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# Ergonomic risk assessment for lifting loads

# Evaluación del riesgo ergonómico por levantamiento de cargas

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## Abstract

The aim of the research was to evaluate the level of ergonomic risk to which a group of recyclers is exposed when manually handling loads, using the NOM-036-1-STPS-2018 standard. The research was quantitative in nature. The data were obtained from a group of 54 recyclers, and the techniques applied to identify patterns in load lifting were the Kuorinka Nordic questionnaire and the two reference guides of the NOM-036-STPS-2018 standard. Two manual load positions were analyzed. In the first, the risk of transporting the load using the shoulders was studied, and an unacceptable risk was identified with a pink code of 21 points. On the other hand, the second position was examined in a recycler who drags the load with her arms extended behind her torso, determining a high risk with a red code of 16 points. The results of the questionnaire showed that back pain occurs on a *very high* scale (70%), followed by leg pain (48%) and wrist pain (37%). NOM-036-STPS-2018 is a fundamental guide for identifying the most ergonomically risky postures in the lifting, handling, and transport of loads; it allows preventive measures to be taken to mitigate risks and musculoskeletal injuries.

**Keywords:** musculoskeletal disorders, ergonomic risks, manual handling of loads, back pain, prevention

## Resumen

El objetivo de la investigación fue evaluar el nivel de riesgo ergonómico al que se expone un grupo de recicladores en el manejo manual de cargas empleando la norma NOM-036-1-STPS-2018. La investigación fue de tipo cuantitativa. Los datos se obtuvieron de un grupo de 54 recicladores y las técnicas aplicadas para identificar los patrones en el levantamiento de cargas fueron el cuestionario Nórdico de Kuorinka y las dos guías de referencia de la norma NOM-036-STPS-2018. Se analizaron dos posturas de carga manual. En la primera, se estudió el riesgo en el transporte de la carga empleando los hombros y se identificó un riesgo inaceptable con código rosa de 21 puntos. Por otro lado, la segunda posición se examinó a una recicladora que arrastra la carga con los brazos extendidos hacia atrás respecto al tronco, determinando un riesgo alto con código rojo de 16 puntos. Los resultados del cuestionario expusieron que el dolor de espalda se presenta en una escala *muy alta* (70%), seguido de dolor de piernas (48%) y dolor de muñecas (37%). La NOM-036-STPS-2018 es una guía fundamental para identificar las posturas de mayor riesgo ergonómico en el levantamiento, manejo y transporte de cargas; permite adoptar medidas preventivas que mitiguen los riesgos y lesiones musculoesqueléticas.

**Palabras clave:** trastornos musculoesqueléticos, riesgos ergonómicos, manejo manual de cargas, dorsalgias, prevención

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## 1. Introduction

The World Health Organization ([OMS] 2021) reported that 568 million people experience low back pain due to musculoskeletal disorders. These are conditions affecting muscles, bones, tendons, cartilage, ligaments, and nerves, which cause disability. Similarly, in Mexico, the Mexican Social Security Institute ([IMSS], 2023) recorded 21,738 cases of back pain in workers who do not use proper technique when manually lifting loads and who adopt awkward postures at work. Fajardo-Bautista et al. (2024) pointed out that ergonomics is the discipline that studies the risk factors of a job or workstation, with the aim of adapting the environment, tools, equipment, and systems to human capabilities.

In Mexico, manual handling of loads is supervised to ensure that workers' health is not put at risk by non-compliance with ergonomic, safety, and health factors. Therefore, the importance of assessing the physical capacity of employees to carry out this work activity of loading and unloading, which has harmful effects, is confirmed. It is estimated that 24.7% of occupational diseases are due to musculoskeletal disorders (IMSS, 2019). Ruiz Barrios et al. (2022) stated that an ergonomic risk occurs when workers perform physical overexertion, repetitive movements, or maintain hyper-extension or flexion postures for prolonged periods of time without breaks.

Manual handling of loads (MMC, by its Spanish acronym) is supervised by the Ministry of Labor and Social Welfare ([STPS] 2018) with standard NOM-036-1-STPS-2018, which contains three instruments for assessing the ergonomic risk to which workers are exposed when lifting, transporting, lowering, and dragging loads. MMC refers to the movement of a load weighing more than 20 kilograms from the moment it is lifted, transported, and deposited, using leg lifting, dragging, and pushing techniques (Celedón et al., 2024).

Morales Perrazo (2019) stated that the development of musculoskeletal disorders (MSDs) is due to overexertion by workers when handling manual loads. MSDs are conditions affecting muscles, tendons, bones, and ligaments that cause pain and inflammation. This has an impact on workers' health, as it limits the mobility of the back, shoulders, arms, and hands in particular (Vaca Sánchez et al., 2023). Moya-Esteban et al. (2023) pointed out that handling heavy objects weighing more than 20 kilograms affects the joints and soft tissues, causing acute and chronic pain.

The Center for Applied Ergonomics (CENEA, by its Spanish acronym) conducted a study with 175 technicians who perform manual handling tasks to identify the variables that pose the greatest risk in MMC. It was noted that, for 89.1% of participants, the weight of the goods is the main risk factor, followed by variability in the height of the grip (86.9%) and the horizontal distance to be covered (77.1%). 86.9% variability in the height of the grip and 77.1% horizontal distance to be covered (CENEA, 2023).

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Sociedad de Investigación sobre Estudios Digitales S.C. | ISSN: 2683-328X

Carel et al. (2021) pointed out that physical exertion not only causes back and neck pain with loads of less than 20 kilograms at least 10 times a day, but also involves manual gripping forces for one hour a day and repetitive movements for more than two hours a day. This causes inflammation in the elbow and forearm muscles. Their results determined that muscular effort develops other disorders such as rotator cuff syndrome, epicondylitis, and knee bursitis.

Ibarra Villanueva and Astudillo-Cornejo (2021) determined in a biomechanical study that high physical demands at work, static postures, lack of techniques for MMC, and keeping the arms raised above the shoulders cause MSDs, cardiovascular diseases, and morbidity. For this reason, mechanized methods should be used for loading and unloading objects weighing more than 20 kilograms. Low back pain is the second most common health problem worldwide, as it is associated with gender, age, obesity, and the type of occupation of the subject. The study requires X-rays, CT scans, and MRIs; medication is carried out with analgesics, therapies, and surgeries (Santos et al., 2020). In this regard, Chamba León (2021) stated that physical effort involves three variables: intensity, duration, and frequency. This is accompanied by an increase in intense caloric expenditure.

Escobar-Rincón and De Arco-Canoles (2021) documented the physical effort required by recyclers when handling bulky and heavy loads on their backs. They concluded that this activity has harmful effects on health, noting that some of these informal workers use motorized vehicles, bicycles, or carts that they adapt to transport recycled materials.

Macias-Arriaga (2024) argued that the collaboration of recyclers in landfills is essential, as they contribute to environmental protection despite the adverse conditions in which they work, making it necessary to improve their working and economic conditions. Therefore, the objective of the research was to analyze the level of risk to which a group of recyclers is exposed in the manual handling of loads, using the NOM-036-1-STPS-2018 standard to intervene with a prevention proposal that mitigates the development of MSDs in this group of informal workers.

## 2. Method of research

The research took a quantitative, cross-sectional, and descriptive approach, as data was obtained from a group of recyclers to assess the ergonomic risk of manual lifting. The Kuorinka Nordic questionnaire and the two reference guides of the NOM-036-1-STPS-2018 standard were applied. This made it possible to determine the level of risk exposed in order to develop a prevention proposal that mitigates MSDs (Figure 1).

Figure 1

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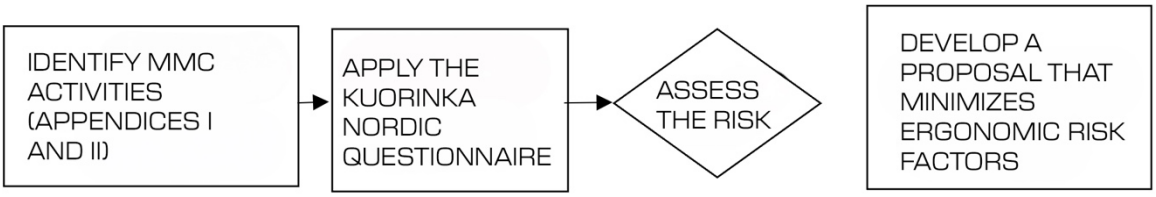
*Methodology of NOM-036-1-STPS-2018*




*Note.* Adapted from STPS (2018).

The census population of the study consisted of 54 recyclers, 40 women and 14 men. All were over 18 years of age and belonged to the same local ethnic group. Seventy-four percent were women, 26% were men, and 72% were between the ages of 18 and 39. Forty-six percent had been recycling materials for more than seven years, 67% had a basic (primary) education, and 38% were single mothers.

## 3. Results

The landfill located in Huajuapan de Leon, Oaxaca, Mexico, receives between 40 and 45 tons of waste daily, which is separated and sorted by informal workers, who are organized and work on their own account. The leader assigns them a pile of garbage to select the materials to be separated into a bag called a *barcina* with a capacity of 500 kilograms. The recyclers only collect plastic, metal, paper, cardboard, and glass. A tour of the landfill facilities was conducted to assess the obstacles and environmental conditions. Ramps and uneven slopes made of earth in poor condition were identified, posing risks of slips, falls, and trips.

Three methods of loading were observed for transporting recycled material: a) carrying it on the shoulders, b) pulling it with both hands, and c) dragging the containers to the entrance of the facilities, where the recycled material is stored for a week until it is sold. The NOM-036-1-STPS-2018 standard establishes that load is considered to be the force exerted on the spine when lifting or lowering a mass greater than three kilograms. This same standard establishes four levels of ergonomic risk: *Low*, from zero to four points; *Medium,* from five to 12 points; *High*, 13-20 points; and *Very high*, from 21-32 points. The scores are determined by nine factors that analyze the probability of the worker developing physical damage from performing these activities.

To identify the level of ergonomic risk, two techniques used by recyclers at the end of the day to transport recycled materials to the entrance of the landfill (approximately 300 meters) were evaluated. This made it possible

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to determine the level of risk involved in lifting, lowering, pulling, pushing, and transporting loads. In the first analysis (Table 1), the load carried by a 24-year-old male worker was evaluated: the mass he held was 12.30 kg divided into three black plastic bags, carrying two on his left shoulder and one on his right. The ergonomic risk was estimated using the manual load transport operations method (Appendix I) of NOM-036-1-STPS-2018.

**Table 1**

*Assessment of the individual risk level*

| Factor analyzed | Lifting and transport of individual cargo | Value |
|---|---|---|
| a) Weight and lifting of the load/transport frequency | 12.30 kilograms/10 minutes (repeat: five times) = 50 minutes | 4 |
| b) Horizontal distance between hands and back | Torso and neck leaning forward | 3 |
| c) Asymmetrical load on the torso | Carries asymmetrical loads on both shoulders | 3 |
| d) Postural restrictions | Restricted position with no possibility of exchange | 1 |
| e) Hand-load coupling | It is considered to have poor grip because it closes the fist to hold the three bags | 2 |
| f) Work surface | The floor is wet/unstable with stones/uneven with slopes | 2 |
| g) Other environmental factors | Exposed to extreme temperatures of over 30° Celsius | 2 |
| h) Transport distance | 300 meters | 2 |
| i) Obstacles along the route | Piles and mounds of trash | 2 |
| **Risk level** | **Very high** | **21** |

*Note.* Adapted from STPS (2018).

Subsequently, the criteria assigned by the standard for determining the risk of manual load carrying on the shoulders were considered. Likewise, the ergonomic risk factors standardized by the standard were considered when a subject is involved.

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Tabla 2

*Evaluation criteria in Appendix I of NOM-036-1-STPS-2018*

| Risk factor | Low | Medium | High | Very high |
|---|---|---|---|---|
| Load weight and lifting per hour | Load between 15 and 20 kilograms.<br>Daily lifts are less than 30 minutes. | Load of 10 to 14 kilograms with five transfers per hour, giving a total of 50 minutes.<br>Holds the load for more than 10 minutes. | - | - |
| Horizontal distance between hands and lower back | Lift below the elbow. | Lift above the knee. | Lift at ground level. | - |
| Asymmetrical load on the torso and load stability | Symmetrical hands in front of the torso. | Asymmetric load and hands. | Carry the load with one hand. | Carry the load resting on one shoulder. |
| Postural restrictions: adopts uncomfortable postures due to space constraints | No restrictions. | Restricted posture. | Severely restricted posture. | - |
| Hand-load couplings | Good grip.<br>It has fastening elements. | Regular grip.<br>The fingers are held at a 90° angle.<br>Pincer grip. | Poor grip.<br>Irregular objects, bulky bags. | - |
| Work surface | Dry, clean, and in good condition. | Floor dry, but in poor condition, worn. | Contaminated, damp, and uneven floor. | - |
| Other environmental factors: temperature, air, and lighting | No risk factors present. | A risk factor present. | Two or more factors present. | - |
| Transport distance | Two to four meters. | More than 4 meters and less than 10 meters. | More than 10 meters. | - |

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Sociedad de Investigación sobre Estudios Digitales S.C. | ISSN: 2683-328X

Tabla 2

*Evaluation criteria in Appendix I of NOM-036-1-STPS-2018*

| Risk factor | Low | Medium | High | Very high |
|---|---|---|---|---|
| Obstacles along the route | No obstacles and the route is flat. | Walking down or up stairs with risk of tripping. | Climb slopes. | - |

*Note.* Adapted from STPS (2018).

The results of the initial analysis determined that action must be taken regarding the recycler's activities through a preventive program. This program must include the use of devices such as hoists, forklifts, or load carts to reduce injuries to the musculoskeletal system in the medium term.

The following study evaluated the risk to a 32-year-old recycling worker who pulled a load weighing 42.80 kilograms on a hand truck measuring 0.90 x 0.90 x 1. 20 meters and sliding it by holding it with both hands extended backward at an angle of 35° to the sagittal plane while moving forward with her torso facing forward. The evaluation criteria varied when a manual push or pull load was performed (Table 3).

Table 3

*Assessment of the level of risk by dragging or pulling*

| Factor analyzed | Dragging/pulling or sliding | Value |
|---|---|---|
| Weight and lifting of the load/transport frequency | 42.80 kilograms for 20 minutes (repetition: one lift per day) | 2 |
| Posture (reasonable) the body is in the direction of the effort | Torso and neck leaning forward with arms extended backward relative to the torso | 2 |
| Hand grip with respect to the load | Grip in supination position with palms facing up, no contact handles | 2 |
| Work pattern (reasonable). There are opportunities to rest or recover through formal and informal breaks | Restricted posture, putting more strain on the arms and legs | 2 |
| Distance per trip | Up to 300 meters | 2 |
| Up to 300 meters | The floor is damp/unstable with stones/uneven with slopes without steps. | 2 |
| Other environmental factors | It is exposed to extreme temperatures of over 30° Celsius and strong winds. | 2 |

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Sociedad de Investigación sobre Estudios Digitales S.C. | ISSN: 2683-328X

| | | |
|---|---|---|
| Obstacles along the route | Piles and mounds of trash | 2 |
| **Risk level** | **High** | **16** |

*Note.* Adaptado de STPS (2018).

Posteriormente, se plantearon los criterios asignados por la NOM-036-1-STPS-2018 para determinar el riesgo por el transporte de cargas arrastrando, jalando o deslizando, señalados en el Apéndice II (Tabla 4).

**Table 4**

*Evaluation criteria according to Appendix II of NOM-036-1-STPS-2018*

| Risk factor | Mild (blue) | Moderate (yellow) | Severe (red) |
|---|---|---|---|
| Weight of the load | Less than 25 kilograms | From 25 to 50 kilograms | From 50 to 80 kilograms |
| Posture | Vertical torso is not twisted | The body is tilted in the direction of the force. | The torso is severely flexed |
| Hand-load coupling | There are handles or grips that allow you to apply force | There are areas of partial grip. | There are no handles, making it uncomfortable to hold |
| Work pattern | The work is not repetitive. | There are opportunities to rest and recover. | There are no breaks. |
| Distance per trip | Two meters or less | Between two and 10 meters | More than 10 meters |
| Work surface | Dry, clean, and in good condition | Floor dry, but in poor condition, worn | Contaminated/damp floor, uneven with steep slope |
| Obstacles along the route | Without obstacles | With obstacles but without steps or ramps | Steps, steep ramps, and two or more obstacles |
| Other factors | There are no other factors. | A factor present | Two or more present |

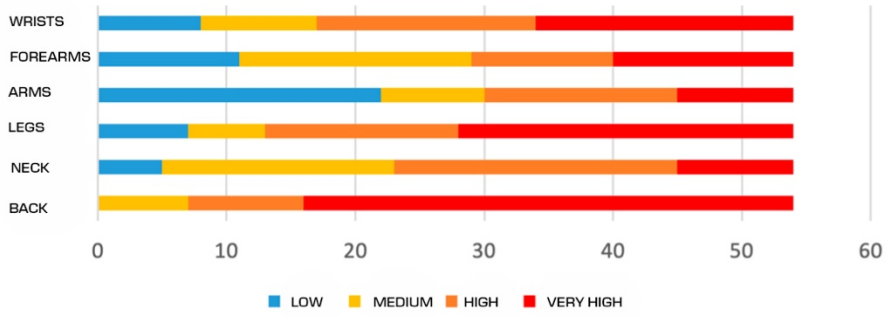
*Note.* Excerpt from NOM-036-1-STPS-2018.

Transdigital journal

Sociedad de Investigación sobre Estudios Digitales S.C. | ISSN: 2683-328X

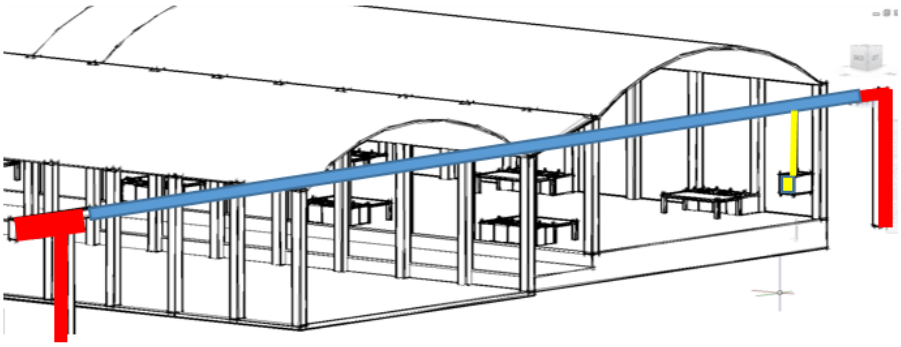
The analysis of the postures adopted by this group of recyclers when handling loads at the end of the day to accumulate the material obtained in the main yard of the landfill resulted in a *High* and significant risk, requiring rapid action to establish control measures through a prevention program. On the other hand, the results of the Kuorinka Nordic questionnaire (Figure 2) revealed the impact that MSDs have had on different areas of the body when performing these activities, which require great physical effort.

**Figure 2**
*Results of the Kuorinka Nordic questionnaire*




The graph shows that back pain among informal workers occurs on a scale of *Very high,* with 70%; followed by leg pain (48%) and wrist pain (37%). These conditions are attributed to poor practices in the manual handling of loads. To minimize the risk of manual lifting among recyclers, it was proposed to implement the use of a hoist (Figure 3) to move loads along the landfill (300 meters) to reduce injuries and physical suffering among these workers.

**Figure 3**
*Hoist proposal*



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Sociedad de Investigación sobre Estudios Digitales S.C. | ISSN: 2683-328X

The use of hoists is a simple mechanical aid that requires the installation of two posts separated by 100 meters and connected to each other with cables and pulleys to transport loads of up to 150 kg. This is intended to reduce exposure to musculoskeletal injuries. The average amount of materials recycled per worker per week is: 90-110 kilograms of polyethylene terephthalate (PET), 90-110 kilograms of cardboard, 30-40 kilograms of iron, 25-30 kilograms of hard plastic, four to eight kilograms of aluminum cans, 60-80 kilograms of paper, and 15-20 kilograms of glass, earning them a profit margin of US$360 per month. NOM-036-1-STPS-2018 suggests that a doctor issue a certificate of physical fitness and determine the recovery periods and active breaks for each recycler, so that they can lift loads without exposing themselves to future health problems.

## 4. Discussion

According to Parreno et al. (2022), improper lifting techniques used by workers cause fractures and muscle injuries in the spine; over time, they limit movement due to the pain they cause when pressing on the spinal cord or nerves. The results identified that 70% of recyclers suffer from back problems due to the inappropriate techniques they use for MMC, making it necessary to train them based on the tasks they perform and with practical training.

Inappropriate manual handling techniques for loads that exceed the average capacity of the musculoskeletal structure cause neck pain in workers engaged in physically demanding activities (Bedoya Marrugo et al., 2024). In the case of recyclers, it was found that 74% of the people who carry out loading activities are women; for these cases, the standard establishes that the load mass for the 18 to 45 age range is 20 kilograms; for women over 45, it is reduced to 15 kilograms. In this way, the loads would not exceed the physical condition of the recyclers; therefore, it was proposed to use a hoist to lift, move, and lower heavy loads efficiently and safely.

## 5. Conclusions

NOM-036-STPS-2018 is a fundamental guide for identifying the most ergonomically risky postures in the lifting, handling, and transport of loads in order to adopt preventive measures that mitigate the risk of musculoskeletal injuries in workers. It was emphasized that, in order to perform these activities, the standard stipulates that personnel must be physically fit, which must be certified by the IMSS or a private institution.

They must also have a medical surveillance program and personal protective equipment appropriate to the activities carried out in the workplace. To reduce exposure to MSDs, it is proposed to modify the process carried

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Sociedad de Investigación sobre Estudios Digitales S.C. | ISSN: 2683-328X

out by recyclers to transport selected materials to the entrance of the landfill using a motorized hoist that travels 300 meters. The use of this official Mexican standard contributes to a culture of prevention, safety, and health at work by promoting ergonomic practices that reduce accidents, illnesses, and injuries.

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