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NOTES

MHAC—An Assessment Tool for Analysing Manual Material Handling Tasks

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This paper describes an assessment tool for analysing material handling tasks and its application for material handling tasks prevalent in engine bearing industry. After a close observation of material handling tasks spread over many days, a list of tasks and parameters/variables affecting those tasks was made. Ergonomic conditions present in these tasks and their deficiencies were then identified and on the basis of the relationships between the tasks and their affinities, categories were developed. Using the data of those categories and various conditions and parameters, an assessment tool called MHAC (material handling assessment chart) was developed.

material handling   manual carrying tasks   working posture   load/weight

1. INTRODUCTION

Moving raw materials and finished products through a facility is a common process in the engine bearing industry. Throughout that process, operators with various manufacturing tasks routinely lift/lower, push/pull and carry objects, where risk factors leading to musculoskeletal disorders (MSDs) may be present. When investigating manual material handling (MMH), health and safety professionals must determine the most practical ways to move objects while decreasing ergonomics risk and positively affecting production and cost.

Low back pain and injuries attributed to manual lifting continue to be a leading occupational health and safety issue faced by the manufacturing industry. Despite efforts to control them, including programs directed at both workers and jobs, work-related back injuries still account for a significant proportion of human suffering and economic cost to any organization. The extent and scope of the problem was summarized in a 1982 report of the U.S. Bureau of Labor Statistics [1]. The U.S. Department of Labor's conclusions were consistent with current workers' compensation data [2] indicating that injuries to the back were one of the more common and costly types of work-related injuries. According to that report, back injuries accounted for nearly 20% of all injuries and illnesses in the work place, and nearly 25% of the annual workers' compensation payments. Another study indicated that overexertion was the most common cause of occupational injury, accounting for 31% of all injuries. The back, moreover, was the body part most frequently injured.

In 1981, the National Institute for Occupational Safety and Health (NIOSH) recognized the growing problem of work-related back injuries and published the Work Practices Guide for Manual

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Lifting [3]. It contained a summary of the lifting-related literature, analytical procedures and a lifting equation for calculating a recommended weight for specified two-handed symmetrical lifting tasks, and an approach for controlling the hazards of low back injury from manual lifting. In 1985, NIOSH convened an ad-hoc committee who reviewed the literature on lifting, including the Guide. The literature review was summarized in a document entitled Scientific Support Documentation for the Revised 1991 NIOSH Lifting Equation [4]. The rationale and criterion for the development of the revised NIOSH lifting equation are provided in Waters, Putz-Anderson, Garg, et al. [5]

McAtamney and Corlett [6] developed a survey method called RULA (rapid upper limb assessment) for use in ergonomics investigations of work places where work-related upper limb disorders were reported. The method uses diagrams of body postures and three scoring tables to provide evaluation of exposure to risk factors. Kee and Karwowski [7] presented a technique for postural loading on the upper body assessment (LUBA). The method is based on new experimental data for a composite index of perceived discomfort (ratio values) for a set of joint motions, including the hand, arm, neck and back, and the corresponding maximum holding times in static postures. Karhu, Kansi and Kuorinka's [8] Ovako working posture analysis system (OWAS) is one of the most widely used methods of observation in working posture studies. It is used to identify and evaluate harmful working postures. OWAS is based on sampling from typical working postures for the whole body. Feyen, Liu, Chaffin, et al. [9] presented a case study for ergonomics analysis of work place design using computer-aided ergonomics software. According to them, one of the primary goals of computer-aided ergonomics is to develop software tools that allow ergonomics information to be accessed at the earliest stages of design.

Westgaard [10] discussed three themes that were likely to be important within health-related ergonomics in the coming years. The first two concerned methods for risk analysis of low-level biomechanical and psychosocial exposures. Approaches to successful implementation of ergonomics interventions was the third one. McGorry [11] described a device for measuring gripping forces and the moments generated by a hand tool since quantification of the forces applied with hand tools could be a difficult but important component of an ergonomics evaluation. Hasle and Moller [12] presented an action plan against repetitive work and discussed a possible new strategy for regulating repetitive work as well as other complicated working environment problems.

Yeung Genaidy, Huston, et al. [13] conducted a study to explore whether professional expertise could be relied on, through the use of a systematic procedure, to quantify the effects of lifting task parameters on perceived effort and risk of injury outcome measures. Mack, Haslegrave and Gray [14] conducted a survey of users to show that many of the aids currently used are poorly designed or inappropriate for the tasks performed. The information gained during the survey was analysed to identify the most important design features and to provide guidance for their selection and evaluation to ensure that aids were suitable for the tasks for which they were used and that they were effective and safe. Burt, Henningsen and Consedine [15] conducted three studies to examine the use of a symbol to prompt the adoption of a correct lifting posture. The first study used an appropriateness test to evaluate nine symbols designed to encourage the adoption of a correct lifting posture. Four symbols met the appropriateness criteria and were tested for comprehension in the second study. The third study examined the effect of the best performing symbol from the second study in a field setting, which involved subjects lifting a small box. Results indicated significant increases in the adoption of the use of correct lifting posture when the symbol was present compared to a control condition.

The Health and Safety Executive (HSE), a UK government body responsible for regulating health and safety in the workplace, developed an assessment tool called the Manual Handling Assessment Chart (MAC) designed to help health and safety inspectors assess the most common risk factors in lifting and lowering, carrying and team handling operations [16].

2. ASSESSMENT OF MATERIAL HANDLING TASKS

The first step in eliminating the hazard related to MMH tasks was to analyse the tasks to identify the ergonomics hazards present in a job. The analysis involved a variety of activities: observing the worker performing the task, interviewing the workers and discussing the task with them, measuring the distance involved in the carrying task, calculating the frequency of the carrying tasks, etc. The MMH tasks were observed for 15 days spread over one month. To identify the ergonomics factors, i.e., parameters that had a direct bearing on the hazards associated with those tasks, an affinity diagram was used. An affinity diagram is a creative process, used with or by a group, to gather and organize ideas, opinions, issues, etc., on the factors affecting these tasks. The exercise was carried out by brainstorming amongst experts, two drawn from each of the four different manufacturing units and the researcher. The researcher co-ordinated the brainstorming session. The technique was used to identify by consensus the factors affecting the MMH tasks and to put them into broad categories. The contributing factors that were identified for assessing MMH tasks were load weight and frequency of handling, position of the upper arm, asymmetrical trunk load, postural constraints, grip on the load, operator's capabilities, floor surface, distance involved in the carrying task, obstacles en route and environmental factors

3. DEVELOPMENT OF THE MATERIAL HANDLING ASSESSMENT CHART (MHAC)

To evaluate the effect of the aforementioned factors on the MMH tasks, the team developed a survey technique called MHAC. It was also developed to assess exposure of individual workers working separately or in team to risk factors associated with MMH tasks. The technique was developed in the engine bearing manufacturing industry, after an assessment of the operators who performed MMH tasks in the production shops, inspection operations and packing. MHAC was also developed to provide a method of screening the working population quickly for exposure to a likely risk of work-related MSDs; to assess the risk associated with employees lifting and carrying loads over a long distance, sometimes on uneven and slippery surfaces; and to give results which could be incorporated in a wider ergonomics assessment covering epidemiological, physical, mental, environmental and organizational factors.

As MHAC is a pen-and-paper technique that can be used without any special equipment, MHAC assessment can be done in confined workplaces without disruption to the workforce.

MHAC was developed in two stages. The first stage consisted in developing a method of assessing and recording the parameters and conditions listed in section 2. The second stage involved the development of a scale of action levels, which provided a guide to the level of risk and the need for a more detailed assessment.

3.1. Development of a Method of Assessing and Recording the Status of Contributing Factors and Conditions

The outcome of the brainstorming session in which experts from four different organizations participated was the conclusion that to carry out risk assessment of MMH tasks it was necessary to consider several factors.

3.1.1. Load

The weight of the load is a significant factor, but one that must be looked at in conjunction with all the other elements of the assessment. Where there is a heavy load, it may be possible to split it into two lighter loads. The assessment must consider whether the benefits of a reduced weight are justified when compared to the increased risks caused by creating twice as many lifting/lowering movements. Is the load unstable or filled with contents that may shift? Where the contents of a load may shift, such as when handling part-full liquid containers, there may be unexpected and injury-causing stress imposed on the body. Is the load hot, cold, slippery or sharp, or otherwise potentially damaging to hold? If so, appropriate personal protective equipment should be readily available.

3.1.2. Working posture

Various working postures may involve holding or handling loads away from the body; awkward movements or awkward posture, such as twisting the trunk, stooping or reaching upwards; excessive lifting or lowering distance; excessive distance involved in the carrying task; excessive pushing or pulling; risk of sudden movements of loads; frequent or prolonged physical effort; insufficient time for workers to rest/recover; a work rate imposed by a process; or limited space that prevents correct posture.

3.1.3. Grip on load

Do the containers have well designed handles or handholds, which fit the purpose? Is the grip comfortable?

3.1.4. Operator's capability

Performance of various MMH tasks may require a person of unusual strength or height. There is a certain amount of self-selection for jobs involving handling of loads, but the employer must still ensure that the task is within the worker's ability. In general, individual capability varies a lot. Women are generally shorter than men, and some lifting tasks may be better suited to workers within a given height range. Physical capability varies with age; teenagers and older workers may be more susceptible to injury and, in the case of older workers, the recovery is longer. The benefits of experience and mature judgment may adequately compensate for declining physical ability.

Performance of MMH tasks may create a hazard to workers who may have a health problem or medical condition, including pregnant workers. Employees are obliged to advise the employer of any condition that is likely to put them at a greater risk of injury. Conditions include pregnancy, recent surgical operations and any relevant previous medical history (both occupational and nonoccupational). It is appropriate to seek relevant health information at the pre-employment stage when a person is being considered for a job that includes manual handling operations with a risk of injury.

3.1.5. Other factors

Floor surface is also an important factor. It may be slippery, uneven or unsuitable, or may have variations in its level, e.g., stairs or slopes. Where a load has to be carried for over 10 m, the physical demands are likely to outweigh those of lifting and lowering the load. If the route on which the material-handling task is performed involves carrying a load up a steep slope or steps or around tripping hazards or climbing up a ladder, the risk of fatigue and subsequent injury is increased. Other factors may include unusually low or high temperatures or extreme humidity, poor lighting conditions, poor ventilation, and bad weather such wind or rain.

3.2. Assigning Rating Scores to Factors

The rating of the effect of each of the aforementioned factors was given in such a way that number 1 was given to the range of activities where the risk factors present were minimal. Higher rating scores were given to the activities with more difficult work conditions, as discussed in the previous sections, indicating an increasing presence of risk factors causing load on the structures of the body segments. This system of scoring for each factor provides a sequence of numbers, which is logical and easily remembered. The ratings have been developed on the basis of a brainstorming session amongst experts.

The rating to assign scores for the load/ weight handled during a lifting and carrying task was assessed and scored on the basis of an experimental study carried out on the operators of the central workshop at the Thapar Institute of Engineering and Technology, India. The experiment was conducted to study the effect of carrying a load on the onset of discomfort rated on a 1–5 scale at various frequencies of the carrying tasks. The task was standardized to ensure that the experiment would be conducted under the same working conditions. The workplace was designed considering ergonomics guidelines with respect to layout, posture, design of grips on load, floor space and ensuring there were no obstacles en route. The subjects selected for the study had similar individual capabilities.

The physical environment with regard to temperature, humidity and light was within normal levels. The temperature was 28 °C, relative humidity 56% and light 2500 lx. The sound level was below 85 dB(*A*), so the subjects did not use earplugs.

3.3. Experimental Design

Twelve operators from among the regular employees were selected on a voluntary basis as subjects. They had at least 6 months of on-the-job experience and at least 8th-grade education. They were given adequate demonstration and instructions before the experiment. The subjects performed the same task in the experimental sessions under specified conditions.

The subjects were asked to lift a pan containing standard samples of mild steel of known weight used for testing on a universal testing machine in a strength of materials laboratory at different frequencies of the carrying tasks. The experimental conditions for each group were explained to all the subjects. The subjects performed one training and two experimental sessions, each session lasting one hour. In every session the subjects were reminded about the experimental conditions. The participants were requested not to discuss their results amongst themselves. The experimental conditions for each subject were as follows: load weight to be carried: 10, 20, 30, 40 and 50 kg; and the number of carrying tasks per hour: each of the weights was to be carried to a destination 2.44 m away at the following frequency: (a) one carrying task per day (one carrying task per 8 hrs); (b) one carrying task per 30 min (two carrying tasks per hour); (c) one carrying task per 5 min (12 carrying tasks per hour); (d) one carrying task per 2 min (30 carrying tasks per hour); (e) one carrying task per 1 min (60 carrying tasks per hour) and (f) one carrying task per 30 s (120 carrying tasks per hour).

The day's discomfort rating was noted at the end of the day's work on a checklist provided to each subject (Table 1) The data for the 12 subjects was compiled to obtain an overall discomfort rating score (Table 2). Also, a mean discomfort score for each subject was calculated by dividing the sum of all ratings for each weight by the number of subjects.

TABLE 1. Rating Scores for Assessing Discomfort

Condition	Rating Score
Practically no discomfort	1
Mild discomfort	2
Heavy discomfort	3
Severe discomfort	4
Extreme discomfort	5

TABLE 2. Individual and Mean Discomfort Scores for Various Frequency Combinations of Loads and Carrying Tasks

Frequency	Weight (kg)	Operator O1	O2	O3	O4	O5	O6	O7	O8	O9	O10	O11	O12	Mean Score
1 carrying task per day	10	1	1	1	1	1	1	1	1	1	1	1	1	1.0
	20	1	1	2	1	1	2	1	1	1	2	1	1	1.3
	30	1	1	2	1	2	2	2	1	1	2	2	1	1.5
	40	3	3	2	2	2	2	3	2	2	3	3	2	2.4
	50	4	4	5	4	4	3	3	4	4	4	5	4	4.0
2 carrying tasks per hour	10	1	1	2	1	1	1	1	1	1	1	1	1	1.1
	20	2	2	2	1	1	2	2	1	1	2	1	2	1.6
	30	3	3	3	2	3	3	2	3	2	3	3	2	2.7
	40	3	4	4	4	4	4	3	4	4	4	5	4	3.9
	50	5	5	5	5	5	5	4	5	5	5	5	5	4.9

TABLE 2. (*continued*)

Frequency	Weight (kg)	Operator O1	O2	O3	O4	O5	O6	O7	O8	O9	O10	O11	O12	Mean Score
12 carrying tasks per hour	10	2	3	2	2	2	3	2	2	3	2	2	2	2.3
	20	2	3	3	3	3	4	3	3	4	3	4	3	3.2
	30	4	4	4	3	4	4	4	3	4	4	4	4	3.8
	40	4	5	5	5	5	4	5	4	5	5	5	4	4.7
	50	5	5	5	5	5	5	5	5	5	5	5	5	5.0
30 carrying tasks per hour	10	3	2	3	3	3	2	2	3	3	3	3	3	2.8
	20	3	3	3	4	3	3	3	4	4	3	3	3	3.3
	30	4	4	4	5	4	4	4	4	5	4	4	4	4.2
	40	5	5	5	5	5	5	5	5	5	5	5	5	5.0
	50	5	5	5	5	5	5	5	5	5	5	5	5	5.0
60 carrying tasks per hour	10	3	3	3	4	3	3	3	3	3	3	3	4	3.2
	20	4	4	4	4	4	3	4	4	3	4	4	4	3.8
	30	4	4	5	5	5	4	5	4	4	4	5	5	4.5
	40	5	5	5	5	5	5	5	5	5	5	5	5	5.0
	50	5	5	5	5	5	5	5	5	5	5	5	5	5.0
120 carrying tasks per hour	10	3	3	3	3	4	3	3	3	3	3	4	3	3.2
	20	4	4	4	5	4	4	4	5	4	4	4	4	4.2
	30	5	5	5	4	4	4	4	5	4	4	5	5	4.5
	40	5	5	5	5	5	5	5	5	5	5	5	5	5.0
	50	5	5	5	5	5	5	5	5	5	5	5	5	5.0

Notes. 1—*practically no discomfort*, 2—*mild discomfort*, 3—*heavy discomfort*, 4—*severe discomfort*, 5—*extreme discomfort*.

3.3.1. Discomfort rating scores

Assessment commenced with observing an operator during several work cycles. The observer recorded the discomfort rating scores for the load/weight on a record sheet. The experts during the brainstorming session concluded

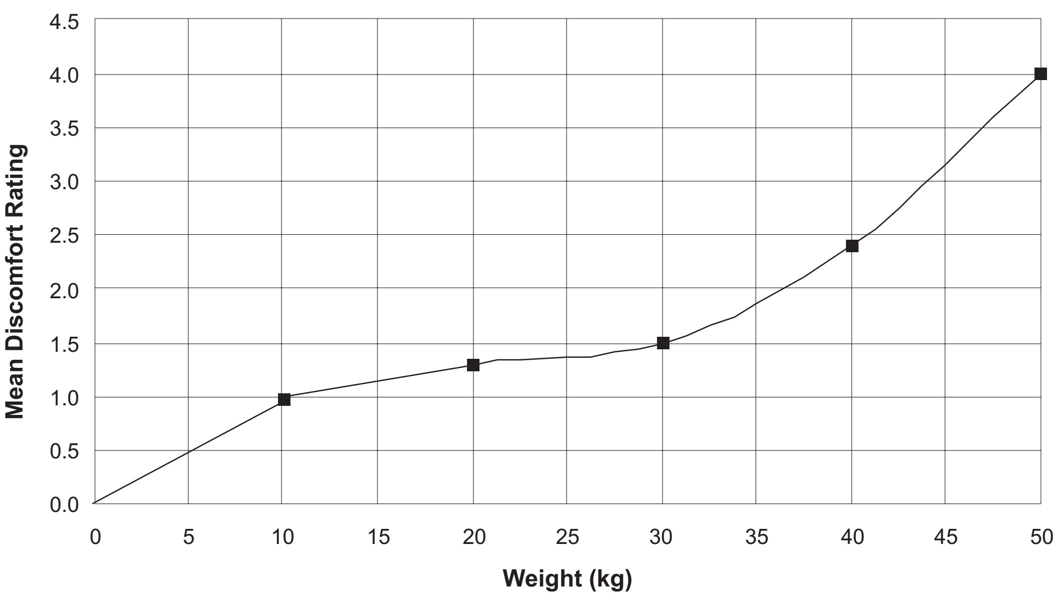

Figure 1. Mean discomfort score for 1 carrying task per day.

that if the discomfort rating score was greater than 3, the task should be examined very closely. Such operations could represent a serious risk of injury and should come under close scrutiny, particularly when one person carried the entire weight of the load. The mean discomfort rating score was plotted for each load carried at the frequencies of the carrying tasks as shown in Figures 1–7.

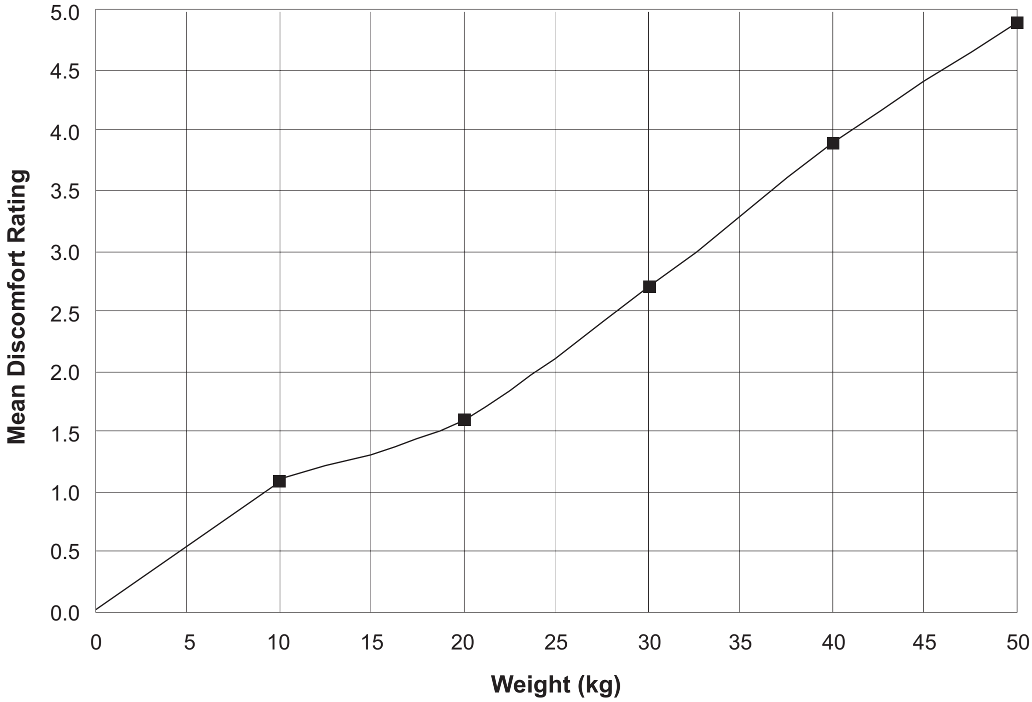

Figure 2. Mean discomfort score for 2 carrying tasks per hour.

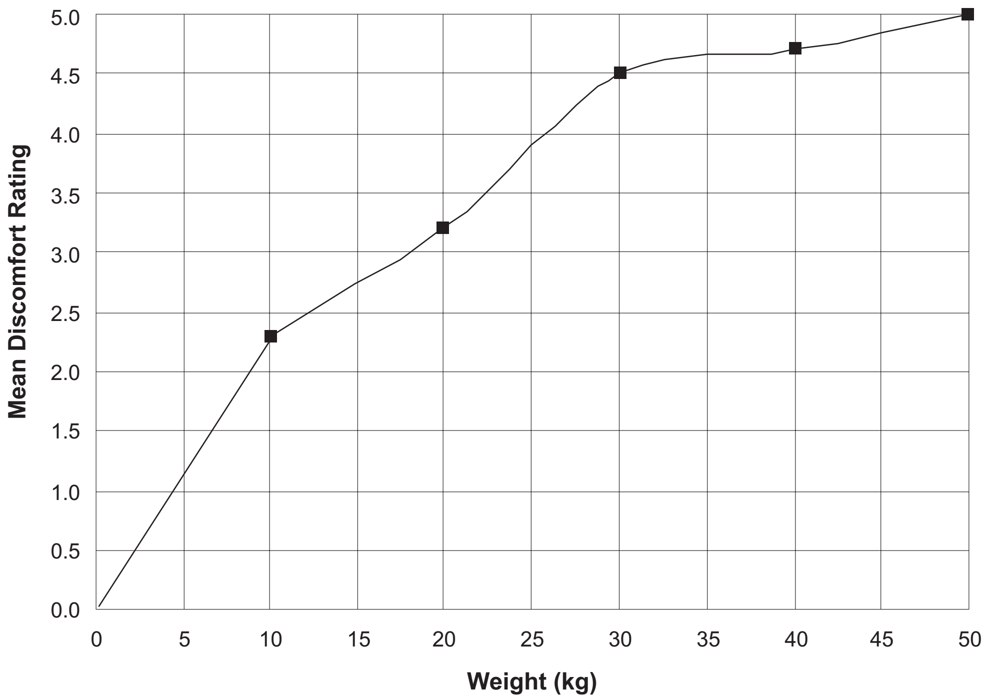

Figure 3. Mean discomfort score for 12 carrying tasks per hour.

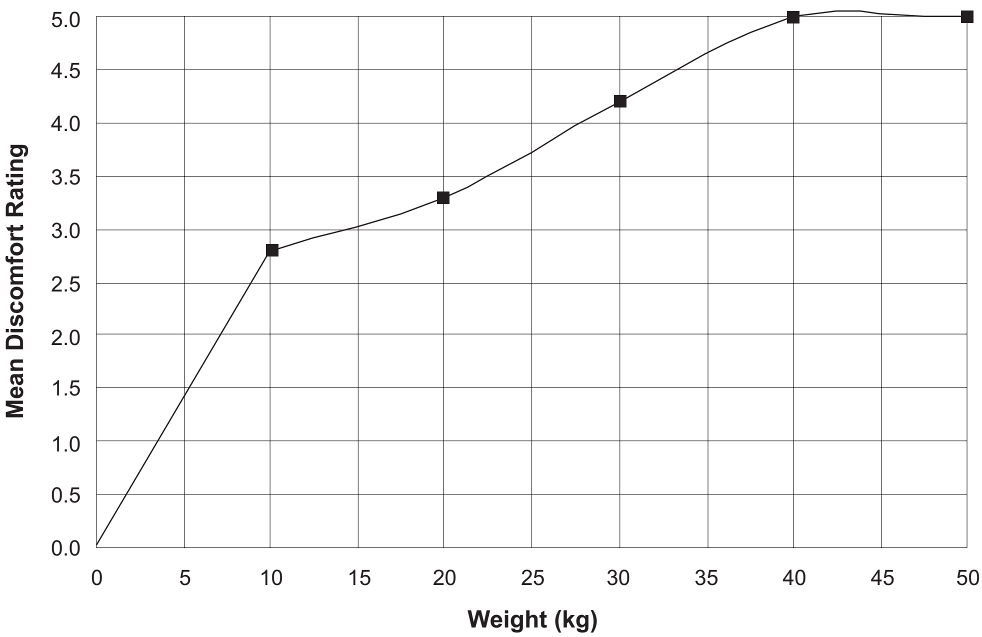

Figure 4. Mean discomfort score for 30 carrying tasks per hour.

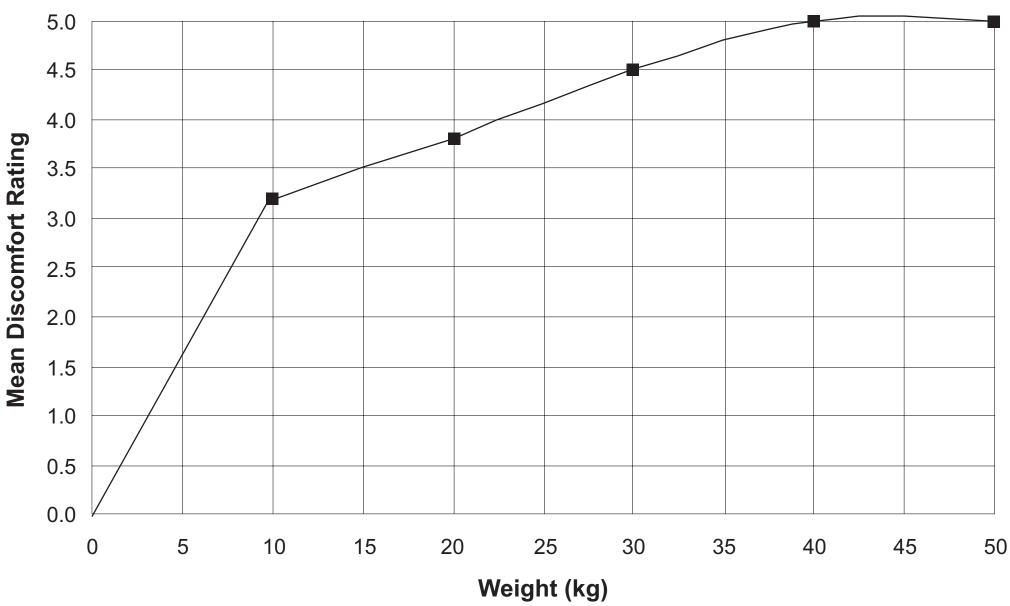

Figure 5. Mean discomfort score for 60 carrying tasks per hour.

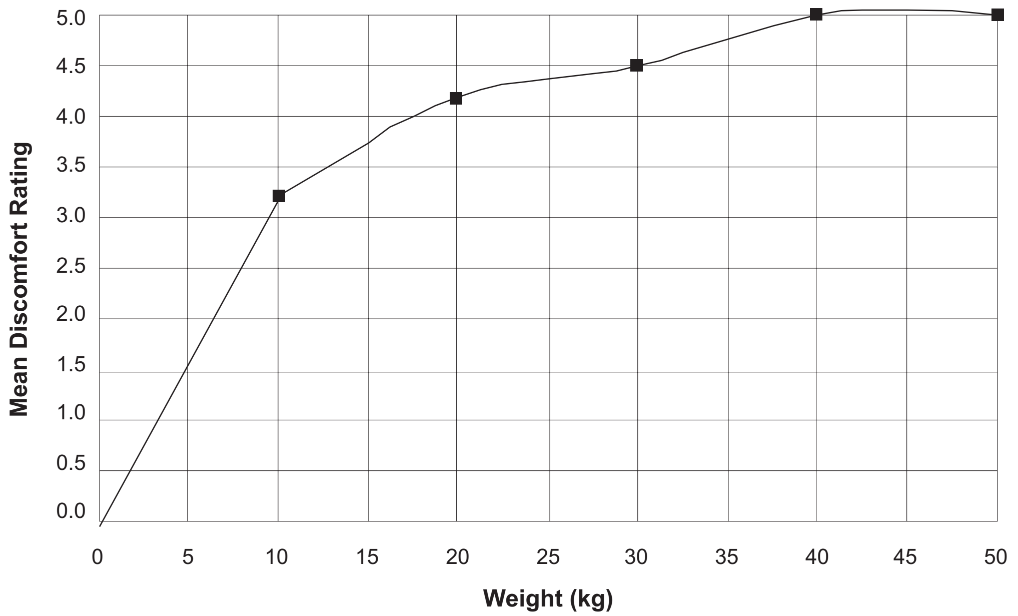

Figure 6. Mean discomfort score for 120 carrying tasks per hour.

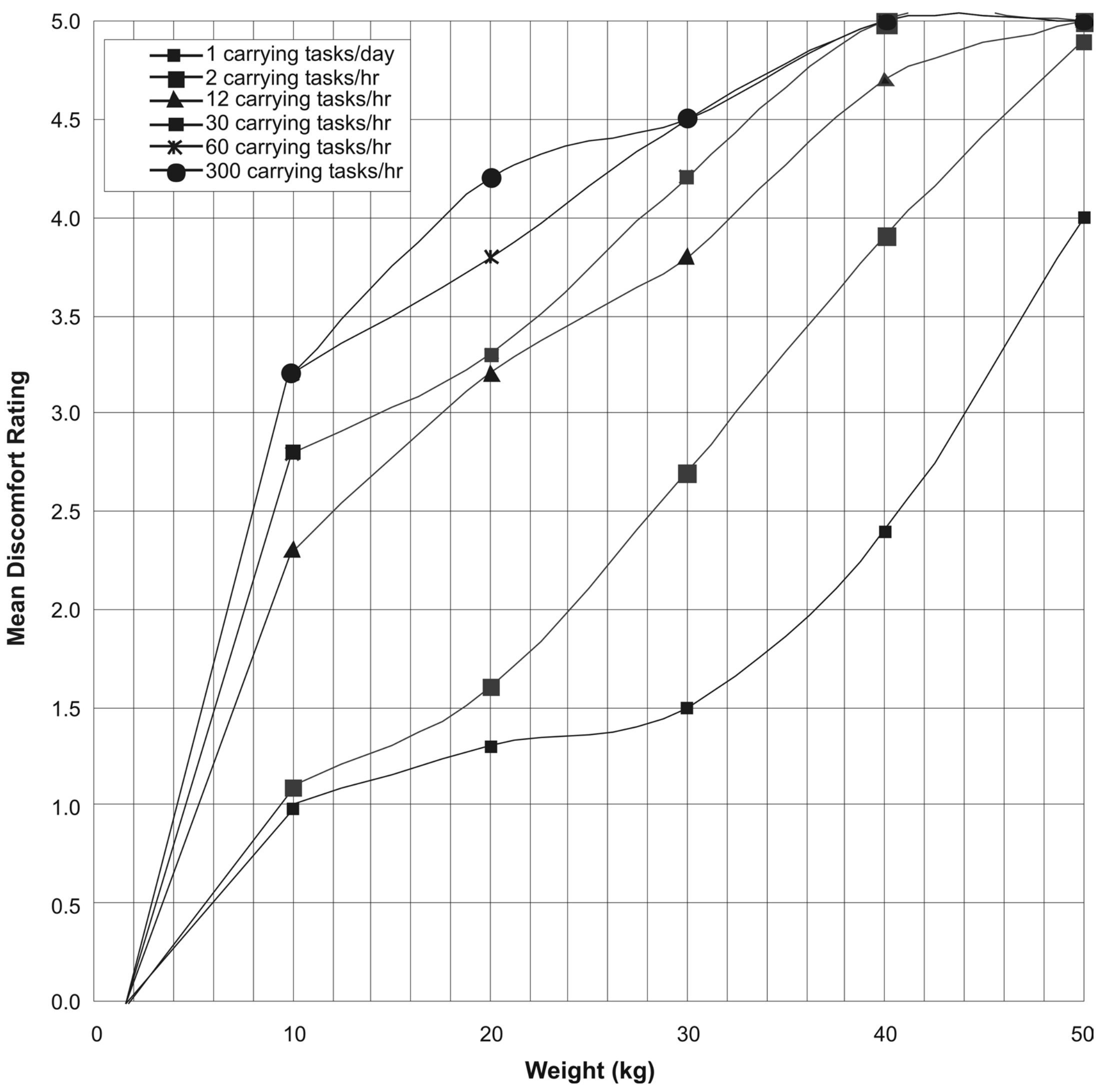

Figure 7. Mean discomfort score at different frequencies of the carrying tasks.

3.3.2. Rating scores for the position of the upper arm

The position of the upper arm was found by observing the task and examining that position. Assessment was always based on the worst-case scenario and the rating method given in Table 3 was used to assess the effect of the position of the upper arm. The experts concluded that if the discomfort rating score was greater than 3, the task should be examined very closely. They felt that such operations could represent a serious risk of injury and should come under close scrutiny, particularly when one person carried the entire load. The discomfort score of 3 is therefore shown in brackets in Table 3. In the discussion of subsequent parameters contained in Tables 4–11, bracketed scores and above represent criticality, i.e., close examination and immediate action are necessary.

TABLE 3. Discomfort Rating Scores for the Position of the Upper Arm

Position of Upper Arm	Discomfort Score
Upper arm aligned vertically and upright trunk with weight within center of gravity of body	1
Upper arm above shoulder height	2
Upper arm angled away from the body	[3]
Upper arm angled away from the body and trunk bent forward	4
Upper arm angled away from the body, trunk bent forward and weight not aligned with center of gravity of body	5

Notes. Square brackets represent criticality, i.e., close examination and immediate action are necessary.

3.3.3. Rating scores for asymmetrical trunk load

The operator's posture and the stability of the load, which are known to be risk factors associated with musculoskeletal injuries, were observed and assessment was always based on the worst-case scenario. The rating method given in Table 4 was used to assess the asymmetrical trunk/load.

TABLE 4. Discomfort Rating Scores for Asymmetrical Trunk/Load

Asymmetrical Trunk/Load	Discomfort Score
Load and hands symmetrical in front of the trunk	1
Load and hands asymmetrical ≤35° and upright body position	2
One-handed carrying to the individual's side	[3]
Load lifted from or to a height above the shoulder with an asymmetrical angle ≤100° but >35°	4
Load lifted from or to a height above the shoulder with an asymmetrical angle >100°	5

Notes. Square brackets represent criticality, i.e., close examination and immediate action are necessary.

3.3.4. Rating scores for postural constraints, grip on load, individual operators' capability and floor surface

By observing the task and examining the operator's posture, the experts decided on the posture constraints; their ratings are given in Table 5. Different conditions of grip on the handle and their scores are given in Table 6. Table 7 lists operators' capability and discomfort score as decided by the experts. The experts decided that by observing the task and examining the floor surface on which the load/weight was carried, the discomfort rating score could be given as shown in Table 8.

TABLE 5. Discomfort Rating Scores for Posture Adopted During Carrying Tasks

Operator's Posture	Discomfort Score
Unhindered movement	1
Restrictive postures while carrying (e.g., a narrow doorway makes the operator turn or move a load to get through)	[2]
Heavily restricted posture while carrying (e.g., carrying loads in a forward bent posture in areas with a low ceiling)	3

Notes. Square brackets represent criticality, i.e., close examination and immediate action are necessary.

TABLE 6. Discomfort Rating Scores for Grip on Handle

Grip on Handle	Discomfort Score
Containers with well designed handles or handholds, fit for purpose, or handling loose parts enabling comfortable grip	1
Containers with poorer handles or handholds or containers which require fingers to be clamped at 90° under it	[2]
Containers of poor design used for carrying loose parts; irregular, bulky or difficult to handle objects; or nonrigid sacks/objects	3

Notes. Square brackets represent criticality, i.e., close examination and immediate action are necessary.

TABLE 7. Discomfort Rating Scores for Individual Operators' Capability

Operators' Capability	Discomfort Score
Unusual strength or height not required	1
Unusual strength or height required	[2]
A health problem or a medical condition are a contraindication	3

Notes. Square brackets represent criticality, i.e., close examination and immediate action are necessary.

TABLE 8. Discomfort Rating Scores for Floor Surface

Floor Surface	Discomfort Score
Dry, clean floor in good condition	1
Dry floor but in poorer condition, worn or uneven	[2]
Contaminated, wet or steep sloping floor or unstable footing	3

Notes. Square brackets represent criticality, i.e., close examination and immediate action are necessary.

3.3.5. Rating scores for environmental factors

The experts determined discomfort rating scores by observing the work environment (Table 9). The environmental conditions considered were (a) extreme temperature; (b) strong air movements; (c) extreme lighting conditions (dark, bright or poor contrast); (d) high humidity and (e) high noise levels.

TABLE 9. Discomfort Rating Scores for Environmental Factors

No. of Environmental Factors Present	Discomfort Score
1	1
2	[2]
>2	3

Notes. Square brackets represent criticality, i.e., close examination and immediate action are necessary.

3.3.6. Rating scores for the distance involved in the carrying task and for obstacles en route

Discomfort rating was assigned (Table 10) following observation of the task and estimation of the total distance that the load had been carried. The route over which the carrying task was performed was observed, too. If the route involved carrying a load up a steep slope or steps or around tripping hazards, 1 was entered on the score sheet. If the task involved carrying the load up the ladder, the score was 2. If the task involved more than one of the risk factors (e.g., a steep slope and a ladder) a score of 3 was entered on the score sheet. The rating method is given in Table 11.

TABLE 10. Discomfort Rating Scores for Distance Involved in a Carrying Task

Distance	Discomfort Score
<4 m	1
4–10 m	[2]
>10 m	3

Notes. Square brackets represent criticality, i.e., close examination and immediate action are necessary.

TABLE 11. Discomfort Rating Scores for Obstacles en Route

Obstacles en Route	Discomfort Score
No obstacles or route is flat	1
Steep slope	[2]
Trip hazards or steps	3

Notes. Square brackets represent criticality, i.e., close examination and immediate action are necessary.

3.4. Development of Total Score and Action Plan

The second stage of MHAC and of its development involved incorporating all the scores from sections 3.3.2.–3.3.6. into a single total score, whose magnitude provided a guide to the priority for subsequent investigations. Each possible combination of the 10 factors was added to arrive at a total score of 10–34. For a score of 10–16 a carrying task would have scored 2 or less for load and asymmetrical trunk and 1 for all other factors. Thus, a carrying task with a total score of 10–16 was considered acceptable if not maintained or repeated for long periods. A score of 17–22 would mean a task was moderately exerting and the load and the working postures were within suitable ranges but the task was repetitive or exertions of force were required. Further investigation was needed for that task and changes could be required. A score of 23–28 indicated that the load, work posture and other factors were not within suitable ranges. That score suggested that the operator was required to perform tasks involving a heavy load with repetitive movements with other factors also having high discomfort scores. Those operations had to be investigated soon and changes had to be made in the short term while long-term measures to reduce the level of exposure to risk factors had to be planned. A score of 29–34 would be given to any task at or near the end of the range of all the 10 factors listed in section 3.3. Investigation and modification of those operations was required immediately to reduce excessive loading of the musculoskeletal system and the risk of injury to the operator. Table 12 shows a score sheet for recording the rating for the factors and calculating total scores.

The MHAC score sheet was adapted from HSE's Manual Handling Assessment Chart (MAC) [16].

4. RESULTS AND CONCLUSIONS

The observational technique MHAC developed for analysing MMH tasks in an engine bearing manufacturing industry provides a method of screening the working population quickly for exposure to a likely risk of work-related MSDs, for assessing risk associated with employees lifting and carrying loads over a long distance and giving results which could be incorporated in a wider ergonomics assessment covering epidemiological, physical, mental, environmental and organizational factors. The factors that contribute to ergonomics hazards in MMH tasks are load weight and frequency of handling, position of the upper arm, asymmetrical trunk load, postural constraints,

TABLE 12. Material Handling Assessment Chart (MHAC) Score Sheet to Obtain a Total Score

MHAC: Score Sheet		
Company name:	*Insert the numerical score for each of the risk factors, referring to your assessment, using the tool*	
Task description:	**Risk factors**	**Score**
	1. Load weight and frequency of carrying task	
	2. Position of upper arm	
	3. Asymmetrical trunk/load	
	4. Postural constraints	
Are there indications that the task involves high risk? (Tick appropriate boxes)	5. Grip on load	
	6. Individual operators' capabilities	
☐ Task has a history of manual handling incidents (e.g., accident record)	7. Floor surface	
	8. Environmental factors	
☐ Task is known to be hard work or involve high risk	9. Distance involved in carrying task	
☐ Employees who do the work show signs of finding it hard work (e.g., breathing heavily, sweating)	10. Obstacles en route	
☐ Other indications, if so what?__________	**Total score:**	
Date:	Signature:	

Notes. Adapted with minor modifications from HSE's Manual Handling Assessment Chart (MAC) [16].

grip on load, operator's capabilities, floor surface, distance involved in the carrying task, obstacles en route and environmental factors. However, it is strongly emphasized that, since human body is a complex and adaptive system, no single method can deal with all the situations that may come up in any carrying or loading task. What the MHAC system provides is a guide, which was developed to draw boundaries around the more extreme situations. However, the combination of factors may increase the risk from within acceptable boundaries to a serious problem. For these reasons the action list leads, in most cases, to suggestions of a more detailed investigation. To draw the limits too tightly would lead to an undue expense in altering jobs without any guarantee that those still within the boundary would be safe. Hence, the use of MHAC prioritizes jobs which should be investigated, whereas the magnitude of the individual scores for the 10 contributing factors listed in section 3.3. indicates which aspects of the carrying task are likely to be a problem. While MHAC provides a guide to the risk associated with carrying tasks there is no substitute for some understanding of occupational ergonomics if sound decisions are to be made when redesigning operations.

REFERENCES

1. Bureau of Labor Statistics. Back injuries associated with lifting (work injury report) (Bulletin 2144). Washington, DC, USA: U.S. Government Printing Office; 1982.
2. Maier M, Ross-Mota J. Work-related musculoskeletal disorders, Oregon, 1990–2000. Retrieved April 9, 2008, from: http://www.cbs.state.or.us/external/imd/rasums/resalert/msd.html
3. National Institute for Occupational Safety and Health (NIOSH). Work practices guide for manual lifting (Report No. 81-122). Cincinnati, OH, USA: U.S. Department of Health and Human Services, NIOSH; 1981.
4. National Institute for Occupational Safety and Health (NIOSH). Scientific support documentation for the revised 1991 NIOSH lifting equation: Technical Contract Reports, May 8, 1991. Cincinnati, OH, USA: U.S. Department of Health and Human Services, NIOSH; 1991.
5. Waters TR, Putz-Anderson V, Garg A, Fine LJ. Revised NIOSH equation for the design and evaluation of manual lifting tasks. Ergonomics. 1993;36(7):749–76.
6. McAtamney L, Corlett EN. RULA: A survey method for the investigation of work-related upper limb disorders. Appl Ergon. 1993;24(2):91–9.
7. Kee D, Karwowski W. LUBA: an assessment technique for postural loading on the upper body based on joint motion discomfort and maximum holding time. Appl Ergon. 2001;32(4):357–66.
8. Karhu O, Kansi P, Kuorinka I. Correcting working postures in industry: a practical method for analysis. Appl Ergon. 1977; 8(4):199–201.
9. Feyen R, Liu Y, Chaffin D, Jimmerson G, Joseph B. Computer-aided ergonomics: a case study of incorporating ergonomics analyses into workplace design. Appl Ergon. 2000;31(3):291–300.
10. Westgaard RH. Work-related musculoskeletal complaints: some ergonomics challenges upon the start of a new century. Appl Ergon. 2000;31(6):569–80.
11. McGorry RW. A system for the measurement of grip forces and applied moments during hand tool use. Appl Ergon. 2001; 32(3):271–9.
12. Hasle P, Moller N. The action plan against repetitive work—an industrial relation strategy for improving the working environment. Human Factors and Ergonomics in Manufacturing. 2001;11(2): 131–43.
13. Yeung SS, Genaidy AM, Huston R, Karwowski W. An expert cognitive approach to evaluate physical effort and injury risk in manual lifting—a brief report of a pilot study. Human Factors and Ergonomics in Manufacturing. 2002; 12(2):227–34.
14. Mack K, Haslegrave CM, Gray MI. Usability of manual handling aids for transporting materials. Appl Ergon. 1995; 26(5):353–64.
15. Burt CD, Henningsen N, Consedine N. Prompting correct lifting posture using signs. Appl Ergon.1999;30(4):353–9.
16. Health and Safety Executive (HSE). Manual handling assessment charts. Sudbury, Suffolk, UK: HSE Books; 2003. Retrieved September 1, 2008, from: http://www.hse.gov.uk/pubns/indg383.pdf