, L., Harrist, R., Moore, A., 2009. The effects of an office ergonomics training and chair intervention on worker knowledge, behavior and musculoskeletal risk. Appl. Ergon. 40, 124–135.
Summer, S.C., 1996. Ergonomics programs and activities in research libraries. Libr. Resour. Tech. Ser. 40, 84–92.
Tepper, D., 1996. Participatory Ergonomics in a University Library. Master's Thesis. Connell University.
Thibodeau, P.L., Melamut, S.J., 1995. Ergonomics in the electronic library. Bull. Med. Libr. Assoc. 83, 322–329.
Tyson, S.F., Connell, L.A., 2009. How to measure balance in clinical practice. A systematic review of the psychometrics and clinical utility of measures of balance activity for neurological conditions. Clin. Rehabil. 23, 824–840.
Vink, P., Wilson, J.R., 2003. 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.
Vink, P., Imada, A.S., Zink, K.J., 2008. Defining stakeholder involvement in participatory design processes. Appl. Ergon. 39, 519–526.
Wick, J.L., Woodford, S., 2006. An investigation of complaints of shoulder pain and discomfort from library workers and the redesign of a circulation desk. In:

Proceedings of the Human Factors and Ergonomics Society 50th Annual Meeting, San Francisco, CA: October 16-20, 2006.
Wilson, J.R., 1995. Ergonomics and participation. In: Wilson, J.R., Corlett, E.N. (Eds.), Evaluation of Human Work: a Practical Ergonomics Methodology, second ed. Taylor and Francis, London, pp. 1071–1096.
Wu, H.-C., Lee, C.-L., Lin, C.-T., 2007. Ergonomic evaluation of three popular Chinese e-book displays for prolonged reading. Int. J. Ind. Ergon. 37, 761–770.
Yuan, L., 2012. Reducing ergonomic injuries for librarians using a participatory approach. In: Soares, M.M., Rebelo, F. (Eds.), Advances in Usability Evaluation Part I. CRC Press, pp. 161–170.