

# Evaluating Individual Physical Work Ability: Examples from the Construction Industry

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**Abstract:** *Background:* Actively searching for musculoskeletal complaints and reduced physical work ability is a key element in a job-specific workers' health surveillance programme for construction workers. The aims of this multiple-case study were 1) to explore the added value of physical performance tests in such a programme among bricklayers and supervisors and 2) to assess if and how these tests facilitate the recommendation of job-specific preventive actions in addition to information gathered by questionnaires.

*Methods:* Musculoskeletal complaints and reduced physical work ability were evaluated by means of a questionnaire and physical performance tests. These tests were designed in such a way that they closely resembled activities in the real working situation. Job-specific activities were performed and individual working posture and working technique were observed by an ergonomist.

*Results:* The present multiple case study consists of a qualitative analysis of the information gathered during a job-specific workers' health surveillance. We included four participants: two bricklayers and two construction supervisors. We found that the information gathered during the tests supplemented the information from the questionnaire. Furthermore, the tests seemed of added value in the assessment of musculoskeletal complaints and reduced physical work ability and in observing working posture and working technique.

*Conclusions:* Standardised physical performance tests, based on a simulation of relevant job activities, are of added value in evaluating and gathering knowledge about construction workers' individual physical work ability. These tests provide the opportunity to observe restrictions in task performance, working posture and technique and to recommend job-specific preventive interventions when necessary.

**Keywords:** Occupational health care, surveillance, physical test, musculoskeletal disorders.

## INTRODUCTION

Construction workers are exposed to high occupational demands [1]. Injuries and adverse health effects such as musculoskeletal complaints may result from these demands [2]. The construction industry is known for a high prevalence of musculoskeletal complaints [3-5], often these are perceived as work-related and lead to substantial problems during work [6]. Due to musculoskeletal complaints [7] or ageing [8], the workers' handling (maximal) capacities are reduced, resulting in even more problems in meeting the physical job demands.

Actively searching for signs of musculoskeletal problems, limitations in performing work tasks and reduced work ability are therefore some of the key elements in a workers' health surveillance programme for construction workers. In such a programme, the focus should not be solely on early

signs of complaints, but also on assessing physical work ability and estimating the scope and nature of possible limitations or restrictions in meeting high physical job demands. Information on work ability [9], work limitations [10] or work functioning [11] is often gathered by questionnaires. However, the usefulness of other methods in gathering knowledge on physical work ability should be explored. In occupations with high physical demands, physical performance tests seem a rational method to consider. The evaluation of individual physical work ability by means of tests has already been applied in the contexts of pre-employment evaluations [12-14], making decisions regarding return to work after injury [15], disability claim procedures [16] and in a workers' health surveillance programme for fire fighters [17]. Up to now, no physical performance tests exist for the evaluation of individual physical work ability in a workers' health surveillance programme for specific construction occupations.

Furthermore, when aimed at identifying workers with reduced physical work ability, it is valuable that the measurements and tests closely resemble the tasks and activities in the working environment [18]. A standardised work simulation seems appropriate when evaluating physical abilities in

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a job-specific manner [19]. In addition to the advantage of high content validity, this type of physical performance testing provides information both about the physical abilities of the worker and any potentially effective interventions, such as appropriate ergonomic training or workplace redesign. As McDermott *et al.* [20] pointed out, such interventions may be most effective if they are tailored to the needs of the individual worker and the demands of the specific industry and occupational tasks. Job-specific physical performance tests seem therefore a helpful starting point to advance the mobilization of ergonomic measures among construction workers.

In the present study we aimed at exploring the value of job-specific physical performance tests for evaluating physical work ability and providing detailed information on unique examples. Therefore, we chose a multiple-case study format. This qualitative design allowed us to describe details and examples which are likely to be lost in a quantitative survey [21, 22].

The purpose of the present multiple case study involving construction workers, is to explore the following:

- 1) the added value of job-specific physical performance tests in
  - evaluating signs of musculoskeletal complaints;
  - assessing physical work ability;
  - evaluating working posture and working technique;
 in addition to information gathered by questionnaires;
- 2) whether and how tests can facilitate the recommendation of preventive actions.

## METHODS

A multiple-case study was developed to explore the added value of physical performance tests in a health surveillance programme for construction workers. The present study was embedded in a larger study that examined the effectiveness of a job-specific workers' health surveillance programme for construction workers [23].

### Participants

A total of 77 construction workers participated in the job-specific WHS from January until July 2012 in the Netherlands. Among the participants were 33 bricklayers (all men, median age 55 years, IQR 11) and 44 construction supervisors (all men, median age 51 years, IQR 16). All participating bricklayers and construction supervisors were 1) primarily bricklayer or construction supervisor; 2) male; 3) able to read, speak and write Dutch sufficiently well and 4) not planning to leave their occupation due to resignation or (early) retirement.

Because the present multiple-case study was exploratory, we selected four cases on a purposive basis from the population, two bricklayers and two construction supervisors. We sought for representative examples of workers with and without self-reported musculoskeletal complaints. To be selected for the multiple-case study, participants had to have either absence of any self-reported musculoskeletal complaints or presence of complaints of the back, knee or neck

(for supervisors) or of the back, shoulder or elbow (for bricklayers). Previous results showed that complaints involving these body areas were the most prevalent in these occupations [24].

Four eligible workers were contacted by the first author in writing to ask for consent to use the relevant data gathered during their health surveillance. Confidentiality was ensured by a written declaration that researchers would not divulge any of the information that they received in the course of the study in any form, that might make it possible to link it to the individual participants. All participants gave their written consent. When designing the study in which the present study is embedded, the Medical Ethics Committee of the institution, the Academic Medical Centre/University of Amsterdam, the Netherlands, decided that medical ethical approval was not obliged.

Three ergonomists and three occupational physicians (OPs) with expertise in the construction industry participated in carrying out the study. These ergonomists conducted the physical performance tests. They were trained in carrying out the tests conform protocol. The occupational physicians counseled the workers based on the results according to a structured protocol.

### Procedure

After the workers had signed up for attending their health surveillance, they received a questionnaire at their home address. They were asked to fill in this questionnaire before attending the occupational health office. At the occupational health office, they performed the physical performance tests under the guidance of an ergonomist. The occupational physician completed the health surveillance consecutively with a consultation with each worker by using the information from both the questionnaire and the physical performance test. The consultation was completed the same day.

### Measurements

We measured physical abilities by assessing complaints of the musculoskeletal system per bodily region and restrictions in performing occupational physical activities. The instruments used were a questionnaire and physical performance tests.

### Questionnaire

We used an adapted version of a questionnaire on MSDs, which has been in previous research among construction workers [24-26] and among other professions [27]. For every region of the body (shoulder and upper arm, elbow, lower arm and wrist, hand, hip, upper leg, knee, lower leg and ankle, foot, neck, back), participants were asked to indicate whether they have had regular or long-lasting complaints during the last six months (yes/no). When the answer was yes, the worker was asked which body region (neck, upper back, shoulder, elbow, forearm, wrist/hand, lower back, hip, knee, lower leg, ankle/foot) the complaints involved, whether they experienced a restriction in performing their job (yes/no); and whether they believed the complaint(s) were a consequence of their work (yes/no). Next, the bricklayers were asked about the following tasks relevant to their occupation: "Do you currently have difficulties with pro-

longed standing / working above shoulder height / prolonged working with a bent or twisted back / lifting and/or carrying blocks / picking up and laying bricks / working with the trowel / repetitive hand-arm movements / climbing stairs / climbing ladders or scaffolds / working at heights / maintaining balance at all circumstances?" (yes/no for each item). Similarly, construction supervisors were asked: "Do you have problems with climbing stairs / climbing ladders or scaffolds / working at heights / maintaining balance at all circumstances / walking across the construction site?" (Yes/no). A yes answer for regular complaints of the musculoskeletal system or difficulties with occupation-specific task performance was considered a sign of impaired physical abilities.

### **Physical Performance Tests**

Physical work abilities were measured during tests resembling physically demanding working situations. The intensity, frequency and duration of the functional tests were based on information from the literature [28], expert knowledge (provided under the auspices of the Health and Safety Institute for the Construction Industry) and the Dutch Occupational Health and Safety Act [29]. For bricklayers, the measured, estimated or maximally allowed load for a full work day was converted to a 90-minute test protocol (see Fig. 1). Bricklayers and supervisors were observed while climbing a 7 m ladder once and walking one flight of stairs up and down six times. For supervisors, climbing the stairs up and down six times was followed by 5 min walking, which was repeated once.

The workers were instructed to perform the tests at their own, regular working pace or at the imposed pace (see Fig. 1). They were asked to perform the tests without becoming unusually tired, weakened, overheated or out of breath. During the tests an ergonomist observed each worker for possible limitations or bodily compensation in the task execution. The ergonomist asked the worker after every part of the test whether he had experienced any discomfort or pain (on a scale from 0 to 10, 0 = no pain, 10 = a lot of pain) or restrictions (on a scale from 0 to 10, 0 = no restrictions, 10 = a lot of restrictions). With respect to the bricklayers, the ergonomist asked about or observed the following factors: lifting (asymmetrical, heavy), deep bending, bending and twisting, kneeling, working with raised/tensed shoulders, working and lifting above shoulder height, lack of variation in working posture, and unilateral physical stress. Based on the observations and findings during the tests, the ergonomist made, if necessary, a recommendation to the occupational physician concerning possible preventive actions, such as a workplace visit, workplace adjustment, another working method or (temporarily) adapted working and resting hours. The ergonomist reported his findings on a structured form.

### **Evaluation of Physical Abilities and Recommendations**

Based on the results and the consultation with the worker, the occupational physician evaluated the physical abilities of the worker as either 'reduced' or 'not reduced' and recommended the worker, if necessary, potential effective preventive actions. Recommendations of the OP were based on a structured protocol. Preventive actions were classified into the following domains: i) more detailed examina-

tion of the complaint or risk factor (for example, a follow-up visit to a general practitioner, or a workplace visit); ii) individual preventive actions aimed at reducing risk factors or increasing work capacity (for example, visiting a physical therapist, starting a training program) and iii) preventive actions taken at the technical or organisational level (for example workplace adjustments or training and education).

### **Analysis**

Relevant data was collected for describing the cases through a qualitative analysis of the following documents for each participant: the questionnaire filled out by the participant and the report prepared by the ergonomist concerning the physical performance tests, which are further described in more detail in (Fig. 1). Analyses of the documents were performed by the first author.

## **RESULTS**

The cases presented below are typical examples of the findings in the total sample of participants. Among the total sample, 70% (23/33) of the bricklayers reported musculoskeletal complaints or restrictions during work, compared to 55% (24/44) of the supervisors. For 32% (25/77) of the workers there was no agreement between the signs found on the questionnaire and physical tests. In three workers musculoskeletal problems arose during the test, but were not reported in the questions. Ultimately, the OPs decided that for 31% (24/77) of the workers the physical abilities were reduced.

### **Case 1. Bricklayer Number 1**

#### **Case Description**

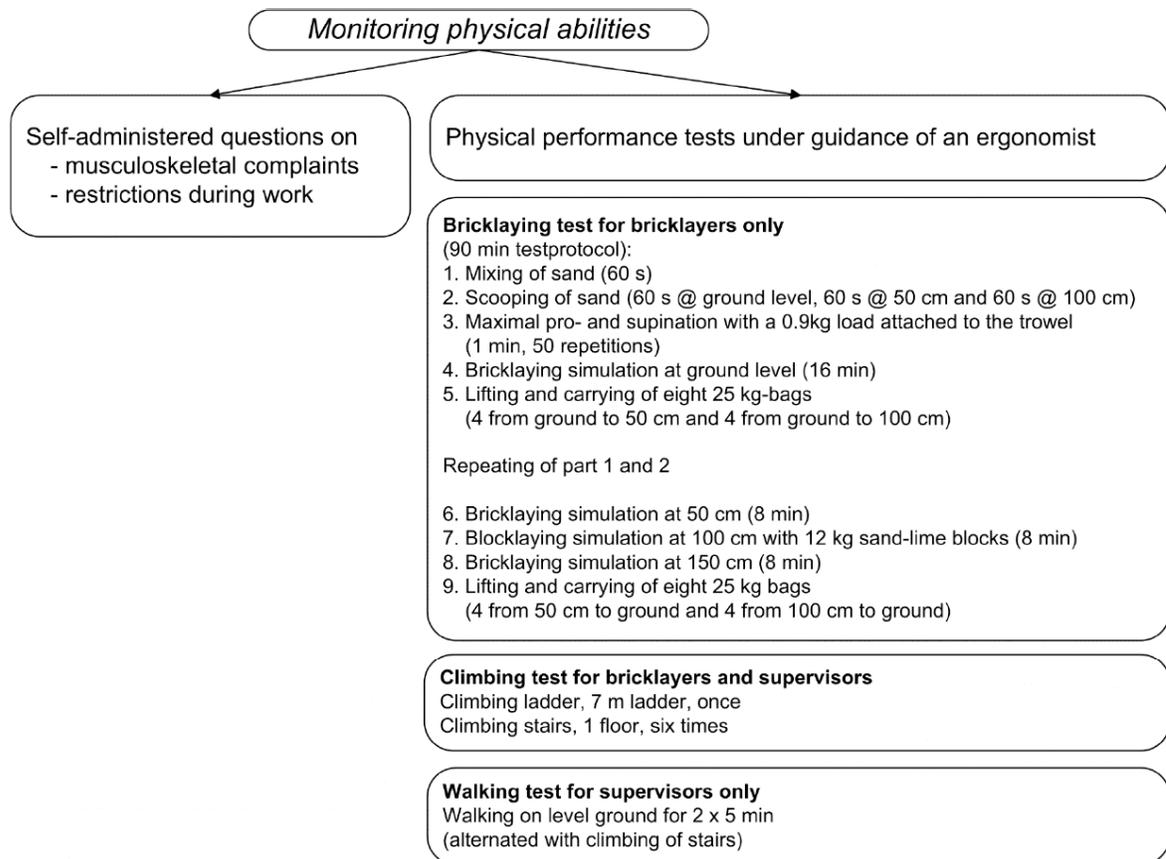
This subject was a 54-year old male, with 37 years experience in the construction industry as a bricklayer. He worked at a specialised company for 40 hours per week. He did not smoke and felt healthy.

#### **Information from the Questionnaire**

This bricklayer reported complaints involving his neck. In his opinion, these complaints were (partly) due to his work. In the questionnaire he reported that he had no difficulties or restrictions in performing the daily tasks and activities at work.

#### **Information from the Physical Performance Tests**

During the tests, complaints or restrictions of the neck, low back, elbows, and hip were mentioned. This subject reported that he had complaints involving both his neck and low back at the end of a regular working day. From the separate parts of the test it was found that the bricklayer had complaints involving the elbow during repetitive maximal pro- and supination. This subject graded his elbow pain at three, on a scale from 0 to 10. The complaints resulted from working with a brick-clasp. Furthermore, he reported right hip complaints during the handling of bricks below knee level (laying bricks from ground to ground level and from a 40 cm raise to ground level). The pain was graded at 4, on a scale from 0 to 10. The ergonomist observed the working



**Fig. (1).** Content of monitoring job-specific physical abilities and the content of each test.

posture during this task and observed that the load on the right hip could be reduced by optimising the working position. The positioning of the mortar was likely to play an important role in this optimisation. No restrictions or complaints were reported during the lifting and carrying of 25-kg bags with mortar, but the ergonomist observed a risk for the low back in the lifting technique.

#### **Physical Work Ability Evaluation and Recommendations**

The ergonomist discussed with the bricklayer the following aspects of his working posture and working technique: the repetitive hand-arm demands, bending and twisting, and lifting. Based on the findings during the test, the ergonomist advised the occupational physician to recommend a workplace visit, primarily aimed at reducing the physical stress on the right hip. In his examination and counseling the occupational physician was provided with information on musculoskeletal complaints from the self-administered questionnaire and with information regarding restrictions from the tests. The occupational physician evaluated the physical work ability as reduced and advised a workplace visit by the occupational physical therapist.

#### **Case 2. Bricklayers Number 2**

##### **Case Description**

This subject was a 46-years-old bricklayer with 28 years experience in the trade. He had a 40 hour work week. He smoked, but felt healthy.

##### **Information from the Questionnaire**

This bricklayer reported complaints involving the following body regions: shoulder, lower arm, wrist, knee and ankle/foot. In the questionnaire, he did not report any difficulties or restrictions in performing the daily tasks and activities at work.

##### **Information from the Physical Performance Tests**

During the tests, the bricklayer did not report any complaints or restrictions, except for a little discomfort in his shoulder during the handling of bricks and blocks at intermediate and high levels. This subject graded his discomfort at one, on a scale from 0 to 10. According to the bricklayer himself, this was caused by the load of the trowel and the extra 0.9 kg load attached to it. The ergonomist observed that he has an excellent working technique. He had no restrictions in climbing the stairs or a ladder.

##### **Physical Work Ability Evaluation and Recommendations**

Based on the findings during the test, the ergonomist reported to the occupational physician that the subject perceived little discomfort, but that he had no difficulties in carrying out the tasks and activities in his work. In his examination and counseling the occupational physician was provided with information on musculoskeletal complaints from the self-administered questionnaire and with the information that no restrictions were observed during the tests. After his examination, the occupational physician recommended individual preventive actions.

### Case 3. Construction Supervisor Number 1

#### Case Description

This subject was a 50-year-old male and had been employed in the construction industry for 32 years, with 11 years in the position of construction supervisor. He worked for 40 hours per week. He smoked, but felt healthy.

#### Information from the Questionnaire

This supervisor reported complaints involving his neck, shoulder, wrist/hand, low back, hip and lower leg. He perceived the complaints of his low back, hip and lower leg to be partly due to his work. In the questionnaire, he did not report any difficulties or restrictions in performing the daily tasks and activities at work.

#### Information from the Physical Performance Tests

During the tests the construction supervisor did not report any physical complaints or restrictions in carrying out the activities.

#### Physical Work Ability Evaluation and Recommendations

Based on the findings during the tests, the ergonomist reported to the occupational physician that the physical ability of the construction supervisor was not reduced and that he had no difficulties in carrying out the tasks and activities in his work. The OP evaluated the physical work ability of the construction supervisor as not reduced and did not recommend preventive actions.

### Case 4: Construction Supervisor Number 2

#### Case Description

The participant was a 40-year old male and had been employed for 23 years in the construction industry as a supervisor in commercial and industrial constructing. At the time of examination, he had been unemployed for less than a year, but not due to disability. When employed, he worked 50 hours per week while he had a 40 hour-contract. He smoked, but felt healthy.

#### Information from the Questionnaire

The construction supervisor did not report any physical complaints in his questionnaire, nor did he report any difficulties or restrictions in performing daily tasks and activities at work.

#### Information from the Physical Performance Tests

During the tests, the construction supervisor did not report any physical complaints or musculoskeletal pain, but he was restricted when he had to walk for 5 minutes at a 5 kmh<sup>-1</sup> pace after climbing the stairs. The ergonomist observed a reduced physical fitness and difficulties with breathing while carrying out the physical activities.

#### Physical Work Ability Evaluation and Recommendations

Based on the findings during the tests, the ergonomist reported to the occupational physician that the energetic ability of the supervisor was reduced. The occupational physician recommended individual preventive actions.

## DISCUSSION

Based on four selected cases, we found that job-specific physical performance tests seem to be of added value in evaluating signs of musculoskeletal complaints and reduced physical work ability. In addition to information gathered by questionnaires, the tests provided an improved understanding of the individual's physical work ability in a specific occupational context and additional job-specific information (e.g. working posture and working technique during bricklaying) (Table 1). It is likely that additional and detailed information provided by an ergonomist may allow for more specific recommendations regarding job-specific preventive actions by the occupational physician within the scope of a workers' health surveillance program.

#### What Can we Learn from these Cases?

Case studies are not designed to provide rigorous scientific evidence, but they can provide valuable and detailed

**Table 1. An Overview of the Health Signs Found on the Questionnaire and the Physical Performance Tests**

| Case | Age (years) - Years in construction | Health sign  | Questionnaire | Tests | Findings of the ergonomist                                    |
|------|-------------------------------------|--------------|---------------|-------|---|
| 1    | 54 - 37                             | complaints   | yes           | yes   | Physical ability reduced                                      |
|      |                                     | restrictions | no            | yes   | Attention to working technique<br>Workplace visit recommended |
| 2    | 46 - 28                             | complaints   | yes           | no    | Physical ability not reduced                                  |
|      |                                     | restrictions | no            | no    | Excellent working technique                                   |
| 3    | 50 - 32                             | complaints   | yes           | no    | Physical ability not reduced                                  |
|      |                                     | restrictions | no            | no    |   |
| 4    | 40 - 23                             | complaints   | no            | no    | Physical (energetic) ability reduced                          |
|      |                                     | restrictions | no            | yes   |   |

Complaints: regular or long-lasting pain, discomfort or complaints in one or more body regions.  
Restrictions: limitations in performing occupational tasks.

information on unique individuals or incidents [21, 22]. We chose a multiple-case study format in order to provide a more complete picture of our strategy to evaluate individual physical work ability. This qualitative design allowed us to describe details and examples of the population at interest. Based on the cases presented a few aspects concerning physical performance testing for construction workers can be highlighted:

First, performance tests allow for a more comprehensive understanding of the physical work ability of workers. As found for cases 2 and 3, reported musculoskeletal complaints do not necessarily lead to restrictions in performing physical tasks. On the other hand, as found for the cases 1 and 4, health complaints or restrictions reported in a self-administered questionnaire do not necessarily correspond with the reported complaints or restrictions during the performance test. Therefore, in a health surveillance programme, both questionnaires and physical tests seem useful in gathering knowledge of health effects and aspects of reduced work ability. However, in addition to physical work ability, other aspects of work ability and health complaints are represented in a workers' health surveillance programme. At the end, the occupational physician has to evaluate, judge and discuss all health signs with the worker and decide which preventive actions are most adequate. As we found in case 2, the occupational physician might find other signs than musculoskeletal signs more relevant to advice and intervene on. The more detailed the information on physical work ability, the more well-founded the evaluation and recommendations of the occupational physician are likely to be.

Second, testing by means of a work simulation allows for an evaluation of the workers' physical work ability and its connection with working posture and applied working technique. Therefore, it seems valuable in determining the individual's physical work ability and needs. As illustrated in case 1, a valid observation of working technique, is only possible when the working method and posture during the test are similar to the real working method and position of the individual worker [30]. Observing a construction worker at the actual construction site might not provide complete information on the risks and potentially effective intervention measures. For a construction worker the risks may vary largely during the day and from day to day as the tasks and the type of work that must be done at a specific moment in the construction process varies. Furthermore, certain risks can not be eliminated, for example the repetitive arm-hand movements for the bricklayer. Therefore it should be assessed whether the worker is able to perform the activity without complaints or restrictions. Hence, we designed standardised tests which cover all essential elements of a particular occupation and which can be performed consecutive in a short period of time at the occupational health service. Furthermore, arranging workplace visits for each construction worker within the scope of a health surveillance would be an extensive and costly undertaking. Additionally, we found it important that the workers could perform the tests in a safe and neutral environment, away from their employer and the construction site. As medical issues might be discussed during the test, we feel that the workplace is not the right entourage, but the occupational health service is.

Third, by having an ergonomic expert participating in the health surveillance programme, next to the occupational physician, the recommendation of potentially effective and job-specific preventive measures is facilitated. As described before, the occupational physician then has more comprehensive, job-specific and individual information to use in their judgment regarding physical work ability and the appropriate interventions. Other professionals than ergonomists could assist in performance testing when they have the required skills and training.

### **Implications for Future Research**

Although our tests are developed to provide qualitative information to the occupational physician, and are not designed to provide quantitative knowledge about physical abilities of individuals, the observations and recommendations should be reliable and reproducible [13]. Therefore, it seems valuable to assess the test-retest reliability and inter-rater reliability of our performance tests.

Along with the strengths and weaknesses of the tests itself, practical considerations should also be explored [13]. A pro is that we were able to implement the tests safely in occupational health care for construction workers [23]. Next to that, the needed materials for the physical performance tests are rather inexpensive (only materials available in a lumberyard were used). On the other hand, it should be kept in mind that developing and implementing analogous tests for all construction occupations will be time consuming and will require financial resources in terms of compensation for the ergonomic personnel and purchase of additional equipment.

Physical performance testing is not a goal in itself, but is one method of medical examination in occupational medicine. When striving for an improvement in quality of workers' health surveillance, the instruments and methods used to gather information of health effects and work ability should be optimised. In physically demanding construction occupations such as the bricklayer profession, adding physical performance tests seems a fruitful approach. It is important to note that we only explored the usefulness of the tests within the scope of health surveillance for construction workers only, but it seems legitimate to study the added value of this type of performance testing in vocational rehabilitation programs or among other relevant occupations.

### **CONCLUSIONS**

Physical performance testing by means of a work simulation, seems to be of value in assessing physical work ability among construction workers. Tests are not a substitution for questions or believed to be a superior method, but as an additional source of information. Information gathered during the performance tests is of added value in interpreting physical complaints and for evaluating restrictions in performing occupational tasks. Overall, physical performance testing allows for an evaluation of job-specific working posture and work techniques and, if necessary, subsequent preventive actions.

### **CONFLICT OF INTEREST**

The author(s) confirm that this article content has no conflicts of interest.

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