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Review article

METHODOLOGICAL APPROACH TO ASSESSMENT OF THE IMPACT OF ERGONOMIC CHARACTERISTICS OF THE WORKPLACE ON THE OCCURRENCE OF MUSCULOSKELETAL DISORDERS IN HEALTH WORKERS

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Abstract

Ergonomic factors are one of the most important risk factors that are present in various specific work processes in the healthcare industry and in different workplaces causing side effects on the health of healthcare professionals. In their daily work activities, doctors, dentists, nurses, physiotherapists and other health professionals and other medical workers are facing cumulative trauma and uninterrupted workloads that lead to chronic diseases and musculoskeletal disorders.

The aim of the study was through analysis of the available literature and studies to determine the most appropriate methodological approach to assess the impact of ergonomic characteristics of the workplace on the occurrence of musculoskeletal disorders in health workers.

The most commonly used instruments in epidemiological research in this field are standardized or specially designed questionnaires for: analysis of musculoskeletal symptoms; medical history and checklist for work-related MSD (Musculoskeletal Disorders) symptoms; job requirements and resources; ergonomic risk assessment in the workplace.

The methodology with an integrated, comprehensive, and multidimensional approach is aimed at obtaining a more efficient way to assess the impact of ergonomic factors in the workplace on the occurrence of musculoskeletal disorders in health professionals of different profiles.

Keywords: ergonomic, musculoskeletal disorders, healthcare workers

Introduction

Ergonomics

Ergonomic variables are one of the most significant risk factors in the healthcare industry and in numerous workplaces, generating negative impacts on the health of healthcare workers.

Ergonomics in the health sector enables the development of a functional workplace arrangement[1]; a safe working environment (management of workload, shortage of health personnel and provision of quality health services within the framework of health care)[2]; provision of interactive medical devices[3]; reduction of work-related psychological stress[4];

reduction of treatment errors[5]; increased patient safety[6,7]. According to OSHA (Occupational Safety and Health Administration), the most common causes of injuries related to ergonomic factors among healthcare workers in hospitals are: 1. Non-physiological posture (48%), particularly while handling patients (paramedics, nurses), 2. Slipping, tripping and falling (25%) when performing work tasks, and 3. Fatigue, especially of the hands due to frequent repetitive movements (surgeons, dentists, sonographers)[8]. In 2011, hospitals throughout the United States recorded 253,700 work-related injuries and illnesses; this equates to a rate of 6.8 work-related injuries and illnesses per 100 full-time employees, approximately twice the rate in the private sector as a whole[9].

Risk factors among healthcare workers (such as: strong strains during patient manipulation and other heavy loads, incorrect body posture, long standing and long sitting, poorly designed workplace, emotional strain, workplace stress, overtime work, work in shifts, night work, etc.) contribute to the development of cumulative injuries that increase the risk of musculoskeletal disorders[10].

Musculoskeletal disorders and health care workers

Doctors, dentists, nurses, physiotherapists, and other health professionals and associates endure cumulative traumas and persistent loads in their everyday work activities, that contribute to chronic diseases and musculoskeletal disorders (MSD) [11].

According to EU-OSHA, the health sector ranks 4th in Europe with 44% representation of MSD [12]. In line with Hoskins study, the percentage of MSD prevalence among nurses in South Korea was 93.6%, 92.6% in Australia, and 78.4% in Japan[13]. According to Rambabu and Long's studies, nurses were most commonly affected by MSD (41.7%), followed by physiotherapists (35%), dentists (22.6%), and surgeons and laboratory technicians (4%)[14,15]. Musculoskeletal disorders were diagnosed in the highest percentage among family physicians (13.3%) and the lowest percentage was found among oncology specialists (2.7%), based on research carried by Lahoti *et al.* in doctors from various profiles[16]. In Bojkoski's study (2020) of surgical workers, 84% of respondents reported work-related musculoskeletal discomfort in at least one part of the body, showing that health workers are at risk for the emergence of work-related musculoskeletal diseases[17].

Risk factors for the occurrence of MSD among health workers

Numerous studies and scientific research have determined the following occupational "risk factors" for the development of MSD among health workers: MSDs are caused by a combination of ergonomic risk factors such as repetitive movements, prolonged standing and sitting, non-physiological body posture at work, lifting and transferring patients, pushing, and pulling heavy loads, vibrations (via manual tools), extreme temperature variations, etc.[18].

Psychosocial/organizational - emotional burden, workplace stress, numerous shifts, night work, overtime work, low appraisal, limited prospects for growth, and inefficient work organization[19,20].

Individual - gender, age, body mass index (BMI), existence of comorbidities, insufficient level of physical fitness, absence of work experience, etc.[18].

The above-mentioned risk factors and the correlation between them are shown below in Figure 1.

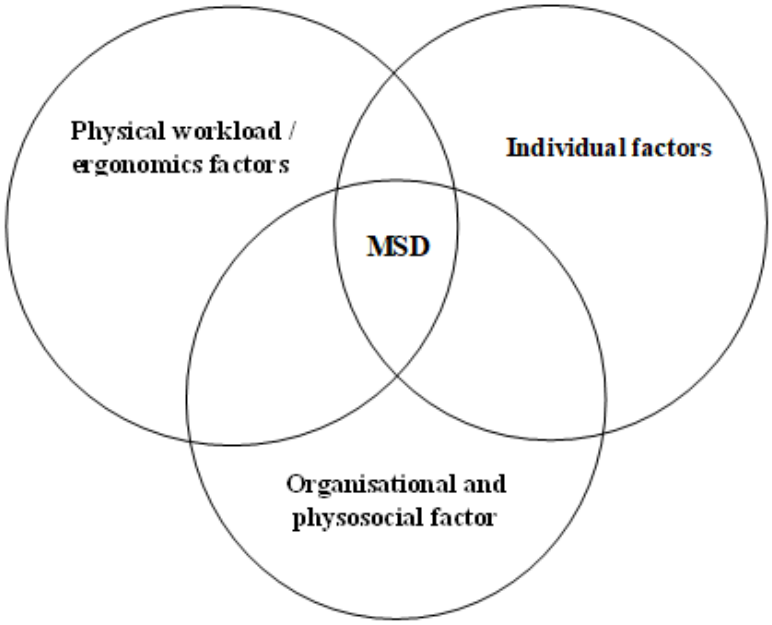

Fig. 1. Risk factors for the development of work-related MSDs
Source: http:// Discussion_paper_MSDs_in_health_care_sector.pdf/ osha.europa.eu

Aim of the study

The aim of this study was to determine the best suitable methodological approach for evaluating the impact of workplace ergonomic factors on the prevalence of musculoskeletal disorders among health workers by analyzing literature data and studies. It is necessary to select efficient instruments for acquiring appropriate data on the occurrence and frequency of musculoskeletal disorders, the influence of demographic characteristics, work engagement, demands and assets at the workplace, the impact of musculoskeletal disorders on the performance of work assignments, daily activities outside of work, health and working ability among various profiles of health workers in various components of the health activity, with the objective of creating preventive strategies with guidelines for action in terms of planning and implementation of preventive measures.

Methodology

In accordance with published literature, many research instruments have been applied to obtain relevant data in the field of ergonomic workplace features and their impact on the prevalence of musculoskeletal disorders among health workers of various profiles. The most widely used instruments in this domain of epidemiological research are standardized or specially designed questionnaires that collect accurate data to determine the various components of the research problem.

Analysis of musculoskeletal symptoms

The standardized Nordic questionnaire and its extended version are basic instruments for the analysis of musculoskeletal symptoms (Standardized Nordic questionnaires for the analysis of musculoskeletal symptoms, Kourinka *et al*. 1987, Extended version of Standardized Nordic

questionnaires - NMQ-E, Roja *et al*. 2013)[21,22]. The questionnaire's major aims are to be utilized as an instrument in the ergonomic screening of musculoskeletal disorders and in occupational medicine to determine occupational etiology. Such questionnaire may be used in occupational medicine for a variety of objectives, including determining workload while performing work tasks, monitoring the impact of workplace modifications, etc.

The questionnaire is divided in three parts:

- Part 1 consists of demographic data and work characteristics that would identify respondents' demographic data (gender, age, level of education, weight and height, smoking) and work characteristics (current and previous workplaces, total length of service, length of service at the current position, shift work, night shift work, number of working hours per week).

- Part 2 is the general component of the standardized Nordic questionnaire[21]. It consists of a diagram of the body in orientation and questions about the occurrence of musculoskeletal symptoms (pain, discomfort, stiffness) in the previous 7 days, i.e., 12 months, and whether there was a restriction to perform regular physical activities at work or at home in the previous 12 months.

- Part 3 refers to the posture of the body during work and is part of the expanded version of the Nordic Questionary [22]. (Whether the body is in the correct position during work, how many hours are spent in a sitting or standing position, whether the hands are raised during work for longer than two hours, in what position the head is at work, and whether the work is physically exhausting).

Since 2017, Lopez-Aragoni *et al.* have been studying the benefits and drawbacks of a broader implementation of the expanded version of the Nordic Questionnaire[23].

The advantages are as follows:

- Question standardization
- World recognized and applied in several scientific studies and research
- Free to use
- Self-evaluation
- Relatively quick identification of symptoms
- Applicability to large populations \
- Frequently used in conjunction with other valuation methods such as RULA, REBA, etc.

The accompanying limits apply:

- Obligatory answer to the questions
- Difficulty assessing the authenticity of the responses
- Difficulty in use in non-English-speaking countries (errors in translation, interpretation, and/or validation)
- Only symptom identification
- Complex data processing for big populations
- Variation in responses based on the person conducting the questionnaire.

The questionnaire was validated using a reliability analysis that measured the questionnaire's internal consistency. The Kuder-Richardson reliability coefficient confirms internal consistency, with a correlation value of 0.855 indicating a good and acceptable dependability[24].

Medical history and checklist for work-related MSD symptom

The basis of this instrument is a medical history questionnaire and a work-related MSD symptom checklist derived from the Canadian Center for Occupational Health and Safety's Ergonomic MSD Prevention Program[25]. The questionnaire is augmented with specially prepared MSD-related questions. The questions refer to the perception of work-related symptoms (pain during work, pain after finishing work, or pain after a week away from work), as well as the effects of the symptoms on the worker's well-being (does the pain affect the performance of work tasks, daily activities outside of work, and sleep). Specially designed questions address the impact of the COVID 19 pandemic on the occurrence of MSDs, physical activity, knowledge of ergonomic principles, risks and measures for MSD prevention, use of medical devices, computers, and training and education for their proper use, use of personal protective equipment, workplace injuries, treatment, absences, or hospitalization due to MSD and their time frame, regularity of health monitoring, and assessment of health status. Most of the variables in the questionnaire are dichotomous, apart from the section augmented by special designs and questions related to MSN, which have numerous potential response possibilities.

Demands and resources in the workplace

The French job demands and resources questionnaire is a multidimensional instrument for specific information on job demands and resources that is well balanced and thorough, since it includes seven categories of job demands and seven areas of job resources (Demeruti *et al*., 2001)[26,27]. As a result, this instrument is beneficial for academics and practitioners engaged in researching the effects of job demands and resources on the work process and the worker, and it may be applied to a broad range of workplace situations independent of occupation. Work characteristics associated with work stress may be divided into two categories: job demands and job resources.

Job demands are defined as "physical, social, or organizational aspects of work that necessarily require sustained physical and/or psychological (i.e., cognitive or emotional) effort on the part of the employee and are thus associated with certain physiological and/or psychological health effects of the worker (e.g., burnout)[28]. Occupational demands are job characteristics that, when exceeded by the worker's capabilities, could generate strain (for example, excessive workload, intense pace of work). The JD-R model is used to indicate specific and persistent demands of the work environment that might create health disorders, particularly when job demands lead to energy depletion[29]. Numerous studies indicate that job demands generate burnout syndrome, health deterioration, and increased absenteeism at work[28].

Alternatively, workplace resources are physical, psychological, social, or organizational aspects of work that (1) minimize job demands and related physiological and psychological impacts, (2) are effective in attaining work goals, or (3) encourage personal improvement, learning, and development[27]. According to Bakker, Demeruti, de Boer *et al.* (2003)[28], resources in the workplace can be of the following types: 1. organization of work at the whole organization level (e.g., higher salary, career opportunity, job security); 2. interpersonal level (e.g., support from governing bodies, teamwork); 3. individual level (e.g., clarity of role in the work process, participation in decision-making); and 4. level of performance of work tasks (e.g., feedback on work performed, application of new skills, autonomy in decision-making)[30]. In contrary to job demands that might generate health problems, the JD-R model implies that the availability of work resources contributes to worker motivation, which improves performance[27]. A Likert scale with scores ranging from 1 for "I do not agree at all" to 5 for "I completely agree"

is used to evaluate the results. Following the collection of points, an average value is computed for each question individually.

In the study by Lequeurre *et al*., the questionnaire was validated employing reliability analysis by measuring the internal consistency of the questionnaire. The internal consistency of the questionnaire is verified by the Cronbach alpha reliability coefficient, with a value between 0.78 and 0.95, indicating a good and acceptable reliability[31].

Assessment of ergonomic risk at the workplace

WERA (Work Ergonomic Risk Assessment) was developed to provide a method for quick screening of tasks when there is exposure to a physical risk factor and connection with the development of work-related musculoskeletal disorders[31,32]. This instrument (WERA) includes six physical risk factors (body posture while performing work tasks, repetitive movements, strain and heavy lifting, vibration exposure, stress contact when using hand tools, and duration of work tasks) as well as the five main body regions (shoulder, wrist, back, neck and leg) [32,33].

The questionnaire includes a scoring system and action levels, resulting in a final ergonomic assessment of the level of risk and the potential need for preventive measures. To obtain a total final score, a score is calculated for each risk factor item by marking the intersection point numbers of each pair of rounded values in the tables (columns *vs*. rows).

The overall final score determines whether the assignment is accepted:

Final score 18-27, low risk, assignment acceptable.

Final score 28-44, medium risk, and requires additional examination and corrective measures.

Final score 45-54, a high level of risk that is unacceptable and it is necessary to urgently change the work task.

This questionnaire requires no additional equipment and may be completed at any workplace without interfering with the work process.

The WERA provides an accurate indicator of work-related musculoskeletal disorders that may manifest pain or discomfort in the affected body region. Experts and management teams concur in studies of the application of the WERA tool that it is simple and quick to use, applicable to workplace assessment for a wide variety of jobs/tasks. It has also been established that no training is necessary to conduct an evaluation using the WERA tool, and that it is reliable in assessing risk factors for the occurrence of MSDs in industrial environments and epidemiological studies[34].

Methodology with an integrated approach

This dynamic process is best evaluated using an integrated and comprehensive approach to the factors impacting the occurrence of MSD among health care workers. An effective framework for assessing the impact of ergonomic characteristics on the occurrence of musculoskeletal disorders should incorporate physiological, epidemiological, and biomechanical knowledge that influences the occurrence of work-related musculoskeletal disorders among health workers. This integrated dynamic approach is carried out in four stages: 1. Musculoskeletal symptom analysis; 2. Medical history and checklist for work-related MSD symptoms; 3. Workplace requirements and resources; and 4. Assessment of ergonomic risk at the workplace.

An integrated approach methodology provides a model of a preventive strategy for dealing with the problem of musculoskeletal disorders among health workers at individual, institutional, and national levels.

Discussion

Numerous studies refer to various methodological principles that examine the ergonomic workplace characteristics that impact the prevalence of musculoskeletal disorders among health workers. Muthukrishnan *et al.* employed the standardized Nordic questionnaire and the WERA (Work Ergonomic Risk Evaluation) tool for ergonomic assessment at the workplace in a 2019 study on nurses. This study revealed a strong correlation between work characteristics, ergonomic risk factors, and the occurrence of MSDs in nurses, most commonly in the lower back, neck, and hips, which contributed to the prevention of performing normal activities at least once in the previous 12 months[35].

The study by Grooten and Johanssons (2018) provided a literature review on ergonomic risk assessment[36]. In this study, three indicators (intensity, frequency, and duration) were analyzed during the ergonomic risk assessment to determine the level of risk for the development of MSD in particular parts of the body. The WERA (Work Ergonomic Risk Assessment) tool was the only one that met all three indicators for MSD development in all parts of the human body, according to a review of 13 ergonomic risk assessment tools[36].

Conclusion

It is proposed to apply a methodology with an integrated and comprehensive multidimensional approach to acquire a more efficient way of assessing the impact of workplace ergonomic factors on the prevalence of musculoskeletal disorders among health workers of various profiles. With this methodology, it is expected to obtain relevant and valid data on the influence of demographic characteristics, as well as job characteristics, workplace demands and resources, the impact of musculoskeletal disorders on the performance of work tasks, daily activities outside of work, health and work ability among various profiles of health workers in different segments of the health activity, which would define the public health dimensions of the problem of musculoskeletal disorders among health workers in our environment, and would offer measures and guidelines for their prevention.

Conflict of interest statement. None declared.

References

1. Rogers B, Buckheit K, Ostendorf J. Ergonomics and nursing in hospital environments. *Workplace Health Saf* 2013; 61(10): 429-439. doi: 10.1177/216507991306101003.
2. Vincent CJ, Li Y, Blandford A. Integration of human factors and ergonomics during medical device design and development: It's all about communication. *Appl Ergon* 2014; 45(3): 413-419. doi: 10.1016/j.apergo.2013.05.009.
3. Punnett L, Warren N, Henning R, Nobrega S, Cherniack M, CPH-NEW Research Team. CPH-NEW research team. Participatory ergonomics as a model for integrated programs to prevent chronic disease. *J Occup Environ Med* 2013: 55(12 Suppl): S19-S24. doi: 10.1097/JOM.0000000000000040.

4. Leape LL, Bates DW, Cullen DJ, Cooper J, Demonaco HJ, Gallivan T, *et al*. Systems analysis of adverse drug events. ADE Prevention Study Group. *JAMA* 1995; 274(1): 35-43. PMID: 7791256.
5. Hignett S, Masud T. A review of environmental hazards associated with in-patient falls. *Ergonomics* 2006; 49(5-6): 605-616. doi: 10.1080/00140130600568949.
6. Worker Safety in Your Hospital. Know the Facts. Available from: https://www.osha.gov/sites/default/files/1.1_Data_highlights_508.pdf
7. How safe is Your Hospitals for Workers. Learn More and Take Action. Available from: https://www.osha.gov/sites/default/files/4.1_Overview_508.pdf
8. Bell J, Collins W J, Dalsey E, Sublet V. Slip, Trip, and Fall Prevention for Healthcare Workers. DHHS (NIOSH) Publication Number 2011–123. Available from: https://www.cdc.gov/niosh/docs/2011-123/pdfs/2011-123.pdf
9. Smith DR, Choe MA, Jeon MY, Chae YR, An GJ, Jeong JS. Epidemiology of musculoskeletal symptoms among Korean hospital nurses. *Int J Occup Saf Ergon* 2005; 11(4): 431-440. doi: 10.1080/10803548.2005.11076663.
10. WHO 2002, Occupational health. A manual for primary health care workers: 87-95 Available from: https://apps.who.int/iris/bitstream/handle/10665/200733/dsa191.pdf
11. Koyuncu N, Karcioglu Ö. Musculoskeletal complaints in healthcare personnel in hospital: An interdepartmental, cross-sectional comparison. Medicine (Baltimore). 2018 Oct;97(40):e12597. doi: 10.1097/MD.0000000000012597. PMID: 30290628; PMCID: PMC 6200550. (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6200550/)
12. Isusi I, Corral A, Durán J, Kok J, Snijders J, Bühring T, Curtarelli M. Workforce diversity and musculoskeletal disorders: review of facts and figures and examples. Luxembourg: Publications Office of the European Union, 2020; p.37. doi:10.2802/499283 Available from: https://oxfordresearch.eu/wp-content/uploads/2021/05/Workforce_ diversity _ and_MSDs.pdf
13. Hoskins A. Occupational Injuries, Illnesses, and Fatalities among Nursing, Psychiatric, and Home Health Aides, 1995-2004. *U.S. BUREAU OF LABOR STATISTICS* 2006. Available from: https://www.bls.gov/opub/mlr/cwc/occupational-injuries-illnesses-and-fatalities-among-nursing-psychiatric-and-home-health-aides-1995-2004.pdf
14. Rambabu T, Suneetha K. Prevalence of work-related musculoskeletal disorders among physicians, surgeons and dentists: a comparative study. *Ann Med Health Sci Res* 2014; 4(4): 578-582. doi: 10.4103/2141-9248.139327.
15. Long MH, Bogossian F, Johnston V. The prevalence of Work-related neck, shoulder and upper back musculoskeletal disorders among midwives, nurses and physicians: A systematic review. *Workplace Health and Safety* 2013; 61(5): 223-229. doi: 10.1177/216507991306100506.
16. Lahoti S, Narayan A, Ottayil ZCVP, Bhaskaran U. Prevalence of musculoskeletal disorders among doctors in Mangalore: A cross-sectional survey. *Int J Health Allied Sci* 2014; 3(3): 204-207. doi: 10.4103/2278-344X.138609.
17. Бојкоски Д. Поврзаност на синдромот на согорување и постоењето на мускулоскелетна болка кај здравствени работници од терциерна хируршка установа (Correlation of the burnout syndrome and the existence of musculoskeletal pain in health workers from a tertiary surgical institution). Институт за медицина на трудот на РСМ – Скопје. Специјалистички труд (2020)

18. Borjanovic S. Ergonomske štetnosti na radu u zdravstvenim ustanovama. Bezbednost i zdravlje na radu zdravstvenih radnika (Ergonomic hazards at work in healthcare institutions. Safety and health at work of healthcare workers), Beograd 2010. Available from: https://www.scribd.com/doc/257446150/Ergonomske-Stetnosti-u-Zdravstvu#
19. Devereux JJ, Vlachonikolis IG, Buckle PW. Epidemiological study to investigate potential interaction between physical and psychosocial factors at work that may increase the risk of symptoms of musculoskeletal disorder of the neck and upper limb. *Occup Environ Med* 2002; 59(4): 269-277. doi: 10.1136/oem.59.4.269.
20. Карацинска-Бислимовска Ј, Мијалков Б, Груневска В и сор. Специфични професионални ризици кај здравствените работници – инфективни и психосоцијални штетности (Specific occupational risks among health workers – infectious and psychosocial harms). Проект бр. 40116101/0. Скопје: Министерство за образование и наука; 2004
21. Kuorinka I, Jonsson B, Kilbom A, Vinterberg H, Biering-Sørensen F, Andersson G, *et al*. Standardised Nordic questionnaires for the analysis of musculoskeletal symptoms. *Appl Ergon* 1987; 18(3): 233-237. doi: 10.1016/0003-6870(87)90010-x.
22. Roja Z, Kalkis H,Roja I. Measuring muscle fatigue in relation to the workload of health care workers. *6th International Conference on Applied Human Factors and Ergonomics (AHFE 2015) and the Affiliated Conferences, AHFE 2015* (https://www.sciencedirect. com/science/article/pii/S2351978915003959).
23. López-Aragón L, López-Liria R, Callejón-Ferre A-J. Applications of the Standardized Nordic Questionnaire: A Review (https://www.researchgate.net/publication/319298152) doi: 10.3390/su9091514.
24. Pugh JD, Gelder L, Williams AM, Twigg DE, Wilkinson AM, Blazevich AJ. Validity and reliability of an online extended version of the Nordic Musculoskeletal Questionnaire (NMQ-E2) to measure nurses' fitness. *J Clin Nurs* 2015; 24(23-24): 3550-3563. doi: 10.1111/jocn.12971.
25. Medical History Checklist: Symptoms Survey for Work-Related Musculoskeletal Disorders (WMSDs). Canadian Centre for Occupational Health and Safety. (https://www.ccohs.ca/oshanswers/diseases/work_related_WMSD.html).
26. Lequeurre J, Gillet N, Ragot C, Fouquereau E. French questionnaire to measure job demands and resources QRCP. (2015)
27. Demerouti E, Bakker A B, Nachreiner F, Schaufeli W B. (2001). The job demands-resources model of burnout. *Journal of Applied Psychology, 86*(3), 499–512. Available from: https://doi.org/10.1037/0021-9010.86.3.499
28. Bakker AB, Demerouti E, Taris T, Schaufeli W B, Schreurs P. A multi-group analysis of the job demands-resources model in four home care organizations. *International Journal of Stress Management* 2003; 10(16-38). https://doi.org/10.1037/1072-5245.10.1.16.
29. Bakker AB, Hakanen JJ, Demerouti E, Xanthopoulou D. Job resources boost work engagement, particularly when job demands are high. *Journal of Educational Psychology* 2007; 99(274-284). https://doi.org/10.1037/0022-0663.99.2.274.
30. Bakker AB, Demerouti E, de Boer E, Schaufeli WB. Job demands and job resources as predictors of absence duration and frequency. *Journal of Vocational Behavior* 2003; 62 (341-356). doi:10.1016/S0001-8791(02)00030-1.

31. Lequeurre J, Gillet N, Ragot C, Fouquereau E. Validation of a French questionnaire to measure job demands and resources. *Revue internationale de psychologie sociale* 2013; 26: 93-124. Available from: https://www.cairn.info/revue--2013-4-page-93.htm.
32. Abd Rahman MN, Abdul Rani MR, Rohani JM. WERA: an observational tool develop to investigate the physical risk factor associated with WMSDs. *J Hum Ergol (Tokyo)* 2011; 40(1-2): 19-36. PMID: 25665205.
33. Rahman MN, Rani MR, Rohani JM. Investigation of work-related musculoskeletal disorders in wall plastering jobs within the construction industry. *Work* 2012; 43(4): 507-514. doi: 10.3233/WOR-2012-1404.
34. Rahman MN, Rani MR, Rohani JM. WERA Tool for Assessing Exposure Risk Factors of Work-Related Musculoskeletal Disorders - A Reliability and Validity Study. Proceedings of the 2012 International Conference on Industrial Engineering and Operations Management Istanbul, Turkey, July 3-6, 2012.
35. Muthukrishnan R, Ahmad JM. Ergonomic risk factors and risk exposure level of nursing tasks: association with work-related musculoskeletal disorders in nurses, *European Journal of Physiotherapy* 2020; 23(4): 248-253. doi: 10.1080/21679169.2020. 1715473.
36. Grooten WJA, Johanssons E. Observational Methods for Assessing Ergonomic Risks for Work-Related musculoskeletal disorders. A Scoping Review. *Rev Cienc Salud* 2018; 16 (especial): 8-38. doi: http://dx.doi.org/10.12804/revistas.urosario.edu.co/revsalud/a. 6840.