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Participatory ergonomics: Development of an employee assessment questionnaire☆

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ABSTRACT

Despite being essential to the success of participatory ergonomics (PEs) programs, there are currently no known quantitative measures that capture the employees' perspective of PE program effectiveness. The present study addresses this need through the development of the Employee Perceptions of Participatory Ergonomics Questionnaire (EPPEQ). The questionnaire is designed to assess five key components that are based on a review of the available literature: *Employee Involvement*, *Knowledge Base*, *Managerial Support*, *Employee Support*, and *Strain related to ergonomic changes*. In Phase 1, a sample of employees and ergonomists working at a manufacturing plant was used to develop and test an initial set of items. In Phase 2, data was collected from a nation-wide sample of employees representing a wide range of jobs and organizations to cross-validate the results from Phase 1. Phase 2 results indicate that the five EPPEQ subscales demonstrate sound convergent validity and are also correlated with traditional indicators of PE program success. Implications and uses of the EPPEQ are discussed.

1. Introduction

Participatory ergonomics (PEs) programs are generally conceptualized as macroergonomic interventions thought to contribute to continuous improvement of the fit between workers and their work environment (Hendrick and Kleiner, 2002). PE programs are intended to involve employees in ergonomic analysis and design. This involvement may occur at the individual level (e.g., personal work-space layout, addressing personal safety concerns) or at the organizational level (e.g., redesigning the organizational reporting structures, refining organizational hazard management). Haims and Carayon (1998) suggest that PE programs act as a type of intervention strategy that can be used to simultaneously address both ergonomic and psychosocial risk factors. With new systems being developed based on PE programs (e.g., Garmer et al., 1995; Haines et al., 2002; Kleiner and Shewchuk, 2001; Laing et al., 2005; Loisel et al., 2001; Henning et al., 2009; Saleem et al., 2003), benefits are expected to go beyond increasing employee performance and safety. It is likely that benefits of a successful PE program will also extend to issues of turnover and absenteeism, organizational culture and learning, development of a workplace community, as well as improvements in the quality of work-life for employees (Haims and Carayon, 1998; Rivilis et al., 2008).

A practical question for many managers and ergonomists is how to evaluate a PE program once implemented, and how to best proceed with changes needed for continuous improvement of the program itself. To date, evaluations of PE programs, as well as more focused PE interventions, have relied on outcomes such as reductions in musculoskeletal disorders, lost production time, compensation costs, and restricted duty days (cf., Lanoie and Tavenas, 1996; May and Schwoerer, 1994; Moore and Garg, 1998). These evaluative criteria, although important, provide only limited guidance for adjusting those key features of PE programs which depend on the successful involvement of workers in ergonomic practices.

Furthermore, such outcome measures can only provide feedback to mature programs, offering no guidance during program startup or in early phases. More importantly, these bottom-line measures fail to assess a core component of PE programs: the employee's perceptions of the program itself. If the implicit purpose of a PE program is to involve employees in ergonomic assessment and design by leveraging their knowledge, skills, and abilities in relation to specific work contexts, then employees are in the best position to know if features of the PE program support these forms of participation. Thus, evaluations of the functional effectiveness of PE programs should also be based, in part, on employee perceptions of the participatory aspects of program (van der Molen et al.,

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2005b). Therefore we propose the use of perception-based evaluative measures to ensure the success of PE programs (van der Molen et al., 2005a).

As such, the purpose of the present research was to develop a reliable set of employee-based evaluative measures to be used by ergonomists, managers, safety councils, as well as employee representatives that sit on an ergonomics committee, interested in assessing the functional effectiveness of PE programs. We also foresee this measure being useful for evaluative purposes in organizations that may have less formalized PE processes in place or those in the process of creating a fully developed PE program. Additionally, the current measure may benefit organizations that have implemented or are going to implement several unrelated PE interventions. With this in mind and for reasons of parsimony, we refer to these situations collectively as PE programs.

Such measures would allow PE stakeholders to identify areas within their PE program in need of improvement, and then be in a position to initiate an iterative improvement process. The proposed evaluative measures are intended to complement rather than replace efficiency-based (i.e., monetarily based) outcome measures by identifying which features of PE programs are in need of improvement. Thus, these evaluative dimensions are designed to be easy to interpret, thereby minimizing the time between survey administration and the implementation of program improvements, a characteristic absolutely essential for organizational tracking and management systems to be successful (Smith et al., 1994; Smith, 2002). Additionally, involving employees in the improvement of existing PE programs is entirely consistent with the central macroergonomic tenet of involving employees in all workplace redesign efforts (van der Molen et al., 2005b).

We first review the conceptual basis of the dimensions included in our survey instrument. We then report on a two-phase study conducted to evaluate and refine survey items for each of these dimensions. Additionally, we report on how these dimensions are related to commonly assessed self-report measures including safety (e.g., work-related injuries and safety communication), psychosocial (e.g., role conflict and perceived time pressure) and organizational outcomes (e.g., turnover and organizational support). We conclude with a general discussion of the practical use of the resulting survey instrument in industrial settings.

1.1. Dimensionality of the proposed evaluative measures

Based on a literature review of the last 25 years, approximately 20 studies specific to defining and measuring key components relating to participatory ergonomics programs were identified. From these articles we sought to identify dimensions related to employee perceptions of the functional effectiveness of PE programs. Our intent was not to develop an exhaustive listing of dimensions. Instead, we sought to identify dimensions that were discussed most frequently in the literature, had the strongest empirical support, and that would have utility across a diverse set of participatory ergonomics programs in a wide range of industries.

As such, we sought to maintain a balance between having sufficient construct breadth, while also ensuring that the assessment questionnaire remained practical in terms of implementation. Dimensions were extracted by the study authors based on independent reviews of the available literature. A frequency coding scheme for possible dimensions was used. Based on these initial examinations of possible dimensions, discussions were held until consensus was reached. Based on these guiding principles, five dimensions were identified for assessing and evaluating a PE program from an employee's perspective: (1) self-involvement in ergonomic practices, (2) ergonomic knowledge base available within the organization, (3) managerial support in relation to ergonomic practices, (4) employee supportiveness of ergonomic practices, and (5) strain related to ergonomic changes[1]. The five dimensions are described more fully below.

1.1.1. Self-involvement

This dimension is defined as the degree to which employees perceive that they can actively affect decisions about ergonomic design and analysis (Haims and Carayon, 1998). It encompasses the ideas of voice and employee decision-making latitude (Wilson, 1991, 1995). Examples of self-involvement include employees' perceptions that they can take part in ergonomic planning and design efforts, and can exert some influence over any workplace redesign activity that affects them. Employee involvement is a long-standing theme in the PE literature (e.g., Noro and Imada, 1991; Vink et al., 2008).

As suggested by Garrigou et al. (1995), only through employee involvement can certain types of knowledge about the work environment, relevant to PE program interventions, be accessible. Furthermore, in a study by Eklöf et al. (2004), the authors report that *self-involvement* in ergonomic efforts, referred to simply as *participation* in their study, was related to lower perceived work demands, higher levels of social support, and lower levels of stress.

1.1.2. Knowledge Base

This dimension is defined as the degree to which an employee perceives that there is ergonomic knowledge within the organization that employees can leverage to make changes to their work stations or greater work environment (Nagamachi, 1995). An ergonomic knowledge base might be present if an internal team is trained in ergonomic analysis and design, or provided by an external resource such as an ergonomics consultant (Haims and Carayon, 1998). However, the PE knowledge base is not limited to people-based resources alone (i.e., individuals with ergonomics training), but is also related to readily accessible informational resources such as pamphlets, checklists, or playbooks that have direct utility for addressing the problems at hand (Saleem et al., 2003).

Liker et al. (1984) suggest that the lack of a general ergonomics base can prove to be a major obstacle in the implementation of ergonomic principles in the workplace. Additionally, Garmer et al. (1995) suggest that providing an effective knowledge base can facilitate employee involvement in PE program. Furthermore, increasing ergonomic knowledge is an important first step in helping workers develop what are often simple, but effective solutions to ergonomic issues in their work environment (Westlander et al., 1995).

The use of ergonomics teams to provide information to a wide array of employees is a common approach in industry (cf., Carrivick et al., 2005; Evanoff et al., 1999). As suggested by Evanoff et al. (1999), PE teams can be effective in identifying and prioritizing ergonomic issues that warrant specific attention, and can also effectively serve as an interface for both employees and management when implementing effective solutions. However, Haims and Carayon (1998) also note that for an organization to truly embrace and incorporate a PE program into organizational culture, the goal is to have an internal program capable of responding to ergonomic issues without the continuing help of the outside experts that were

[1] It should be noted that after these five dimensions were identified, a subject matter expert in the field of ergonomics was consulted. The subject matter expert, drawing on numerous applied experiences implementing participatory ergonomic interventions, as well as experience in publishing more than 20 chapters and peer reviewed research articles, endorsed the construct breadth covered by these five dimensions.

brought in to establish the PE program. The criticality of having a solid knowledge base is noted Eklöf et al. (2004) who suggest that without a sound PE knowledge base, the program will likely fail irrespective to employee or management support.

1.1.3. Managerial Support

This dimension is defined as the degree to which employees perceive that both line managers and upper management have a genuine and supportive interest in developing a safer, more productive work environment via the PE program. A fundamental aspect of this dimension is related to employee perceptions regarding organizational willingness to allocate resources for ergonomic analysis and design efforts as opposed to only identifying problems with little or no resource allocation and investment (Loisel et al., 2001).

The need for managerial support has been cited in several PE-related field studies (cf., Carrivick et al., 2005; Eklöf et al., 2004; Garmer et al., 1995; Laing et al., 2005; van der Molen et al., 2005b; Vink et al., 1995), and Wilson (1991) suggested that it is a critical requirement for a PE program to be successful. Furthermore, Haims and Carayon (1998) cite data that managerial support is necessary in order to provide employees with the time and opportunity to gain the necessary ergonomic knowledge and expertise. Eklöf et al. (2004) also report a strong positive correlation between managerial support (referred to as *integration* in their study) and employee involvement in the PE program (referred to as *participation* in their study).

1.1.4. Employee Supportiveness

This dimension is the degree to which employees are willing to be directly or indirectly involved in ergonomic programs, and also follow through with the implementation of design solutions generated by the PE program. In a study of participative office automation, Brenner and Östberg (1995) suggest that one of the primary reasons the interventions in their study were well received was extensive and early involvement and supportiveness of employees. As discussed by Garrigou et al. (1995), failure to elicit employee supportiveness of a PE intervention can result in an intervention that is not successful in its goals and aims. This is an issue also noted by Laing et al. (2005) in their quasi-experimental field study of participatory ergonomics; they report that ambivalence on the part of employees may have been a key limitation affecting study results.

1.1.5. Strain related to ergonomic changes

This fifth and last dimension is defined as employee perceptions that changes made as part of a PE program have unintended negative consequences on employees or on the work they do. Specifically, this construct has been operationalized in terms of perceived negative effects of a PE program on an employee's ability to effectively and safely complete their work. Although ergonomic interventions are always intended to have a positive impact on the work environment, previous research has demonstrated that they can also have unforeseen negative consequences (e.g., Anderson and Terborg, 1988; Lawler and Drexler, 1985). Despite the benefits of PE programs outweighing such negative consequences, it is still important that leaders track the severity of negative consequences in order to address program deficiencies that employees may be struggling with and which could undermine the effectiveness of the PE program. For this reason, we include a fifth evaluative dimension relating to perceived negative consequences related to changes initiated as part of the PE program (Wilson, 1995).

Drawing on work by Lazarus and Folkman (1984) we have intentionally conceptualized these negative outcomes in terms of strain. Generally speaking, an individual experiences strain as a negative outcome when they appraise stressors in the work environment as either being beyond their coping ability or as a threat to available resources (Lazarus and Folkman, 1984). As such, an individual who scores high on the *Strain related to ergonomic changes* dimension is effectively evaluating changes introduced as part of the participatory ergonomics program as negative to the point that the changes are perceived by workers as having a negative impact on their well-being.

Even though the participation of employees in ergonomics programs is expected to be generally beneficial to both the organization as well as the employees, it would be generally useful for leaders of such programs to know if certain aspects of the PE program are having negative effects. For example, awareness of employees' concerns that engaging in a PE program could significantly increase role and/or time demands may motivate leaders to increase communication with employees to dispel this misperception. Given the negative focus of this evaluative dimension, it is expected to be negatively correlated with all of the other dimensions of the EPPEQ.

2. Phase 1: manufacturing plant field study

A deductive item-generation methodology was used (Spector, 1992). Items were developed in part based on interview questions obtained as part of the literature review as well as empirical results reported in past research. Subject matter experts (SMEs) from the field study host organization who were familiar with PE program administration reviewed an initial set of items pertaining to the proposed evaluative dimensions. The SMEs included a representative of senior organizational management, the Chief Union Safety Representative, and three PE employee practitioners who had received training in the application of PE programs. Upon concurring with the operational definitions and important nature of the five evaluative dimensions, the SMEs were asked to review and critique a set of 72 items developed by the study researchers; they were also asked to provide additional items as needed to ensure adequate content validity. This process resulted in a final set of 42 items. To evaluate item psychometric properties, these 42 items were administered to employees.

2.1. Methods

2.1.1. Participants and procedure

Field study participants were hourly employees from one department of approximately 1800 employees at a large New England manufacturing plant with an established PE program. At the time of the study, numerous participatory-based ergonomics interventions had been implemented in the approximately five years the program had been in existence, from the purchase of ergonomically designed gripping gloves, to the purchase of large-scale machinery to help reduce employee workloads and eliminate awkward postures in everyday work tasks. All employees were line workers who were involved in the building, maintenance, or testing of aircraft engines.

Recruitment memos were sent to company employees explaining the purpose of the study, and expressed both management and union support for the project. Two separate data collection protocols were used to collect study data. In the first protocol, employees were randomly selected to receive an invitation asking for their voluntary participation. Over a 3-day period, 108 company employees were scheduled to participate. Of those, 56 employees participated (response rate = 51.9%). Employees were given the option of completing a one-on-one interview or completing the survey in a paper-and-pencil format. All participants responded to the same set of structured items, in the same order. In the interview option, items on the paper-and-pencil survey were read to the participants and participant responses were logged on the survey accordingly. The use of this dual-protocol approach [paper-and-pencil survey ($n = 36$) or interview format ($n = 20$)] was at the request of the host organization.

In the second data collection protocol ($n = 7$), the same paper-and-pencil survey was used but the surveys were distributed by union safety representatives to employees interested in participating (employees recruited in the first protocol were not eligible). Employees completed the survey anonymously and returned it to one of two on-site locked collection boxes. Given the nature of this data collection methodology, a response rate cannot be calculated.

A total of 63 employees participated in Phase 1. All participants were eligible to receive sport memorabilia in a raffle drawing held at the end of the study. Similar to the overall demographic breakdown of the department from which participants were drawn from, 87.5% of the sample were men; the average age of the sample was 52.6 years ($SD = 5.1$), with an average reported organizational tenure of 28.3 years ($SD = 5.4$). Most participants worked the first of three possible shifts.

2.1.2. Measures

Of the 42 items included in the survey to assess employee perceptions of the organization's PE program, both positively and negatively worded items were included. Nine items were included to assess *Self-involvement*. Seven items were included to assess *Knowledge Base*. Ten items were included to assess *Managerial Support*. Nine items were included to assess *Employee Supportiveness*. Seven items were included to assess *Strain related to ergonomic changes* resulting from ergonomic changes. For all items, participants were asked to respond based on a 5 point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree).

2.1.3. Analyses

Principal components factor analysis (PCA) with oblimin rotation (delta = 0), was used to explore the factor structure of the proposed 42 items. Oblimin rotation was selected because although we expected each of the dimensions to be empirical distinct from one another, we did not anticipate that they would be completely orthogonal; thus, allowing for some correlation between factors was appropriate. Given the minimal amount of missing data within each of the 42 items (less than 2%), variable mean imputation was used to retain all participants.

2.2. Results

Preliminary analyses indicated that the seven *Strain related to ergonomic changes* items did not function in a systematic manner within this sample; these items were removed from further analyses. Based on item analyses procedures recommend by Child (2006) the remaining 35 items were examined in terms of basic psychometric characteristics (i.e., mean, standard deviation, skewness, kurtosis). Fifteen items were identified as problematic in terms of their level of skewness (skewness > |2|), kurtosis (kurtosis > 3), or limited sensitivity (means < 2, or standard deviations < .5) and were excluded.

Next, an exploratory factor analysis (using principal components analysis) of the remaining 20 items was conducted. A stable four factor solution (with eigenvalues > 1) explaining 62.65% of the variance was achieved[2]. However, there were seven items that demonstrated poor loading (loading less than .40 on any factor), as well as a number of items that demonstrated split loadings (loading greater than .35 on two or more factors); these items were also removed.

The remaining 13 items were consistently related to four of the proposed dimensions; *Self-involvement* (three items), *Knowledge Base* (three items), and *Employee Supportiveness* (three items) and *Managerial Support* (four items). Scale means, standard deviations, internal consistencies, and intercorrelations for the four evaluative dimensions are reported in Table 1. All four dimensions demonstrated acceptable levels of reliability. Based on recommendations by Robinson et al. (1991) for internal consistency reliabilities (Cronbach's alpha), the *Managerial support* dimension ($\alpha = .83$) demonstrated an exemplary reliability (.80 or greater), the Self-involvement ($\alpha = .74$) and the Knowledge Base ($\alpha = .71$) dimensions demonstrated extensive reliability (.70 to .79), and the Employee Supportiveness ($\alpha = .67$) dimension demonstrated a moderate reliability.

2.3. Discussion

Based on the results of the above analyses, four of the five proposed evaluative dimensions were found to be supported: *Employee Knowledge Base*, *Managerial Support*, *Self-involvement*, and *Employee Supportiveness*. Each of these factors demonstrated adequate internal consistency. Items in the *Strain related to ergonomic changes* dimension did not load highly or consistently enough to warrant retaining them as a separate factor. However, anecdotal information collected from participants suggested that strain due to ergonomic changes was an important factor to consider when evaluating the functional effectiveness of a PE program. In particular, respondent's who completed the interview protocol in made several comments about problems that arose during various PE initiatives. Subsequent review of the strain items indicated that in some cases the items were too lengthy or were 'double-barreled,' meaning that two different concepts were posed in one question. This complexity may have introduced response bias, thereby degrading the measurement properties of this dimension. For this reason we decided items for the *Strain related to ergonomic changes* dimension should be modified. Additionally, anecdotal information collected from participants suggested that wording for several of the items from the four other dimensions could be improved. Again, this was made clear when respondents would ask for clarification on what was meant by certain items.

Several additional concerns should be noted in terms of the Phase 1 data. First, our overall sample size was small ($n = 63$) and the sample was primarily male. Although the high proportion of men is consistent with the host organization's demographics, it is possible that our results may not generalize to other organizations with more balanced gender representation. Additionally, our respondents had, on average, 28 years of experience, which may have influenced their interpretation of the PE program. With these issue in mind, and based on the empirical results of Phase 1 and the feedback obtained from study participants in Phase 1, Phase 2 was conducted to refine the items developed in Phase 1 and also to provide evidence of construct validity for the measure as a whole using a larger and more heterogeneous sample of respondents.

3. Phase 2: expanded field study

The purpose of Phase 2 was two-fold. First, a larger sample was used to examine the revised items from the evaluative PE measures tested in Phase 1. Revised items were included for each of the first four evaluative dimensions; *Self-involvement*, *Knowledge Base*, *Managerial Support*, and *Employee Supportiveness*. Also based

[2] Although the ratio between number of items to the number of respondents was not ideal (Bryant and Yarnold, 1995), we felt conducting the EFA was justifiable given the initial exploratory purposes of Phase 1 as well as our planned Phase 2, which would further refine our items.

Table 1
Means, standard deviations, internal reliabilities[a], and intercorrelations for manufacturing plant field study.

	Mean	*SD*	# Items	1	2	3	4
1. Self-involvement	3.46	.89	3	(.74)			
2. Knowledge base	3.36	.91	3	43**	(.71)		
3. Managerial support	2.82	.94	4	.41**	.24	(.83)	
4. Employee supportiveness	3.87	.67	3	.38**	.35**	.19	(.67)

[a] Internal reliabilities reported along the diagonal.
** $p < .01$, two-tailed test.

on anecdotal reports from employees in Phase 1, items from the *Strain related to ergonomic changes* dimension were revised. Given an a priori factor structure was proposed, a confirmatory factor analysis was used to verify the factor structure of the evaluative measures.

Additionally, outcome measures conceptually related to a successful PE program were included in Phase 2 to provide convergent support for the utility of the proposed evaluative measures. The intent of these analyses was to provide some insights on the nomological network surrounding the proposed dimensions of the measure. Three classes of outcome variables were assessed: (1) self-reported safety outcomes, (2) psychosocial risk factors, and (3) other worker-related outcomes (i.e., turnover intentions). Although exploratory in nature, it was expected that the strain dimension would be positively related to unsafe behaviors and psychosocial risk factors, and the other four evaluative dimensions would be negatively related.

3.1. Methods

3.1.1. Participants and procedure

An Internet sampling procedure was used to increase the number of organizations represented in our sample. The Internet sampling procedure was also selected in order to better manage costs and facilitate expedient data collection. Participants were recruited using an online participant recruitment panel that is managed as part of an IRB-approved university-based research study intended to provide diverse samples for a wide range of research studies (www.studyresponse.org) in the summer of 2005. To increase the likelihood that participants would be familiar with participatory ergonomics practices, participants were selected from the panel's population based on their occupation; participants were limited to those who had previously reported working in more traditional "blue collar" occupations. An initial e-mail recruitment message was sent to 2730 participants. A follow-up reminder was sent 1 week later. The survey was in a multi-page format and took approximately 15–20 min to complete. In return for their participation, respondents' names were entered into a raffle for monetary prizes.

Four hundred and seven individuals participated (response rate = 15.0%). Of the 407 respondents, 49 were removed for failing to complete at least 80% of the survey. Of the remaining respondents, 193 indicated that their organization did not have a PE program and were excluded. Thus, the final analysis sample consisted of 165 participants who indicated, as part of the data collection process, that their organization had some form of a PE program. Participants were not required to be actively involved in the PE program. Of the 165 participants, the self-reported demographics were as follows: 58.2% were men, the mean age was 41.3 years (*SD* = 9.9), average job tenure was 7.8 years (*SD* = 8.1), with an average work week of 40.6 hours (*SD* = 10.8). The majority of participants reported working in a production-related occupation (46.1%); sample job titles included assembler, driver, laborer, and operator. An additional 30.3% reported working in construction and installation/maintenance occupations. Sample job titles included laborer, mechanic, and technician. Only 9.7% ($n = 16$) of the sample reported working in a management or supervisory role.

3.1.2. Measures

3.1.2.1. PE evaluation measures. In addition to the 13 items developed and retained in Phase 1, additional items were developed based on written information and anecdotal reports collected from employees in Phase 1. A total of six items were included to assess *Self-involvement*, five items were included to assess *Knowledge* base, eight items were included to assess *Managerial Support*, and six items were included to assess *Employee Supportiveness*. An additional five revised items were included to assess *Strain related to ergonomic changes*. Of the thirty total items, eight were negatively worded. The wording of those final items included in the five evaluative measures can be found in Table 3. Participants were given the prompt "Thinking about your organization's Participatory Ergonomics program, please respond to each of the following items to your best of your ability. . ." and were asked to respond using a 5-point Likert scale (1 = *Strongly Disagree*, 5 = *Strongly Agree*). Internal consistencies reliabilities (i.e., Cronbach's alpha) for each of these measures are in the acceptable range and are reported in Table 4.

3.1.2.2. Safety outcomes. Three safety-related outcomes were assessed: (1) the number of work-related injuries participants had experienced in the past three months based on the following item, "In the past three (3) months, how many work-related injuries have you experienced?" (2) perceived likelihood of being injured on the job based on the following item, "How likely do you feel it is that you will get injured on the job in the next three (3) months?" (1 = *Very unlikely* to 5 = *Very likely*); and (3) upward safety communication, assessed with a modified 7-item scale reported in Hofmann and Stetzer (1998; $\alpha = .87$). Upward safety communication relates to the individual's perceived comfort with discussing general safety concerns with his/her supervisor. A sample item includes, "I feel free to discuss safety-related issues with my supervisor" (1 = *Strongly disagree*, 5 = *Strongly agree*).

3.1.2.3. Psychosocial risk factors. Three psychosocial risk factors were assessed with measures developed by Ivancevich and Matteson (1990). Role conflict was assessed with four items ($\alpha = .84$). A sample item is, "I am asked to do a lot of unnecessary projects." Perceived time pressure was assessed with four items ($\alpha = .84$). A sample item is, "The time deadlines for completing work assignment are too unreasonable." Qualitative overload was assessed with four items ($\alpha = .80$). A sample item is, "I can't do a good job with my present skills and abilities." A Likert scale was used for all three measures (1 = *Strongly disagree*, 5 = *Strongly agree*) where higher scores indicate higher levels of conflict, pressure, or overload, respectively.

3.1.2.4. Other worker-related outcomes. First, turnover intention was assessed with a 3-item measure (Konovsky and Cropanzano, 1991; $\alpha = .91$). A sample item includes "How likely is it that you will look for a job outside of this organization during the next year?" Participants used a 5-anchor response scale (i.e., 1 = *Very unlikely*

Table 2
Confirmatory factor analysis of the proposed PE dimensions.

Models	χ^2	*df*	Fit indexes		
			CFI	RMSEA	SRMR
Null	3710.9	435	–	–	–
One factor	2125.03**	406	.48	.16	.17
Uncorrelated	2056.88**	405	.50	.16	.31
Correlated	1655.53**	395	.62	.14	.15
Respecified	220.39**	108	.93	.08	.07

Note: CFI = comparative fit index; RMSEA = root mean square error of approximation; SRMR = standardized root mean residual.
** $p < .01$.

to 5 = *Very likely*), with higher scores indicating a greater perceived likelihood to leave the organization. Second, perceived organizational support, was assessed with a 3-item measure (Eisenberger et al., 2002; $\alpha = .73$). An example item is, "My organization really cares about my well-being." Third, organizational trust was assessed with a modified 3-item measure (Robinson, 1996; $\alpha = .80$), with higher scores indicating greater organizational trust. A sample item is "I believe my employer has high integrity." A 5-point Likert scale was used for both the perceived organizational support and the organizational trust measures (1 = *Strongly disagree* to 5 = *Strongly agree*).

3.1.3. Analyses

Missing data within each variable were minimal (less than 2%). Given the unsystematic nature of the missing data, variable means were imputed to retain as many participants as possible. Responses to the evaluation dimensions were analyzed conjointly using structural equation modeling software package AMOS 5 (Arbuckle, 2003). A four-stage, marker variable, confirmatory factor analysis (CFA) strategy was used to test the proposed structure of the evaluative dimensions (Kline, 1998; Noar, 2003; see Appendix A for specific details regarding the four stages).

Four measures of model fit were calculated: χ^2, standard root mean residual (SRMR), comparative fit index (CFI), and root mean square error of approximation (RMSEA). A non-significant χ^2 indicates good model fit; however, χ^2 is sensitive to sample size. The CFI and RMSEA are less sensitive to sampling characteristics and take degrees of freedom into account. A CFI value of .90 or higher (Medsker et al., 1994), a RMSEA value of .08 or lower, and a SRMR value of .08 or lower are considered indicative of good model fit (Hu and Butler, 1999).

Pearson correlational analyses were also conducted to examine how the resulting evaluative dimensions were related to various classes of outcome variables of interest.

3.2. Results

Results of the four-stage CFA model testing procedure are reported in Table 2. As expected, the null model had the worst fit. Both the CFI and RMSEA improved when either the one-factor model or the uncorrelated factors model were compared to the null model. Fit increased further when latent factors were correlated. However, the fit of the fourth model was still well below standard cut-off values. Various respecification strategies were utilized to examine if a better fitting model could be achieved.

As discussed by Kline (1998, pp. 216–219) several respecification strategies can be employed to increase model fit. In the present study, latent variable indicators were reviewed. Indicators with low standardized loadings (.35 or less) and/or high standardized residual covariances (greater than 1.98) were considered for removal. Following this methodology, several promising indicators were identified.

Table 3
Revised PE assessment items and standardized factor loadings.

	Loading[a]
Self-involvement	
I am interested in being involved in future ergonomic improvements being made at my company	.67
In discussions about ergonomics, I am asked for my input on how I use my workspace	.83
I have been involved in ergonomics changes that have taken place at my company	.82
Knowledge base	
Through my company, there are individuals I can work with to make ergonomic changes	.61
Through my company, there is training available to me on how to identify an ergonomic hazard	.73
Through my company, I can obtain useful information about ergonomics	.94
Managerial support	
My supervisor is responsive to answering my questions when I am unclear about ergonomic issues	.71
Upper management is supportive of ergonomic changes implemented by employees	.78[b]
My supervisor encourages me to take advantage of the ergonomic programs	.77[b]
My supervisor is genuinely interested in concerns I have about the ergonomic issues	.90
Employee supportiveness	
I warn other employees when they are not following ergonomic practices	.40
I think ergonomic changes made by employees are a good thing for my company to invest in	.72
I support ergonomic changes employees are making at my company	.98
Strain	
Changes that have been made for ergonomic reasons have made my work environment more unsafe	.73
Changes that have been made for ergonomic reasons have added a lot of unwanted time demands on my schedule	.79
Changes that have been made for ergonomic reasons have created conflict between me and my coworkers	.70
Changes that have been made for ergonomic reasons have made it difficult for me to work productively	.82

[a] Loadings that share superscripts were set free to correlate with one another.

A total of 13 items were removed for having low standardized loadings and/or high standardized residual covariances. Three *Self-involvement*, two *Knowledge Base*, and three *Employee Supportiveness* items were removed, respectively. Four *Management Support* items and one *Strain related to ergonomic changes* item were also removed. In addition, based on suggested modification indices, one pair of measurement errors was set free to correlate within the *Management Support* dimension (see Table 3). The overall fit of the respecified model was adequate, indicating that the model has the ability to reproduce the data [$\chi^2(108) = 220.39$, $p < .05$, CFI = .93, RMSEA = .08, SRMR = .07]. As reported in Table 2, although the χ^2 fit statistic was significant, the CFI, RMSEA, and SRMR met their respective criteria for good fit.

Given the iterative nature of respecifications (Kline, 1998), only the final outcome of the process is reported below. The standardized estimates from the respecified model are reported in Table 3. Scale means, standard deviations, reliabilities, number of items, and intercorrelations for the respecified model are reported in Table 4. All five evaluative dimensions demonstrated acceptable internal consistencies (Robinson et al., 1991). The five evaluative dimensions also all demonstrate modest to strong intercorrelations, but these are not so strong as to imply issues of multicollinearity (Kline, 1998). As should be expected, *Strain related to ergonomic changes* was negatively related to the other four evaluative dimensions.

3.2.1. Outcomes analysis

As indicated previously, additional analyses were conducted to examine how the evaluative dimensions were related to relevant

Table 4
Means, standard deviations, internal reliabilities[a], and intercorrelations for the expanded field study.

	Mean	*SD*	# Items	1	2	3	4	5
1. Self-involvement	3.22	.75		(.81)				
2. Knowledge base	3.31	.72		.61**	(.80)			
3. Managerial support	3.30	.76	4	.68**	.63**	(.88)		
4. Employee supportiveness	3.44	.66		.67**	57**	.61**	(.73)	
5. Strain	2.42	.74	4	−.25**	−.30**	−31**	−.34**	(.85)

[a] Internal reliabilities reported along the diagonal.
** $p < .01$, two-tailed test.

Table 5
Relationships between evaluative dimensions and outcomes of interest for the expanded field test.

	Mean	*SD*	Alpha	Self-involvement	Knowledge base	Managerial support	Employee supportiveness	Strain
Safety outcomes								
Number of injuries	.21	.69	–	.00	−.04	−.03	.10	.19*
Perceived injury likelihood	1.85	1.01	–	−.17*	−.25**	−.23**	−.09	.38**
Upward safety communication	3.70	.78	.87	42**	37**	53**	41 **	−.50**
Psychosocial risk factors								
Role conflict	2.43	.91	.84	−.11	−.17*	−.22**	−.09	47**
Time pressure	2.58	.90	.84	−.18*	−.25**	−.23**	−.06	32**
Qualitative overload	2.06	.78	.80	−.20**	−.26**	−.26**	−.13	.45**
Other worker outcomes								
Turnover intentions	2.98	1.36	.91	−.24**	−.22**	−.33**	−.13	.26**
Perceived organizational support	3.20	.98	.73	.33**	23**	.37**	.15	−.28**
Organizational trust	3.35	.94	.80	27**	.16*	32**	.10	−.38**

* $p < .05$, two-tailed test.
** $p < .01$, two-tailed test.

outcomes for organizations with PE programs. The results of these correlational analyses ($\alpha = .05$, two-tailed) are reported in Table 5.

3.2.1.1. Safety-related outcomes. The five evaluative dimensions were related as might be expected. *Self-involvement*, *Knowledge Base*, and *Managerial Support* were all positively related to reports of upward safety communication (correlations ranged from .37 to .53), and all three were negatively related to perceived likelihood of being injured on the job (correlations ranged from −.17 to −.25). For these three evaluative dimensions, individuals reporting higher scores were less likely to report feeling they would be hurt on the job, and were more likely to report feeling comfortable discussing safety issues with their supervisor. Similarly, *Employee Supportiveness* was also positively related to upward safety communication ($r = .41$). In the case of reports of *Strain related to ergonomic changes*, individuals reporting more strain were more likely to report that they would be hurt on the job ($r = .38$), and less likely to report feeling comfortable discussing safety issues with their supervisor ($r = -.50$). In addition, *Strain related to ergonomic changes* was positively related to the number of injuries reported by participants ($r = .19$). Participants reported higher frequencies of work-related injuries in relation to strain due to ergonomic changes.

3.2.1.2. Psychosocial risk factors. *Knowledge Base* and *Managerial Support* were negatively related to the three psychosocial risk factors (correlations ranged from −.17 to −.26). Additionally, when participants perceived higher levels of *Strain related to ergonomic changes*, they were more likely to report role conflict, time pressure, and overload ($r = .47$, .32, and .45, respectively). In contrast, *Self-involvement* was negatively related to time pressure and overload ($r = -.18$ and −.20, respectively).

3.2.1.3. Other worker outcomes. *Employee Supportiveness* was not statistically related to any of the three other worker-related outcomes assessed, although the other four evaluative dimensions were (see Table 5). *Self-involvement*, *Knowledge Base*, and *Managerial Support* were all negatively related to turnover intentions (correlations ranged from −.22 to −.33), but were positively related to perceived organizational support (correlations ranged from .23 to .37) and organizational trust (correlations ranged from .16 to .32). On the other hand, *Strain related to ergonomic changes* was positively related to turnover intentions ($r = .26$), and negatively related to perceived organizational support ($r = -.28$), and organizational trust ($r = -.38$).

3.3. Discussion

The five evaluative dimensions initially tested as part of Phase 1 were developed further and tested in Phase 2 using an independent sample of workers from multiple organizations who reported having experience with either a formal PE program or less formalized PE process within their organization. Results of Phase 2 support the proposed five-factor model. Results also demonstrate that these five dimensions (*Self-involvement*, *Knowledge Base*, *Managerial Support*, *Employee Supportiveness*, and *Strain related to ergonomic changes*) can all be assessed reliably (i.e., consistently) with a limited number of items, increasing their usability as diagnostic devices to assess distinct aspects of a PE program.

Analyses also provide evidence that employee perceptions of a PE program, based on these five evaluative measures, are associated with a variety of important outcome measures. In terms of safety outcomes, perceived strain due to ergonomic changes as well as managerial support for the PE program appear to be important correlates of upward safety communication. Thus for example, when employees perceive little strain due to ergonomic changes and also perceive that management supports the PE program, they are more likely to feel comfortable discussing safety issues with their supervisor. This is particularly interesting because previous research has demonstrated that being willing to discuss safety issues with management is an important predictor of employee commitment to safety practices as well as reduced accident frequency (Hofmann and Morgeson, 1999). In terms of employees' perceived likelihood of being hurt on the job, strain due to ergonomic changes as well as perceived PE knowledge base appear to be important correlates. Once again, having little strain due to ergonomic changes as well as knowing where and how to obtain information on ergonomic processes were both related to a reduced likelihood of feeling like one might be hurt on the job in the near future.

Turning to the psychosocial risk factors assessed, the evaluative dimensions were moderately to strongly related to role conflict, time pressure, and qualitative overload, except in the *Employee Supportiveness* dimension. The lack of a statistical relationship between *Employee Supportiveness* and these outcomes is discussed in more detail below. Previous research has demonstrated that psychosocial risk factors can have diverse negative effects on outcomes such as sick absenteeism (e.g., Linton and Halldén, 1998), work-related upper extremity symptoms (e.g., Bongers et al., 2002) and coronary disease (e.g., Kudielka et al., 2004). By reducing psychosocial risk factors through an effective PE program, it is likely that a variety of negative outcomes related to these psychosocial risk factors might also be reduced.

In support of this, a post hoc analysis was conducted to determine how the three psychosocial risk factors assessed were related to injury frequency reported by participants All three were moderately correlated to injury frequency; role conflict correlated at .20 ($p < .01$), time pressure correlated at .24 ($p < .01$), and qualitative overload correlated at .18 ($p < .05$). Thus, future research might seek to not only test the direct relationships between the evaluative dimensions of and the outcomes of interest, but also to test for possible mediational effects of the dimensions of *Self-involvement*, *Knowledge Base*, *Managerial Support*, and *Strain related to ergonomic changes* on both predictors (e.g., psychosocial risk factors) and outcomes (e.g., injury frequency). Although beyond the scope of the present study, it will be particular important that in the future, researchers consider different theoretical paradigms that might be applied to the study of these issue in order to develop testable, theoretically driven, hypotheses.

Most of the evaluative dimensions were consistently related to the other job outcomes assessed. When participants evaluated the PE program positively, they were less likely to report that they were looking to leave the organization, were more likely to feel that the organization was supportive of them, and were more likely to trust the intentions of the organization. This is consistent with reports in the literature that an organization whose employees are highly committed are more likely to have a stable, productive, and safe workforce (e.g., Fogarty, 2004; Lowe et al., 2003; May et al., 1997; Parker et al., 2001; Zacharatos and Barling, 2004).

Returning to the *Employee Supportiveness* dimension, this dimension does not appear to be statistically related to the outcomes examined here. However, *Employee Supportiveness* may still be an important factor when evaluating PE programs. Given the strong theoretical basis for *Employee Supportiveness*, which is the degree to which employees are willing to be directly or indirectly involved in ergonomic programs and also support implementation of design solutions generated by the PE program, it is possible that *Employee Supportiveness* is more fundamental than the other PE dimensions. As such, in order for employees to take the time to familiarize themselves with the availability of an ergonomic knowledge base, or to take notice of how supportive management is of the PE program, they must first be willing to be involved in the PE program. Subsequently, the effect of *Employee Supportiveness* on various outcomes may also be mediated by other similar dimensions of the PE program such as *Managerial Support*. Future research could examine these possible relationships in greater detail.

3.3.1. Limitations

First, our sample in Phase 2 is one of convenience, using a web-based data collection methodology. As discussed by Messick (1989), the use of a convenience sample like this may limit the generalizability of study findings as it can lend itself to self-selection biases (e.g., those with access to computers and those who are more computer savvy are more likely to participate). Although Internet sampling has been demonstrated to be a valid sampling procedure (Stanton, 1998), additional studies are needed to verify that these evaluative measures are stable when other data collection methods are used (i.e., standard paper and pencil). To address representativeness, efforts were taken to stratify our sample within occupations where PE programs are more likely to be found. Additionally, our sample was limited to only those individuals who indicated, as part of the data collection process, that they had some form of familiarity with a PE program or process within their organization. It should be noted that our data does not allow us to determine the degree to which our respondents were involved in a more formalized PE program or less formalized PE process. In future research examining the utility and validity of the EPPEQ, it will be important to consider how well these measures function for more formalized PE programs as compared with organizations with less formal PE processes in place. Although the present research provides the first step for measuring PE efforts in organizations, additional research will be important in establishing how well results gathered from the EPPEQ can be generalized across organizations with varying degrees of formalizations in their PE programs. To this end, it will be important to collect data not only across multiple organizations as well as different departments within an organization to ensure a greater diversity in responses and to avoid potential response bias issues as well.

Additionally, although a 15% response rate is lower than desired, researchers have found that web surveys typically have lower response rates than traditional mail surveys (Crawford et al., 2001), and therefore it is not uncommon for web-based survey response rates to be 20% lower than mail survey response rates. Despite these lower response rates, web-based samples have been found to be diverse in regards to socioeconomic status, geographic region, age and occupation. Additionally, findings from web-based studies have been found to be consistent with findings from more traditional methods (Gosling et al., 2004).

Another potential issue of concern is common method variance. All of our measures were self-reported single-source measures, which gives rise to potential issues of relationships that are inflated in a spurious manner. However, as discussed by James et al. (1979), common method variance should only be considered a serious issue if there appears to be a systematic and pervasive inflation of observed relationships. Common method variance does not appear to be a significant concern in either or our studies given that the correlations for our sample ranged between .00 and .68, and although a number of these correlations were significant, none were so high as to imply issues of multicollinearity (Kline, 1998) nor imply non-intuitive theoretical relationships.

4. General discussion

Based on the results of two field studies, we were able to develop reliable evaluative measures for assessing employee perceptions of PE programs that can be used by ergonomists and managers interested in tracking the health of their PE program, and making changes in their program whenever needed as part of a continuous improvement process. Five key dimensions were proposed: (1) employee perceptions of self-involvement in ergonomic practices, (2) employee perceptions of an ergonomic knowledge base available within the organization, (3) employee perceptions of managerial support in relation to ergonomic practices, (4) employee supportiveness of ergonomic practices, and (5) strain due to ergonomics changes. The results show that all five dimensions can be reliably assessed with only a limited number of survey items (three to four items each); with the full set of evaluative measures consisting of only 17 items that would usually require less than 8 min for each employee to complete.

Involving employees in a continuous improvement effort of their existing PE program is entirely consistent with the central macroergonomic tenet of involving employees in all workplace redesign efforts (van der Molen et al., 2005b). We suggest that the evaluative measures reported here can serve a number of important functions. First, these evaluative measures are intended to be used by companies to assess the functional effectiveness of the PE program, whether they are in the process of developing their PE program or if it has been in place for some time. It is possible that the measures could also be used as part of a needs analysis to justify revising a PE program, or to justify investing additional resources into an existing PE program as it was by the field site in the Phase 1 study.

The proposed survey instrument will also help provide information on workplace micro- and macroergonomics changes that may be causing bottlenecks that interfere with the effective implementation and continuation of a PE program. For example, it is possible that managers and ergonomists may not be aware that a significant number of employees are not supportive of the PE program, and without widespread employee support, it is unlikely that the PE program will ever be fully effective. Based on information gained from administration of these evaluative measures, managers, union leaders, and ergonomists will be better able to identify when employees need to be more engaged with the PE program.

Additionally, use of all five measures will help PE practitioners identify "the low hanging fruit" types of program interventions that will convince employees that changes are being made to the PE program in response to their input on the survey instrument. For example, this can be done by working with employees, based on their responses to the different dimensions, to identify some programmatic changes that can be quickly implemented. Such changes represent timely feedback that can help motivate employees to be a part of the PE program and to support it, thus promoting worker "buy in" and commitment. For example, if it is determined that employees do not feel that there is not enough ergonomics training available to them, management can offer additional training opportunities soon after survey administration.

Given the ease of administration of these evaluative measures, managers can periodically survey employees to obtain timely information on employee perceptions of the PE program in the spirit of continuous improvement. Additionally because the full survey takes no more than 8 min to complete, lost-time expenses are minimal. Survey results can also be readily interpreted by calculating the mean of all items in each evaluative measure, and also showing histogram plots of item responses or dimensional means to examine their consistency across employees. In keeping with the participatory nature of these programs, results should be shared with all employees as soon as possible to engage employees at all levels of the organization to address any program shortcomings, and also to promote organizational learning. Future research may seek to examine cost-benefit issues as a means of gaining further empirical support for the added value of this proposed means of enabling continuous improvement of a participatory ergonomics program through assessment of employee perceptions.

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Appendix A.

Description of four-stage, marker variable, confirmatory factor analysis (CFA):

Stage 1, Null model. A null model is defined as a model in which all of the correlations or covariances are zero. It serves as a baseline for comparison with other models.
Stage 2, One-factor model. This model tests the fit of a single overall factor, rather than multiple evaluative dimensions. If a one-factor model demonstrates good fit it could be argued that evaluation of a PE program could be based on a single factor.
Stage 3, Uncorrelated factors model. This model tests whether the proposed latent variables, i.e., the five evaluative dimensions, are orthogonal to one another. If this model is supported, the indication would be that separate constructs are being measured. Thus, the evaluative dimensions should be treated as independent of one another.
Stage 4, Correlated factors model. This model allows for covariance among the latent variables and tests whether participants discriminate between latent variables but allows for the possibility that the latent variables are still related to one another.

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