Ergonomic measures in construction work: enhancing evidence-based implementation
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CHAPTER 4.3

EFFECT OF TWO GUIDANCE STRATEGIES OF A PARTICIPATORY ERGONOMICS INTERVENTION ON THE USE OF ERGONOMIC MEASURES IN CONSTRUCTION WORK: A RANDOMISED TRIAL

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Submitted for publication
ABSTRACT

Objective
To study the effect of two guidance strategies of a participatory ergonomics (PE) intervention in the construction industry on the use of ergonomic measures.

Methods
Twelve construction companies were randomly assigned to a face-to-face guidance strategy (F2F; N=6) and an e-guidance strategy (EG; N=6). Ergonomic consultants guided the companies through face-to-face contact in the F2F, or through email contact in the EG. The primary outcome measure – the percentage of workers using ergonomic measures – and secondary outcome measures – work ability, physical functioning and limitations due to physical problems of workers – were assessed using questionnaires at baseline and after six months. A comparison was made on individual level between F2F and EG. In addition, a cost-benefit analysis was performed on company level.

Results
Using ergonomic measures to adjust working height improved over time was significantly different (p=0.001) between F2F (+1%) and EG (+10%). The use of newly-implemented ergonomic measures was 23% for F2F and 42% for EG after six months (p=0.271). There were no differences between F2F and EG in work ability, physical functioning or limitations due to physical problems. The costs in the first year varied between €3,294 and €5,781 for F2F and €1,479 and €3,754 for EG.

Conclusion
A PE e-guidance strategy improved the use of some type of ergonomic measures more compared with a face-to-face guidance strategy. No differences in work ability, physical functioning or limitations due to physical problems of workers were found. Costs were determined by guidance costs in the F2F group and purchasing costs in the EG group.
INTRODUCTION

Construction workers experience high physical work demands, especially when handling materials manually and assuming awkward body postures. Effective ergonomic measures are available to reduce the high physical work demands, for instance scaffolding consoles or tools enabling them to work in an upright position for floor layers. Nevertheless, ergonomic measures are not implemented to a large extent in daily practice.

According to Rogers, the use of an innovation, e.g. the introduction of an ergonomic measure, is characterized by different adopter categories: ‘innovators’, ‘early adopters’, ‘early majority’, ‘late majority’, and ‘laggards’. Each adopter category experiences different barriers with respect to using ergonomic measures. Barriers for the majorities are lack of information, availability, and test possibilities. In addition, the use of new tools requires training and therefore also time and money on the part of the employers. When the benefits of the new measures are unclear in the short term, employers are not easily motivated to invest in new ergonomic measures. These studies showed that different stakeholders in a company must pass different behavioural phases, like ‘being aware’ or ‘have the ability to use’ before construction workers actually use ergonomic measures.

One way to facilitate a change in employer and employee behaviour is thought to be through participatory ergonomic (PE) interventions. Although Van Eerd et al. found that PE interventions had a positive effect and were used to implement tools and equipment, other studies did not show an increase in the use of ergonomic measures despite an increase in the ability to use ergonomic measures. In the study of van der Molen et al., companies were guided by external experts in PE interventions. However, it is not clear whether the external experts had a planned and systematic guidance strategy for the PE intervention. It was found by Van Eerd et al. that having a systematic guidance strategy is a facilitator for the effectiveness of PE interventions.

In the last decade, more and more health-based treatment and prevention strategies have been delivered via the Internet. Most of these e-strategies are based on face-to-face interventions. The advantage of the Internet strategies is that they can reduce face-to-face guidance barriers, for instance the inconvenience of scheduling appointments and travelling, and reduce costs as a consequence of the travelling and the presence of an external expert. For the present study, two systematic guidance strategies of a protocol for the implementation of ergonomic measures in construction companies was developed. In the first guidance strategy, construction companies were guided face-to-face by an ergonomic consultant. The second guidance strategy was an e-guidance strategy in which construction companies were guided by e-mails from the ergonomic consultant.

In the present study, the effect of both guidance strategies on the use of ergonomic measures by individual construction workers was studied. It is expected that using ergonomic measures reduces exposure to high physical work demands, resulting in the improvement of work ability and physical functioning, and a decrease in limitations due...
to physical problems of individual construction workers. Due to the presence of an
ergonomic consultant in the face-to-face guidance strategy, this strategy is expected to
have a higher compliance to the protocol compared to the e-guidance strategy. Since
following a systematic guidance strategy improved the effectiveness of PE interventions, it was hypothesized that the face-to-face guidance strategy would improve the use of
ergonomic measures, work ability, and physical functioning while decreasing limitations
due to physical problems more when compared to the e-guidance strategy. To assess
the economic differences between the two guidance strategies, an economic cost-benefit
analysis will be performed on company level. The financial costs are expected to be higher
for the face-to-face guidance group, due to the face-to-face contacts. However, due to an
expected higher use of ergonomic measures in the face-to-face guidance group, the
cost-benefit analysis will be in favour of the face-to-face guidance group compared to the
e-guidance group.

This results in the following research questions: Is there a difference between the
face-to-face guidance strategy and the e-guidance strategy on: 1) the use of ergonomic
measures; 2) work ability, physical functioning, and limitations due to physical problems;
and 3) economic cost-benefit?

METHODS/DESIGN

Study design
The present study was a randomised parallel intervention trial with a follow-up at six
months. The design and reporting of this study adhere to the CONSORT guidelines of
Baker et al. The design of the study was described in Visser et al.

Participants
Based on a sample-size calculation, 12 companies needed to be included to be able to
detect significant differences in the use of ergonomic measures. Inclusion was performed
from May 2012 to June 2013. The study population included all construction workers of
the twelve participating companies. The inclusion criteria for the construction companies
were: 1) less than 50 employees (small and medium enterprises in the Dutch construction
industry); 2) working in physically high demanding jobs such as laying floors, glazing,
ironworking, plastering, paving, constructing walls and ceilings, carpentry or masonry
trade; and 3) having the potential to improve the use of ergonomic measures among their
workers.

Four different strategies were used for the recruitment of the companies; through
occupational health services, the Dutch Labour Inspectorate, National Board of Employers
of four physically demanding trades, and within the network of the researchers. Recruitment of the companies was done from June 2012 to June 2013.
Procedure
Construction companies that wanted to participate were visited by a researcher (SV). During this meeting, the procedure of the study was explained and questions about the study were answered. Once construction companies were enrolled in the study, an informed consent form was signed. In addition, contact information of the contact person, and demographic characteristics, e.g. number of employees, of the company were assessed.

With the help of nQuery Advisor 7, companies were randomly assigned to one of the guidance groups by one researcher (SV) with a block size of two. Blocks were formed by trades. The first included construction company within a trade was randomly assigned to the face-to-face guidance group or e-guidance group by SV, the second construction company was assigned to the opposite strategy group. The method chosen of the present study made blinding for the participating companies, the ergonomic consultants and for the researchers impossible. The allocated guidance group and contact information of the company were passed to the ergonomic consultants before the start of the intervention.

Interventions
Two ergonomic consultants developed two guidance strategies for the implementation of ergonomic measures based on the PE intervention of van der Molen et al.5 The first strategy consisted of four face-to-face contacts with the ergonomic consultant. In the second strategy, construction companies were guided with 13 email contacts. Both guidance strategies lasted six months. The guidance strategies are described briefly below. A comprehensive description of both guidance strategies is described in Visser et al.16

In both guidance strategies, a steering committee was installed consisting of the director, the prevention worker, work planners, foremen and construction workers. In addition, the contact person of the company had to assess physical work demands of the workers and possible ergonomic measures. In the first meeting of the steering committee, an ergonomic measure was selected based on the physical work demands of the workers. This ergonomic measure was tested by construction workers in a test environment during the second meeting, and experiences with the ergonomic measure in daily practice were discussed in the third meeting. The final decision of whether to implement the ergonomic measure was made in the fourth meeting.

In the face-to-face guidance strategy, the ergonomic consultant got in touch with the contact person of the company through a telephone call. In addition, during the guidance the ergonomic consultant was present at the meetings of the steering committee.

The ergonomic consultant was not present at the meetings in the e-guidance strategy, but guided the intervention through email contact with the contact person. Each email contained assignments to the contact person for the participants in the intervention, and a form through which the completed assignments could be returned to the ergonomic consultant for feedback and the next assignments.
Outcome measures

Primary outcome
The primary outcome was the percentage of workers that used ergonomic measures. Because of the diversity in trades, the ergonomic measures were clustered in: 1) measures for transportation; 2) measures for raising equipment or materials; 3) measures to adjust working height on the worksite; and 4) ergonomic handtools. For the four clusters, construction workers were asked at baseline (T0) and after six months (T1) whether or not they had used ergonomic measures during the last two months. An example of a question was: “In the last two months, did you use mechanical measures for transportation, such as [. . .].” Construction workers answered with a ‘yes’ or ‘no’. The examples of ergonomic measures were adjusted for the different clusters and trades.

In addition to the use of clusters of ergonomic measures, construction workers were asked at T1 whether the implemented ergonomic measure had been used during the previous 10 workdays.

Secondary outcomes
The secondary outcomes were work ability, physical functioning, and limitations due to physical problems of individual construction workers, and were assessed at baseline and after six months.

Work ability was assessed using the first three items of the Work Ability Index (WAI)\textsuperscript{18}. The items for perceived work ability with respect to physical demands and perceived work ability with respect to mental demands were adjusted to the same 11-point scale as for the overall work ability (0 = completely unable to work, 10 = work ability at its best). The higher the score, the higher the level of work ability.

Physical functioning was measured using a subscale of the RAND-36 questionnaire\textsuperscript{19}. Whether construction workers were limited in performing daily activities was measured for 10 items on a 3-point response rate (1 = severe limitations, 2 = light limitations, 3 = no limitations). A score was calculated ranging from 0 to 100. The higher the score, the fewer physical limitations in daily life.

Another subscale of the RAND-36\textsuperscript{19} was used to measure role limitations due to physical problems. Construction workers were asked whether they had experienced limitations or difficulties in their work during the previous four weeks (1 = yes, 2 = no) on four items. A scale score between 0 to 100 was calculated. The higher the score, the less limited construction workers were.

Descriptive variables
At baseline, gender, age (years), work experience as construction worker (years), work experience in current job (years), occupation level, and managerial position of the construction workers were assessed.
Economic cost-benefit

For the cost-benefit analysis, costs were divided into three items: the costs of the guidance strategy, purchasing the ergonomic measures, and costs of training the workers. The costs of the guidance strategy consisted of the reported time spent, including travelling, of the ergonomic consultants, charged at their hourly rate. For the costs regarding purchasing the implemented ergonomic measure, suppliers of the implemented ergonomic measures were asked to supply information about the costs for purchasing the ergonomic measures, depreciation time, maintenance costs of the ergonomic measure, and additional energy costs for using the ergonomic measure. Costs for each worker given training were calculated by multiplying the number of hours of the training (obtained from interviews with the employers) by their hourly costs.

To arrive at the benefits, a calculation was made for the required change in production (in percentage) and the change in sick leave (in days) to break even with the total costs. For the calculation of the required change in production, the employers were asked to state for what proportion of the total working time the ergonomic measure was applicable. The calculated required change in production was compared with an estimation given by the employers and construction workers of the change in production while working with the ergonomic measure compared with the traditional working method. The change in sick leave required was compared with a history of sick leave during the previous year on company level assessed at baseline.

Statistical analyses

Differences between baseline and six months of both guidance strategies on the primary and secondary outcome measures and the use of new ergonomic measures were tested using a Generalized Linear Mixed Model, in which the outcomes of individual workers were corrected for company level. The economic cost-benefit analysis was analysed descriptively on company level. All statistical analyses were performed using IBM SPSS Statistics 20.0.

RESULTS

Participants

Figure 1 shows a flow diagram for the recruitment of the construction companies. In addition, the numbers of analysed construction workers is given. One company in the face-to-face guidance group dropped out before the intervention was started.

Response rate, demographic and occupational characteristics of the construction workers at baseline are presented in table 1. No significant differences were found between the face-to-face and e-guidance group for age, work experience as construction worker and work experience at current job. More workers had followed secondary education in
Figure 1 Overview of the recruitment and the participating and analysed number of construction workers.
Table 1  An overview of the number of workers responded and the age, work experience as construction worker and the work experience in the current job (in years) at baseline per company.

<table>
<thead>
<tr>
<th>Guidance group</th>
<th>Company</th>
<th>Response (n)</th>
<th>Age (years)</th>
<th>Work experience as construction worker (years)</th>
<th>Work experience in current job (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Face-to-face</td>
<td>1</td>
<td>18/21</td>
<td>33</td>
<td>14</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>16/23</td>
<td>45</td>
<td>10</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>0/35</td>
<td>.</td>
<td>.</td>
<td>.</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>28/61</td>
<td>46</td>
<td>12</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>4/15</td>
<td>39</td>
<td>13</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>9/17</td>
<td>33</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>E-guidance</td>
<td>7</td>
<td>28/51</td>
<td>40</td>
<td>14</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>20/20</td>
<td>36</td>
<td>15</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>3/3</td>
<td>42</td>
<td>8</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>13/20</td>
<td>37</td>
<td>8</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>4/9</td>
<td>42</td>
<td>8</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>2/2</td>
<td>45</td>
<td>1</td>
<td>10</td>
</tr>
</tbody>
</table>

* Company dropped out before the intervention was started and before the baseline questionnaires were sent to the workers.
** Companies went bankrupt during the intervention and the workers of these companies were left out of the analyses.

the face-to-face guidance group, and more workers had a managerial position in the face-to-face guidance group.

Use of ergonomic measures

Table 2 shows the percentage of workers that used ergonomic measures at baseline and after six months per cluster of ergonomic measures. A significant interaction effect of time and guidance strategy was found for the use of ergonomic measures to adjust working height (p=0.001). The percentage of workers in the e-guidance group using these measures increased by 10%, while the percentage of workers remained the same in the face-to-face guidance group. In addition, the percentage of workers using ergonomic handtools increased by 26% in the e-guidance group. In the face-to-face guidance group, the percentage of workers using ergonomic measures to raise equipment or materials increased by 10%.
### Table 2
The number of workers (n) and the percentage of workers (%) in the intervention groups using ergonomic measures at baseline and at six months follow-up.

<table>
<thead>
<tr>
<th>Ergonomic cluster</th>
<th>Face-to-face guidance strategy</th>
<th>Baseline</th>
<th>Follow-up</th>
<th>Face-to-face guidance strategy</th>
<th>Baseline</th>
<th>Follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
<td>%</td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td>Measures for transportation</td>
<td>49/70</td>
<td>70</td>
<td>36/47</td>
<td>77</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Measures for raising equipment or materials</td>
<td>31/61</td>
<td>51</td>
<td>23/38</td>
<td>61</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Measures to adjust working height</td>
<td>55/69</td>
<td>80</td>
<td>38/47</td>
<td>81</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ergonomic handtools</td>
<td>39/69</td>
<td>57</td>
<td>30/47</td>
<td>64</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Statistical testing of the interaction between time and guidance was not feasible due to the lack of variance in the e-guidance strategy group.

### Table 3
Mean and standard deviation of work ability, physical functioning and limitations due to physical problems at baseline and at six months follow-up.

<table>
<thead>
<tr>
<th>Face-to-face guidance strategy</th>
<th>Baseline</th>
<th>Follow-up</th>
<th>Face-to-face guidance strategy</th>
<th>Baseline</th>
<th>Follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perceived work ability (scale 0-10)</td>
<td>8</td>
<td>2.1</td>
<td>71</td>
<td>8</td>
<td>1.7</td>
</tr>
<tr>
<td>Perceived work ability with respect to physical demands (scale 0-10)</td>
<td>7</td>
<td>2.1</td>
<td>71</td>
<td>8</td>
<td>1.7</td>
</tr>
<tr>
<td>Perceived work ability with respect to mental demands (scale 0-10)</td>
<td>8</td>
<td>1.9</td>
<td>71</td>
<td>8</td>
<td>1.9</td>
</tr>
<tr>
<td>Physical functioning (scale 0-100)</td>
<td>85</td>
<td>20.2</td>
<td>70</td>
<td>89</td>
<td>13.9</td>
</tr>
<tr>
<td>Limitations due to physical problems (scale 0-100)</td>
<td>86</td>
<td>30.9</td>
<td>69</td>
<td>86</td>
<td>28.2</td>
</tr>
</tbody>
</table>

*The residuals of all items of perceived work ability, physical functioning and limitations due to physical problems were not normally distributed, therefore a Generalized Linear Mixed Model was not applicable. The difference-scores between baseline and follow-up were calculated and tested with a Generalized Linear Mixed Model or, when not applicable, with a t-test of independent samples, therefore the p-value represents the effect of guidance and not the interaction effect of Time×Guidance.
### Table 2

The number of workers (n) and the percentage of workers (%) in the intervention groups using ergonomic measures at baseline and at six months follow-up.

<table>
<thead>
<tr>
<th>Ergonomic cluster</th>
<th>Face-to-face guidance strategy</th>
<th>E-guidance strategy</th>
<th>Time×Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline (n)</td>
<td>Baseline (%)</td>
<td>Follow-up (n)</td>
</tr>
<tr>
<td>Measures for transportation</td>
<td>49/70 (70)</td>
<td>36/47 (77)</td>
<td>40/42 (95)</td>
</tr>
<tr>
<td>Measures for raising equipment or materials</td>
<td>28/36 (78)</td>
<td>19/25 (76)</td>
<td>23/42 (55)</td>
</tr>
<tr>
<td>Measures to adjust working height</td>
<td>55/69 (80)</td>
<td>38/47 (81)</td>
<td>23/42 (55)</td>
</tr>
<tr>
<td>Ergonomic handtools</td>
<td>39/69 (57)</td>
<td>30/47 (64)</td>
<td>20/42 (48)</td>
</tr>
</tbody>
</table>

*Statistical testing of the interaction between time and guidance was not feasible due to the lack of variance in the e-guidance strategy group.

### Table 3

Mean and standard deviation of work ability, physical functioning and limitations due to physical problems at baseline and at six months follow-up.

<table>
<thead>
<tr>
<th>E-guidance strategy</th>
<th>p-value</th>
<th>Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline</td>
<td>Follow-up</td>
</tr>
<tr>
<td>Mean</td>
<td>SD</td>
<td>n</td>
</tr>
<tr>
<td>Perceived work ability (scale 0-10)</td>
<td>8</td>
<td>2.0</td>
</tr>
<tr>
<td>Perceived work ability with respect to physical demands (scale 0-10)</td>
<td>8</td>
<td>2.0</td>
</tr>
<tr>
<td>Perceived work ability with respect to mental demands (scale 0-10)</td>
<td>8</td>
<td>2.0</td>
</tr>
<tr>
<td>Physical functioning (scale 0-100)</td>
<td>95</td>
<td>13.8</td>
</tr>
<tr>
<td>Limitations due to physical problems (scale 0-100)</td>
<td>95</td>
<td>13.9</td>
</tr>
</tbody>
</table>

The residuals of all items of perceived work ability, physical functioning and limitations due to physical problems were not normally distributed, therefore a Generalized Linear Mixed Model was not applicable. The difference-scores between baseline and follow-up were calculated and tested with a Generalized Linear Mixed Model or, when not applicable, with a t-test of independent samples, therefore the p-value represents the effect of guidance and not the interaction effect of Time×Guidance.
Five companies – two in the face-to-face guidance group and three in the e-guidance group – implemented new ergonomic measures during the intervention. For the face-to-face guidance group, the percentage of workers using a newly-implemented ergonomic measure after the PE intervention was 23% (11 out of 48 workers) and 42% (13 out of 31 workers) for the e-guidance group. This difference was not statistically significant ($p=0.271$).

**Work ability, physical functioning and limitations due to physical problems**

Work ability did not change significantly between the groups. On average, the general, physical and mental work abilities were between 7 and 8 on a scale from 0 to 10 (table 3). The average change between baseline and after six months in general work ability, physical work ability and mental work ability was 0.2, 0.4 and 0 for the face-to-face guidance group and 0, -0.1 and 0.1 for the e-guidance group respectively.

No differences were found between baseline and follow-up between the guidance groups in physical functioning of the construction workers nor in limitations due to physical problems.

**Economic cost-benefit**

The cost-benefit analysis was performed for the five companies in which a new ergonomic measure was implemented. Due to the small number of companies and the large variety in costs of the ergonomic measures, a comparison of the cost-benefit analysis between the groups was not feasible. The total costs in the first year were between €3,294 and €5,781 for the companies in the face-to-face guidance group and were mainly due to the guidance costs (58% to 94%). The purchasing of the ergonomic measures accounted for 2% to 29% of the costs incurred. For the e-guidance group, the total costs in the first year were between €1,479 and €3,754. The biggest costs were guidance costs (82% of the total costs) for one company and the purchasing costs (83% to 93% of the total costs) for two other companies.

For a break-even of the total costs of the first year, an increase in production ranging from 1% to 5% or a decrease in sick leave of 1 to 11 days was calculated for the face-to-face guidance group. In the e-guidance group, the increase in production had to be between 4% and 8% to break even, or a decrease in sick leave of 8 to 18 days.

Compared with the history of sick leave during the previous year, the reduction of days of sick leave does not seem to be a realistic option for the companies, with the exception of a reduction of one day. Employers of three companies reported that working with ergonomic measures increased the productivity, the other two reported no change in productivity. Construction workers reported on average no change in productivity while working with the ergonomic measures.
DISCUSSION

We studied differences between a face-to-face guidance strategy and an e-guidance strategy by ergonomic consultants offered to construction companies on: 1) the use of ergonomic measures; 2) work ability, physical functioning, and limitations due to physical problems; and 3) cost-benefit. Over time, more workers used ergonomic measures to adjust working height in the e-guidance group compared to the face-to-face guidance group. No differences over time were found between the two guidance strategies for the other ergonomic measures and the work ability, physical functioning and limitations due to physical problems of workers. A cost-benefit analysis was not feasible due to the small number of companies that participated in the end, and since the costs varied considerably due to the type of ergonomic measure implemented and the number of workers in a company.

Comparison of the guidance strategies

Some explanations for the different findings compared to our hypotheses exist. First of all, only half of the companies implemented ergonomic measures during the intervention. Two of the five companies received the face-to-face guidance strategy and completed the intervention. Three companies received the e-guidance strategy, only one of which completed the entire intervention. The other two companies implemented the ergonomic measure on their own without following the guidance. Since no ergonomic measure was implemented in the other companies, it is questionable whether the differences in use of ergonomic measures can be attributed to the different guidance strategies. In a process evaluation of the intervention we hope to publish was shown that companies in the face-to-face guidance group even got more dose delivered of the intervention compared to the companies in the e-guidance group. Not following a systematic guidance strategy was found to be a barrier for the PE intervention to implementing ergonomic measures. In the two companies in the e-guidance group that implemented ergonomic measures without the systematic guidance strategy, the director had already decided to introduce the ergonomic measures before the official start of the intervention. The fact that the decision had already been made was found to be a facilitator for implementation. This facilitator might be of such importance that additional extensive guidance for the implementation may no longer be necessary.

The new ergonomic measures implemented in the five companies were unequally distributed over the clusters of ergonomic measures. In three companies – one in the face-to-face guidance group and two in the e-guidance group – ergonomic measures to adjust working height were implemented. In the other two companies – one in the face-to-face and the other in the e-guidance group – implemented ergonomic handtools. Due to the unequal distribution of the newly-implemented ergonomic measures in the clusters between the face-to-face and the e-guidance group, the results of the use of a cluster of ergonomic measures are not generalizable.
Despite the increase in number of workers using the ergonomic measures and the number of workers using new ergonomic measures, no improvement in the secondary outcomes were found in this study. This contrasts with a review of Rivilis et al., where positive effects on musculoskeletal disorders, reducing injuries and lost days from work or sickness absence showed an association with PE interventions. It was found in the present study that construction workers had strikingly high scores for physical functioning and limitations due to physical problems, even compared with the general population, which as a consequence has a ceiling effect at baseline. Therefore, based on the outcomes at baseline, no improvement might be expected for these outcome measures.

The steering groups in the companies were free to select any ergonomic measure for the implementation. Four companies implemented ergonomic measures which were already approved by the Dutch Labour Inspectorate and available on the market. The fifth company, which got face-to-face guidance, wanted to implement a new ergonomic measure to adjust working height that had not yet been approved by the Dutch Labour Inspectorate. This company was an innovator with regard to the implementation of this ergonomic measure. Due to the lack of approval from the Dutch Labour Inspectorate, the ergonomic measure was not fully implemented, which resulted in less improvement of use compared to the other companies and may have affected the results between the face-to-face and the e-guidance group.

**Strengths and limitations**

To generalise the effect of the guidance strategies to the construction industry, different trades in the construction industry were recruited and the steering committees were free to select an ergonomic measure. To compare the use of ergonomic measures among the different trades, the clustering of the ergonomic measures was established in the questions. However, the clustering affected the results, since a sufficient distribution of companies implementing measures in a cluster was lacking. It might be better for future research to increase the number of participating companies or focus on one cluster of ergonomic measures. Since the recruitment of companies was difficult, the latter option seems more feasible.

Although the cost-benefit analysis provided insight into the economic consequences of the ergonomic measures to the companies, the large variety in purchasing costs made a comparison between the two guidance strategies impossible. In addition, the consequences of the ergonomic measures in terms of sick leave and productivity proved to be difficult to assess. Whether sick leave will be reduced is difficult to predict due to the multifactorial nature of sick leave. For the second possible benefit, productivity can be better assessed when workers are fully accustomed to working with the ergonomic measures. Economic analysis in implementation research can therefore be used to gain insight into costs and necessary benefits of individual companies rather than research purposes.
Implications

Over and above the differences in use of ergonomic measures within the clusters between the face-to-face guidance strategy and the e-guidance strategy, both guidance strategies led to an increase in the use of new ergonomic measures. Therefore, this study showed that the guidance through the Internet or email is not only applicable for the guidance of individual persons, but can also be used to guide steering committees associated with a PE intervention. The biggest challenges with this guidance strategy is getting the intervention started and keeping companies alert to completing the intervention. Starting the e-guidance with a face-to-face meeting could enable better compliance on the part of the companies.

CONCLUSION

The e-guidance strategy of a PE intervention improved the use of some type of ergonomic measures compared with the face-to-face guidance strategy. No differences in work ability, physical functioning and limitations due to physical problems of workers were found. Despite the differences, both guidance strategies are thought to be capable of improving the use of new ergonomic measures.
REFERENCES