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## The process evaluation of two alternative participatory ergonomics intervention strategies for construction companies

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### ABSTRACT

To gain insight into the process of applying two guidance strategies – face-to-face (F2F) or e-guidance strategy (EC) – of a Participatory Ergonomics (PE) intervention and whether differences between these guidance strategies occur, 12 construction companies were randomly assigned to a strategy. The process evaluation contained reach, dose delivered, dose received, precision, competence, satisfaction and behavioural change of individual workers. Data were assessed by logbooks, and questionnaires and interviews at baseline and/or after six months. Reach was low (1%). Dose delivered (F2F: 63%; EC: 44%), received (F2F: 42%; EC: 16%) were not sufficient. The precision and competence were sufficient for both strategies and satisfaction was strongly affected by dose received. For behavioural change, knowledge (F2F) and culture (EC) changed positively within companies. Neither strategy was delivered as intended. Compliance to the intervention was low, especially for EC. Starting with a face-to-face meeting might lead to higher compliance, especially in the EC group.

**Practitioner Summary:** This study showed that compliance to a face-to-face and an e-guidance strategy is low. To improve the compliance, it is advised to start with a face-to-face meeting to see which parts of the intervention are needed and which guidance strategy can be used for these parts.

**Trial registration:** ISRCTN73075751

**Abbreviation:** PE: Participatory Ergonomics

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### KEYWORDS

Process evaluation;  
participatory ergonomics;  
guidance strategies;  
construction industry

### Background

The construction industry is a highly physically demanding sector. Awkward body postures and manual material handling frequently occur during a working day (e.g. Boschman et al. 2011; Visser et al. 2013; Visser, van der Molen, Kuijer, et al. 2014), which can result in a high prevalence of musculoskeletal disorders (e.g. Boschman et al. 2012; Jensen et al. 2000). To reduce exposure to these physical work demands, effective ergonomics tools or equipment are available (e.g. Jensen and Kofoed 2002; Vander Molen et al. 2004). Because of the conservative and complex nature of the construction industry (Hunter and Silverstein 2014; Koningsveld and van der Molen 1997), the use of ergonomics tools or equipment is not implemented in daily practice to a great extent (e.g. van der Molen et al., "Implementation of Participatory Ergonomics Intervention," 2005).

Providing construction workers with information of highly physical work demands alone will not be effective in increasing the use of ergonomics tools or equipment (Wiberg 2012) due to the complex working environment of the construction industry, with the involvement of many different stakeholders (e.g. employers, employees, construction safety coordinators, architects). All the various stakeholders must go through different behavioural phases to facilitate the use of ergonomics tools such as having awareness of risk factors; their attitude towards ergonomics tools or equipment; and their ability/skills to use ergonomics tools or equipment; change of behaviour (van der Molen et al., "Conceptual Framework," 2005). To produce behavioural change on the part of all relevant stakeholders, Participatory Ergonomics (PE) interventions could be used (e.g. Haines et al. 2002; van der Molen et al., "Effectiveness of Measures," 2005). The basic concept of PE interventions is to involve all relevant stakeholders in adaptations to the workplace.

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Although the theoretical background of PE interventions is plausible, the evidence of the effectiveness of PE interventions to reduce musculoskeletal disorders in complex work environments is inconsistent (van Eerd et al. 2010; Rivilis et al. 2008). It was found that the content of many PE studies was not clearly described, nor was a measurement performed of whether the programmes had been implemented as planned (van Eerd et al. 2010; Jaegers et al. 2014; Rinder et al. 2008; Rivilis et al. 2008). This could lead to the conclusion that the programme was not effective without acknowledging that the programme had not been delivered as intended (Brownson, Fielding, and Maylahn 2009; Durlak and DuPre 2008; Jaegers et al. 2014; Linnan and Steckler 2002).

To increase the use of ergonomics tools or equipment to reduce physical work demands in construction companies, two protocols for the guidance of a PE intervention were developed: a face-to-face guidance strategy and an e-guidance strategy (Visser, van der Molen, Sluiter, et al. 2014). The protocol consisted of a six-step approach for a PE implementation strategy (van der Molen et al., "Implementation of Participatory Ergonomics Intervention," 2005), which were guided by four face-to-face meetings or 13 email contacts between an ergonomics consultant and a steering committee.

This study is a process evaluation of these two strategies and is an extension of the research originally submitted as part of the thesis of Visser (2015). By process we are referring to whether the PE intervention was delivered, received and executed as intended within construction companies and their workers. Therefore, the aim of this study was to gain insight into the process of applying the guidance strategies, alongside a trial, and whether a difference between the face-to-face and e-guidance strategy occurs in the process outcomes of dose delivered, dose received, precision, consultant competence, satisfaction and behavioural change. This resulted in the following research questions: (1) were the guidance strategies implemented as planned; and (2) were there differences between the face-to-face guidance strategy and the e-guidance strategy on the process outcomes of the intervention.

## Methods

### Study design

Twelve construction companies were involved in this cluster randomised intervention trial with a follow-up at six months. The background and methods of this process evaluation have been reported in more detail in Visser, van der Molen, Sluiter, et al. (2014).

### Study population

From June 2012 until June 2013, 982 construction companies were approached for participation in the study. Recruitment of the companies was done through four different approaches: (1) the Occupational Health Services approach; (2) the Dutch Labour Inspectorate approach; (3) the National Board of Employers of four physically demanding occupations within the construction industry approach; and (4) companies within the network of the researchers. The inclusion criteria of the construction companies were: (1) small and medium enterprises; (2) working in the floor laying, glazing, ironworking, plastering, paving, wall and ceiling constructing, carpentry or masonry trade; and (3) having the potential to improve the use of ergonomics tools or equipment among their workers.

### Procedure

The directors of construction companies that wanted to participate were visited by one researcher (SV). In this meeting, the procedure of the study was explained, both guidance strategies were explained, and additional questions were answered. After agreement to participate, an informed consent was signed by the director, and demographic characteristics and contact information of the company were assessed. In addition, the baseline questionnaire was sent to the construction workers of the company. After sending the baseline questionnaire, the contact information was sent to the consultants, with the randomised allocation to one of the two interventions. After this, the consultant started the intervention. After six months of starting the intervention, the follow-up questionnaire was sent to the same workers who received the baseline questionnaire. Workers who did not return the questionnaire within the specified time received a reminder within two weeks. In addition, after six months of starting the intervention, the director was interviewed about the guidance strategy process and members of the steering committee received a questionnaire about the guidance strategy process.

### Intervention

Two ergonomics consultants developed two guidance strategies for the implementation of ergonomics tools or equipment. The first strategy consisted of four face-to-face contacts with the consultant. In the second strategy, construction companies were guided through 13 e-mail contacts. Both guidance strategies lasted six months. A comprehensive description of both guidance strategies is given in Visser, van der Molen, Sluiter, et al. (2014).

Both guidance strategies were based on the behavioural change phases and consisted of a six-step approach for a PE implementation strategy (van der Molen et al., "Implementation of Participatory Ergonomics Intervention," 2005). The six steps were: (1) preparation in which a steering committee was installed in the companies, consisting of the director, the prevention worker, work planners, foremen and construction workers. In addition, the objectives and planning for the steering committee were explained; (2) information sources were consulted to gain knowledge about physical work demands and possible ergonomics tools or equipment. In addition, workers of the company were informed about the physical work demands and possible ergonomics tools or equipment; (3) the selection of an ergonomics tool; (4) instruction and training for the chosen ergonomics tool or equipment was given to the workers to increase the ability to use the ergonomics tool or equipment; (5) the ergonomics tool or equipment was tested in daily practice; and (6) the ergonomics tool or equipment was implemented in the company. The six steps contained 31 performance indicators, of which 19 were defined as essential by van der Molen et al., "Implementation of Participatory Ergonomics Intervention" (2005). During the guidance, the consultants gave assignments to the steering committee which refer to these 31 performance indicators, furthermore consultants could be consulted for information on ergonomics aspects. An overview of the six steps and the performance indicators is given in Appendix 1.

In both guidance strategies, the steering committee held four meetings. Steps 1 and 2 were assessed before the first meeting of the steering committee by a contact person of the ergonomics consultant. For these steps, the contact person was guided via a telephone meeting in the face-to-face guidance strategy or by an e-mail in the e-guidance strategy. Step 3 was performed during the first meeting of the steering committee, step 4 in the second meeting, step 5 in the third and step 6 in the fourth meeting. In the face-to-face guidance strategy, the consultant was present at the meetings of the steering committee. In the e-guidance strategy, the consultant guided the contact person through e-mail contacts before and after the meetings of the steering committee. The consultants guided the process of the intervention, the contact person or steering committee had to fulfil the assignments on their own. The steering committees were free to decide which ergonomics tool or equipment they wanted to implement in their company. In addition, they had to obtain the ergonomics tools or equipment on their own. The ergonomics tools were categorised in: (1) tools or equipment for transportation; (2) tools or equipment for raising equipment or materials; (3) tools or equipment to adjust working height on the worksite; and (4) ergonomics hand tools.

## Measurements

Multiple measurements were involved for the process evaluation to gain insight into the process of the intervention.

- One of the researchers (SV) monitored the number of companies that were approached for participation in this study. Information was gathered on the number of companies approached, those who responded and participating companies. In addition, reasons for non-participation were requested from the director.
- With the help of a logbook, the progress of companies on the intervention was monitored by means of the 31 delivered and achieved performance indicators through face-to-face contacts or through e-mail contacts. The researcher (SV) was present at meetings of the steering committee of the participating companies. During these meetings, also an attendance sheet was filled in.
- Workers of the companies completed questionnaires at baseline and after six months.
- Members of the steering committee completed a questionnaire after six months.
- An interview was held with the director of the company after six months about the guidance programme and the guidance strategy.
- An interview was held with the consultants after six months about the guidance programme and the guidance strategy.

## Process evaluation components

Whether the intervention was delivered as planned was evaluated by the process evaluation components reach, dose delivered and dose received as described by Linnan and Steckler (2002). In addition, the following aspects were evaluated: precision, competence of the consultant and satisfaction and behavioural change of the construction workers. All components are described in more detail below with in between brackets the level for which stakeholder the component is measured (company, steering committee/contact person, worker, consultant).

### Reach (company)

Reach is defined as the attendance rate of the construction companies that were invited to participate. Attendance was defined as the number of construction companies participating in this study relative to the number of construction companies invited through the recruitment strategies. Only those construction companies that were contacted by the researcher (SV) and did not wish to participate were asked to explain why.

### *Dose delivered (company and worker)*

Dose delivered refers to the specific part of the intended intervention that was actually delivered to the contact persons of the participating companies and was defined as the total number of performance indicators. The contact persons got these performance indicators as assignments of the consultants and dose delivered was sufficient when at least the 19 essential performance indicators were assigned to the contact person. When companies dropped out of the study or did not follow the entire intervention, they were asked to justify this by the researcher (SV).

In addition, six performance indicators were defined for dose delivered from the steering committee to all construction workers within the included companies. The performance indicators were: (1) information given on the objective of the project; (2) information given on musculoskeletal complaints within the occupation; (3) information given on ergonomics tools or equipment; (4) involvement with the choice of an ergonomics tool or equipment; (5) information and training given regarding the chosen ergonomics tool or equipment; and (6) testing of the ergonomics tool or equipment in the daily work situation. Dose delivered to the workers was sufficient when all six performance indicators were delivered.

### *Dose received (company and worker)*

Dose received refers to the assignments of performance indicators that were actually performed by the steering committees of the construction companies. Dose received of the steering committee was defined as sufficient when at least the 19 essential performance indicators were performed by the steering committee. Whether or not a step of the PE intervention strategy was fulfilled was assessed according to whether the essential performance indicators of this step were received.

Whether or not construction workers had had the dose received was assessed by means of seven questions about the six performance indicators in the questionnaire after six months. An example of a question is: 'Did you get information about the objective of the project from your company?' Construction workers could answer either 'yes' or 'no'. Dose received was sufficient when all seven performance indicators were received.

### *Precision (company)*

The precision of the intervention is defined as whether the implemented ergonomics tools or equipment aimed to reduce the physical work demands. This was measured by comparing the implemented tools or equipment with tools or equipment as described by websites of the branch organisation (<https://arbovriendelijkehulpmid-delen.volandis.nl/>) or sectorial codes of practice. An ergonomics tool described in these two information sources

was expert-based and aimed to reduce the physical work demands. The type of ergonomics tools or equipment implemented within the construction companies was assessed and compared with the websites and codes of practice by one researcher (SV). If the chosen tool in the company was correspond with a tool from above-mentioned website or code of practice, the required precision was considered to be sufficient.

### *Consultant competence (ergonomic consultant for the company)*

The question of whether the consultant possessed the competence to guide the steering committees of the construction companies was asked with the help of a questionnaire after the six months of guidance had been completed. The contact person was asked whether the assignments in preparation of the meetings had been clear, whether the objectives of the four meetings had been clear, whether the objectives of the feedback of the assignments to the ergonomics consultant had been clear, whether the questions asked by the contact person had been answered satisfactorily, and whether the consultant had been able to help with any problems occurring during the six months of guidance. All items were answered with 'yes', 'no' or 'not applicable' and additional information on the given answer was requested. The consultant competence was considered as sufficient when at least the preparation assignments, the objectives of the meetings and the feedback was considered to be understood by the contact person.

### *Satisfaction (steering committee, workers and consultant)*

After six months, the company stakeholders within the steering committee were asked via a questionnaire whether they were satisfied with the guidance strategy and if it had been of value for the construction company. The questionnaire contains seven items, including the duration of the intervention, the duration of the meetings and the involvement of construction workers with the choice of an ergonomic measure. In addition, with two open-ended questions, members of the steering committee could give suggestions for improvements to the intervention, to the guidance strategy and to the consultant. With the exception of the duration of the intervention and the open-ended questions, all items were answered with 'yes', 'no' or 'I don't know'. For all questions, additional information on the given answer was requested.

In addition, workers of the companies were asked via a questionnaire after six months whether or not they were satisfied with the intervention. The workers were asked whether they were satisfied with: the information on the intervention; the possibility to choose an ergonomic

measure; the training/instruction on the ergonomic measures; the duration of the training/instruction; and the possibility to test the ergonomic measure in daily practice. The workers could respond with 'yes', 'no' or 'did not receive'.

The consultants were interviewed to assess their satisfaction with the duration of the intervention, the involvement of the employees, duration of the meetings and the additional value of the different meetings.

### ***Behavioural change: knowledge, attitude, motivation, ability to use, availability of tool and culture (workers)***

It was considered that the interventions would change the behaviour of construction workers towards working with ergonomic measures. Therefore, measurements of the items for behavioural change were done at baseline and after six months by means of a self-made questionnaire.

First of all, the knowledge of the relationship between ergonomic measures, physical work demands and musculoskeletal disorders was asked through two statements. The statements were adapted for the different occupations, and construction workers were asked if they agreed with the statement by answering 'yes', 'no' or 'I don't know'. Knowledge was rated as sufficient when both questions were answered affirmatively, and knowledge within a construction company was defined as sufficient when 75% of all the construction workers had sufficient knowledge.

The attitude of the construction workers towards working with ergonomics tools or equipment was asked about using five yes/no items and was defined as sufficient when four of the five items were scored positively. On the company level, attitude was considered sufficient when at least 75% of the construction workers scored positively.

The motivation to work with ergonomics tools or equipment was asked about with a single yes/no question. If the question was answered in the affirmative, construction workers were considered to have the motivation to work with ergonomics tools or equipment. Motivation was considered as sufficient at company level when at least 75% of the construction workers answered the question in the affirmative.

For each category of ergonomics tools or equipment, the ability to use ergonomics tools or equipment and their availability within categories was asked about. Ability refers to whether construction workers had the skills to work with a tool, and this was assessed into two categories: sufficient or poor. The availability of ergonomics tools or equipment was assessed by asking the construction workers whether or not the tools or equipment were present during their work. An additional question was asked for the availability concerning whether the construction company had set up rules or procedures for the use of ergonomics measures. The ability to use ergonomics tools or equipment and their availability was considered sufficient

when 75% of the construction workers answered in the affirmative.

The culture of the construction company with respect to using ergonomics tools or equipment was assessed using three yes/no items, measuring the norms, values and expectations of the company regarding working with ergonomics tools or equipment. An example of such an item is: 'It is expected of me and my colleagues that we work with ergonomics tools or equipment as much as possible'. The culture of the construction company was sufficient for an individual construction worker when all three items were answered affirmatively. At least 75% of the construction workers had to experience a positive culture for the construction company to be considered as possessing a positive culture.

### ***Statistical analyses***

With the exception of the behavioural change concepts, all data were analysed descriptively using Microsoft Office Excel 2010. For the analysis of the behavioural change concepts, Generalized Linear Mixed Models were used to test whether differences occurred between the face-to-face guidance group and the e-guidance group, with a correction for the dependency of the company. IBM SPSS 20.0 statistics was used for the statistical analysis.

## **Results**

### ***Recruitment and reach***

To obtain the 12 construction companies for the study, 982 companies were informed about the study among the four recruitment approaches (Figure 1). Due to the different recruitment strategies, most of the companies (96%) could not be reached for an explanation of their decision not to participate. The most frequently mentioned reasons among the other non-participating companies who could be asked for an explanation ( $N = 32$ ) were 'Main focus on survival of the economic crisis' and 'No urgency to implement ergonomics tools or equipment'. The total reach was 1% (12/982).

The 12 construction companies employed floor layers ( $N = 4$ ), glaziers ( $N = 2$ ), ironworkers ( $N = 1$ ), plasterers ( $N = 1$ ), wall and ceiling constructors ( $N = 1$ ), carpenters ( $N = 1$ ), paviours ( $N = 1$ ) and masons ( $N = 1$ ). A total of 277 construction workers worked at the 12 companies: 172 in the face-to-face guidance group and 105 in the e-guidance group. One company in the face-to-face guidance group, with 35 workers, dropped out before the actual intervention started because they discovered that the intervention did not meet their expectations. The response rate of the questionnaires at baseline was 60% (146 out of 242 employees from 11 companies), ranging from 30 to 100%

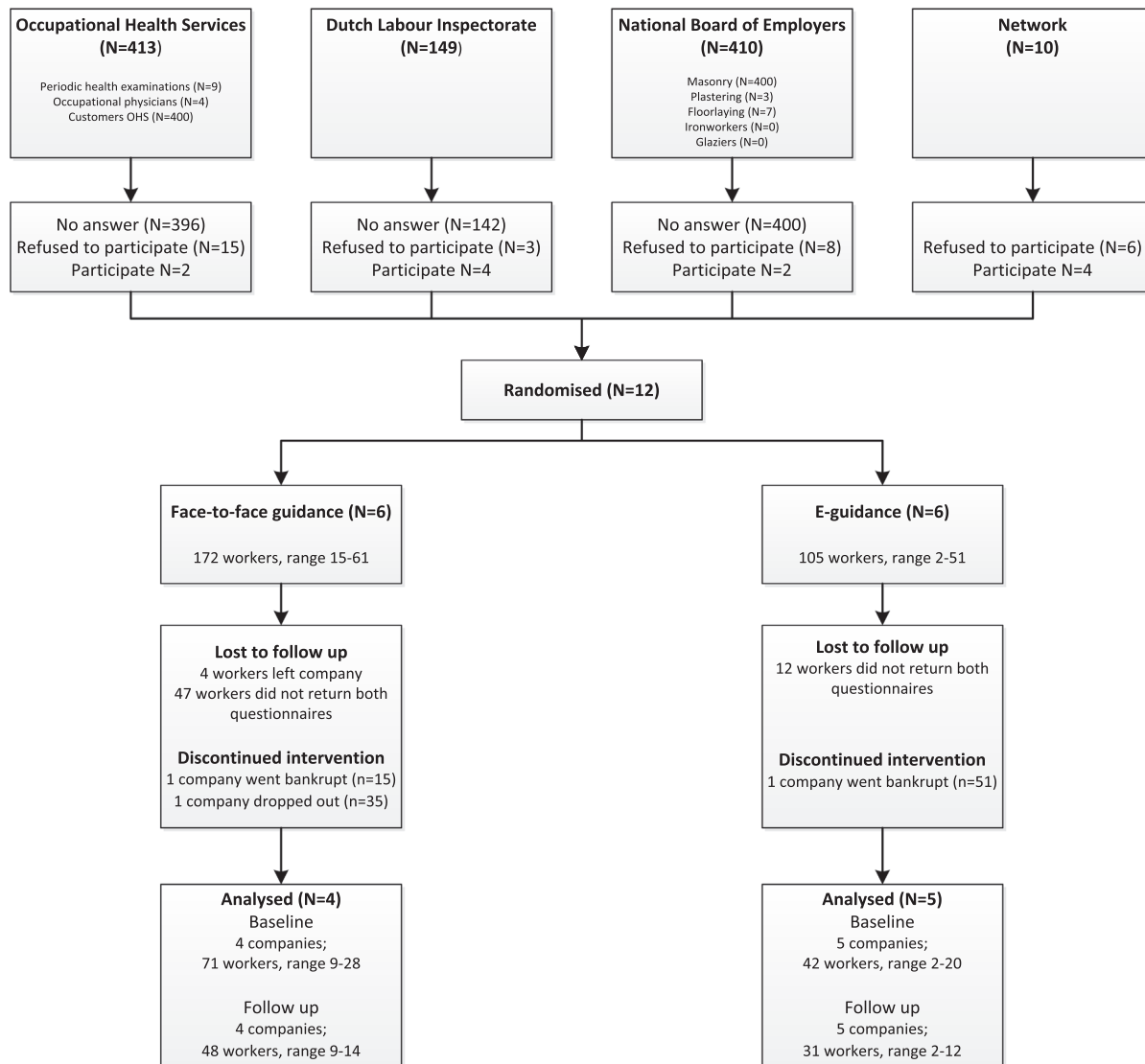


Figure 1. Overview of the recruitment and allocation of the construction companies (reused from Visser 2015).

per company. The lowest scores were seen in company 4 (30%) and company 11 (44%). Two companies went bankrupt during the intervention period, and four workers of another company were lost to follow-up due to retirement and the economic situation of the company. Consequently, 118 workers from four companies in the face-to-face guidance group and 54 workers from 5 companies in the e-guidance group received the questionnaire at follow-up, with a response rate of 46%.

### Dose delivered

Table 1 shows the dose delivered to the construction companies and individual workers and the dose received by the construction companies and individual workers. The dose delivered to the construction companies was

63 and 44%, respectively, for the face-to-face and the e-guidance group. Two of the four companies in the face-to-face guidance group and one of the five companies in the e-guidance group had all 19 essential performance indicators delivered. Company number 3, 5 and 7 went bankrupt or dropped out during after the first telephonic meeting or email contact with the consultant. In the e-guidance group, company number 9, 10 and 11 did not respond after the first email of the consultant.

The entire dose delivered to the individual workers was not sufficient, 3% for the face-to-face guidance group and 2% for the e-guidance group. In the e-guidance group, all workers were informed about the goal of the steering committee, in comparison with 56% of the workers in the face-to-face guidance group.



**Table 1.** Overview of the process evaluation components dose delivered, dose received, precision and consultant competence on company level (numbers of employees). In addition, the dose delivered and received by individual construction workers is given.

Process evaluation component	Face-to-face guidance strategy						E-guidance strategy						Overall	
	1 (n=21)	2** (n=23)	3* (n=35)	4 (n=61)	5* (n=15)	6 (n=17)	Overall	7* (n=51)	8 (n=20)	9 (n=3)	10 (n=20)	11 (n=9)		12 (n=2)
<i>Dose delivered</i>														
All PI	31/31	11/31	11/31	21/31	11/31	31/31	62	9/31	31/31	9/31	9/31	9/31	11/31	42
%	100	35	35	68	35	100	62	29	100	29	29	29	35	42
Essential PI	19/19	7/19	7/19	13/19	7/19	19/19	63	6/19	19/19	6/19	6/19	6/19	7/19	44
%	100	37	37	68	37	100	63	32	100	32	32	32	37	44
<i>Dose received</i>														
All PI	26/31	8/31	1/31	8/31	1/31	27/31	38	2/31	25/31	2/31	2/31	4/31	4/31	21
%	84	26	3	26	3	87	38	6	81	6	6	13	13	21
Essential PI	19/19	7/19	0/19	6/19	0/19	16/19	42	0/19	18/19	0/19	0/19	0/19	0/19	16
%	100	37	0	32	0	84	42	0	95	0	0	0	0	16
Steps fulfilled	6/6	0/6	0/6	0/6	0/6	3/6		0/6	5/6	0/6	0/6	0/6	0/6	
<i>Dose delivered to workers</i>														
Familiar with goal of steering committee	21/21	23/23		1/61	15/15	17/17	77/137	51/51	20/20	3/3	20/20	9/9	2/2	105/105
%	100	100		2	100	100	56	100	100	100	100	100	100	100
Information delivered about health risks	3/21	5/23	1/61	1/61	0/15	17/17	26/137	0/51	20/20	0/3	3/20	4/9	1/2	28/105
%	14	22	2	2	0	100	19	0	100	0	15	44	50	27
Information delivered about tools/equipment	3/21	0/23	1/61	1/61	0/15	17/17	21/137	4/51	20/20	0/3	0/20	9/9	2/2	35/105
%	14	0	2	2	0	100	15	8	100	0	0	100	100	33
Involved in choice of tools/equipment	3/21	0/23	1/61	1/61	0/15	2/17	6/137	0/51	3/20	0/3	0/20	0/9	1/2	4/105
%	14	0	2	2	0	12	4	0	15	0	0	0	50	4
Got training/instruction of tools/equipment	2/21	0/23	0/61	0/61	0/15	5/17	7/137	0/51	4/20	0/3	0/20	3/9	0/2	7/105
%	10	0	0	0	0	29	5	0	20	0	0	33	0	7
Tested tool/equipment in daily practice	6/21	0/23	0/61	0/61	0/15	4/17	10/137	0/51	4/20	0/3	0/20	6/9	2/2	12/105
%	29	0	0	0	0	24	7	0	40	0	0	67	100	11
All delivered	2/21	0/23	0/61	0/61	0/15	2/17	4/137	0/51	2/20	0/3	0/20	0/9	0/2	2/105
%	10	0	0	0	0	12	3	0	10	0	0	0	0	2
<i>Dose received by workers</i>														
Information about the intervention	3/12	6/14		7/13	8/8	8/8	24/47		10/11	2/2	7/11	4/4	2/2	25/30
%	25	43		54	100	100	51		91	100	64	100	100	83
Information about health risks	6/13	4/14		6/12	7/8	7/8	23/47		7/10	0/2	3/11	1/4	1/2	12/29
%	46	29		50	88	88	49		70	0	27	25	50	41
Information about tools/equipment	5/13	0/14		7/13	8/8	8/8	20/48		11/12	0/2	0/11	4/4	2/2	17/31
%	38	0		54	100	100	42		92	0	0	100	100	55
Read information	6/13	0/14		7/13	8/8	8/8	21/48		9/12	0/2	0/11	4/4	1/2	14/31

(Continued)



Table 1. (Continued).

Process evaluation component	Face-to-face guidance strategy							E-guidance strategy					Overall	
	1 (n = 21)	2** (n = 23)	3* (n = 35)	4 (n = 61)	5* (n = 15)	6 (n = 17)	Overall	7* (n = 51)	8 (n = 20)	9 (n = 3)	10 (n = 20)	11 (n = 9)		12 (n = 2)
% Involved in choice of tools/equipment	46 4/13	0 0/14	54 1/11	100 4/8	44 9/46	75 3/12	0 0/11	100 0/4	50 1/2	45 4/31				
% Got training/instruction	31 3/12	0 0/14	9 6/13	50 3/8	20 12/47	25 6/12	0 0/11	0 2/4	50 0/2	13 8/31				
% Tested tool/equipment in daily practice	25 6/13	0 0/14	46 6/13	38 7/8	26 19/48	50 7/12	0 0/11	50 4/4	0 2/2	26 13/31				
% All received	46 2/12	0 0/14	46 0/11	88 2/17	40 4/45	58 2/20	0 0/3	100 0/9	100 0/2	42 2/29				
% Precision	17	0	0	12	9	10	0	0	0	7				
Website	+			+		+		+		+				
Code of practice	+			-		-		+		+				
Consultant competence														
Preparation assignments	+			+		+		+		+			+	
Objectives of meetings	+			+		+		n.a.		n.a.			+	
Feedback form for consultant after meetings	+			+		+		+		+			+	
Answered questions about protocol	+			n.a.		n.a.		+		n.a.			n.a.	?
Help with problems	+			-		+		+		n.a.			n.a.	?

Notes: n.a.: not applicable.  
 +: item was sufficient (for precision: the tool was mentioned on the website or code of practice; for consultant competence: the contact person found the items clearly expressed by the consultant).  
 -: item was not sufficient.  
 ?: no statement can be made about the item.  
 \*: Companies went bankrupt or dropped out before the intervention was started; \*\*: Change of management during the intervention.

### **Dose received**

The overall dose received of the 19 essential performance indicators to the construction companies were 42 and 16%, respectively, for the face-to-face and e-guidance group. One company in the face-to-face guidance group received all 19 essential performance indicators. In addition, another company in the face-to-face guidance group received 16 of the 19 essential performance indicators and one company in the e-guidance group received 18 of the 19 essential performance indicators.

However, the overall dose received by individual workers was not sufficient, 9 and 7%, respectively, for construction workers in the face-to-face guidance group and the e-guidance group. In three companies, two workers received the entire dose of the intervention from the steering committee. Of the workers in the e-guidance group, 83% received information on the intervention compared with 48% in the face-to-face guidance group.

### **Precision**

Five companies implemented ergonomics tools or equipment during the intervention. These ergonomics tools or equipment were all described by websites the branch organisation of and/or sectorial codes of practice.

### **Consultant competence**

In Table 1, an overview of the consultant competence is given for each item of the consultant competence. Due to a change of management in one company, the competence of the ergonomics consultants was assessed by eight of the nine remaining companies. The consultant competence was rated as sufficient in both guidance strategies, although the content of the assignments was not always perceived as relevant. Since most companies had not started the intervention, the competence of the consultants about questions concerning the protocol or help with problems in general was rated not applicable in these companies and no general rating could be given.

### **Satisfaction**

Table 2 shows an overview of the satisfaction of the members of the steering committee and the workers on the intervention. Overall, around 60% of the members of the steering committee in the face-to-face guidance group and 50% of the steering committee members in the e-guidance group were satisfied with the entire intervention. The satisfaction regarding the four meetings was sufficient in both guidance groups. In the e-guidance group, most members of the steering committee were

not satisfied about the additional value of the consultant. However, satisfaction with the guidance strategy varied between the steering committees of the companies, with companies with more dose received being more satisfied with the intervention compared with companies with less dose received for both guidance strategies. The protocol could be followed on its own, and interaction with the consultant about the physical work demands and measures was lacking. The satisfaction of the workers was not high for either of the two strategies, with the exception of one company in the e-guidance group.

According to the consultants, the six months duration of the intervention was too long. This should be shorter so that the companies are more likely to persist with the intervention. The number of e-mails in the e-guidance group should be reduced, and some assignments could be combined. The consultants recommended a combination of the two guidance strategies, beginning with a face-to-face meeting with the director to assess company needs for the implementation of ergonomics tools or equipment.

### **Behavioural change**

The percentage of workers per company going through a predefined behavioural change phase is represented in Table 3. Whether or not the topics of behavioural change were sufficient (more than 75% of the workers) was highly variable between the companies.

Compared to baseline, the workers in three more companies had sufficient knowledge in the face-to-face guidance group – from one company at baseline to four companies at follow-up. While in the e-guidance group the number of participating companies stayed the same – two companies – between baseline and follow-up, the percentage decreased to slightly below 75% for one company in the e-guidance group at follow-up. The attitude towards working with ergonomics tools was only sufficient for one company in both the face-to-face and the e-guidance group at baseline. At follow-up, the workers in one additional company in the e-guidance group had sufficient attitude. The motivation of workers to work with ergonomics tools was in both guidance groups at both time moments sufficient for all companies.

More changes between baseline and follow-up were found in the ability to use and the availability of ergonomics tools or equipment. Especially in the e-guidance group, the availability of and awareness of tools and the number of sufficiently improved. The reverse finding was found in the face-to-face guidance group, the workers of company 6 – in which a tool to adjust working height was implemented – switched from sufficient ability to use ergonomic tools at baseline (78%) to insufficient at follow-up (56%). In addition the workers of both companies who

**Table 2.** Overview of the numbers of members of the steering committee and the construction workers satisfied with aspects of the intervention.

Process evaluation component	Face-to-face guidance strategy						E-guidance strategy							
	1	2**	3*	4	5*	6	Overall	7*	8	9	10	11	12	Overall
<b>Satisfaction</b>														
<i>Members of steering committee</i>														
Additional value	2/2	1/1		0/3		3/3	6/9		6/6	0/1	0/1	0/1	1/2	7/11
Involvement employees with choice of ergonomic tool	1/2	0/1		1/3		3/3	5/9		6/6	0/1	1/1	0/1	0/2	7/11
Involvement employees with implementation	2/2	0/1		0/3		3/3	5/9		6/6	0/1	1/1	0/1	0/2	7/11
Duration of guidance (6 months)	2/2	1/1		2/3		2/3	7/9		5/6	0/1	0/1	0/1	1/2	6/11
Meetings														
	1	2/2	n.a.	1/3		3/3	6/8		6/6	n.a.	n.a.	n.a.	n.a.	6/6
	2	2/2	n.a.	n.a.		3/3	5/5		5/6	n.a.	n.a.	n.a.	n.a.	5/6
	3	2/2	n.a.	n.a.		3/3	5/5		6/6	n.a.	n.a.	n.a.	n.a.	6/6
	4	2/2	n.a.	n.a.		3/3	5/5		6/6	n.a.	n.a.	n.a.	n.a.	6/6
Duration of meeting of the steering committee (1 to 2 h)	1/2	n.a.		2/3		3/3	6/8		4/6	0/1	0/1	0/1	0/2	4/11
Additional value of ergonomics consultant	1/2	0/1		0/3		2/3	3/9		1/6	0/1	0/1	0/1	1/2	2/11
<i>Workers</i>														
Information on the intervention	3/12	5/14		5/13		7/8	20/47		8/10	0/2	4/11	4/4	2/2	18/29
%	25	36		38		88	43		80	0	36	100	100	62
Possibility to choose an ergonomic tool	5/12	0/14		4/13		6/8	15/47		8/11	0/2	0/11	0/4	1/2	9/30
%	42	0		31		75	32		73	0	0	0	50	30
Training/instruction session	7/12	0/14		5/12		3/8	15/46		7/11	0/2	0/11	0/4	0/2	7/30
%	58	0		42		38	33		64	0	0	0	0	22
Duration of training/instruction session	5/12	0/14		5/13		3/8	13/47		7/11	0/2	0/11	0/4	0/2	7/30
%	42	0		38		38	28		64	0	0	0	0	23
Possibility to test in daily practice	6/12	0/14		8/13		7/8	21/47		9/10	0/2	0/11	4/4	2/2	15/29
%	50	0		62		88	45		90	0	0	100	100	52

Note: n.a.: not applicable.

\*Companies went bankrupt or dropped out before the intervention was started; \*\*Change of management during the intervention.

implemented ergonomic tools reported that the ergonomic tools became insufficient available at follow-up (69% for company 1 and 44% for company 6).

In both groups, differences between companies were found for having rules or procedures regarding working with ergonomics tools. With the exception of two companies – one in the face-to-face guidance group and one in the e-guidance group, no difference between baseline and follow-up were found. Two companies in the face-to-face guidance group remained a positive culture towards working with ergonomic tools. In the e-guidance group, three out of five companies had a positive culture at baseline, which changed to all companies at follow-up.

## Discussion

This process evaluation study was performed to gain insight into whether the participatory ergonomics guidance strategies were implemented as planned and whether there was a difference in the implementation process between

the two guidance strategies. The reach of the intervention was very low. The part of the intervention provided to the companies and individual workers (dose delivered) and performed by the companies and individual workers (dose received) was not sufficient for either of the guidance strategies. The ergonomics tools or equipment implemented by five companies were described on the websites of the branch organisation and/or sectorial codes of practice (precision). The consultant competence was perceived as sufficient in both guidance strategies. Satisfaction was strongly affected in both guidance strategies by the dose received. The workers of the companies in the face-to-face guidance group mostly improved their knowledge and awareness about physical work demands and ergonomics tools or equipment between baseline and follow-up, while the workers in the e-guidance group developed a positive culture during the intervention. For both groups, the implementation of ergonomic tools affected the ability to use and the availability of ergonomics tools, however, in the face-to-face group the results were contrary than might be expected.



**Table 3.** Overview of the percentage of workers scoring good at the six topics of behavioural change at baseline (T0) and follow-up after six months (T1) for the face-to-face guidance strategy and the e-guidance strategy.

Measurement moment	Face-to-face guidance strategy						E-guidance strategy						Overall	p-Value***
	1 (n = 21)	2** (n = 23)	3* (n = 35)	4 (n = 61)	5* (n = 15)	6 (n = 17)	Overall	7* (n = 51)	8 (n = 20)	9 (n = 3)	10 (n = 20)	11 (n = 9)		
<i>Behavioural change</i>														
Knowledge	T0	13/18	15/16	18/28	3/9	33%	69%	5/20	3/3	11/13	1/4	1/2	1/2	0.108
	T1	72%	94%	64%	10/13	8/9	89%	69%	25%	100%	85%	25%	50%	50%
Attitude	T0	14/18	9/16	12/28	6/9	67%	83%	8%	100%	73%	75%	50%	48%	0.113
	T1	78%	56%	43%	4/12	5/9	89%	83%	12/20	3/3	8/13	1/3	50%	61%
Motivation	T0	16/17	16/16	28/28	8/9	56%	57%	55%	100%	82%	50%	50%	67%	-
	T1	94%	100%	100%	13/13	9/9	97%	97%	100%	100%	75%	100%	98%	-
Ability to use	T0	8/18	14/16	23/27	8/9	89%	76%	18/20	2/3	13/13	4/4	2/2	2/2	0.382
	T1	44%	88%	85%	8/13	9/9	76%	90%	67%	100%	100%	100%	93%	-
Tools for raising equipment or materials	T0	13/18	13/16	23/27	8/9	81%	80%	75%	100%	100%	n.a.	n.a.	86%	0.000
	T1	72%	81%	85%	10/12	9/9	80%	80%	12/12	2/2	11/11	n.a.	86%	-
Tools to adjust working height	T0	18/18	12/15	26/27	7/9	79%	91%	19/20	3/3	10/13	3/4	1/2	1/2	0.147
	T1	100%	80%	96%	9/12	9/9	78%	91%	95%	100%	77%	75%	86%	-
Ergonomic hand tools	T0	16/18	14/16	20/27	9/9	56%	87%	100%	100%	82%	100%	100%	94%	0.726
	T1	89%	88%	74%	10/12	9/9	84%	84%	60%	100%	100%	100%	81%	-
Availability of	T0	10/18	16/16	23/18	8/9	89%	80%	20/20	3/3	13/13	4/4	2/2	2/2	0.641
	T1	56%	100%	82%	9/12	8/9	80%	100%	100%	100%	100%	100%	100%	-
Tools for raising equipment or materials	T0	6/18	10/16	21/28	n.a.	n.a.	60%	95%	67%	100%	n.a.	n.a.	94%	0.000
	T1	33%	63%	75%	8/12	7/12	63%	60%	11/12	1/2	11/11	n.a.	94%	-
Tools for raising equipment or materials	T0	7/14	9/12	8/12	67%	75%	63%	92%	50%	100%	n.a.	n.a.	92%	0.000
	T1	50%	75%	67%	8/12	7/12	63%	63%	92%	50%	100%	n.a.	92%	-

(Continued)

Table 3. (Continued).

Measurement moment	Face-to-face guidance strategy							E-guidance strategy				Overall	p-Value***	
	1 (n = 21)	2** (n = 23)	3* (n = 35)	4 (n = 61)	5* (n = 15)	6 (n = 17)	Overall	7* (n = 51)	8 (n = 20)	9 (n = 3)	10 (n = 20)			11 (n = 9)
Tools to adjust working height	T0	18/18	8/16	28/28	100%	6/9	85%	20/20	100%	3/3	3/13	2/4	2/2	0.018
	T1	100%	50%	100%	11/12	67%		100%	100%	100%	23%	50%	100%	71%
Ergonomic hand tools	T0	100%	50%	92%	16/28	44%	74%	100%	100%	100%	64%	100%	2/2	87%
	T1	14/18	10/16	16/28	57%	100%	69%	11/20	55%	100%	13/13	100%	2/2	79%
Rules or procedures	T0	9/17	58%	7/12	75%	89%	72%	11/12	92%	100%	11/11	100%	2/2	97%
	T1	53%	38%	3/12	79%	89%	64%	17/19	89%	67%	10/13	50%	0/2	76%
Culture	T0	12/18	13/16	19/28	68%	89%	73%	12/20	60%	100%	9/13	75%	100%	68%
	T1	67%	81%	8/11	73%	78%	78%	10/12	83%	100%	11/11	100%	2/2	94%

Notes: For each behavioural change component, having a percentage of 75% of the workers was rated as sufficient. For ability to use and availability, the category in which an ergonomic tool was implemented was marked bold and italic.

--: no stable testing possible.

\*Companies went bankrupt or dropped out before the intervention was started; \*\*Change of management during the intervention; \*\*\*p-Value represents the interaction (guidance strategy (face-to-face or e-guidance) × time (T0 and T1)) of the Generalized Linear Mixed Models.

### Comparison with other studies

The low reach of the intervention in this study (1%) is comparable with the low participation rate (3%) of Dutch construction companies in a study of Hengel et al. (2011). In the study of Hengel et al. (2011), the explanation was that the content and additional time and costs were unknown during the recruitment phase. In our study, however, content and time costs were well described in our recruitment materials to the companies. Still the time demands of the intervention were an important factor for non-participation, especially in the economic crisis that forces companies to focus on survival.

The dose delivered and dose received were in general low. However, they fluctuated over the construction companies in this study. It was found that the entire intervention was delivered to three companies, two in the face-to-face guidance group and one in the e-guidance group, while other companies did not get any further than the first e-mail contact. This was in line with van der Molen et al., "Implementation of Participatory Ergonomics Intervention" (2005) where some companies received almost all essential performance indicators, while other companies did not meet any of them. Another explanation lays in the guidance method itself. Where both strategies started with the delivery of 7 (face-to-face guidance) or 6 (e-guidance) essential performance indicators. These performance indicators refer to the members within the steering committee and the availability of financial budget. Therefore, similar results of performance indicators delivered for companies that did not follow the entire intervention could be found in this study. Additionally, in the face-to-face group, the first meeting of the steering committee was planned at the same time as the delivery of the first seven essential performance indicators. This first meeting already resulted in a higher dose received, since a steering committee was actually formed. In the e-guidance group, when a company did not respond to the first email of the consultant – even after reminders – no additional performance indicators could be delivered neither could the performance indicators performed be assessed. Although the companies with a higher number of achieved performance indicators implemented ergonomics tools or equipment, other companies implemented ergonomics tools or equipment almost without the help of the PE intervention. It is therefore questionable whether all steps of the PE intervention should be followed, or followed in a strictly sequential order, as was the case in the guidance strategies. In line with the recommendations of members of the steering committee and the consultants, a face-to-face meeting before the actual start of the intervention should be held to make an inventory regarding which steps of the PE intervention

are necessary for the company. This step might also be the solution for the major challenge of getting and maintaining commitment from different stakeholders (van der Molen et al., "Implementation of Participatory Ergonomics Intervention," 2005).

In involvement of employees – represented by dose delivered and dose received of individual workers – was for both guidance strategies <10%. This is explained by the fact that most steering committees used representatives of the employees for the involvement of workers. This is in line with most PE interventions, as 79% of the studies in the review of van Eerd et al. (2010) used representatives of the workers in the steering committee. Since they were part of the steering committee, these representatives got the entire dose delivered and received the entire dose – i.e. got all the information and training.

Direct involvement of all other workers might be low due to the intermediate of a steering committee and therefore the involvement of these workers should probably also be organised in other ways in different companies. Especially in the training and testing session, direct involvement of the workers is necessary. With the direct involvement, they could give their opinion about the tools before the tool is actually purchased. As a result, both management of the companies and the construction workers are involved in the choice of tool (Dale et al. 2016).

### **Strengths and weaknesses**

A strength of this study was the use of quantitative and qualitative data from different stakeholders, which resulted in a more detailed insight of the process. By means of the specific performance indicators used for the development of the guidance strategies of the PE implementation strategy, the registration and monitoring of dose delivered and dose received was easily done. In addition, with the defined performance indicators for dose delivered to and dose received by the individual construction workers, this study gave an insight into the involvement of individual workers to the PE intervention. The concepts for the process evaluation were assessed using questionnaires filled in by the individual workers and members of the steering committees, interviews with the director of the construction companies and the consultants, and with logbooks.

Another strength of the study was that the chosen PE intervention of van der Molen et al., "Implementation of Participatory Ergonomics Intervention" (2005) with 31 performance indicators covered facilitators or barriers of PE interventions, also found by Rasmussen et al. (2017) and Driessen et al. (2010). For instance, it was stated that the company was responsible, that there was a budget and foremen were involved in the steering committee. Furthermore, with the six-step approach, workers should

have had time to test the tools and try the tools on daily practice. However, the time available in this study (six months) hindrance some companies to try other tools when the first chosen tool did not met the expectations.

Because of the difficulties during the recruitment of companies, the results might not be generalisable to the sector and there might be a selection bias of companies that were willing to implement tools. However, the low reach also indicates that more effort should be done to get companies involved in studies to increase use of ergonomics tools or equipment. Other studies (Cherniack et al. 2010; Johnson et al. 2008; Kidd et al. 2004) have shown that there are many reasons for non-participation. Due to the different recruitment strategies, asking for reasons for non-participation was not feasible for all non-participating companies; when assessed, one of the main arguments was that companies had 'no urgency to implement ergonomics tools'. Additionally, it was found that some directors of participating companies that dropped out or did not use the entire intervention had other expectations of the intervention, despite the information given by the researchers during the recruitment. It was, for instance, thought that the consultant would come up with an ergonomics tool or equipment. This is also an explanation that the satisfaction with the intervention and consultant was different per company. Companies that did participate in the study mentioned that they were willing to take action to improve the working conditions of their workers or already found a tool to implement. This implies that a great effort should be made in finding out what the needs or motivations are for companies to implement ergonomics tools. Interventions strategies can then be adjusted to these needs and motivations. Another consequence of the difficulties during the recruitment was that the size of the companies recruited were not sufficient to meet the calculated number of workers to have sufficient power (Visser, van der Molen, Sluiter, et al. (2014)). By presenting the results per company, a better insight in the actual performances within the companies is given.

The guidance provided by the consultants did not have to be paid by the companies. It was thought that this was a strength of the study since financial consequences might affect the participation rate. However, the compliance with the intervention is low in both guidance groups. Apparently, most companies felt no urgency to maintain the intervention. Besides the different expectations of the intervention, the consultants expected that this could be caused by the lack of financial costs for the companies. The consultants have the opinion that if the guidance strategies are part of the services of Occupational Health Services – and therefore come with costs for the companies, the commitment of the companies to the protocol will be higher as a result of the financial aspect.

Due to the low response rate within some construction companies, the results of the behavioural change might be affected and are therefore difficult to interpret, especially for companies with a small number of workers. However, it was found that especially knowledge in the face-to-face guidance group and culture in the e-guidance group improved. This might be the result of an increased awareness within the companies, which can be the result of the PE strategy in which the steering committee had to inform the workers about physical work demands and solutions to reduce these. With the exception of one company, the workers of the companies who implemented ergonomic measures stated that they received such information. Regarding the different findings in ability to use and availability of ergonomics tools between the face-to-face and the e-guidance groups, the reverse findings in the face-to-face guidance group – less sufficient ability and availability at follow-up – can be explained by the new implemented ergonomic tools. At baseline, the workers could refer to tools they are familiar with and know how to use, however at follow-up, they could have the new implemented ergonomics tools as a reference, so a response shift because of different framing could explain this finding. Since it was found that not all workers were trained in how to work with the tool, they might report for that category of tools that they are not able to work with the tool. Additionally, the tool which was implemented by company 6 had a high purchase cost, especially when purchased for more people. This might explain the reduction in availability, since not all workers had that tool at the moment of follow-up.

Finally, due to the protocol, the consultants felt restricted in the way they were able to approach the contact person, especially in the e-guidance strategy. The ergonomics consultants could only send e-mails to the contact persons in the e-guidance strategy and had no opportunity to call the contact person if the e-mails were not answered. When the protocol is implemented in the services of the Occupational Health Services, this weakness may be resolved, for instance, by allowing telephone contacts.

### **Implications for research and practice**

Several lessons can be learned from this study for both research and practice. Because of the indirect way of recruitment through Occupational Health Services, the Dutch Labour Inspectorate and national board of employees, the reach of the intervention was low and most companies could not be reached for an explanation for non-participation. To increase reach and gain insight into the reasons for non-participation of the target group of interest, recruitment strategies to the directors of

companies should be more direct, for instance, by telephone (e.g. van der Molen and Frings-Dresen 2014) followed by personal visits. By having more direct contact with the directors of companies, the intervention could be better explained.

Future studies should investigate what the needs of construction companies are regarding the implementation of ergonomics tools or equipment. Directors of companies might be more interested in an improvement in productivity due to ergonomics tools or equipment, while workers are more concerned about reducing their physical work demands. When the needs of construction companies are investigated, recruitment strategies and recruitment information can be adjusted to these needs. Because of these possible discrepancies in interests between the company directors and their workers, full involvement of both stakeholders in the implementation of ergonomics tools is necessary. In line with Dale et al. (2016), future studies should take the participation of both employer and eventually all construction workers in a company programme into account.

Another lesson is, as mentioned earlier, that not all the steps of the PE intervention have to be followed and that the order of the steps does not have to be strictly sequential. Following all steps in a sequential order makes the assumption that all companies are at the same starting point with respect to implementing ergonomics tools or equipment. It was found that the starting point of the companies was quite diverse. In addition, not all steps or parts of the intervention were found to be relevant for all construction companies. A more tailor-made intervention for individual companies is expected to be more beneficial. A face-to-face meeting between the consultant and the director of the company before the intervention should provide insight into which steps are necessary and which steps could be left out of the intervention. In addition, in this first face-to-face step, the type of guidance could also be discussed with the director of the company. Some parts of the intervention could be easily guided through e-mail contacts, for instance, the test session for the construction workers in daily practice, where it was found that the face-to-face guidance was more suitable for other parts, for instance, the training session. A combined version of the strategies is therefore likely to improve the compliance and the satisfaction of the companies, especially for the e-guidance group.

### **Conclusions**

The results of this study showed that the PE intervention was not delivered as intended. Compliance with the intervention was low, especially for the e-guidance group.

Among the companies that followed the complete intervention, consultant competence and satisfaction with the intervention was perceived as sufficient. In the e-guidance group, members of the steering committee had a preference for a face-to-face meeting with the consultant. To increase the compliance, a combination of the face-to-face guidance and the e-guidance strategy seems to be a solution, with a face-to-face meeting before the actual start of the intervention to gain insight into which parts of the PE intervention are required for that specific company.

### Authors' contributions

SV was responsible for the data collection and drafted the manuscript. All authors conceived and designed the study, read and corrected draft versions of the manuscript and approved the final manuscript. HFM, JKS and MFD obtained funding for the study.

### Disclosure statement

The authors declare that they have no competing interests.

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### References

- Boschman, J. S., H. F. van der Molen, J. K. Sluiter, and M. H. W. Frings-Dresen. 2011. "Occupational Demands and Health Effects for Bricklayers and Construction Supervisors: A Systematic Review." *American Journal of Industrial Medicine* 54 (1): 55–77. doi:10.1002/ajim.20899.
- Boschman, J. S., H. F. van der Molen, J. K. Sluiter, and M. H. W. Frings-Dresen. 2012. "Musculoskeletal Disorders among Construction Workers: A One-year Follow-up Study." *BMC Musculoskeletal Disorders* 13: 196. doi:10.1186/1471-2474-13-196.
- Brownson, R. C., J. E. Fielding, and C. M. Maylahn. 2009. "Evidence-based Public Health: A Fundamental Concept for Public Health Practice." *Annual Review of Public Health* 30: 175–201. doi:10.1146/annurev.pu.30.031709.100001.
- Cherniack, M., T. Morse, R. Henning, A. Seidner, and L. Punnett. 2010. "Health Promotion Site Selection Blues: Barriers to Participation and Implementation." *Journal of Occupational and Environmental Medicine* 52 (6): 626–634. doi:10.1097/JOM.0b013e3181e138a4.
- Dale, A. M., L. Jaegers, L. Welch, B. T. Gardner, B. Buchholz, N. Weaver, and B. A. Evanoff. 2016. "Evaluation of a Participatory Ergonomics Intervention in Small Commercial Construction Firms." *American Journal of Industrial Medicine* 59 (6): 465–475. doi:10.1002/ajim.22586.
- Drissen, M. T., K. Groenewoud, K. I. Proper, J. R. Anema, P. M. Bongers, and A. J. van der Beek. 2010. "What are Possible Barriers and Facilitators to Implementation of a Participatory Ergonomics Programme?" *Implementation Science* 5: 64–72. doi:10.1186/1748-5908-5-64.
- Durlak, J. A., and E. P. DuPre. 2008. "Implementation Matters: A Review of Research on the Influence of Implementation on Program Outcomes and the Factors Affecting Implementation." *American Journal of Community Psychology* 41 (3–4): 327–350. doi:10.1007/s10464-008-9165-0.
- van Eerd, D., D. C. Cole, E. Irvin, Q. Mahood, K. Keown, N. Theberge, J. Village, M. St. Vincent, and K. Cullen. 2010. "Process and Implementation of Participatory Ergonomic Interventions: A Systematic Review." *Ergonomics* 53 (10): 1153–1166. doi:10.1080/00140139.2010.513452.
- Haines, H., J. R. Wilson, P. Vink, and E. A. P. Koningsveld. 2002. "Validating a Framework for Participatory Ergonomics (the PEF)." *Ergonomics* 45 (4): 309–327. doi:10.1080/00140130210123516.
- Hengel, K. M., B. M. Blatter, H. F. van der Molen, C. I. Joling, K. I. Proper, P. M. Bongers, and A. J. van der Beek. 2011. "Meeting the Challenges of Implementing an Intervention to Promote Work Ability and Health-related Quality of Life at Construction Worksites." *Journal of Occupational and Environmental Medicine* 53 (12): 1483–1491. doi:10.1097/JOM.0b013e3182398e03.
- Hunter, D., and B. Silverstein. 2014. "Perceptions of Risk from Workers in High Risk Industries with Work Related Musculoskeletal Disorders." *Work* 49 (4): 689–703. doi:10.3233/WOR-131697.
- Jaegers, L., A. M. Dale, N. Weaver, B. Buchholz, L. Welch, and B. Evanoff. 2014. "Development of a Program Logic Model and Evaluation Plan for a Participatory Ergonomics Intervention in Construction." *American Journal of Industrial Medicine* 57 (3): 351–361. doi:10.1002/ajim.22249.
- Jensen, L. K., and L. B. Kofoed. 2002. "Musculoskeletal Disorders among Floor Layers: Is Prevention Possible?" *Applied Occupational Environmental Hygiene* 17 (11): 797–806. doi:10.1080/10473220290096041.
- Jensen, L. K., S. Mikkelsen, I. P. Loft, and W. Eenberg. 2000. "Work-related Knee Disorders in Floor Layers and Carpenters." *Journal of Occupational and Environmental Medicine* 42 (8): 835–842.
- Johnson, A. M., A. M. Dale, J. R. Strickland, P. Venditti, and B. A. Evanoff. 2008. "Employers' Concerns regarding Research Participation." *International Journal of Occupational and Environmental Health* 14 (1): 11–17. doi:10.1179/oeh.2008.14.1.11.
- Kidd, P., M. Parshall, S. Wojcik, and T. Struttman. 2004. "Overcoming Recruitment Challenges in Construction Safety Intervention Research." *American Journal of Industrial Medicine* 45 (3): 297–304. doi:10.1002/ajim.10335.
- Koningsveld, E. A. P., and H. F. van der Molen. 1997. "History and Future of Ergonomics in Building and Construction." *Ergonomics* 40 (10): 1025–1034. doi:10.1080/001401397187586.
- Linnan, L., and A. Steckler. 2002. *Process Evaluation for Public Health Interventions and Research*. San Francisco, CA: Jossey-Bass.
- van der Molen, H. F., and M. H. W. Frings-Dresen. 2014. "Strategies to Reduce Safety Violations for Working from Heights in Construction Companies: Study Protocol for a Randomized Controlled Trial." *BMC Public Health* 14: 559. doi:10.1186/1471-2458-14-541.
- van der Molen, H. F., J. K. Sluiter, C. T. J. Hulshof, P. Vink, C. J. van Duivenbooden, and M. H. W. Frings-Dresen. 2005. "Conceptual Framework for the Implementation of Interventions in the Construction Industry." *Scandinavian Journal of Work, Environment and Health* 31 (suppl.2): 96–103.



- van der Molen, H. F., J. K. Sluiter, C. T. J. Hulshof, P. Vink, C. J. van Duivenbooden, R. Holman, and M. H. W. Frings-Dresen. 2005. "Implementation of Participatory Ergonomics Intervention in Construction Companies." *Scandinavian Journal of Work, Environment and Health* 31 (3): 191–204.
- van der Molen, H. F., J. K. Sluiter, C. T. J. Hulshof, P. Vink, and M. H. W. Frings-Dresen. 2005. "Effectiveness of Measures and Implementation Strategies in Reducing Physical Work Demands due to Manual Handling at Work." *Scandinavian Journal of Work, Environment and Health* 31 (suppl.2): 75–87.
- Rasmussen, C. D. N., N. K. Lindberg, M. H. Ravn, M. B. Jørgensen, K. Sogaard, and A. Holtermann. 2017. "Processes, Barriers and Facilitators to Implementation of a Participatory Ergonomics Program among Eldercare Workers." *Applied Ergonomics* 58: 491–499.
- Rinder, M. M., A. Genaidy, S. Salem, R. Shell, and W. Karwowski. 2008. "Interventions in the Construction Industry: A Systematic Review and Critical Appraisal." *Human Factors and Ergonomics in Manufacturing* 18 (2): 212–229. doi:10.1002/hfm.20109.
- Rivilis, I., D. Van Eerd, K. Cullen, D. Cole, E. Irvin, J. Tyson, and Q. Mahood. 2008. "Effectiveness of Participatory Ergonomic Interventions on Health Outcomes: A Systematic Review." *Applied Ergonomics* 39 (3): 342–358. doi:10.1016/j.apergo.2007.08.006.
- Vander Molen, H. F., R. Grouwstra, P. P. F. M. Kuijer, J. K. Sluiter, and M. H. W. Frings-Dresen. 2004. "Efficacy of Adjusting Working Height and Mechanizing of Transport on Physical Work Demands and Local Discomfort in Construction Work." *Ergonomics* 47 (7): 772–783. doi:10.1080/0014013042000193309.
- Visser, S. 2015. The Process Evaluation of a Randomised Trial for Implementing Two Guidance Strategies of a Participatory Ergonomics Intervention on the Use of Ergonomic Measures among Construction Workers – Chapter 4.2. "Ergonomic Measures in Construction Work: Enhancing Evidence-Based Implementation." PhD diss., University of Amsterdam.
- Visser, S., H. F. van der Molen, P. P. F. M. Kuijer, B. J. van Holland, and M. H. W. Frings-Dresen. 2013. "Evaluation of Two Working Methods for Screed Floor Layers on Musculoskeletal Complaints, Work Demands and Workload." *Ergonomics* 56 (1): 69–78. doi:10.1080/00140139.2012.736541.
- Visser, S., H. F. van der Molen, P. P. F. M. Kuijer, M. J. M. Hoozemans, and M. H. W. Frings-Dresen. 2014. "Evaluation of Team Lifting on Work Demands, Workload and Workers' Evaluation: An Observational Field Study." *Applied Ergonomics* 45 (6): 1597–1602. doi:10.1016/j.apergo.2014.05.009.
- Visser, S., H. F. van der Molen, J. K. Sluiter, and M. H. W. Frings-Dresen. 2014. "Guidance Strategies for a Participatory Ergonomic Intervention to Increase the Use of Ergonomic Measures of Workers in Construction Companies: A Study Design of a Randomised Trial." *BMC Musculoskeletal Disorders* 15: 772. doi:10.1186/1471-2474-15-132.
- Wiberg, V. 2012. "Communication of Ergonomics in Building and Construction." *Work* 41 (suppl.1): 4111–4115. doi:10.3233/WOR-2012-1038-4111.

**Appendix 1. Description of the 6 steps and 31 performance indicators of the PE implementation strategy. The 19 performance indicators in italics were defined as essential elements in this strategy (based on van der Molen et al., "Implementation of Participatory Ergonomics Intervention," 2005).**

Performance indicator (PI)		Explanation
Step 1	Preparation	
<i>Steering committee</i>		
P1	Involvement of Company chairman	Company is responsible to perform the intervention
P2	<i>Financial budget by chairman</i>	<i>Control and facilitation of investments</i>
P3	<i>Involvement of construction workers</i>	<i>Knowledge of hindrances/end user</i>
P4	<i>Involvement of construction workers' assistant(s)</i>	<i>Knowledge of hindrances/end user</i>
P5	<i>Involvement of work preparation</i>	<i>Early involvement of facilitator</i>
P6	<i>Involvement of worksite managers/foreman</i>	<i>Commitment middle management</i>
P7	Involvement of ergonomist/consultant	Experiences of guidance of participatory processes
P8	No change of steering group	Ensure continuity <i>during the intervention</i>
<i>Objectives</i>		
P9	<i>Subscribed objectives</i>	<i>Clarity and intention to implement tools or equipment</i>
<i>Planning</i>		
P10	<i>Meetings (≥3) of steering committee</i>	<i>Ensure continuity during the intervention</i>
P11	<i>Meeting on problems</i>	<i>Increase knowledge of stakeholders</i>
P12	Meeting on solutions	Awareness and understanding of available tools or equipment by stakeholders
P13	<i>Meeting after first experience</i>	<i>Sharing experiences of stakeholders after first experiences</i>
P14	Within 6 months	More change of success when intervention is performed within this time
Step 2	Information strategies	
P15	<i>Written information to workers</i>	<i>Knowledge of problems and solutions supports implementation</i>
P16	<i>Oral information to workers via meetings</i>	<i>Knowledge of problems and solutions supports implementation</i>
P17	Visual information to workers	<i>Knowledge of problems and solutions supports implementation</i>
Step 3	Selection of measures	
P18	Tailored information on tools or equipment	Detailed knowledge of measures to workers
P19	<i>Meeting on (dis)advantages</i>	<i>Anticipation on hindrances when using tool or equipment</i>
P20	<i>Selection tools or equipment by workers</i>	<i>Commitment of the workers</i>
Step 4	Ability to use	
P21	<i>Instruction and training</i>	<i>Knowledge and skills to use tool or equipment</i>
P22	Testing without financial risks	Stimulate experience with tool or equipment for workers
P23	<i>Intervention on hindrances</i>	<i>Counteract hindrances on implementation found during testing</i>
P24	Cost-benefit analysis	Clarity about financial consequences when purchasing the tool or equipment
Step 5	Experiences on measures	
P25	<i>Testing measures</i>	<i>Actual experience of tool or equipment in daily work</i>
P26	Adaptations on a test basis	Consideration to stakeholders' experiences
Step 6	Implementation	
P27	<i>Feedback on test results</i>	<i>Increase commitment by interaction within steering committee</i>
P28	<i>Announcement of deployment</i>	<i>Communication to the workers increases commitment</i>
P29	<i>Agreements about implementation</i>	<i>Support logistics and implementation</i>
P30	Information middle management	Incorporation policy to use tool or equipment in organisation
P31	Feedback on use of tools or equipment	Increase of knowledge and commitment