J Occup Health 2017; 59: 256-266

Journal of Occupational Health

Original

A randomized controlled trial of the effect of participatory ergonomic low back pain training on workplace improvement

Shigeyuki Kajiki[1], Hiroyuki Izumi[2], Kenshi Hayashida[3], Akira Kusumoto[1], Tomohisa Nagata[1] and Koji Mori[1,4]

[1]Department of Occupational Health Practice and Management, Institute of Industrial Ecological Science, University of Occupational and Environmental Health, Japan, [2]Department of Ergonomics, Institute of Industrial Ecological Science, University of Occupational and Environmental Health, Japan, [3]Department of Medical Informatics and Management, University of Occupational and Environmental Health, Japan and [4]Occupational Health Training Center, University of Occupational and Environmental Health, Japan

Abstract: Objectives: This study aimed to determine the effects of participatory workplace improvement (PWI)-based provision of ergonomic training and ergonomic action checklists (ACLs) to on-site managers on workplace improvement activities for low back pain (LBP). **Methods:** A randomized controlled trial (RCT) was conducted at a manufacturing company in Japan. Teams entered in the study were randomly assigned to a control and an intervention group. A total of three interventional training sessions on methods of ergonomics were provided to on-site managers in the intervention group, with 1-month intervals between sessions. Ergonomic ACLs were provided at the same time. After completion of the training sessions, each team then provided a report of improvements each month for the next 10 months. Two people in charge of safety and health chose two major objectives of the implemented activities from the five categories. The reported number of improvements was analyzed using a Poisson regression model. **Results:** In the intervention group, although the incident rate ratio (IRR) of PWIs in countermeasures for the LBP category was significantly elevated after the training sessions, the IRR of improvements decreased over time during the 10-month follow-up period. No significant difference was observed in the IRR of total PWIs in either the control or intervention group. **Conclusions:** PWI-based provision of ergonomic training sessions and ergonomics ACLs to on-site managers was shown to be effective for workplace improvement activities targeted at LBP. However, because the effects decrease over time, efforts should be made to maintain the effects through regular interventions.
(J Occup Health 2017; 59: 256-266)
doi: 10.1539/joh.16-0244-OA

Key words: Action Checklist (ACL), Low Back Pain (LBP), Participatory Action Oriented Training (PAOT), Participatory Ergonomics (PE), Participatory Workplace Improvement (PWI), Randomized Controlled Trial (RCT)

Introduction

Musculoskeletal disorders are major issues at worksites in the manufacturing industry. Of these, low back pain accounts for approximately 62% of occupational diseases in Japan and is the most common condition among diseases attributable to work[1)]. In Europe and the US, low back pain is the major cause of presenteeism, leading to reduced work efficiency and labor productivity[2-4)].

Participatory ergonomics (PE) is a widely used measure for musculoskeletal disorders at the workplace, including low back pain[5-7)]. PE is defined 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[8)]" and "practical ergonomics with participation of the necessary actors in problem solving[9)]." Various interventions exist, via combinations of participants (workers, managers, in-

Received October 20, 2016; Accepted February 8, 2017
Published online in J-STAGE March 17, 2017
Correspondence to: S. Kajiki, Department of Occupational Health Practice and Management, Institute of Industrial Ecological Science, University of Occupational and Environmental Health, 1-1 Iseigaoka, Yahatanishi-ku, Kitakyushu, Fukuoka 807-8555, Japan (e-mail: skajiki@med.uoeh-u.ac.jp)

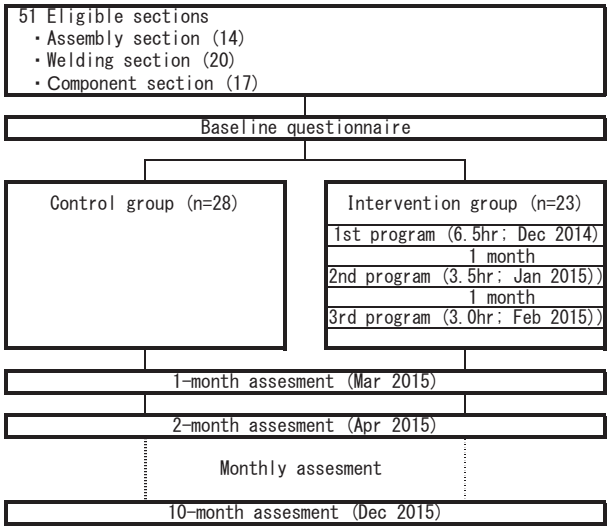

Fig. 1. Flowchart of enrolment and study design.

house technical staff, external experts), specific efforts (trainings, group consultations, identification of problems and development of solutions), and changes in the workplace (introduction of tools and instruments, change of workplace, review of work processes)[5-7].

Among PE improvement activities, training sessions account for approximately 73% of all activities. Among participants, 53% are workers and 24% are workplace leaders[5]. The length of sessions varies from 2 h to 100 h. They include diverse items such as a general outline of ergonomics (e.g., identification of mechanisms of diseases, risk factors and hazards, and methods for reduction), promotion of problem-solving skills and teamwork, and dissemination of an awareness of ergonomics[5]. Regarding training sessions for on-site managers, managers often bring back their new knowledge to the workplace and implement improvements in worker activities[5].

A number of effects of PE have been reported, including decreased musculoskeletal symptoms and industrial accidents, reduced work injury-related expenditure, and fewer days of absence[6,10-16]. However, the results of randomized controlled trials (RCTs) have shown no effect on the prevalence of low back pain or neck pain[17], no decrease in pain intensity[18], and no prophylactic effects on musculoskeletal disorders[19,20]. The value of PE is thus controversial.

Action checklists (ACLs) are supporting tools which enable workers to tackle workplace improvement on-site[21,22]. A number of studies have reported successful workplace improvements using ACLs[23-27]. Although ergonomic ACLs have been developed at worksites and utilized as a PE tool, they have not been evaluated in controlled trials. Moreover, the effects of integrated interventions of ergonomic training sessions and ACLs have not yet been reported.

The aim of this study was to determine the effects of participatory ergonomic training for low back pain using ergonomics ACLs on improvements in activity at workplace units.

Study Population and Methods

Study design

The study setting was the production department of a factory of a Japanese manufacturing company. The study was conducted as a unit-based randomized controlled trial which investigated participatory workplace improvement (PWI) targeted at workers' low back pain by evaluating the effect of participatory ergonomic intervention using action checklists. Fig. 1 shows a flow chart of the study.

Study sample

The organization was a factory which manufactures construction machinery and equipment. The production department of the factory consists of an assembly section (assembling machines), a welding section (welding machines), a component section (processing detailed components of machines), and a building section (manufacturing/maintenance of jigs used for machine operation). Among these, the assembling, welding, and component sections, all of which involve heavy work (work carrying a certain physical burden), were selected. The selected sections were staffed by 51 teams. Each team had a team leader and 5 to 20 workers, and each worker in a section had a similar workload regardless of the team they belonged to.

The organization had been holding participatory workplace improvement (PWI) activity sessions held by small groups of workplace units such as teams. Supported by the management and lead by team leaders, various efforts involving all workers had been made to improve product quality and work efficiency, as well as workplace safety and health. PWI activities were conducted at least biweekly (for 30 min to 1 h at each session) under the leadership of team leaders, in which the team members participated. Although the organization did not know the content or number of separate improvements, an outline of activities was regularly reported to the management of the organization.

Randomization

Simple randomization was performed using computer-generated random numbers which were used to randomly assigned teams to one of the two groups. The protocol of the study was approved by the Ethics Committee of the University of Occupational and Environmental Health, Japan (No. H26-119).

Intervention program (3 months: 13 h in total)

Team leaders (participants) in the intervention group were trained in "Methods of ergonomic assessment and

improvement" and "Preparation and utilization of ergonomic ACL." The lecturer was an expert in ergonomics. A total of three training sessions were given at monthly intervals from December 2014 to February 2015 (1st session, 6.5 h; 2nd session, 3.5 h; 3rd session, 3 h). This was the first training in ergonomics held for the organization.

The training session consisted of lectures and hands-on practice. After lectures on "Work posture and work-related musculoskeletal disorders (WMSD)," "Mechanism of developing WMSD," "Principles of motion economy and viewpoints on improvement," "Characteristics of PWI activities and procedures," and "Basic policy of work improvement," groups of about five people each were formed and the group members worked together on "Sampling ergonomic issues and consideration of measures for improvement" using "pictures and videos of actual work settings." Furthermore, ACLs were explained at the first training session, and after the first and second training sessions, the lecturer requested the participants to introduce ACLs to their section members at PWI; revise an ACL to conform with actual conditions of the site; and report with photos on improvements they had achieved at their workplace.

After the 3rd training session, the lecturer organized the ACL-related information collected from each section, and prepared a revised version of the ergonomics ACL for the organization (hereafter "ergonomics ACL"). Similarly, a "Photobook of favorable cases of improvement" (hereafter "photobook") was prepared using pictures and descriptions of workplaces before and after improvements that were submitted from the sites. The photobook and the ergonomics ACL were distributed to the participants. Details of the three training sessions are provided in the Appendix.

After the three training sessions, the lecturer recommended that the participants conduct PWI activities using ergonomics ACLs and photobooks and then asked them to report the results of the monthly team PWI activities.

Control group

The control group team was requested to make monthly reports of the improvement in PWI activities implemented as part of their regular work.

Data collection and outcomes

To determine any bias between the two groups, the number of teams, workers in the control and intervention groups, as well as workers' basic personal information were investigated before the intervention. Workers' basic information included job title, employment status, age, sex, years of work, presence/absence of night shifts (daytime/night time double shifts), and education.

After three training sessions, the teams in the intervention group and the control group reported improvements through PWI activities (introduction of jigs, review of work procedures, facility/supply changes, etc.). The report was created monthly for ten months from the end of the training and included the name of the team, the month of execution, and the contents of each improvement.

Anonymized improvement results containing the team name only were sent to two persons in charge of the safety and health staff (experts with 20 years' experience each at the production site). A reported improvement was determined to be an improvement, regardless of the degree of improvement, when the two persons in charge of safety and health staff judged it to be an improvement in its category. The contents of improvements were classified into the following five categories based on previous PWI improvement reports: 1) countermeasures for low back pain; 2) reduction of localized physical load (excluding low back); 3) improved safety (described using the five Japanese terms [5Ss] of Sort (Seiri), Set In Order (Seiton), Shine (Seiso), Standardize (Seiketsu), Sustain (Shitsuke); 4) improved work efficiency; and 5) improved quality and others. The two people in charge of safety and health reviewed the reported contents of improvements individually, and chose two major objectives of each improvement from the five categories above. When the two people in charge of safety and health chose different items, they discussed the items to reach a concensus. The concluded results were sent back to the first author, the team names were deanonymized, and the data were reclassified into the control and intervention groups with blinds.

Statistical analysis

Incidence was defined as the occurrence of an improvement reported at each workplace. The number of improvements in the five categories reported from each team was analyzed. Results were analyzed based on the intention-to-treat (ITT) principle. Incident rate ratios (IRR) of improvement activities were estimated by a multilevel Poisson regression model, including the logarithm of the number of teams as offset since the improvement activities were based on teams.

The linear trend was assessed by treating the number of months (1 to 10) as a continuous variable in Poisson regression model. In addition, the chronological effect of the intervention for improvement activities was also examined. STATA14 was used for statistical analysis.

Results

Randomization and subjects

A total of 51 teams were randomized, with 28 teams assigned to the control group and 23 to the intervention group. The number of participating workers in the PWI was 315 in the control group and 301 in the intervention group. During the 10-month follow-up period, each team reported the contents of improvements monthly, even

Table 1. Baseline information

Variable	Control group (n=28)	Intervention group (n=23)
Type of manufacturing		
Assembly section	9	5
Welding section	11	9
Component section	8	9
Characteristics of workers		
Workers, no.	315	301
Occupational title, %		
Group manager	9.2	9.3
On-site manager (Team leader)	16.4	16.6
Worker	74.4	74.1
Employment, %		
Permanent	98.4	99
Temporary	1.6	1
Men, %	98.4	99
Age, range (mean), year	20-64 (36.5)	19-65 (35.4)
Employed work, range (mean), year	1-48 (13.7)	1-50 (12.9)
Work shift, %		
Only daytime	41.3	35.8
Day and night time	58.7	64.2
Educational level, %		
Undergraduate from a technical college	86.9	90
Graduate of a technical college or higher	13.1	10

when there was no improvement to report.

Characteristics of workers participating in the PWI activities

Table 1 shows the characteristics of the teams and workers in the control and intervention groups. Although there was a minor deviation in the number of teams in the assembling section, there was no difference between the control and intervention groups in number of workers, job title, employment status, sex, age, years of work, presence/absence of night shifts (daytime/night time double shifts), or education.

Total number of improvements in the control and intervention groups

During the 10-month follow-up period after the training sessions, the total number of improvements (multiple choice) was 663 in the control group and 467 in the intervention group, with an IRR of improvements of 1.15 (95% confidence interval [CI], 0.66-2.01; p=0.623) and no significant difference between the two groups. There were 53 improvements in countermeasures for low back pain in the control group and 96 in the intervention group, showing an IRR of improvements of 2.33 (95% CI, 1.13-4.80; p=0.022) showing significant improvement in the intervention group. On the other hand, there were 43 reports of improvements aimed at a reduction in localized physical load (excluding low back) in the control group and 73 in the intervention group, with an IRR of improvements of 2.17 (95% CI, 0.87-5.38; p=0.095). Regarding the number of reports of improvements in other fields, for safety there were 432 in the control group and 305 in the intervention group, with an IRR of improvements of 1.24 (95% CI, 0.72-2.14; p=0.435); for work efficiency, there were 252 in the control group and 222 in the intervention group, with an IRR of improvements of 0.88 (95% CI, 0.44-1.77; p=0.728); for quality and others, there were 208 in the control group and 259 in the intervention group, with an IRR of improvements of 1.21 (95% CI, 0.52-2.83; p=0.659). Accordingly, there were no significant differences between the two groups in these four categories (Table 2).

Examples of improvement cases

- A handle was installed to improve working posture
- A delivery form was changed so that parts can be taken out at waist height
- Guide pins were created so that parts can be attached

Table 2. Category of improvement in each group during 10 months

	Number of Improvements		IRR*	95%CI		p value
	Control group (n=28)	Intervention group (n=23)				
Total improvement	663#	467#	1.15	0.66	2.01	0.623
Low back pain measures	53	96	2.33	1.13	4.80	0.022
Local pain measures except for the waist	43	73	2.17	0.87	5.38	0.095
Safety measures	432	305	1.24	0.72	2.14	0.435
Improvement in production efficiency	252	222	0.88	0.44	1.77	0.728
Quality improvement and others	259	208	1.21	0.52	2.83	0.659

* Incident rate ratio.
# Due to duplicate application, the number of total improvements does not match the sum of each item.
The number of workers in the contorl group is 315 and the number of workers in the intervention group is 301.

Table 3. Time trend for improvements in low back pain

	Intervention group (n=23)				Control group (n=28)			
	IRR*	95%CI		p value	IRR*	95%CI		p value
1-3 months	reference				reference			
4-6 months	0.44	0.22	0.89	0.021	0.52	0.26	1.05	0.068
7-10 months	0.46	0.24	0.90	0.023	0.59	0.32	1.09	0.090
trend	0.90	0.81	0.99	0.034	0.92	0.84	1.02	0.101

* Incident rate ratio.
The number of workers in the intervention group is 301 and the number of workers in the contorl group is 315.

while maintaining a reasonable posture

- Process organization was conducted to allow a controller box to be installed while maintaining a comfortable posture
- A suspension hanger was installed to allow jigs to be easily exchanged
- The height of an on-site work desk was changed

Time-course effects of improvements in countermeasures for low back pain between the intervention and control groups

Regarding trimonthly changes in the number of improvements in countermeasures for low back pain during the follow-up period, and using the number of improvements 1 to 3 months after the intervention (training sessions) as reference, the IRR of improvements during the period from the 4th through to the 6th month was 0.44 (95% CI, 0.22-0.89; p=0.021), and 0.46 (95% CI, 0.24-0.90; p=0.023) from the 7th through to the 10th month, with both showing significant reductions. Regarding the trend during the entire follow-up period, the IRR of improvements was 0.90 (95% CI, 0.81-0.99; p=0.034), showing a significant reduction (Table 3). These results confirmed that the effects of interventions decrease over time.

Discussion

The PE workplace improvement activities used in this study resulted in significantly increased improvements in countermeasures for low back pain in the intervention group, with an IRR of improvements of 2.33 (95% CI, 1.13-4.80; p=0.022). This was likely prompted by efforts to improve the workplace as a countermeasure for low back pain through the provision of ergonomic training and ergonomics ACLs (including the photobook of favorable cases of improvements) to on-site managers, combined with PWI activities in the intervention group. Ergonomic interventions at workplace units appear to impact workers' health by changing the awareness of workers, as well as by changing the culture, work procedures, and facilities/supplies of the workplace. Effects such as reduced musculoskeletal system symptoms and industrial accidents have been reported[6,10], and our present results suggest a prior step in the effects on workplace improvement activities.

Advantages of the implementation process of this program were that the participation rate of employees in the target division was high, and that management agreement and the support of the entire workplace was obtained. Retirement of employees and the absence of organizational

restructuring and merger were also considered advantageous. These advantages are believed to incorporate important factors for advancing the health improvement of the employees by intervention at the tissue level[28].

In this study, although the IRR of improvements in countermeasures for low back pain was elevated in the intervention group, the effect was greatest at 1 to 3 months after the third training session (intervention program) and then decreased over time. This suggests that organizations which implement PWI activities need to repeat training sessions using similar ergonomic intervention programs to maintain the effect of countermeasures for low back pain.

The IRR of improvements in the reduction of localized physical load (excluding low back) was 2.17 (95% CI 0.87-5.38, p=0.095). Although not statistically significant and showing a tendency only, potency is expected to increase with a greater sample number. The PE training sessions in this study focused on the assessment and prevention of musculoskeletal disorders in the trunk, especially low back pain, and included work posture and WMSD, and the mechanism of developing WMSD. Therefore, significant results may not have been achieved in the reduction of localized physical load excluding low back pain. If a reduction in localized physical load other than low back pain should be included in the target, the training sessions and ergonomics ACLs should be revised to include more related items.

There was no significant difference between the control and intervention groups in the IRR of total improvements, and no significant differences in the IRR of improvements in improved safety, improved work efficiency, or improved quality and others during the 10-month follow-up period after the interventions. In the sections subjected to the study, PWI activities had already been conducted, and efforts had been made to improve safety and work efficiency, as well as the quality of products. These background factors may have been reflected in the results.

Characteristics of the intervention program

The intervention program in this study provided ergonomic training sessions and ergonomics ACLs to on-site managers. This program, together with the preexisting PWI activities, brought about the outcomes of PE. The training sessions in the present study were held three times and the total length of the sessions was 13 h. To enhance learning, the training sessions included group activities, as well as pictures and videos of actual worksites to attract participant's interest. The training was divided into three sessions, with 1-month intervals between sessions. At the 2nd and 3rd training sessions, cases of improvement at each workplace were reported as homework assignments from the previous session and as a means of reviewing the previous training. These efforts may have helped increase improvements aimed at countering low back pain and were closely similar to those used in intervention methods against back pain in other fields, such as improving the motivation of participants to learn about countering back pain[29].

In addition, the use of ACLs may have contributed to the results through the development of tools suitable for the participants' own workplaces, and the provision of opportunities to use the tools at their workplace immediately after training sessions.

Compared with various other PEs reported to date, the present intervention program, which consisted of 13 h of training sessions and ACLs, is practical and convenient. PWI activities have been introduced to many enterprises in Japan, and the ergonomic intervention program for on-site managers in this study may become widespread in Japanese workplaces.

Study strengths

This study is the first RCT to determine the effects of ergonomic training sessions and ergonomics ACLs directed at on-site managers as key persons at workplaces on improvement activities at enterprises in which PWI activities have already been established.

An important characteristic and strength of our study was that the observation (follow-up) period after the interventions was set at 10 months, during which each team reported both qualitative and quantitative improvements every month. The two people in charge of safety and health had very substantial experience at production sites and were blinded in their assessment of the content of each improvement, affirming the objectivity of the results.

As the results show, there was no significant difference in the IRR of improvements of the entire workplace, nor in the IRR of improvements in reduction of localized physical load (excluding low back), improved safety, improved work efficiency, or improved quality and others, except countermeasures for low back pain. We speculate that these findings reflect the daily impact of team-based work improvement activities.

The significant improvement observed in activities for low back pain demonstrates that the provision of training sessions and ergonomics ACLs to on-site managers may alter the quality of team (small group unit)-based workplace improvement activities, to a certain degree at least, and this result is significant.

Limitations

A weakness of this study is that only improved results were subjected to analysis. Some improvements may not have been implemented due to issues such as cost, time, and labor, and these were not included in the results. The ideas for methods of improvement raised at the ergonomic training sessions included items that were difficult to solve at the workplace unit level and were time-

consuming to complete, such as the introduction of or changes to facilities and machinery, as well as revisions of manufacturing processes. However, since the duration of the follow-up period was 10 months, major improvements and revisions beyond the workplace unit might not have been included. We consider that this study focuses on improvements that can be implemented within a workplace unit.

Since our study workplace was accustomed to PWI, the nature of our workplace might have amplified the effects of training sessions and ergonomics ACLs, even though the scope of the intervention program was limited to on-site managers. It is not clear whether the same results would be obtained if the same intervention program were implemented for organizations in which PWI activities were not conducted.

To date, research subjects have not been obliged to report the results of PWI activities. The present intervention study was the first occasion on which the section-based reporting of results was required. Our requirement for monthly reports of improvement results in both groups may have increased the reported improvement numbers in both groups. However, this study was an RCT, and this factor was adequately controlled.

The intervention program used in this study combined the provision of educational training sessions and ergonomics ACLs to on-site managers. Comparison of educational training only and educational training plus ergonomics ACLs has not been conducted at workplaces at which PWI is prevalent, and future investigation is anticipated. The evaluation in this study was aimed at determining improvements in activity, rather than the prevention of low back pain. The question of whether such intervention programs are effective in preventing back pain requires verification.

Conclusions

We found that the PWI-based provision of ergonomic training and ergonomic ACLs to on-site managers can help to promote workplace improvements for measuring low back pain. However, because the effects of the interventions decreased over time, continuous training and support appear necessary to maintain efficacy.

Acknowledgments: This study was conducted with the cooperation of Komatsu Ltd. The authors express their sincere gratitude to all those who cooperated with the study. This study was supported by a grant of FY2013-2015 “Research on effects of workers’ health status and industrial health activities on labor productivity (H25-Occupational-General-007) (Leader, Koji Mori),” Health and Labour Sciences Research Grants (Research on Occupational Safety and Health) from the Ministry of Health, Labour and Welfare (MHLW).

Conflicts of Interest: The authors declare that there are no conflicts of interest.

References

1) Japan Industrial Safety & Health Association. Rodo Eisei no Shiori Heisei 27 nendo. [Handbook for occupational health 2015].
2) d’Errico A, Viotti S, Baratti A, et al. Low back pain and associated presenteeism among hospital nursing staff. J Occup Health 2013; 55: 276-283.
3) Wieser S, Horisberger B, Schmidhauser S, et al. Cost of low back pain in Switzerland in 2005. Eur J Health Econ: HEPAC: health economics in prevention and care 2011; 12: 455-467.
4) Mannion AF, Horisberger B, Eisenring C, Tamcan O, Elfering A, Muller U. The association between beliefs about low back pain and work presenteeism. J Occup Environ Med 2009; 51: 1256-1266.
5) van Eerd D, Cole D, Irvin E, et al. Process and implementation of participatory ergonomic interventions: a systematic review. Ergonomics 2010; 53: 1153-1166.
6) Rivilis I, Van Eerd D, Cullen K, et al. Effectiveness of participatory ergonomic interventions on health outcomes: a systematic review. Appl Ergon 2008; 39: 342-358.
7) Kogi K, Kawakami T, Itani T, Batino JM. Low-cost work improvements that can reduce the risk of musculoskeletal disorders. IJIE 2003; 31: 179-184.
8) Wilson JR, Haines HM. Participatory Ergonomics. In: Salvendy G, editor. Handbook of Human Factors and Ergonomics. New York: Wiley; 1997. p. 490-513.
9) Kuorinka I. Tools and means of implementing participatory ergonomics. IJIE 1997; 19: 267-270.
10) Habibi E, Soury S. The effect of three ergonomics interventions on body posture and musculoskeletal disorders among stuff of Isfahan Province Gas Company. J Educ Health Promot 2015; 4: 65.
11) Kruger K, Petermann C, Pilat C, Schubert E, Pons-Kuhnemann J, Mooren FC. Preventive strength training improves working ergonomics during welding. Int J Occup Saf Ergon 2015; 21: 150-157.
12) Rasmussen CD, Holtermann A, Bay H, Sogaard K, Birk Jorgensen M. A multifaceted workplace intervention for low back pain in nurses’ aides: a pragmatic stepped wedge cluster randomised controlled trial. Pain 2015; 156: 1786-1794.
13) Sudiajeng L, Adiputra N, Leibbrandt R. Ergonomics work stations decreases the health impairment and saves electrical energy at the woodworking workshop in Bali, Indonesia. J Hum Ergol 2012; 41: 41-54.
14) Carrivick PJ, Lee AH, Yau KK. Consultative team to assess manual handling and reduce the risk of occupational injury. Occup Environ Med 2001; 58: 339-344.
15) Evanoff BA, Bohr PC, Wolf LD. Effects of a participatory ergonomics team among hospital orderlies. Am J Ind Med 1999; 35: 358-365.
16) Baydur H, Ergor A, Demiral Y, Akalin E. Effects of participatory ergonomic intervention on the development of upper ex-

tremity musculoskeletal disorders and disability in office employees using a computer. J Occup Health 2016; 58: 297-309.
17) Driessen MT, Proper KI, Anema JR, Knol DL, Bongers PM, van der Beek AJ. The effectiveness of participatory ergonomics to prevent low-back and neck pain—results of a cluster randomized controlled trial. Scand J Work Environ Health 2011; 37: 383-393.
18) Haukka E, Leino-Arjas P, Viikari-Juntura E, et al. A randomised controlled trial on whether a participatory ergonomics intervention could prevent musculoskeletal disorders. Occup Environ Med 2008; 65: 849-856.
19) Haukka E, Pehkonen I, Leino-Arjas P, et al. Effect of a participatory ergonomics intervention on psychosocial factors at work in a randomised controlled trial. Occup Environ Med 2010; 67: 170-177.
20) Morag I, Luria G. A framework for performing workplace hazard and risk analysis: a participative ergonomics approach. Ergonomics 2013; 56: 1086-1100.
21) Thurman JE, Louzine A, Kogi K. Higher productivity and a better place to work: practical ideas for owners and managers of small and medium-sized industrial enterprises: International Labour Organization. 1988.
22) Kogi K. Training in practical ergonomics improvements. J Hum Ergol 1989; 18: 147-150.
23) Kogi K. Participatory methods effective for ergonomic workplace improvement. Appl Ergon 2006; 37: 547-554.
24) Kobayashi Y, Kaneyoshi A, Yokota A, Kawakami N. Effects of a worker participatory program for improving work environments on job stressors and mental health among workers: a controlled trial. J Occup Health 2008; 50: 455-470.
25) Kogi K. Participatory ergonomics that builds on local solutions. J Hum Ergol 1995; 24: 37-45.
26) Kogi K. Advances in participatory occupational health aimed at good practices in small enterprises and the informal sector. Ind Health 2006; 44: 31-34.
27) Kogi K. Facilitating participatory steps for planning and implementing low-cost improvements in small workplaces. Appl Ergon 2008; 39: 475-481.
28) Montano D, Hoven H, Siegrist J. Effects of organisational-level interventions at work on employees' health: a systematic review. Bmc Public Health 2014; 14: 135.
29) Kim S-L, Lee J-E. Development of an intervention to prevent work-related musculoskeletal disorders among hospital nurses based on the participatory approach. Appl Ergon 2010; 41: 454-460.

Appendix. Training program (intervention program)

1st program	December 2014	6.5 hours

The theme of the lecture was "Methods of participatory workplace improvement (PWI) and ergonomic assessment and utilization of the action checklist (ACL)". The program consisted of 2 hours of lectures and 4.5 hours of group work. At the lecture, the following items were explained:

- Basic policy of work improvement
- Characteristics of PWI activities
- Simple procedures for implementing participatory activities
- Procedures for PWI activities (examples)
- Preparation and utilization of ACLs
- Work posture and work-related musculoskeletal disorders (WMSD) (basic)
- Mechanism of developing WMSD
- Principles of motion economy and viewpoints on improvement

In the training session, the basic ideas of ergonomic assessment and work improvement, the PWI activities, and the procedures were first explained. Methods of preparing ACLs were then described. Furthermore, the principles of work posture assessments and the mechanisms of musculoskeletal disorder development were described, and viewpoints on conducting improvements for these were explained. Participatory group work was conducted for each item using pictures and videos to enhance understanding of the lecture, and the lecturer provided advice and feedback of the results.

At the end of the training session, the participants were assigned the homework of returning to their sections and informing the team members of the content of the training session. They were also told to collect favorable cases of ergonomic improvements at their workplace, together with pictures to make an original ergonomics ACL and a booklet of improvement cases with photos for the organization to bring to the next training session.

2nd program	January 2015	3.5 hours

The theme of the lecture was “Collection of favorable cases and ways to prepare ergonomics ACLs”. The program consisted of 30 minutes of lectures and 3 hours of group work. The theme of the group work was “How to make an ergonomics ACL,” based on learning from favorable cases at the participant’s own workplace.

In the lecture, after brief review of the content of the previous session, presentations were given on cases of ergonomic improvement at each workplace. After the group-based presentations were given, the favorable cases presented in them were included in the booklet of favorable cases of the entire organization (Photobook of favorable cases of improvements).

At the end of the training session, the participants were assigned the homework of returning to their sections and informing the team members of the content of the training session, then work on the following:

- Submit favorable cases of ergonomic improvements implemented at each workplace (team-base) to the lecturer before the next training session (continued).
- Referencing the prepared original ergonomics ACL of the organization (template), make an original ergonomics ACL and a photobook of favorable cases of improvement at each workplace.

3rd program	February 2015	3 hours
The theme of the lecture was “Making an original ergonomics ACL of the factory using favorable cases of each workplace, implementing trials, and revising the ACL in addition to the photobook of favorable cases of improvements”. The program consisted of 30 minutes of lectures and 2.5 hours of group work. After a brief review of the content of the previous session in the lecture, sites were inspected using the original ergonomics ACL of the organization prepared by each team and the photobook of favorable cases of improvements, and the prepared ACL was tested. The results of the trials were then summarized within the team and the presentation was given to the whole group. At the end of the training session, the original ergonomics ACL of the organization and a photobook of favorable cases of improvements developed through the 3-session program were provided to the participants, and a proposal was made to use the materials to facilitate voluntary workplace improvement activities from the ergonomic perspective at each team in the intervention group.		