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Ergonomics, workplace safety and pallet stability: the dea project and the new dispenser hi.dea

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Abstract
International regulations ask companies to take care of their workers, paying attention to the social dimension of sustainability. In this contest, an Italian packaging films producer conceptualized the need of a new film packaging dispenser to facilitate the operations of workers, promoting correct posture and avoiding trauma during the work routine. The so-called Dispenser Eumos Application (DEA) project was therefore set up to study all aspects of manual packaging and develop a method to improve and streamline this type of application, which is too often left to the subjectivity of the human operator. The work was carried out in-house, with the support of highly specialized product designers, and resulted in the development from scratch of a next-generation dispenser (patent pending) that could be a natural extension of the operator's manual dexterity, improving performance and benefits in the short, medium and long term. The final element of the project was the development of a durable, cost-effective and ergonomic dispenser to assist the operator in manual packaging operations and contribute to high standards of health and safety at work. This latter aspect was certified by sliding acceleration tests according to European Safe Logistics Association (Eumos) 40509-20, which is a non-profit association dedicated to improving safety throughout the logistics chain exchanging the best practices when working towards higher transport safety standards for logistics. Finally, the positive impact on the health and safety of manual packing workers, including a reduction in injuries and musculoskeletal disorders, was monitored through the LEA posture analysis system and the Rapid Upper Limb Assessment (RULA) ergonomic standard.

1 Introduction

International regulations ask companies to take care of their workers, paying attention to the social dimension of sustainability. Workplace safety, Corporate Social Responsibility (CSR) and sustainability are deeply interconnected. Ensuring safe working conditions is a fundamental aspect of a company's social responsibility. By prioritizing employee well-being, businesses not only comply with legal standards but also foster trust and loyalty. This contributes to long-term sustainability, as a safe and healthy workforce is more productive and engaged. Moreover, companies that emphasize safety and CSR are often seen as more ethical and attractive to stakeholders [1]. Sustainability also includes environmental practices, and a safe workplace reduces the likelihood of accidents that could harm both people and the planet. In essence, integrating safety, CSR, and sustainability leads to a more resilient, responsible, and sustainable business model. Ergonomic risks are yet another important consideration in blue collar jobs.

Ergonomics, the science of designing and arranging workspaces, equipment, and tasks to fit the capabilities and limitations of workers, is fundamental to ensuring health and safety in the logistics industry. Logistics is a physically demanding sector, where workers frequently perform repetitive motions, lift heavy objects, and operate in fast-paced environments. Poor ergonomic practices can lead to a range of health issues, including Musculoskeletal Disorders (MSDs), fatigue, and long-term injuries that affect productivity and overall worker well-being. As the global demand for logistics services grows—driven by e-commerce, just-in-time delivery, and global supply chains—the focus on ergonomics in this sector has become more critical than ever. One of the key ergonomic challenges in logistics is the physical strain workers endure from manual handling tasks. Many logistics jobs involve repetitive movements, awkward postures, and heavy lifting, all of which can lead to cumulative trauma injuries. Over time, these strains can result in conditions like back pain, joint degeneration, and other MSDs, which are among the leading causes of lost workdays in the industry [2]. Without proper ergonomic interventions, the long-term effects on worker health can be severe, leading to reduced productivity and even permanent disability in extreme cases. Warehouse workers often need to manually wrap pallets instead of using robots due to several factors: the flexibility required for handling irregularly shaped or fragile goods that robots may struggle to wrap correctly; the high cost of automation makes it impractical for smaller warehouses. In some cases, the variability of load sizes and materials also demands human judgment. Lastly, manual wrapping allows for real-time adjustments and inspection, which automated systems cannot always replicate efficiently. An additional factor compounding the need for ergonomic improvements in logistics is the aging workforce [3]. In many industrialized countries, the average age of workers in sectors like logistics is steadily increasing [4]. Older workers may be more susceptible to injury and may recover more slowly from physical strain compared to their younger counterparts. Age-related declines in strength, flexibility, and balance can make physically demanding tasks more hazardous for older employees. As a result, aging workers are at a higher risk of developing chronic injuries related to poor ergonomic conditions [5]. Therefore, the logistics industry must adapt to this demographic shift by implementing ergonomic solutions that accommodate an aging workforce. For example, reducing the need for manual lifting and bending through mechanized tools and automated systems can mitigate the risk of injury [6]. Additionally, ergonomic training tailored to older workers—focusing on safe body mechanics, stretching exercises, and regular rest breaks—can help reduce the impact of aging on worker health. By addressing the specific needs of older employees, companies can maintain productivity while ensuring that workers remain healthy and engaged as they age [7]. Recent technological advancements have introduced innovative solutions to many of the ergonomic challenges faced by logistics workers [8]. Automation and robotics are revolutionizing the way tasks are performed in warehouses and distribution centers. For instance, automated conveyor systems and robotic picking machines can reduce the need for workers to handle heavy loads or perform repetitive motions [9]. Exoskeletons are another emerging technology with potential ergonomic benefits [10]. These wearable devices are designed to support and enhance human movement, providing workers with additional strength and reducing the load on their muscles and joints. In logistics, exoskeletons can assist workers in lifting heavy objects, reducing the risk of back injuries and other MSDs [11]. Wearable sensors are also gaining traction in the logistics sector. These devices monitor workers' movements in real time, providing feedback on posture, lifting techniques, and body mechanics. By alerting workers when they are at risk of injury, wearable sensors can help prevent accidents before they occur [12]. Moreover, the data collected from these sensors can be used to identify patterns of risky behavior, allowing companies to make informed decisions about ergonomic interventions. While technological advancements offer significant potential for improving ergonomics in logistics, they are not a cure-all. Many warehouses and distribution centers still rely heavily on manual labor, and even with the best technology, ergonomic risks cannot be entirely eliminated. High work demands, tight delivery schedules, and the constant pressure to increase efficiency can sometimes lead to the neglect of proper ergonomic practices. Workers may skip safety procedures or adopt poor body mechanics to keep up with the pace of work, increasing their risk of injury [13]. To address these challenges, a holistic approach to ergonomics is needed. This includes not only the adoption of ergonomic technologies but also a strong focus on education, training, and organizational culture. Workers should receive regular training on proper lifting techniques, posture, and body mechanics, and management should prioritize ergonomics as part of the company's overall safety strategy. Additionally, regular risk assessments should be conducted to identify and address potential ergonomic hazards before they lead to injury. Moreover, the involvement of workers in the development and implementation of ergonomic solutions is essential. Employees are often the best source of information about the physical demands of their tasks and involving them in the process can lead to more practical and effective solutions. Encouraging worker feedback and participation in ergonomic initiatives can also improve compliance and increase the likelihood of success. A comprehensive approach that combines technology with training, risk assessment, and worker involvement is essential for creating a safer and healthier work environment in logistics. By addressing these challenges head-on, companies can not only improve the well-being of their employees but also enhance productivity and efficiency, ensuring a sustainable future for the logistics industry.

In this contest, the present work aims at contributing to scientific literature with an example of new technology easily implementable for enhancing the social sustainability of logistic operation. The paper presents a case study developed by an Italian packaging films producer who conceptualized the need of a new film packaging dispenser to facilitate the operations of workers, promoting correct posture and avoiding trauma during the work routine. Section 2 illustrates the materials and methods used in the case study. Then, the results of the application are presented highlighting its advantages and disadvantages. Finally, in the last section, the conclusions of the work are discussed.

2 Materials and methods

The aim of the research was to identify a more sustainable scenario for manual pallet wrapping operators. For this purpose, a traditional scenario was identified and compared with the proposal of an innovative scenario. This section not only describes the two selected scenarios (sub-sections 2.1 and 2.2), but also the methods used to compare them (sub-section 2.3).
Since the logistics sector is characterized by great variability in the weight and dimensions of the palletized goods, which inevitably translates into the overall shape of the load, the load chosen for the case study has an extremely irregular profile; specifically, the load has the characteristics summarized in Table 1, which are commonly seen in real-life sector practice.

Characteristics	Quantity
Load average perimeter (top)	3.6 m
Load average perimeter (middle)	3.56 m
Load average perimeter (bottom)	3.6 m
Load heigh	1.37 m
Load weight	384 kg

Table 1 - description of the load used for the case study

2.1 Description of the current scenario

Most operators in the logistics sector are still wrapping loads manually: this activity represents a risk in the workplace, because they are forced to walk backwards without seeing exactly what is happening behind them. Moreover, manual wrapping has critical issues related to the posture that the operators are forced to adopt, especially when bending to wrap the lower part of the load or when twisting their trunks to wrap around the goods. In addition, the manual activity, related to the strength and subjectivity of the operator, does not guarantee that the goods are wrapped in a consistent and replicable manner, with the risk of shipping loads that are unstable during transportation, thus endangering road safety firstly, as well as the integrity of the wrapped goods. A stretch film reel was chosen to represent the current scenario: LLDPE stretch film for general use with standard mechanical properties (elongation, puncture, tearing), referred to in this article as standard film. Its characteristics are summarized in Table 2. The market offers the possibility of using special dispensers that help the operator to dispense the film evenly, reducing the strain on muscles and joints. These dispensers, as well as being still not very widespread, have some criticalities that make them inefficient from an ergonomic point of view. The initial analysis of the dispensers available in the European market has in fact revealed, in experts' opinion, that some of them are too heavy (their weight being more than 2 kg) and that others do not allow for an actual reduction in the workload of the operator, who (for example) has to keep bending to wrap the lower part of the load. In some cases, the dispensers show both criticalities.

2.2 Description of the new scenario with the DEA Project

In order to reduce and/or eliminate the state-of-the-art criticalities of the hand wrapping, especially but not exclusively for the logistics sector, a new scenario was considered by an Italian packaging film producer. In the so-called Dispenser Eumos Application (DEA) project, the company developed both a specific hand wrapping method and a next-generation (HI.DEA) dispenser. The manual packaging method defines a new type of film reel: 555 Rigid NetRoll film, thinner stretch film available in virgin raw materials or post-consumer recycled LLDPE with high mechanical properties (elongation, puncture, tearing), reel without paper core, referred to in this article as innovative film (Table 2).

Film Type	Film width	Film thickness	Reel length	Film support	Reel gross weight
Traditional standard film	500 mm	23 μm	180 m	Cardboard tube (600 g)	2.5 kg
Innovative film	450 mm	12 μm	180 m	No paper core: the film is wounded on itself	0.895 kg

Table 2 - current scenario and innovative scenarios, stretch film reel features

The new load wrapping scheme for the optimization of the operator movements, illustrated in Figure 1, can be described as follows: the operator must avoid bending to fix the stretch film at the wooden pallet and start wrapping at the bottom of the load. On the contrary, the wrapping cycle must begin at the top of the pallet. The wrapping cycle is made of 10 wraps, 2 at the top of the load, 4 downwards and 4 at the bottom of the load. The operator must ensure that he also wraps the top of the wooden pallet to secure the goods to the pallet. Moreover, he must wrap the goods to have at least 50% film overlap. The stretch applied by the operator on the stretch film should be consistent over time.

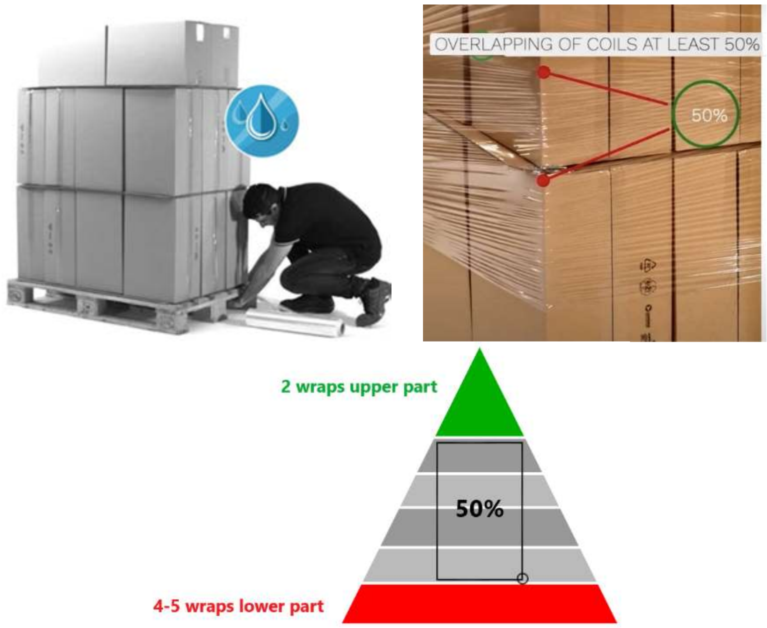

Fig. 1. New wrapping scheme: start wrapping at the top of the load instead of at the bottom. Film overlapping should be around 50% and pyramidal wrapping pattern with 4 wraps at the bottom and 2 wraps at the top of the load.

The HI.DEA dispenser (Figure 2) brings together a series of innovations that optimize manual packaging operations. Firstly, it is extremely light (1.3 kg). Therefore, the total weight of the dispenser and the innovative film is 2.195 kg, namely 12% lower than the weight of the standard reference reel (2.5 kg). Secondly, it is extremely ergonomic thanks to its peculiar 'harp' shape, the knobs which are placed to facilitate the wrapping of the upper and central part of the load, and above all thanks to the presence of a wheel that allows the lower part of the load to be wrapped without bending, providing support for the operator who relieves effort during the packing phase. Moreover, it allows a constant and regular stretch to be applied to the stretch film, thanks to its special knob for adjusting the brake applied to the reel-holder.

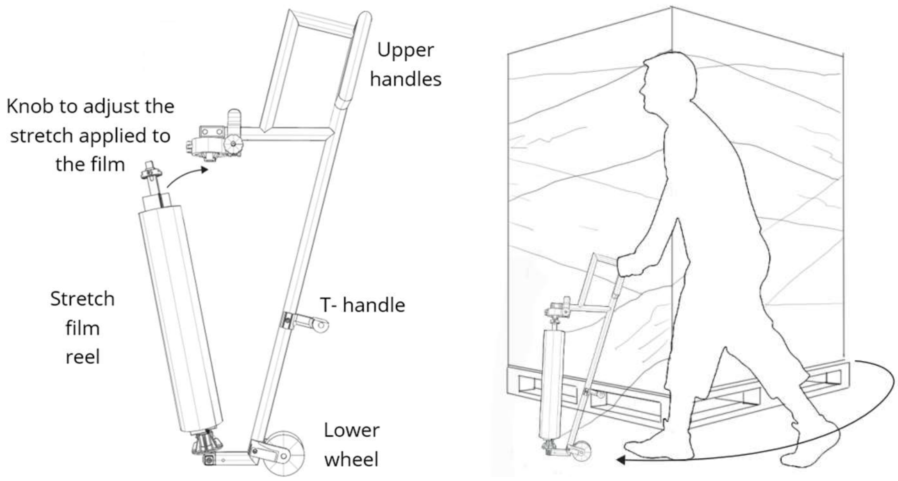

Fig. 2. The HI.DEA Dispenser

2.3 Methods to compare the traditional and innovative scenarios

LEA SOFTWARE

The traditional standard film and the innovative film, described in Table 2, have been compared in real life tests of hand wrapping. Clearly, the innovative film has been used with the HI.DEA dispenser; for ease of comparison, in both cases the hand wrapping cycle has been kept fixed as described in Section 2.2. The hand wrapping operations have been registered and evaluated with LEA, a postural analysis software capable of detecting the position of the main joints of the human body and measuring their angles with respect to a reference position. Specifically, this tool is based on the Rapid Upper Limb Assessment (RULA) approach [14]: it returns to the user a series of biomechanical scores that classify the impact of the movement on the human body. Score 1 or 2 means that the movement or posture is overall correct, and it can be maintained or repeated for long periods; score 3 or 4 indicates that changes in the posture may be required; scores 5 or 6 are the worst scenario which requires immediate modification to the movements. For a better understanding, Figure 3 shows the angle of the trunk with respect to the vertical (neutral) position:

- If the back is straight (0° angle), the score is 1.
- If the back is tilted between 0° and 20° forward, the score is 2.
- If the back is tilted between 20° and 60° forward, the score is 3.
- If the back is tilted beyond 60° forward, the score is 4.

Additionally, if the back is inside bending (lateral flexion) or twisted (rotating), you need to add 1 point for each movement.

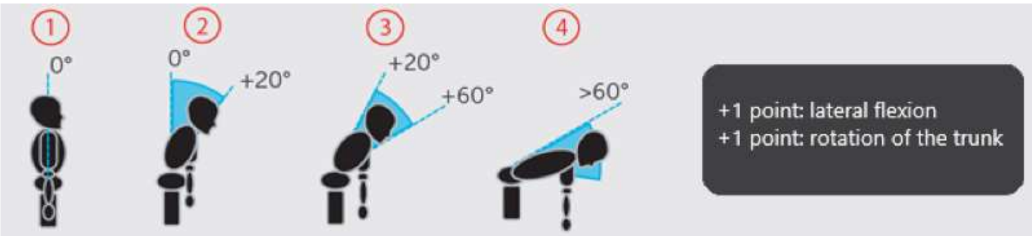

Fig. 3. Example (trunk) of RULA scores.

HAND WRAPPER TESTER

The stretch films used for the study have been tested on the Hand Wrapper Tester (HWT) system to measure the holding force they are able to exert, in compliance with the international standard ASTM 8314-20. In addition, the film consumption per pallet has been registered.

EUMOS ACCELARATION TESTS

After the wrapping cycle, the unit load has been tested in compliance with the international standard Eumos 40509-2020, especially designed to measure the rigidity of a unit load, i.e. the stability of the wrapped goods during transportation.

This test prescribes subjecting the load to a certain acceleration, achieved and maintained for a certain time interval, measuring the maximum elastic deformation (i.e. during the test) and permanent deformation (i.e. after the test) of the goods. The test is considered successfully passed if the elastic and plastic deformation remain within 10% and 5% of the height of the load respectively. The load unit is considered completely stable if it passes the test at a set acceleration of 0.5 g. The acceleration tests have been run at "TechLab" accredited by ACCREDIA (Lab n° 1772L).

3. Results and discussion

3.1 ERGONOMICS ANALYSIS

The comparative LEA analysis between the HI.DEA dispenser coupled with the innovative film and the traditional film itself used without any dispenser show a significant reduction of the RULA score, especially for the trunk, the right shoulder and the right elbow of the operator:

- Trunk: the HI.DEA dispenser allows the operator to spend 53% of the time in a correct position; moreover, a score above 4 has never been registered. On the other hand, the traditional wrapping method leads to 45% of the time with a negative (5-6) score, that calls for posture correction.
- Right shoulder: the use of the dispenser leads to a fully correct position.
- Right Elbow: the use of the dispenser has overall positive effect on the posture of the operator; specifically, the time with bad posture (5-6) decreases from 23% to 8%.

The left shoulder and elbow, which are not heavily involved in the wrapping process, remain unaltered. Results are summarized in Table 3 and illustrated in Figure 4.

	TRUNK		RIGHT SHOULDER		RIGHT ELBOW	
	Time Percentage		Time Percentage		Time Percentage	
Score RULA	Innovative scenario	Traditional scenario	Innovative scenario	Traditional scenario	Innovative scenario	Traditional scenario
Score 1-2	53%	20%	98%	48%	45%	20%
Score 3-4	47%	35%	2%	52%	47%	57%
Score 5-6	0%	45%	0%	0%	8%	23%

Table 3 - LEA postural analysis

Fig. 4. LEA comparison between traditional film application and innovative scenario

3.1 HWT ANALYSIS

The results indicate a comparable holding force between the traditional standard film and the innovative film, both at the top and bottom of the load. The film consumption drops from 332 to 150 g per pallet, thus leading to 55% material saving (Table 4).

Product	Holding Force [kg]		Film Consumption [g]	Saving [%]
	Top Position	Bottom Position		
Traditional scenario	4.96	10.34	332	-
Innovative scenario	5.93	9.36	150	55%

Table 4 - HWT tests

3.2 EUMOS ANALYSIS

The unit load passed the acceleration tests at 0.5 g, both with the traditional film and the innovative film. The results are shown in Table 5 and Figure 5.

Measured quantity	Film type	Measured value [mm]	Acceptability criterion in the teste method		Extended uncertainly value [mm]	Maximum admissible value [mm]	Outcome
			Maximum percentage value [%]	Maximum numerical value [mm]			
Maximum permanent deformation on the horizontal axis	Standard	4.04	5%	68.44	0.56	67.88	OK
	Innovative	7.7				67.88	
Maximum permanent deformation on the horizontal axis within h=20 cm	Standard	1.49	/	40	0.56	39.44	OK
	Innovative	2.49				39.44	
Maximum temporary deformation on the horizontal axis	Standard	31.35	10%	136.88	2.83	134.05	OK
	Innovative	87.07				134.05	

Table 5 - Acceleration test results (EUMOS 40509-20)

The actual benefit related to the use of innovative film and the HI.DEA dispenser is the possibility to reduce the amount of the film per pallet, without compromising on the security of the unit load. The stretch film reel contains the same number of meters as the traditional standard film described in Table 2, but its weight is 64.2% lower, as a consequence of the lower thickness and of the absence of the paper core. Moreover, the film used contains 60% PCR plastic and that means a reduced environmental impact [15].

Fig. 5. EUMOS 40509-20 Test pallet stability

4 Conclusions

In a national and international context that asks companies to increase social sustainability in operations involving their workers, this article aimed to analyze a case study in the logistics sector. In particular, the traditional scenario in which an operator manually wraps a load with plastic film was compared with an innovative scenario given by the combination of an advanced film and a patented technology consisting of a dispenser that allows the operator not to bend during wrapping operations. The two scenarios were compared using different methodologies, namely the LEA software based on the RULA approach, the Hand Wrapper Tester (HWT) system, and the Eumos acceleration test. All tests recorded results in favor of the new scenario, confirming it to be more sustainable from a social (allowing operators to reduce physical effort), economic and environmental (reducing the amount of material used) point of view. Overall, this case study has shown how shrewdness in technology and materials can bring great benefits not only to the operators but also to the environment. It can therefore positively influence companies that want to introduce more comfortable and suitable practices for operators of all ages into their operations. The results can be extended to all realities in which similar works are carried out, becoming an inspiration and/or starting point for the introduction of innovative practices to enhance the sustainability of many sectors.

5 References

[1] Macassa G., McGrath C., Tomaselli G., Buttigieg S.C. Corporate social responsibility and internal stakeholders' health and well-being in Europe: a systematic descriptive review. Health Promotion International. 2021; 36 (3): 866–883.

[2] Bevan S. Economic impact of musculoskeletal disorders (MSDs) on work in Europe. Best Practice & Research Clinical Rheumatology. 2015; 29 (3): 356-373.

[3] Stedmon A. W., Howells H., Wilson J. R., Dianat I. Ergonomics/Human Factors Needs of an Ageing Workforce in the Manufacturing Sector. Health Promotion Perspectives. 2012; 2: 112-125.

[4] Dohm A. Gauging the labor force effects of retiring baby-boomers. Monthly labor review. 2000: 123 (7): 17-25.

[5] Smith P. M., Berecki-Gisolf J. Age, occupational demands and the risk of serious work injury. Occupational Medicine. 2014; 64 (8): 571-576.

[6] Roper K.O., Yeh D. C. Ergonomic solutions for an aging workforce. Journal of Facilities Management. 2007; 5.

[7] Yang S., Wang T., Li H., Liu L., Yao W., Ren G. The Cross-Cutting Effects of Age Expectation and Safety Value on Construction Worker Safety Behavior: A Multidimensional Analysis. Buildings. 2024; 14 (8).

[8] Loske D., Klumpp M., Keil M., Neukirchen T. Logistics Work, Ergonomics and Social Sustainability: Empirical Musculoskeletal System Strain Assessment in Retail Intralogistics. Logistics. 2021; 5(4): 89.

[9] Buerkle A., Eaton W., Al-Yacoub A., Zimmer M., Kinnell P., Henshaw M., Coombes

M., Chen W. H., Lohse N. Towards industrial robots as a service (IRaaS): Flexibility, usability, safety and business models. Robotics and Computer-Integrated Manufacturing. 2023; 81 (102484).
[10] Kuber P.M., Rashedi W. Product ergonomics in industrial exoskeletons: potential enhancements for workforce efficiency and safety. Theoretical Issues in Ergonomics Science. 2020; 729-752.
[11] Botti L., Melloni R. Occupational Exoskeletons: Understanding the Impact on Workers and Suggesting Guidelines for Practitioners and Future Research Needs. Applied Science. 2024; 14 (1).
[12] Aksut G., Eren T., Alakas H. M. Using wearable technological devices to improve workplace health and safety: An assessment on a sector base with multi-criteria decision-making methods. Ain Shams Engineering Journal. 2024; 15 (2).
[13] Nelson A., Baptiste A. S. Evidence-Based Practices for Safe Patient Handling and Movement. The online journal of issues in nursing. 2004.
[14] McAtamney L., Nigel Corlett E. RULA: a survey method for the investigation of work-related upper limb disorders. Applied Ergonomics. 1993; 24 (2): 91-9.
[15] Stefanini R., Paini A., Busti M., Archetti M., Buffoli A., Cangiano V. Packaging Stretch film alternatives in a circular economy perspective: comparison of three scenarios with a Life Cycle Assessment approach. IFAC-PapersOnLine. 2024; 58: 457-462.