A REVIEW ON SAFE ERGONOMICS IN MATERIAL HANDLING TO MITIGATE THE DEFECTS

[1]U.Mohamed Faizal, [2]A.R.Jaideep Suriya, [3]A.M.Mohamed Nadeem, [4]R.Priyadharshan, [5]D.Raguram
[1]Assistant Professor, [2,3,4,5]Undergraduate Scholar
Department of Mechanical Engineering,
Sri Shakthi Institute Of Engineering And Technology, Coimbatore, India

Abstract: Safe ergonomics is necessary in present manual material handling conditions. Musculoskeletal disorders take place due to poor ergonomic methods. Safe ergonomics is the most efficient way of avoiding musculoskeletal disorders. In this review the evidence for this claim and description for different programs and its implementation learned has been explained.

***Index Terms* – Manual material handling, Ergonomics, Workplace design parameters, Lifting techniques.**

1. INTRODUCTION

Ergonomics is the study of postures of human body to avoid musculoskeletal disorders. These disorders are occurred due to poor ergonomic postures and improper handling methods. These disorders can be overcome by following proper postures while working. In this survey different research papers has been learned and different programs has been described and discussed.

2. PROBLEMS FACED DUE TO POOR ERGONOMICS

To identify the potential presence of compensatory strategies in obese and non-obese handlers and to evaluate the impact of these strategies on trunk kinematics and kinetics. The risk of back injury during work remains high today for manual materials handler. A significant amount of research has identified population-wide risk factors for injuries during manual material handling work-related risk factors include lifting heavy objects, along with frequent bending and twisting of the trunk, as well as personal risk factors including age and obesity[25].

The work techniques of female and male workers were analysed during manual material handling (MMH).The lifting technique difference observed in female compared to male was perhaps due to a strength difference. To test whether female workers would repeat the same lifting technique with a load adjusted to their overall strength (females: 10 kg; males: 15 kg), which can be considered a "relative load"[26]. To identify the work cycles imposing high loads on the upper limb and low-back among trailer assembly workers for an ergonomic intervention. The generic risk factors that have been associated with elbow, wrist and hand disorders include repetitive work movements, use of high forces of the hand and non-neutral wrist postures the occurrence of upper limb and low-back disorders, major changes in work methods or redesign of work are often needed to decrease exposure to most important risk factors effectively[18].

To verify whether there was a consensus among experienced handling methods and to identify the factors taken consideration by them. Handlers do not favour the same method, first, because they do not necessarily evaluate a factor in the same manner, and second, because they do not give the same priority to the different factors when choosing a method. To what was a good handling method and to identify the factors taken into consideration by them[17]. The effect of workplace design parameters on continuous sequential lifting, carrying, and lowering of boxes weighing from 2 kg to 14 kg. To predict the times required to complete each task. The influence of the workplace design and the worker's characteristics on the task time[30].

The effects of handle design on these parameters has received little attention. Yet, a poor handle design might lead to overexertion and altered movement dynamics, or result in misinterpretation of results in research studies. In this study, twelve healthy subjects performed repetitions of a wrist flexion task against a dynamic load generated by a 1-DOF robotic wrist manipulation. Handles are compared using ergonomics criteria such as comfort, fatigue and pain evaluated through questionnaires, as well as an analysis of muscle activity patterns in wrist and hand muscle groups measured with surface electromyography (EMG)[29]. That handles can help and that some are better than others but agreement on how handles should be studied, parametric values of 'optimum' handles, and even criteria for handle choice is low. Handle is one device available to designers of products and packages to improve the coupling between a human operator and the load he/she has to lift, hold or carry[4].

The subject at the beginning of transfer and at deposit (position of the back, knees and feet, pelvic orientation, position of the hands), his way of moving during the transfer (position of the feet) and his way of positioning and moving the box during handling (tilt). It is difficult to determine the extent to which the methods developed by the expert handlers were efficient or safe[14].

Using larger containers for supplying and presenting materials can be that the load factor in transport can often be increased by the use of large containers small containers at assembly stations, without compromising the load factor in transport, it is common to perform repacking within, or in association with, the assembly plant. Therefore, whether at the assembly stations or in repacking areas, manual picking from large containers is still frequently performed in association with manufacturing operations[16]. Their use does not always result in the anticipated reduction of workload or musculoskeletal stress. Identify the most important design features and to provide guidance for their selection and evaluation, in order to ensure that aids are suitable for the tasks for which they are used and that they are effective and safe[12].

The occupational work of lifting, lowering, holding, carrying loads. Pushing and pulling weights etc. requires high muscular effort'-j in awkward postures. Giving rise to muscular-skeletal strains and low-back signs and symptoms. The physiological and biomechanical analysis of different modes of materials handling and training of workers in the correct methods of handling loads may largely obviate the problems of low-back pain in industry[6]. To assess the physiological consequences of using an upper limb exoskeleton during manual handling task, as muscle activity, upper limb kinematics, postural balance and cardiac cost. Participants performed three tasks (load lifting (LIFT), carrying (WALK) and stacking-unstocking (STACK)) with (EXOS) and without (FREE) an exoskeleton. During LIFT and STACK, the activity of the deltoid anterior muscle was significantly lower for EXOS than for FREE. During LIFT, the activity of the triceps bacchii (TB) and tibialis anterior muscles significantly increased for EXO[8].

To avoided hand discomfort and a reduction of work efficiency by using proper grip designs. To measure grip force distribution on a tool handle[5]. The coordination between the trunk and the pelvis during a sustained asymmetric repetitive lifting task between a group with a history of low back pain (LBP; HBP) and a group with no history of LBP (NBP). There were no main effects for group, a significant interaction between time and group indicated that, in the frontal plane, the NBP group coordination was more anti-phase toward the end[9].To develop and test an expert system for the design of new and existing repetitive manual materials handling (RMMH) tasks. For new jobs, the expert system provides recommendations on the maximum acceptable weight to be handled under a variety of worker and task variables. The tremendous amount of information published in the literature on how much individuals can handle safely, back injuries are still growing at an alarming rate[11].

The most common cause of musculoskeletal disorders (MSDs) and low back pain (LBP). It involves manual lifting, lowering, carrying, pushing and pulling loads. This study has three main objectives, first: to identify ergonomics awareness towards MMH activities amongst the workers; second, to identify the body discomfort or body pain of the workers using Body Parts Symptom Survey (BPSS); and third to study the LBP and MSDs risk exposure in reference to MMH practiced by the workers[3]. The widespread acceptance of need for and value of the systems orientation of ergonomics/humans factors is increasing. It is seen as one of the ways in which we can distinguish ourselves from other professions and define ourselves and our approach to potential clients[10].

To determine if a proposed change in the cardiac rehabilitation training program would lead to patients overexerting themselves. The changes proposed involve simulating actual work elements, such as handling materials, in the CR training program. Since materials handling is physically the most demanding of the modified CR training program activities, this study focused on materials handling[21]. Manual Handling of Loads sets out a hierarchy of measures aimed at reducing the risks of manual handling and training is one of the obligations on employers. This study involved a survey of current practices in relation to manual handling training and sought to identify components believed to be effective. That manual handling training is more effective if it is tailored to specific industry and task demands. Practical elements in training were believed to reinforce learning, particularly if tailored to individual job demands[7].

The incomplete attachment material should be low stress and low outgassing while also minimizing stress relaxation over time, which can lead to scale-factor shifts in sensor devices[15]. The workplace, including absence or presence of manual materials handling (MMH) with the number of hours per week and several psychosocial and physical hazards including various risk factors of musculoskeletal disorders. The frequency of MMH across economic activities was described for the 48,190 workers in the survey. The highest occurrences of intensive MMH were observed in the manufacture of wood, paper, wood and paper products, retail trade and repair, manufacture of food products, manufacture of mineral products, wholesale trade, transport, and construction[22]. Manual handling of objects in an industrial setting has been a significant concern to occupational health professionals who attempt to prevent injury. Tasks that demand frequent and heavy lifting are associated with an increased risk of low back pain. To date, a majority of studies have focused on the lifting of rectangular shaped objects and to a limited extent on irregular shaped objects such as shopping bags or sacks[1].

The segment being analysed, which accounted for more than 20% of the overall variability. There was substantial left–right symmetry in individual segment variability estimates, which were largest for the upper arm segment and tended to be larger for the upper limbs than the lower limbs. Task-related factors accounted for variability mainly as a function of the segment being considered ore anti-phase toward the end[19]. Increasing demand for manual handling aids, but the survey has shown that many of the aids currently in use are poorly designed from the user's point of view. Moreover, the provision of such aids has not guaranteed that stress levels on the body are reduced and some of the design faults identified can actually increase the risk of injury, defeating the primary objective for the introduction of the aid[12].

There is a need for basic and applied research to enhance the methodologies for aggregating multiple-component MMH tasks with MMH criteria. In particular, research is needed to done which methods of aggregation provide the best assessment of exposure to complex jobs involving 414 P.G. Dempsey / International Journal of Industrial Ergonomics 24 (1999) 405}416 MMH. This will require an interactive approach incorporating both end and laboratory research, and will Benet compliance and risk assessments[22]. An ergonomic analysis of the job of stocker was conducted in a warehouse superstore. The main determinants of the handling activity and related constraints were described. These pertain to the physical layout, containers, equipment, management of stocks and arriving merchandise. The simple physical layouts observed are designed to increase sales but do generate several physical constraints that were described[27].

Musculoskeletal accidents during weight lifting on work reach up to 52%, pushing or pulling 13%, carrying things 10%, repetitive movement 13%, and 12% of other activities. That musculoskeletal disorders involve variety and degenerative of injury conditions that affect muscle, tendon, ligament, joints, peripheral nerve, and blood vessels support. Parts of human body that often exposed by musculoskeletal disorders are back, neck, arms, and hands[2]. Differences in work demands, energetic workload and workers' discomfort and physical effort in two regularly observable workdays in ironwork; one where loads up to 50 kg were handled with two persons manually (T50) and one where loads up to 100 kg were handled manually with four persons (T100). Differences between these typical workdays were assessed with an observational within-subject field study of 10 ironworkers[26].

3. RESULT

The results clearly show that the increase in external moments observed in obese handlers (compared with healthy-weight handlers) during the handling tasks are largely attributable to the anthropometric traits of obesity. There can be no doubt that the excess weight of an obese worker has a deleterious effect on the external loading of the musculoskeletal structures of the back[25].

Hypothesis proved true for some variables such as task duration and cumulative loading, and partially true for variables defining posture. The sequential inter joint coordination pattern previously seen in females with an absolute load (15 kg), when compared to expert males, was still present with the use of the same overall relative load (females 10 kg; males: 15 kg). Considering that the sequential lifting pattern stretches the posterior passive tissues, potentially leading to higher risk of injury, the reason for this sex effect must be identified in order to propose preventive interventions[26].

The upper limb and the low-back before and after the intervention comparable as regards the effects of various changes on work load, the work loads of individual workers were calculated per one trailer. The statistical significance of the effects of the changes in work were tested by t-test and Wilcoxon signed rank test. The hypothesis was that the intervention will result in a reduction in work load and therefore one sided tests were used[18].

The lack of consensus on the best methods. Handlers favour different strategies depending on the work context and their own priorities. Back effort is not a factor favoured by all handlers since some of them never or only rarely mentioned this factor as being important in choosing a method. However, this does not imply that those handlers do not try to reduce back effort. There are possibly indirect ways of reducing stresses on the spine other than those traditionally recommended, which lead the handlers to focus on factors other than back effort[17].

That the box's weight and the lifting and lowering heights influenced the tasks' times. The effect of the workplace design on the time required to complete manual material handling tasks (i.e. lifting, carrying, and lowering masses of 2e14 kg) that together comprise work processes common in industry. Effect of handle design on movement dynamics and muscle co-activation in a wrist flexion task. That the grooved handle was significantly less comfortable than the palm handle, and two subjects further reported minor pain while using the grooved handle. The curved handle for such tasks, as it is the most versatile and universal option[30].

The load to be carried with both hands rather than one hand. The load interfering with the legs while being carried. Load to be lifted and lowered without exceeding the range of human wrist movement. Load must be carried by one hand make the load as thin as possible and not more than the heights. The expert handlers chose handling techniques rather different than those of the novices, particularly with regard to the position of the knees, feet and pelvis, the location of the grip, the movement of the feet during transfer, and the position of the box during handling. Standing possibly allows the handler to use more of his body weight to initiate the transfer[4].

To increase the understanding of the range of variations of picking strategies that pickers of different heights would adopt for different components and different zones of the pallets[16]. The design faults identified can actually increase the risk of injury, defeating the primary objective for the introduction of the aid. If more attention was paid to ergonomic design factors by manufacturers and purchasers of aids, a significant improvement in efficiency and reduction in the number of injuries should be achievable. Given the range of design factors identified during the user survey, and the fact that these tend to interact and be affected by task factors, it will be important to address the usability of the aids through task analysis and user trials in order to identify the most important design features for the different types of aids and the different jobs for which they are used[12].

The results of variations in trunk positions indicated that the handling of loads was better performed in trunk-bent/knee-straight postures. This also supports the usual practice of the workers where they commonly adopt trunk-bent postures for lifting. On the contrary, it has been generally understood that the trunk straight/knee-bent posture is convenient and safe for lifting loads. Apart from human strength and material characteristics, the techniques of load holding and lifting, i.e. postures, load placement, foot placement, surface conditions, etc. are all relevant to the load which is to be handled". Physiological consequences of using an upper limb exoskeleton during manual handling tasks. The benefits induced by this device did not appear without broader physiological consequences, such as increased antagonist muscle activity, postural strains, cardiovascular demand and even changes in upper limb kinematics. The need for companies to thoroughly and specifically analyse each work situation in which an exoskeleton is intended to protect a worker against muscular over-solicitation to ensure that its contribution is perfectly well-adapted[6].

More uniform force distribution provided by the foam grip should positively affect consumer performance and satisfaction with the tools. The increased uniformity of the force distribution for the foam grips may have contributed to their increased preference for the foam grip this may be due to the perceived 'loss of control' as expressed by the subjects caused by the deformation of the foam under the forces applied by the hand. The grip force distribution, on the other hand, was more uniform for the foam grip[5]. There were no main effects for group, a significant interaction between time and group indicated that, in the frontal plane, the NBP group coordination was more anti-phase toward the end[9].

The weight handled on the job is greater than the weight that can be safely handled (which is 13.94 kg in this case) with the existing job conditions. There are four possible solutions to this problem. These are: (1) to reduce the weight handled to 15 kg, (2) to change other job conditions such as reducing the frequency of lift to 2 times/minute, (3) to provide adequate rest periods to alleviate the effect of fatigue due to these stressful job conditions, or (4) to provide mechanical aids such as a mechanical lifter[11]. Evaluation of ergonomic awareness on MMH amongst workers on research area shows that they possess a moderate awareness level. This can be seen by the overall mean score, which shows a moderate awareness level at 3.68. Mean score obtained from ergonomics awareness through three factors; the ergonomics application at workstation 2.81, work environment 3.36 and workers commitment 2.74[3].

There are some dangers of course in taking a systems perspective. In fact there might seem to be some irony in investigating and enhancing at a systems level, since the very descriptor "system" can imply dealing with a number of constituent parts rather than being holistic. A study or implementation that starts out as manageable can become unwieldy and even impossible if layer upon layer of connected systems are brought into the remit; a clear danger is of micro-analysis where this is not needed[10].

They operate at workloads that will not lead to overexertion. In fact, when the metabolic energy expenditure rates are measured at psychophysically determined loads, an excellent agreement is obtained between the psychophysical and physiological design criteria[21]. A practical element to the training can reinforce learning. A practical element is likely to be more effective if it is tailored to individual job demands, i.e. trainees undertake manual handling tasks using familiar equipment relevant to their work. Manual handling training offered by external consultancies is likely to be more effective if consultancies develop an understanding of organisational needs. This is best achieved through a site visit undertaken before training commences. To be effective, manual handling training needs to be embedded as an on-going process in organisations and reinforced with regular refresher courses[7].

MEMS packaging is quite different from conventional integrated circuit (IC) packaging. Whereas many MEMS devices must interface with the environment to perform their intended functions, the package must be able to facilitate access with the environment while protecting the enclosed devices. The package must also not interface with or impede the action of the MEMS device[15]. MMH is not the only risk factor of low back pain. Moreover, the aim of the French survey was to describe present occupations rather than workers. The health status of a subject depends on age, past exposure, and other factors. The current job of a worker may be the consequence of a selection process[22].

The preventive strategies that are used to reduce the load on the back associated with lifting tasks involve engineering controls (redesigning the workplace) and administrative controls, such as training and instruction in lifting posture[1]. The model evaluation process, benchmarks against which models can be compared must be established and used. Both of these aspects are considered in this report, in the context of manual materials handling (MMH) tasks. Improvements in model accuracy during the model development process are achieved through determination, quantiWcation, and incorporation of factors that are responsible for the variability that will be modelled[19]. The range of design factors identified during the user survey, and the fact that these tend to interact and be affected by task factors, it will be important to address the usability of the aids through task analysis and user trials in order to identify the most important design features for the different types of aids and the different jobs for which they are used. The aim should be to make the handling of loads easier and safer, and in so doing reduce musculoskeletal stresses and the number of handling injuries[12].

One method of dealing with the shortcomings associated with the current state of MMH criteria is to focus on how and when the criteria are most useful. In the case of pure design, MMH criteria provide a theoretical framework from which design decisions can be guided. In a sense, task and workplace parameters can be thought of as more deterministic variables which can be controlled at the present state of knowledge[22]. The results indicate four problem situations and document the strategies adopted by the workers. They further indicate that dysfunctions in stock and arrival management lead to an increased workload and time pressure. This initial study therefore provides an accurate

picture of the handling activities in a warehouse superstore. The results obtained were linked to the inherent characteristics of warehouse superstores and their marketing strategies which impact on the handling activity and the resulting risks[27]. MSDs (Musculoskeletal Disorders) survey conducted with NBM questionnaire showed that all workers had complaints on most of the jobs. Complaints of painful (score 3) and very painful (score 4) on hips, back, wrists, arms, and legs are mostly experienced to the workers with the age above 40[2].

Handling up to 50 kg with two ironworkers (T50) and up to 100 kg with four ironworkers (T100) did not result in differences in the duration and frequency of tasks, activities and lifting characteristics during a workday. In addition, the energetic workload and perceived discomfort of the body regions did not differ between T50 and T100 workdays. Seven out of 10 ironworkers rated the T100 workday as physically more demanding. During both workdays, up to 68% of the times loads above 25 kg were not transported with the number of workers required based on load mass. Load mass appears therefore not to be the determinant factor for the number of persons during team lifting. Other factors like environment, task, and shape of the load also appear of importance[26].

4. CONCLUSION

The study helped us to compare the strategies of obese and healthy-weight handlers. The result that stands out the most in this study is the considerable increase in back extension moments and in asymmetrical moments during lifting and deposit of boxes at different heights. Temporal variables and kinetic variables (moments) during lifting are mainly related to load mass; posture variables to load and expertise; and joint coordination parameters to load and perhaps sex. The main findings that we observed in the present study should reflect an individual approach. Identify the work cycles imposing high loads on the upper extremity and low-back among a group of trailer assembly workers. Measure the physical loads imposed on the upper limb and low-back among trailer assembly workers before and after an ergonomic intervention, and explore the effects of changes in work methods on work load in individual work cycles.

Control of the load may be other important ways to reduce spinal stress. Therefore, maybe we now need to focus on these different means developed by handlers to reduce back effort. As a matter of fact, these means, if evaluated using normal field observation systems, could be considered disadvantageous because they often result in bent postures. Manual Material Handling (MMH) tasks such as lifting, lowering, and carrying are common in various industries (e.g. Manufacturing, agriculture, and construction). The objective of comparing the three handles in terms of movement dynamics and subjective ergonomic criteria such as fatigue, comfort and pain during repeated wrist flexion tasks.

That the grooved handle was significantly less comfortable than the palm handle, and two subjects further reported minor pain while using the grooved handle. Design handles to distribute the load over the largest possible surface area of the hand and fingers. Prevent high point-loadings by eliminating sharp corners, edges, ridges, and finger grooves. Lightly knurl or texture handles to prevent hand slipping.

REFERENCE

[1] Andre Plamondon, Alain Delisle, Karin Trimble, Pierre Desjardins, Trevor Rickwood, (2006) “Manual materials handling in mining: The effect of rod heights and foot positions when lifting ‘‘in-the-hole’’ drill rods”, Volume 37, pp.709 – 718

[2] Arip Wahyudi .M, Wike A.P. Dania, Rizky L.R. Silalahi (2015), “Work Posture Analysis of Manual Material Handling Using OWAS Method”, Volume 3, pp. 195 – 199

[3] Baba Md Derosa, Dian Darina Indah Daruisb, Ishak Mohamed Basir (2015), “A Study on Ergonomic Awareness among Workers Performing Manual Material Handling Activities”, Volume 195, pp. 1666 – 1673.

[4] Drury.C.G (19801), “Handles for manual materials handling”,Applied Ergonomics, Volume 11, pp. 35-42.

[5] Fellows.G.L and A. Freivalds (1991), “Ergonomics evaluation of a foam rubber grip for tool handles”, Applied Ergonmics, Volume 22, pp. 225-230.

[6] Ghosh S N and P K Nag (1986), “Muscular strains in different modes of load handling”,Clinical Biomechanics, Volume 1, pp. 64-70.

[7] Hilary McDermott, Cheryl Haslam, Stacy Clemes, Claire Williams, Roger Haslam (2012), “Investigation of manual handling training practices in organizations and beliefs regarding effectiveness”, Volume 42, pp.206 – 211

[8] Jean Theurel, Kevin Desbrosses, Terence Roux, Adriana Savescu (2018), “Physiological consequences of using an upper limb exoskeleton during manual handling tasks”,Applied Ergonomics, Volume 67,pp 211-217.

[9] Joseph F. Seay , Shane G. Sauer , Tejash Patel , Tanja C. Roy (2015), “A history of low back pain affects pelvis and trunk coordination during a sustained manual materials handling task”, Volume 5, pp.52 – 60

[10] John R. Wilson (2014), “Fundamentals of systems ergonomics/human factors”, Volume 45, pp. 5 – 13

[11] Kabuka .M, A.M. Genaidyt and S.S. Asfour (1988), “A knowledge-based system for the design of manual materials handling” Volume 19.2, pp.147 – 155

[12] Kathleen Mack, Christine M. Haslegrave and Michael I. Gray (1995), “Usability of manual handling aids for transporting materials”,Applied Ergonomics, Volume 26, pp. 353-364.

[13] Kevin Desbrosses (2017), “Manual handling tasks performed with an upper limbs exoskeleton at the workplace”, Volume 60, pp.100 – 101

[14] Lortie.M, R. Pelletier (1996), “Incidents in manual handling activities”, Safety Science, Volume 21, pp. 223-237.

[15] Mahsa Parvini, Packaging and Material Handling.

[16] Marie Authier, Monique Lortie ,Micheline Gagnon (1996), “Manual handling techniques: Comparing novices and experts”,International Journal of Industrial Ergonomics, Volume 17, pp. 419-429.

[17] Marie Authier and Monique Lortie (1993), “Assessment of factors considered to be important in handling tasks by expert handlers”, International Journal of Industrial Ergonomics, Volume 11, pp. 331-340.

[18] MarkettaIGkkGnen, EiraViikari- Juntura and Esa-PekkaTakala (1996), “Effects of changes in work methods on musculoskeletal load. An intervention study in the trailer assembly”, Applied Ergonomics, Volume 28, pp 99-108.

[19] Miguel A. Perez,Maury A. Nussbaum (2006), “Posture and motion variability in non-repetitive manual materials handling tasks”, Human Movement Science, Volume 25, pp. 409-421.

[20] Mital, G.M. Kumar (1997), “Cardiac rehabilitation (CR)" Use of manual materials handling”, Volume 20, pp. 93 – 99

[21] Odile Heran-Le Roy, Isabelle Niedhammer, Nicolas Sandret, Annette Leclerc (1999) “Manual materials handling and related occupational hazards: a national survey in France”, Volume 24, pp.365 – 377

[22] Patrick G. Dempsey (1999), “Utilizing criteria for assessing multiple-task manual materials handling jobs”, Volume 24, pp. 405 – 416

[23] Robin Hanson, Lars Medbo, Cecilia Berlin, Jonas Hansson (2017), ”Manual picking from flat and tilted pallet containers”,International Journal of Industrial Ergonomics, Volume 13, pp. 1-13.

[24] Philippe Corbeil, Andre Plamondon, Grant Handrigan, JasminVallée-Marcotte, Simon Laurendeau, Jasmin Ten Have, Nancy Manzerolle (2019), "Biomechanical analysis of manual material handling movement in healthy weight and obese workers", Applied Ergonomics, Volume 74, pp. 124-133.

[25] Plamondon.A, C. Lariviere, D. Denis, H. Mecheri, I. Nastasia (2017), "Difference between male and female workers lifting the same relative load when palletizing boxes",Applied Ergonomics, Volume 60, pp. 93-102.

[26] Steven Visser, Henk F. van der Molen, P. Paul F.M. Kuijer, Marco J.M. Hoozemans, Monique H.W. Frings-Dresen (2014), "Evaluation of team lifting on work demands, workload and workers'evaluation: An observational field study", Volume 45, pp. 1597 – 1602

[27] Vincent .M, D. Denis, D. Imbeau, M. Laberge (2005), "factors affecting manual materials handling in a warehouse superstore", Volume 35, pp. 33 – 46

[28] Werner L. Popp, Olivier Lambercy, Christian Müller, Roger Gassert (2016), "Effect of handle design on movement dynamics and muscle co-activation in a wrist flexion task", International Journal of Industrial Ergonomics, Volume 56, pp. 170-180.

[29] Yaar Harari, RazielRiemer ,AvitalBechar (2018), "Factors determining workers' pace while conducting continuous sequential lifting, carrying, and lowering tasks",Applied Ergonomics, Volume 67, pp. 61-70.