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Improvements in Workers' Health through Ergonomic Measures in the Brick Kiln Industry

Dr P R Wadnerkar

Assistant Professor, Mechanical engineering
P R Pote Patil College of engineering and management, Amravati
Mail- ahpparag@gmail.com

Abstract: Traditional kilns in India, which are part of the larger category of unorganised small-scale enterprises, manufacture burnt clay bricks. About 10 million people in India work in burned clay brick kilns, part of the 458 million people that are employed in India's unorganised industry. With over 140,000 brick kilns, India is the second-largest brick production in the world. Despite its economic significance, India's clay brick manufacturing industry is far from cutting-edge; in fact, almost all bricks are still made the old-fashioned way, by hand. There are a lot of boring, routine tasks involved in creating clay bricks. Brick kiln employees often suffer from musculoskeletal problems as a consequence of years of conducting hard labour in the same, uncomfortable positions. Workers in this area are less likely to be aware of the risks of musculoskeletal disorders than those in other labor-intensive fields. Ergonomic treatments for brick kiln employees may reduce the prevalence of work-related musculoskeletal disorders. Ergonomic treatments have been shown to be helpful in a number of studies. Workers in the clay brick industry do a wide variety of manual jobs, but little research has been published on the prevalence of musculoskeletal complaints and the associated postural concerns. Few studies on ergonomic interventions in this field have been published. Therefore, the current study was undertaken to investigate the efficacy of ergonomic treatments in reducing the prevalence of musculoskeletal disorders among manual brick kiln employees.

Keywords: musculoskeletal, ergonomic interventions, postural risks, clay brick

Introduction

Today, worker welfare has become an important topic in both industrialised and developing nations. Workplace safety and worker comfort are widely regarded as crucial to boosting productivity and product quality in most structured industries. Managing the biomechanical and psychological strain at work may help reduce musculoskeletal problems. Despite the extensive literature on occupational health management, this field has received very little attention in the form of ergonomic studies aiming to minimise pertinent difficulties. There have been a few investigations of the brick manufacturing industry in India, with much of the research focused on gauging the health and safety of the female employees in the industry. The following topics were identified as being essential to exploratory study on ergonomic improvements in the brick kiln industry after a thorough literature assessment.

- Very few studies have investigated musculoskeletal symptoms in different body regions among kiln workers.

- The literature lacks significant research related to the association of the prevalence of musculoskeletal issues and risk factors.

- Applications of ergonomic interventions in the brick kiln sector have also not been satisfactorily addressed so far.

Figure 1 depicts a variety of jobs and working circumstances that are done manually during clay brick production. First, the clay is dug out by hand using instruments like spades, mattocks, and shovels. Next, a mallet is used to break the clay into smaller pieces. The second stage involves prepping the clay by soaking it and then mixing it by hand or with a shovel. After the clay has been prepared, it is hand-cut into clots. To prevent the clay from clinging to the moulding box and to promote the burning of brick, a coating of coal dust is sometimes applied on formed clots. Green brick is then drained from the ground and the clot is put into the moulding box. Bricks are piled to dry for a few days, and then they are transported and put in the kiln in preparation for fire. After a few days in the kiln, the bricks are ready to be put into trucks and sent to the market. Workers at the brick kilns are required to stand in one position for up to 10 hours a day, doing a variety of manual jobs. The majority of people who work in this business have a low level of education or none at all, and they have not received any training in safe and healthy workplace practises.

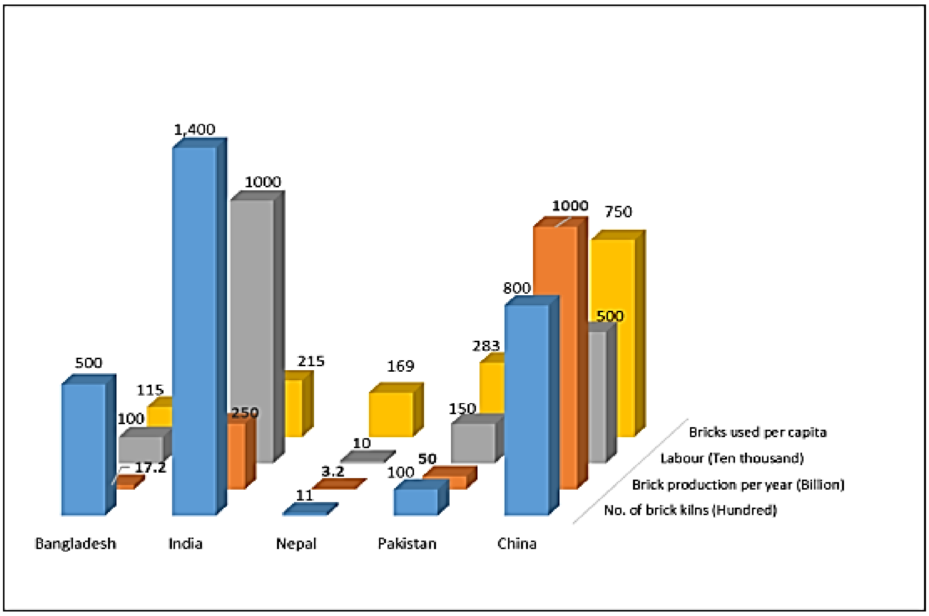

Figure 1: Comparative view of the clay brick industry in various Asian countries (Source: Kamyotra, 2015)

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Clay bricks are extensively utilised as a building material all over the globe. Making bricks out of clay is a time-honored practise. Sun-dried clay bricks were in use as far back as 5,000 years ago, as shown by excavations of ancient civilizations like Harappa and Mohenjodaro. The global infrastructure and construction industry has been expanding at a quicker rate due to developing economies, rising populations, and rising urbanisation. The "Pradhan Mantri Awas Yojana" and "Smart City Projects" programmes run by the Indian government are anticipated to be significant development drivers for the country's brick sector. Traditional and disorganised small-scale enterprises in India create burnt clay bricks. roughly 457.5 million persons in India are employed by the unorganised sector (NCEUS, 2007), with roughly 100 million of them working in burned clay brick kilns. India has more than 1.40 lac brick kilns, making it the world's second biggest brick manufacturer. Of these, 25,000 are located in the northern Indian states of Rajasthan, Haryana, Punjab, and Uttar Pradesh. Figure 1 depicts a regional analysis of the clay brick market throughout Asia, with a focus on India. India produces around 13% of the world's clay bricks. The making of clay bricks in India is vital, but the industry is not as advanced as it might be. In India, the vast majority (99%) of bricks are made by hand, with just 1% made by machines. Various brick-making processes, however, are mechanised and totally automated in industrialised and high-income nations. Making clay bricks requires a variety of laborious tasks, many of which are repetitious and must be done repeatedly while in uncomfortable positions with just basic hand tools.

Ergonomics

Ergonomics is the study of how people interact with their environments when they are working. The name comes from the Greek words ergon (labour) and nomos (rules). "Ergonomics is a field of science concerned with the study of interactions to humans and other elements of a system," (International Ergonomics Association, 2000) and "the profession that applies concepts, concepts, data, and techniques to design in order to optimise human well-being and overall system performance." Ergonomics is both a science that provides basic understanding and a technology that applies that knowledge to the design of work-systems in their broadest meaning. Hardware, software, space, and the interaction of individuals with one another and with social groupings are all considered part of the human-environment system in this perspective

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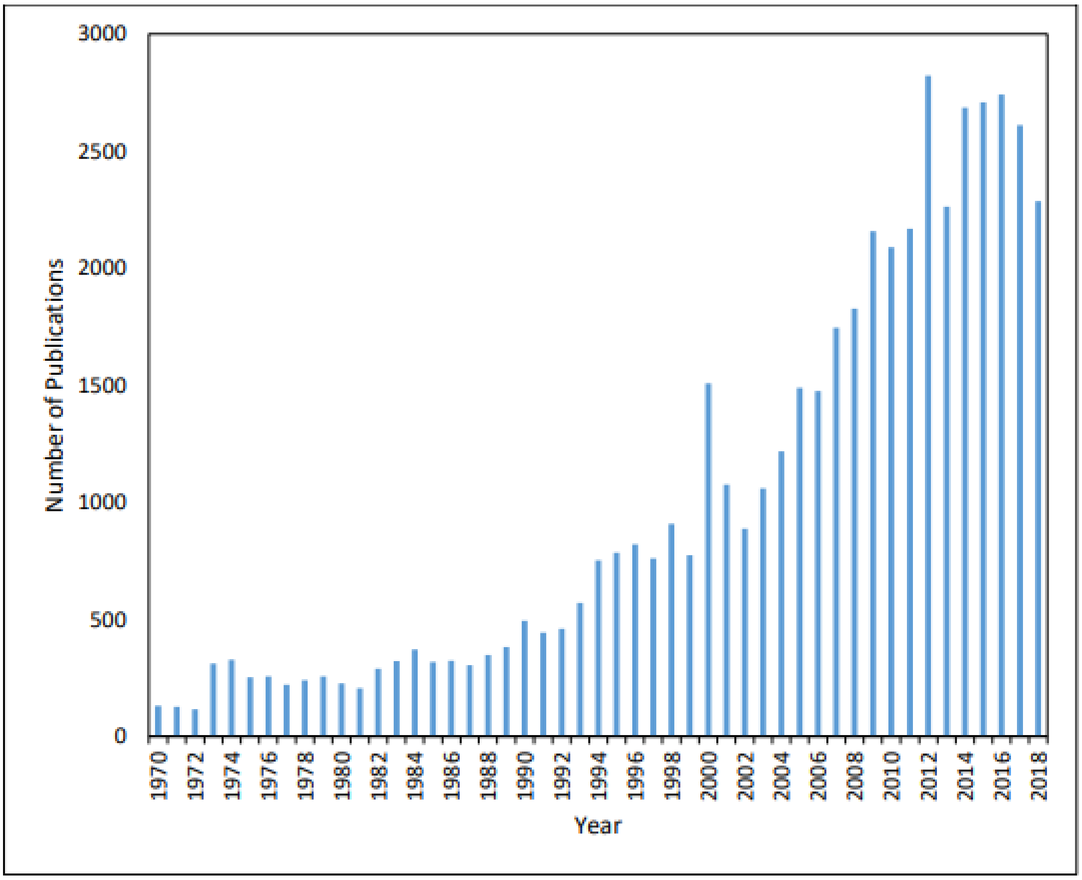

Figure 2: Global research trend on ergonomic issues (Source: Scopus)

According to Wickins et al. (1998), the goal of human factors is to include workers' needs and preferences while creating new systems for the workplace. Instead, they see engineering psychology as a means to an end—the discovery of general principles and the theory of how the human mind works. The term "ergonomics" has entered the mainstream lexicon thanks to its usage by product marketers to describe the excellence of product layout and navigation. The current situation has highlighted the need of ensuring the comfort, safety, and welfare of employees everywhere. Ergonomics is, thus, a rapidly expanding area of study. Figure 2 depicts the growing number of articles written on ergonomics throughout the globe. In the last several decades, there has been an explosion of new studies in this area. The advancement of ergonomics studies in India has been painfully sluggish. However, the last decade has seen a dramatic increase in the number of publications.

Ergonomic Interventions

Management may benefit financially by implementing ergonomic treatments to reduce the incidence of musculoskeletal disorders and other occupational health problems among employees doing manual labour. Ergonomic interventions are any changes made to equipment, methods, or procedures that adhere to ergonomic principles in order to lessen the likelihood of injury. Training and the usage of PPE by employees for both safety and

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cleanliness are also emphasised. Workers' occupational health is enhanced by ergonomic changes, allowing them to put in more hours in a risk-free environment..

Ergonomic design of hand tools

Tools that people use with their hands date back thousands of years. It has been shown that even prehistoric man used hand tools (Fraser, 1980). Hand tools have been refined or invented with the help of developing technology as human needs have multiplied. We still utilise hand tools in our everyday lives and in the workplace, while their outward design and materials have evolved somewhat. Hand tools that aren't made with ergonomics in mind may put a lot of strain on your shoulders, arms, hands, and wrists. There are several challenges that stem from these problems (, including cumulative trauma disorders, decreased productivity, and disability. The Bureau of Labour Statistics reports that 4.6% of all work-related accidents and illnesses in the United States include the use of hand tools in the workplace (BLS, 2014). Over the last four decades, ergonomics have been more concerned with the design, assessment, selection, and usage of hand tools. Numerous ergonomists have spent considerable time developing the fundamental ergonomic design principles and recommendations involved in tool design, the ergonomic evaluation process for tools, checklists for ergonomic evaluation, and attributes desirable for specific hand tools (Users have reaped significant advantages in terms of safety, comfort, productivity, and ease-of-use from ergonomists' attention to ergonomics as a scientific system throughout product design

Framework of research

Workers in the Indian manual clay brick kiln business suffer from a number of musculoskeletal and occupational health issues, and this study proposes to investigate these issues and provide remedies. Methods for assessing the current state of workplace ergonomics and developing solutions to promote better musculoskeletal health.Literature evaluation and topic selection come first in the framework, followed by pilot investigations and the pinpointing of knowledge gaps. The next phase is an ergonomic examination of the current workplace, which may include a survey questionnaire, posture assessment methods, instruments for measuring musculoskeletal strength, etc. Critical tasks and potential pitfalls for future enhancements are provided at this stage. Worker musculoskeletal health may be improved by ergonomic evaluation, followed by the creation and validation of ergonomic treatments. Interventions were built using a variety of design applications and then evaluated in both simulated and actual field settings. The majority of the work for this project was done outside; however, there was also lab and computer work involved.

Study area and selection of subjects

The participants in this research were employed in one of 32 kilns in the state of Maharashtra in India, where traditional burnt clay bricks are made. Forty four hundred and eighty-six kiln employees served as participants in the research. Subjects were chosen for the research using both convenient and random sampling techniques. From January 2021 to October 2022, researchers gathered data for this exploratory project.

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Brick kilns were inspected, and workers at each stage of the process were tallied before the final list was compiled. Extraction of clay with digging tools, breaking clay into small pieces, mixing clay with a spade or by hands, clot cutting, filling clots into moulding boxes, mould evacuation, stacking bricks for drying, transporting bricks, and arranging bricks in kiln for firing are all examples of the many manual tasks involved in making clay bricks. It was discovered during the first visits that personnel who were responsible for spading, clot cutting, mould filling, mould emptying, and transporting had to assume the most unnatural positions. A random sample of employees doing these duties was chosen for analysis. Figure 3 depicts the many processes involved in making clay bricks.

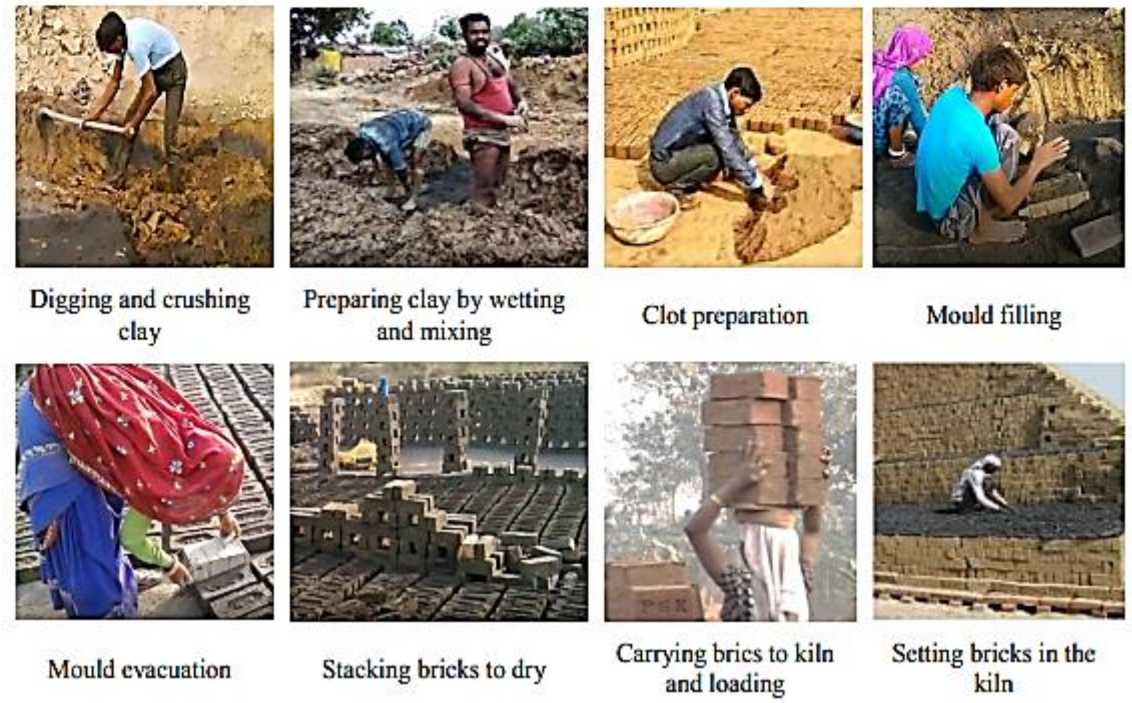

Figure 3: Various manual activities performed during clay brick manufacturing

First, digging tools are used to uncover clay deposits. If necessary, the excavated clay is then broken up into smaller pieces. The second stage entails soaking and mixing clay by hand or with a spade. Clots are made by compressing the prepared clay, which is occasionally combined with coal dust. Next, green bricks are removed from the ground and clots are packed into moulding boxes. Bricks are piled to dry for a few days, and then they are transported to the kiln and organised for fire. Fired bricks are ready to be placed into trucks after a period of time. Spading, clot preparation, mould filling, mould evacuation, and brick transporting are the four jobs seen and studied further.

Data collection and analysis

The information was gathered with the use of a modified Nordic questionnaire to determine the frequency and causes of musculoskeletal disorders in the workforce. The dynamometers employees used to measure their hand grip strength while working with different hand tools were digital. Workers' postural risk was evaluated using the REBA and RULA score sheets. Using a standardised questionnaire and a Likert scale from 1 to 5, the incidence of lower back pain was determined. The effectiveness of hand tools was evaluated with the use of the Comfort Questionnaire for Hand Tools (CQH). We used a weighing machine and an anthropometric equipment to collect this information. Bar graphs, pie charts, and tables were employed to display the collected data. The tables displayed descriptive statistics. The data was analysed using a variety of statistical methods, including logistic regression and the paired t-test.

Questionnaire development

Workers' demographic and musculoskeletal health information was gathered using a systematic, modified Nordic Questionnaire. The Standard Nordic Questionnaire (Kourinka et al., 1987) was piloted with a sample of 50 brick kiln employees in order to make necessary adjustments. The SNQ was updated to provide more room for feedback. Since only a small percentage of employees (5%) reported problems with their elbows, hips, thighs, and ankles, questions about these areas were omitted from the revised survey. However, questions on the upper arm, lower arm, and fingers were included to the survey since these areas were reported to be problematic for more than 20% of respondents. Most of the processes involved in making clay bricks (such as spading, clot cutting, mould filling, mould evacuation, etc.) need the use of both hands at once. The vast majority of employees (96%) in the pilot study said their right and left sides both had problems. As a result, the survey no longer includes a section asking about right- and left-side concerns. Expert input was also used to revise the provisions for both private and professional matters. After discussing the questionnaire with three professionals, the final version was created. The modified questionnaire had three sections: (i) general information about the respondent (such as age, height, weight, gender, education level, smoking status, etc.), (ii) details about the respondent's job (such as the nature of their duties, their level of experience, how long they spend on each shift, how long they get to rest between shifts, etc.), and (iii) details about the respondent's symptoms (such as the location and severity of any pain or discomfort). The final section asked the employees whether they were experiencing any pain or discomfort, and recorded their answers as either a '0' (no) or a '1' (yes). Because most employees lacked formal education, the survey was translated into Hindi and the surveyor assisted them as they filled it out.

Postural assessment techniques

It was found in the first investigation that employees utilised all parts of their bodies to make bricks. Therefore, the postures were analysed using the Rapid Upper Limb Assessment (RULA) 30) and the Rapid Entire Body Assessment (REBA) techniques. When compared to other forms of observation, these methods are simple to implement and don't break the bank. For this reason, experts in the field of manual labour often use these techniques for postural analysis (Ma et al., 2009; Singh et al., 2012). Work postures were scored using RULA and REBA score sheets based on attentive observation throughout working sessions.

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Data analysis

Working hours, years of experience, tasks completed, etc. were classified with demographic information such as age, weight, height, BMI, gender, and employment status. Workers' body mass indexes were determined by plugging their height and weight into the following relation::

$$BMI = \frac{\text{Weight in kg}}{(\text{Height in meters})^2}$$

IBM's statistical analysis programme, SPSS version 22, was utilised. Binary and multinomial logistic regressions were employed to investigate potential causes of musculoskeletal disorders. We validated the p value as the level of significance.

Hand grip strength analysis

Brick moulders (i.e., those engaged in clot cutting, mould filling, and mould evacuation) often had problems with their wrists and fingers. The hand grip strength of employees was tested and compared to that of a control group that was not subjected to these activities. Fifty brick moulders with a minimum of one year of experience were selected at random from the same pool of people as the questionnaire survey. A computerised hand grip dynamometer was used to assess the participants' grip strength.

Design and Validation of Ergonomic Interventions

A questionnaire survey for the prevalence of musculoskeletal symptoms, hand grip analysis, and postural assessment found that most brick kiln workers experienced osteoarthritis in the wrist, lower back, shoulder, finger, upper arm, and knee regions due to working in a specific task with a load, repetition, and awkward postures. Significant risks were found during the spading and mould filling processes, both of which were performed in the kiln. Removing mould and transporting it were also shown to be tasks with high degrees of danger. The hand grip strength of brick moulders has been shown to decline as a result of their strenuous work. Manual brick kiln employees may benefit from ergonomic solutions to their musculoskeletal problems. Worker safety may be improved by the use of "ergonomic interventions," which refer to the adaptation of equipment, processes, and policies to conform to ergonomic principles. Reducing musculoskeletal problems and their symptoms may be accomplished by a variety of therapies advocated for in the literature. These include alterations to the work environment, adjustments to hand tools, employee and management training, exercise, and the use of properly designed and implemented PPE. There is a lack of information in the literature on the effectiveness of ergonomic interventions in clay brick kilns on the health and safety of workers. With the goal of improving the health of brick kiln workers in India, several ergonomic therapies have been created. In addition to being ergonomically evaluated in the field, these solutions have been proven effective. This chapter focuses on the design and validation of three ergonomic solutions: a lumbar belt to reduce back discomfort, a moulding box, and a clot cutter/mud extractor..

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Effect of lumbar belt on lower back issues

According to global surveys (Das, 2015; Wynne, 2014), lower back pain (LBP) is the most often reported musculoskeletal disorder. Musculoskeletal problems in the lower back are more common among manual labourers, especially those whose jobs require them to spend long periods of time hunched over and using their arms and hands in the same ways. It has been suggested that, in addition to load, bending and twisting postures may be significant contributors to LBP in the workplace (Driscoll et al., 2014; Sterud and Tynes, 2013). Brick kiln employees have been observed to have regular difficulties with their lower backs in the past (Das, 2014; Das, 2015). Workers in the spading and mould removal industries had the highest rates of lower back problems, according to the current research. Several methods, including ergonomic workplace design, physical therapy, employee education, and lumbar supports, have been recommended for the prevention and treatment of LBP. The lumbar belt lessens the stress on the trunk and provides spinal support by reducing flexo-extension and lateral bending (Ammendolia, 2005; Van Poppel, 2000). The purpose of this research was to examine whether or not brick kiln employees who reported lower back problems in a questionnaire survey had relief from using a flexible lumbar belt.

A lumbar belt and other gentle exercises were tested in a trial meant to relieve back pain. Lower back pain was a common complaint among the 125 employees who responded to the questionnaire survey mentioned in the preceding chapter. In addition, these employees were given a Likert scale on which to score their levels of lower back pain and discomfort from 0 (no pain) to 5 (extreme pain). Seventy-two employees with moderate to severe lower back pain (scoring of 3-5) used an adjustable lumbar belt. For 15 days and 3 hours a day, workers in the intervention group wore a flexible lumbar belt (Tynor manufactured), as illustrated in Figure 4. Participants were polled again on their lower back discomfort 15 days later. Light activities (i.e. hamstring stretch, hip rolls, knee bends, extension exercises, knee to chest, etc.) were also recommended for workers with moderate or high lower back discomfort after every two hours. There were a total of three months spent on the intervention. The paired t-test was used to compare employees' lower back pain before and after the intervention, and the mean and standard deviation of workers' characteristics were computed.

Figure 4: Lumbar belt used in the study

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Study Results

The survey included 125 employees with a mean age of 33. In the survey form, every single participant mentioned suffering from lower back pain. There were a total of 72 people in the intervention research groups. Table 1 displays the demographic information of the study's workforce participants.

Table 1: Characteristics of participants (N = 125, male = 89, female = 36).

Characteristics	(Mean ± SD)
Age (year)	33 ± 8.16
Weight (kg)	60 ± 7
Height (cm)	171 ± 5
Body mass index	25 ± 2.52
Work experience	3.5 ± 2.5
Pain score before intervention	2.5 ± 2.2
Pain score after intervention	1.6 ± 0.8

Note: SD is standard deviation

Conclusion

When combined with modest stretching exercises, wearing a lumbar belt has been shown to considerably reduce lower back troubles in the workplace. Musculoskeletal disorders are less common in brick kiln workers thanks to a newly designed clot cutting/mud pulling equipment and a changed moulding box, as shown by a postural evaluation and usability test.

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