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A new bricklayers' method for use in the construction industry

by Pim AJ Luijsterburg, MSc,[1] Paulien M Bongers, PhD,[2,3] Ernest MM de Vroome, PhD[2]

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Objectives The aim of this study was to investigate the effect of raised bricklaying on physical workload, reported musculoskeletal disorders, sickness absence, and job satisfaction.
Methods A controlled intervention study with a follow-up period of 10 months was performed among 202 bricklayers from 25 construction companies.
Results The introduction of devices for raised bricklaying decreased the physical load on the lower back and, to a less extent, on the shoulders and upper extremities. Although raised bricklaying had no effect on the number of lifts, decreases in trunk bending lowered the biomechanical moment. The results showed no decrease in reported musculoskeletal symptoms as a result of the adoption of raised bricklaying. Irrespective of the reason(s), the percentage of bricklayers in the intervention group reporting sickness absence was significantly lower than the same percentage in the control group. The results also showed that, in general, the bricklayers in this study were very satisfied with the use of devices for raised bricklaying.
Conclusions Controlled intervention studies on ergonomic improvements are rare. This study shows that the introduction of an ergonomic improvement in the construction industry may reduce physical load and the incidence of sickness absence.

Key terms back pain; ergonomics; intervention; physical load; raised bricklaying; sickness absence.

Approximately 20 000 bricklayers and 7000 bricklayers' assistants are currently employed in the construction industry in The Netherlands. These workers comprise 20% of the total workforce in the construction industry. In general, bricklayers work in teams consisting of one assistant and three bricklayers. The main task for a bricklayers' assistant is to transport bricks and mortar to bricklayers. The job of the bricklayers is to pick up bricks and place them in the wall, together with mortar. As described by Jørgensen et al (1), bricklaying is heavy work. Positioned between the place in which the bricks are set out and the wall that is being built, bricklayers lay between 800 and 1000 bricks each workday. A bricklayer must therefore frequently bend and rotate at the trunk, and this movement can be regarded as the main physical workload problem (2, 3). A study by Jäger and his colleagues (4) showed that lumbar load during bricklaying (as indicated by the moment of force and the force at the lumbosacral disc) was unacceptably heavy when bricks were stacked at a height between 0 and 20 inches (0–50.8 cm) from the floor (4). When building low walls, bricklayers spend up to 75% of the total duration of their activity in an inclined posture (5). This percentage decreases with wall height by between 20% and 25% (5).

There is ample evidence that frequent bending and rotation of the trunk and lifting at work carries a high risk for back pain (6–10). Disorders of the neck and shoulders can result from frequent bending of the neck and work with the arms elevated (11–13). The Panel on Musculoskeletal Disorders and the Workplace (14) confirmed the existence of a clear relationship between back disorders and physical load (ie, manual materials handling, load moment, frequent bending and twisting, heavy physical work, and whole-body vibration). Repetition, force, and vibration are particularly important work-related factors contributing to disorders of the upper extremities. In the long term, therefore, reducing the extent of bending at the trunk and work with elevated arms is likely to help decrease the incidence of musculoskeletal complaints and sickness absence in bricklaying.

A review by Linton & Van Tulder (15), however, did not identify any controlled ergonomic intervention

1 Erasmus Medical Center, Department of General Practice, Rotterdam, The Netherlands.
2 TNO Work and Employment, Hoofddorp, The Netherlands.
3 Body@Work: Research Center Physical Activity, Work and Health, TNO and VU University Medical Center (EMGO Institute), Amsterdam, The Netherlands.

Correspondence to: TNO Work and Employment, Dr PM Bongers, PO Box 718, 2130 AS Hoofddorp, The Netherlands. [E-mail: P.Bongers@Arbeid.TNO.nl]

in the construction industry. In a controlled study, Parenmark et al (16) identified a 20% reduction in sickness absence as a result of ergonomic intervention by employees at a chain saw factory. A controlled intervention study by Ketola and her colleagues (17) showed that an intensive ergonomics approach reduced the level of discomfort in work with a video display unit.

In The Netherlands, the Bricklayers Contractor Society, the Royal Dutch Brick Manufacturers, and the Dutch Society of Subcontractors in the Construction Industry have cooperated with TNO Construction to develop a new method for bricklaying, which is called “raised bricklaying”. In most cases, raised bricklaying involves placing stools on the scaffolding to raise the bricks and mortar approximately 20 inches (50.8 cm) above the floor, while the bricklayer stands on the floor (figure 1). In some cases, scaffoldings with split floors were also introduced that allowed the boards to be placed at varying heights between the scaffolding floors, or “consoles” (figure 2). Height-adjustable (“hoist-console”) scaffoldings that can be raised according to the height of the wall were introduced as well.

Three studies have been conducted in The Netherlands that investigated the workload of bricklayers. Vink & Koningsveld (18) used a “laboratory” setting to test oxygen uptake, discomfort, and back loading in three situations. Studies by Vink and his colleagues (19) and by van der Molen and his colleagues (20) examined the short-term effects of physical workload and local discomfort in the back and shoulders in the context of raised bricklaying. Using small samples (ranging from 3 to 12 bricklayers), these studies concluded that raised bricklaying reduces the workload on the back and shoulders, as well as perceived discomfort, in the short term. The long-term effects of raised bricklaying on musculoskeletal complaints, sickness absence, and job satisfaction in larger samples, however, have not yet been studied.

The aim of this study was, therefore, to investigate whether the implementation of devices for raised bricklaying in the field results in long-term decreases in the physical workload on the lower back, shoulders and arms, decreases in the number of reported musculoskeletal complaints and sickness absence, or increases in job satisfaction among bricklayers.

Study population and methods

Study population

Sixty bricklaying teams from 25 bricklaying firms participated in the study, the total study population consisting of 202 bricklayers. At the start of the study, 130 bricklayers were assigned to the control group and 72 to the intervention group. The companies in the intervention group were committed to the implementation of raised bricklaying. Registration of activities during the 10-month follow-up period, however, showed that 28 bricklayers had not implemented raised bricklaying. These bricklayers were therefore excluded from the intervention group, and the number of bricklayers in this group was, therefore, reduced to 44. The 28 bricklayers were then assigned to the control group, bringing the total in that group to 158.

Raised bricklaying was used in the intervention group for more than half of the worktime during the follow-up period. The reasons that bricklaying firms gave for not adopting devices for raised bricklaying at all, or not all the time, included the following: (i) cost of the devices, (ii) contractor decisions on the materials used (eg, scaffolds, cranes), and (iii) too little communication between contractors and bricklaying firms concerning the desirability of raised bricklaying.

At baseline, there were few differences between the intervention and control groups. The mean age of the

Figure 1. Raised bricklaying with stools.

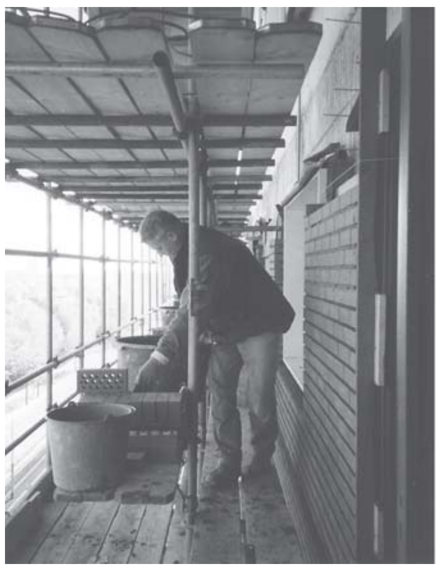

Figure 2. Raised bricklaying with consoles.

participating bricklayers was 38 years, and they had all finished primary school and vocational training. Most of the bricklayers in the intervention group were working in industrialized areas, however, while this was the minority in the control group. As shown in table 1, the response to the questionnaire at baseline was 89% (N=39) in the intervention group and 75% (N=119) in the control group.

The baseline and 10-month follow-up measurements at the workplace were taken for one bricklayer for each team in the intervention group (N=11) and for one bricklayer from each of approximately half of the teams in the control group (N=20). Due to this procedure, data on physical workload were gathered for 41 bricklayers in the intervention group and for 76 bricklayers in the control group. Due to missing values, the numbers on specific items from the baseline and follow-up measurements and the questionnaires may vary.

Design

The new raised bricklaying method was implemented separately in each bricklaying firm. It was therefore not possible to distribute the participating bricklayers randomly over the intervention and control groups. In addition, the investments required for acquiring the devices for raised bricklaying precluded the random distribution of the participating bricklaying firms across conditions. Moreover, effective randomization would have required the participation of more bricklaying firms. Instead of a true randomized clinical trial, therefore, a controlled longitudinal intervention study was conducted with measurements before and after the intervention, using a comparable control group. The baseline measurements (before the intervention) were taken between July of 1997 and March of 1998 by the bricklaying firms that intended to implement raised bricklaying. During the same period, baseline measurements were taken in bricklaying firms that had no intention of implementing raised bricklaying. The follow-up measurements were taken 10 months after the baseline, between June of 1998 and April of 1999, in both the intervention and control groups.

Table 1. Questionnaire response rate and measurement data at baseline and in the follow-up.

	Intervention group (N=44)		Control group (N=158)	
	Rate	%	Rate	%
Response to questionnaire at baseline	39	89	119	75
Response to questionnaire at baseline and follow-up	30	68	67	42
Measurement of lifting at baseline and follow-up	41	93	76	48
Measurement of bending trunk at baseline and follow-up	38	86	67	42
Measurement of elevating arms at baseline and follow-up	41	93	75	47

Assessment of physical workload

The physical load at work was measured for one bricklayer in a team, and the data were extrapolated to the other bricklayers within the same team. The measurements were taken according to a standard protocol. The physical workload for each task was assessed by means of a 10-minute video recording, along with measurements of forces at the workplace. An assessment of the amount of worktime spent with the trunk in flexion of >30 degrees or >60 degrees and of the amount of worktime spent with the arms in elevation of >30 degrees or >60 degrees was based on observations from the video recordings from each task. Extensive prior measurements have indicated that flexion of >30 degrees provides a better contrast between workers than does flexion of >20 degrees (21). The frequency of lifts and corresponding weights, measured at the workplace, were observed directly, using the Task Recording and Analysis on Computer system (TRAC system) (22).

The bricklaying tasks that were measured were as follows: preparation for laying bricks, bricklaying, applying insulating material, and cleaning up. The duration of the various bricklayers' tasks were also observed directly with the TRAC system for an entire workday. The frequency and duration of the load variables for each task, which were based on the measurements of task duration, were converted to a daily dose and presented as the percentage of a full 8-hour workday. All the measurements regarding physical workload at baseline were repeated for each of the same bricklayers 10 months after the intervention.

Musculoskeletal complaints

The 10-month prevalence of musculoskeletal complaints of the lower back, shoulders, and arms was measured using a Dutch adaptation of a Nordic questionnaire (23, 24). The bricklayers used a self-administered questionnaire to report all of the back, shoulder, or arm complaints that they had experienced in the past 10 months. The questionnaire asked the following question: "During the last 10 months, did you have trouble (pain, complaints) with your neck, upper back, lower back, left shoulder, right shoulder, or various other musculoskeletal regions?" The question was accompanied by an illustration of the regions on a sketch of a manikin. The bricklayers could choose from the following responses: "no, never", "yes, sometimes", "yes, regularly", and "yes, prolonged". For complaints concerning the lower back (low-back complaints), shoulders (shoulder complaints), elbow (elbow complaints), and wrist or hand

(hand–wrist complaints), responses of “yes, regularly” or “yes, prolonged” were identified as cases.

Sickness absence

The bricklayers reported sickness absence by answering the following open-ended questions in a self-administered questionnaire: “In the last 10 months, how many times did you report yourself absent from work?” and “In the last 10 months, how many days (total) did you report yourself absent from work?”

Job satisfaction

Job satisfaction was measured by the Work APGAR questionnaire (25). The bricklayers’ opinions of working with devices for raised bricklaying were also assessed with a self-administered questionnaire.

Statistical analysis

The changes in the effect variables between the baseline and follow-up measurements in the intervention group were compared with corresponding data from the control group. The differences between the intervention group and the control group were tested for statistical significance (α=0.05), using a multivariate analysis of variance with repeated measurements.

Results

Use of raised bricklaying devices

As shown in table 2, most of the bricklayers strongly favored the use of raised bricklaying devices.

The bricklayers reported that the quality of their work did not decrease, but either kept pace or increased, depending on the kind of device used. The advantages that they reported included a perceived increase in productivity and self-reported reduction of the physical load on the back. The disadvantages that they reported included fuller scaffolds and an increase in the amount of equipment that had to be transported.

Physical workload

As shown in table 3, the percentage of the workday spent with the trunk flexed more than 30 degrees was reduced by 20% (from 60% to 40% of the workday) in the intervention group. The control group also showed a slight reduction in workhours with the back bent by more than 30 degrees, but the reduction was only by 9% (from 62% to 53%). The difference between the reduction in trunk flexion experienced by the intervention group and that experienced by the control group was statistically significant. In other words, the use of devices for raised bricklaying decreased the time spent working with the trunk flexed >30 degrees from an average of 3.5 hours to an average of 3.0 hours during a typical workday.

The time working with the trunk flexed >60 degrees was reduced in the intervention group by 17% (from 38% to 21% of the workday). The control group experienced a reduction of only 6% (from 41% to 35% of the workday). These results indicate that the use of devices for raised bricklaying decreased the amount of time spent with the trunk flexed >60 degrees from an average of 2.0 hours to an average of 1.3 hours in a typical workday.

In the intervention group, the time working with the arms elevated >30 degrees was reduced by 8% (from 67% to 59% of the workday). The control group

Table 2. Level of support for using devices for raised bricklaying. Responses to the question, “Do you support using devices for raised bricklaying?”.

Device	Not at all		Some		Much	
	N	%	N	%	N	%
Stools	2	5	8	19	33	77
Consoles	1	5	7	35	12	60
Hoist-console scaffolding	0	0	2	12	15	88

Table 3. Percentage and duration of several postures of the back and arms at baseline and after 10 months of follow-up in the intervention (N=41) and control (N=76) groups. (° = degrees, B = baseline, F = follow-up, C = change)

Group	Back >30° flexion						Back >60° flexion						Arm >30° elevated						Arm >60° elevated						Number of lifts during a day >0 kg		
	Workhours (%)			Duration (minutes)			Workhours (%)			Duration (minutes)			Workhours (%)			Duration (minutes)			Workhours (%)			Duration (minutes)					
	B	F	C	B	F	C	B	F	C	B	F	C	B	F	C	B	F	C	B	F	C	B	F	C	B	F	C
Intervention	60	40	−20	203	171	−32	38	21	−17	127	87	−40	67	59	−8	223	251	+28	30	22	−8	99	95	−4	1075	962	−113
Control	62	53	−9	220	228	+8	41	35	−6	146	151	+5	68	69	+1	240	296	+56	32	30	−2	116	129	+13	1137	826	−311
P-value	0.001			0.001			0.001			0.001			0.001			0.01			0.01			0.03			0.09		

experienced a slight increase of 1% (from 68% to 69% of the workday) in the amount of time spent working with the arms elevated. In comparison with the control group, the bricklayers in the intervention group worked 30 fewer minutes with their arms elevated >30 degrees and 20 fewer minutes with the arms elevated >60 degrees during a typical workday. All of these differences were statistically significant.

The use of devices for raised bricklaying had no effect on the number of lifts during a workday. As a result of raised bricklaying, however, the vertical distance of lifting decreased. This decrease reduced the amount of trunk bending, which subsequently decreased the biomechanical moment on the lower back during the lifts.

Musculoskeletal complaints

Musculoskeletal complaints included reports of problems with the back, shoulders, or hands. As shown in table 4, there were no statistically significant differences between the number of such complaints reported by bricklayers in the intervention group and those reported by bricklayers in the control group.

Most of the complaints were reported at similar levels during the baseline and follow-up. Although the intervention group reported more shoulder complaints in the follow-up than they had reported at baseline, the difference from the control group was not statistically significant.

Sickness absence

As shown in table 5, the number of bricklayers reporting sickness absence in the intervention group at least once in the last 10 months decreased by 20% (from 53% to 33%). In contrast, the number of bricklayers in the control group reporting sickness absence increased by 7% (from 40% to 47%). The difference between the intervention and control groups was statistically significant.

The reported frequency of sickness absence periods (irrespective of the reason) among the bricklayers in the intervention group decreased significantly, while the frequency of sickness absence in the control group increased. This result may imply that the introduction of devices for raised bricklaying reduced both the number of employees reporting sickness absence and the frequency of sickness absence for each employee. The effects on the reported duration of sickness absence and sickness absence due to back complaints were similar, but they were less pronounced and not statistically significant. Bricklayers in both the intervention and control groups reported hardly any sick leave due to shoulder complaints.

Job satisfaction

Almost all the bricklayers were satisfied with their work, both before and after the intervention. There were no differences between the intervention and control groups in this respect.

Table 4. Percentage of reported complaints among the bricklayers at baseline and after 10 months of follow-up in the intervention (N=30) and the control (N=67) groups. (B = baseline, F = follow-up, C = change)

Group	Low-back complaints (%)			Shoulder complaints (%)			Hand–wrist complaints (%)			Low-back complaints due to work (%)			Shoulder complaints due to work (%)			Hand–wrist complaints due to work (%)		
	B	F	C	B	F	C	B	F	C	B	F	C	B	F	C	B	F	C
Intervention	54	54	0	11	22	+11	27	31	+4	50	50	0	11	11	0	27	23	–4
Control	51	56	+5	16	19	+3	25	27	+2	44	49	+5	10	13	+3	17	23	+6
P-value	0.65			0.46			0.95			0.68			0.68			0.40		

Table 5. Reported sickness absence of bricklayers at baseline and after 10 months of follow-up in the intervention (N=30) and the control (N=67) groups. (B = baseline, F = follow-up, C = change)

Group	Percentage of reporting any sickness absence in the past 10 months			Frequency of sickness absence [a]			Average duration of sickness absence (days)			Average duration of sickness absence due to back problems			Average duration of sickness absence due to shoulder problems		
	B	F	C	B	F	C	B	F	C	B	F	C	B	F	C
Intervention	53	33	–20	0.64	0.29	–0.35	11.8	4.8	–7.0	3.2	0.2	–3.0	0.0	0.0	0.0
Control	40	47	+7	0.50	0.64	+0.14	7.6	10.8	+3.2	3.1	2.9	–0.2	0.0	1.3	+1.3
P-value	0.03			0.01			0.09			0.47			0.26		

[a] Number of episodes per person in the past 10 months.

Discussion

The use of devices for raised bricklaying reduced the physical load on the lower back, and, to a less extent, the physical load on the shoulders and upper extremities. Raised bricklaying had no significant effect, however, on the number of lifts or on job satisfaction. The results also showed no decrease in reports of musculoskeletal complaints, but raised bricklaying did appear to decrease sickness absence, irrespective of the reason(s).

Comparability of the intervention and control groups

The intervention, raised bricklaying, was implemented by bricklaying firms that had already decided to introduce the use of such devices. For this reason, these firms may form a selective group. On the other hand, the bricklayers in the intervention and control groups showed few initial differences, with the exception of the fact that bricklayers in the intervention group had higher monthly salaries and were working in more industrialized areas. There is no reason to believe that these minor differences influenced the results.

Allocation to the intervention and control groups

Adding the bricklayers that did not use the devices for raised bricklaying to the control group may have reduced the contrast between the two groups. This step was necessary, however, to maintain the power of the statistical analyses. In order to assess the results, we performed similar analyses comparing the original intervention group with the original control group. These "intention to treat" analyses produced essentially the same results.

Follow-up

It is possible that the follow-up period of 10 months was too short for the reduced physical load to have an impact on the reported musculoskeletal symptoms. Because not all of the bricklayers in the intervention group used raised bricklaying all the time, the results could have underestimated the benefit of raised bricklaying.

Full implementation of this new method, however, may prove difficult in practice, and its desirable effects in practice will be accordingly limited, as are the results of our study.

The fact that the results showed a reduction in sickness absence but not in complaints may reflect the fact that reducing physical workload can enable work with mild or moderate complaints or hasten return to work after a period of sick leave. This effect has no time lapse after physical load is decreased.

Measurement of physical load

This study applied a task-based group measurement strategy to assess physical load, using direct observation of video recordings as the main method. Two previous studies compared various measurement methods and strategies for assessing physical load in the construction industry (26, 27). Paquet and his colleagues (26) concluded that, under appropriate conditions, discrete observations can be used to obtain reasonably accurate estimates of exposure frequency for broad categories of certain body postures. Buchholz and his colleagues (27) showed the necessity of task-based exposure assessment strategies to the proper assessment of ergonomic risk profiles for such nonstructural jobs as construction. They also showed a considerable variability in posture for the same worker and between workers. A group-measurement approach to assessing physical load is therefore preferable (28). Bricklaying teams are likely to constitute an effective grouping with a fair between-group contrast and little within-group contrast, since they work at the same construction site with the same material.

Literature

De Jong and her colleagues (29) presented some additional results of our study in another paper, which concerned only a selection of the self-reported questionnaire data and none of the data measuring physical load at the workplace. The results showed that most of the bricklayers in the intervention group attributed the reduction in physical load to the use of stools (75%), consoles (56%), and hoist-console scaffolding (75%).

A recent study by Koningsveld and his colleagues (30), among 567 bricklayers in The Netherlands, showed that bricklayers were very satisfied with devices for raised bricklaying, although the actual use of these devices was limited. The most important reason for not using these devices was that they were not present at the construction site. The bricklayers in our study reported more back complaints than did the bricklayers in the study by Koningsveld et al (30) (54% versus 41%) and just as many shoulder complaints (22%).

Concluding remarks

The introduction of devices for raised bricklaying reduced physical load on the lower back, and, to a less extent, on the shoulders and upper extremities. In addition, the bricklayers who used devices for raised bricklaying reported taking less sick leave. No reduction in musculoskeletal symptoms was observed. The bricklayers were very satisfied with the use of the devices for raised bricklaying. This controlled intervention study shows that the introduction of ergonomic improvements in the construction industry is beneficial.

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