Global Journal of Engineering and Technology [GJET].
ISSN: **2583-3359** (Online)
Frequency: Monthly
Published By GSAR Publishers
Journal Homepage Link- https://gsarpublishers.com/journal-gjet-home/

POSTURAL AND PHYSICAL – STRAIN ASSESSMENTS; MAJOR FACTORS FOR ERGONOMICS AND SAFETY CONSIDERATION IN RAILWAY INDUSTRY IN NIGERIA

By

[1]IGE D. O., *[1]AJAYEOBA A. O., [2]OJO O. O., [3]AJAYEOBA A. S., AND [4]OLADAPO S. O.

[1]Department of Mechanical Engineering, Ladoke Akintola University of Technology, Ogbomoso, Nigeria
[2]Department of Mechanical Engineering, Babcock University, Ilisan Remo, Ogun State, Nigeria
[3]Works Department, Babcock University, Ilisan Remo, Ogun State, Nigeria
[4]Department of Mechanical Engineering, Olusegun Agagu University of Science and Technology, Okitipupa, Nigeria.

Article History

Received: 15/11/2024
Accepted: 23/11/2024
Published: 26/11/2024

Vol – 3 Issue – 11

PP: - 18-29

Abstract

The document looks into the ergonomics and safety aspects of the railway maintenance workers in Nigeria stating the physical strain and hazards involved in the profession. It shows high rates of Musculoskeletal Disorders (MSDs) among others sustained from repetitive movement, awkward positioning and poor ergonomic measures. Moreover, they encounter additional exposure from other environmental factors such as high temperature, poor equipment and poor infrastructure. Basic measures such as provision of Personal Protective Equipment (PPE) and enhanced safety training have been done, but there are systemic issues that remain, for example inadequate mechanized tools and absence of appropriate ergonomic protocols. This work argues in favour of holistic ergonomic approaches in managing work related health issues, safety and improving worker's productivity. Some of these are provision of superior instruments, devices and programs for posture improvement, mechanical devices for lifting and training. To reduce risks and improve working conditions in Russia, it is advisable to introduce international norms such as ISO 11226 for static postures and ISO 5349 for vibration exposure. Postural assessment methods such as RULA, REBA and OWAS have been perceived as essential methods of great importance for the evaluation and the control of ergonometric risk factors. This poses a high opportunity for the Nigerian railway sector to implement ergonomic solutions and focus on effective strategies to address existing problems.

1.0 Introduction

Ergonomics and safety are vital considerations for maintenance personnel in railway industry, which is part of transportation sector essential to the economy and needed in facilitating the efficient and sustainable movement of goods and people (Naweed and Golightly, 2022 and Ryan et. al.,2021). This industry is one of the strength of national and international transportation systems which sustainability is reliant on well-organized maintenance team Georgiev, 2013). Maintenance workers play a fundamental role in ensuring uninterrupted rail service, yet they are frequently exposed to considerable ergonomic and safety hazards and risks due to the high physical demands and intricate machinery they use (Guidi, 2022). These hazards include musculoskeletal strain from repetitive movements and awkward postures, as well as significant risks such as electrical shock, machinery entanglement, and slip-and-fall accidents grouped under physical, biological, chemical, ergonomics and psychological hazards (Abiramalakshmi and Shree, 2018; Sabri, et. al., 2022). An appraisal of ergonomic procedures and safety measures tailored to this particular transport system is desperately needed, given the increasing complexity of railway systems. Enhancing ergonomics and safety system will not only increase the operating efficiency and dependability of the railroads but also has the potential to safeguard the health and safety of maintenance workers. While sophisticated safety procedures, such as suitable Personal Protective Equipment (PPE), frequent hazard training and technology-driven monitoring, can lower the chance of accidents, incorporating cutting-edge ergonomic solutions, such as adjustable tools and better-designed workplaces, can ameliorate musculoskeletal stress (Khan, et. al., 2023 and Fasinu, 2023).

The railway industry can create a more sustainable workplace that supports its employees, reduces injury rates, and maintains high productivity. These initiatives help not only the employees but also the larger business and the communities that depend on dependable rail transport, underscoring the need of putting worker safety first in this vital industry. Railway maintenance workers encounter many physical and ergonomic difficulties, such as heavy lifting, awkward postures, repetitive actions, and extended standing or kneeling (Landsbergis et. al., 2021 and Landsbergis et. al., 2020). These elements lead to a high prevalence of work-

*Corresponding Author: AJAYEOBA A. O

related injuries and Musculoskeletal Disorders/Injuries (MSD/Is), which have long-term health consequences that lower productivity, raise absenteeism, and lower quality of life (Sundstrup et. al., 2024. Additionally, workers performing railway maintenance are subject to additional risks due to restricted areas, moving trains, and high-voltage equipment. To find best practices that reduce risks, adjust to new technology, and provide a safer, more efficient work environment for maintenance staff, a thorough evaluation is necessary.

Evaluation of ergonomic and safety factors for railway maintenance workers is essential for people, environment and industry industrial safety. Improving ergonomics in railway industry has extensive industrial benefits, such as reduced injury-related costs, improved workforce retention, and increased productivity. However, a healthier workforce minimizes service interruptions, a healthier workforce benefits both freight and passenger customers and implements efficient safety procedures to reduces workplace accidents, indirectly providing funds for operational enhancements Sparks et. al., 2001)

2.0 Ergonomics in Railway Maintenance in Nigeria

Nigeria's railway industry is a sector of the economy that ensures easy movement of the populace and their resources from one location to another, although, the chances are limited in specific parts of Nigeria. However, there are major ergonomic deficiencies regarding the maintenance of this infrastructure, which have consequences on the productivity, safety, and health of the railway maintenance employees Eyayo, 2014). Despite improvements in maintenance standards, ergonomic procedures remain non-existent in most establishments, and this results to a high incidence of Musculoskeletal Disorders MSDs among employees. In other words, maintenance staff in the railway industry in Nigeria have many ergonomic issues. These originate from the type of work they do, and such work entails lifting heavy loads, repetitive work, and maintaining an odd body position over a long period of time. Tasks like lifting railway components from one place to another, repairing bulky machines and welding in cramped places are sources of severe physical stress. Forced by circumstances to have little mechanized equipment, construction workers frequently lift heavyweight. This opens them up to more vulnerability to abnormal bone forces referred to as MSDs.

Also the repetitive activities are exacerbated by working in awkward postures such as kneeling, bending, and working overhead, which further damage the body over time (Al Salaheen, et. Al. 2020 and Gillespie, 2005). The existing ergonomic interventions currently available in the railway maintenance and repair workshops in Nigeria are very basic and of low quality. Some of the commonly employed measures to prevent MSD/Is and reduce physical effort include minimising repetitive movement and manual handling, use of PPE and periodic update on the safety of the workers. However, such indices are often superficial and poorly evaluated. For example, manual handling training, though encouraging, is most times inadequate unless combined with the use of proper mechanised lifting tools. Although PPE does render some degree of defence, it simply overlooks the core issues of excessive stress on the body caused by frequent lifting and maintaining awkward body positions for prolonged durations. Adjustable workbenches, and a few ergonomic instruments have been used by some centres, but these are piecemeal and there is no standardization to the practices in the industry. In order to advance ergonomic procedures in construction and maintenance of the railway, a more coordinated approach is needed.

Extended handled wrenches, mechanical elevator head, and other ergonomic chairs can go a significant way toward lowering danger accompanied by physical strain (Fray, and Davis, 2024). Employees' postures and movements can also be assessed through digital monitoring devices Ranavolo et al. 2018). This method can enable even quicker identification and alleviation of ergonomic issues and risks. Embracing ergonomic practitioners and medical personnel into the setups of the railway industry and also ensuring the enactment of ergonomic policies might create a more effective and safer working environment. The promotion of sustainable ergonomic practices may be enhanced through collaborations with engineering and health professionals, which will eventually protect workers and improve operational efficiency in the Nigerian railway sector.

3.0 Postural Assessments in Occupational Health in Railway Maintenance Activities in Nigeria

Postural analysis is the other form of posture assessment and it involves the evaluation process which is done systematically where an individual's body posture is observed as a person works, to identify positions or movements that may present ergonomic challenges Seo and Lee, 2021; Yu, 2021 and Lowe, 2014). This evaluation often considers postures that include bending, twisting, reaching, or lifting, as is the case of railway maintenance tasks Ray and Teizer, 2012). Through these postures, researchers and caregivers get the biomechanical load of the body in a better way and try to devise measures that will relieve strain, fatigue, and injury. Postural assessments are crucial to the primary health care strategies for work-related disorders, especially those in physically demanding occupations such as railway maintenance and construction. In Nigeria, many workers who are in the railway sector involve themselves in a lot of physically demanding and monotonous tasks and this places them at a high risk of developing Musculoskeletal Disorders (MSDs). One of the reasons why chronic injuries and low productivity turnovers happen is overworking in bad posture and performing maintenance tasks. With postural assessments, railway industry management can pinpoint risks, make ergonomic changes, and safeguard workers' health.

Postural analysis within railway maintenance activities emphasizes the investigation of specific tasks and conditions

*Corresponding Author: AJAYEOBA A. O

that contribute to biomechanical stress on the body. For example, in Nigeria, railway maintenance workers are also described as lifting heavy objects, sitting on their knees for long periods, and turning their bodies to different angles while repairing or inspecting the railway track. Such actions impose both static and dynamic loading on the musculoskeletal system and enhance the chances of developing MSDs. If these postures are defined and reviewed, there is a possibility of making the right changes to the working conditions to reduce health threats and ultimately the degree of dissatisfaction among employees. The severity of postural analysis among the workers concerning injuries sustained from the activities carried out is paramount because if the working ergonomics are not properly adhered to, it leads to the impairment of the workers and a subsequent decrease in production as well as refrained expenditures for the organization on treatment (Khan and Singh, 2018). There are also several environmental and structural problems in Nigeria within which railway maintenance activities are carried out. For this reason, there is a need for adequate assessments of posture to attain a better working environment. It should also be noted that Nigeria Railway Corporation through ergonomic assessments takes into consideration the occupational health aspect and minimizes absenteeism and damages associated with workplace injuries to the people's economic status.

Nevertheless, industries can take measures beforehand by changing the design of workstations or equipment and educating workers on the principles of a biologically correct posture and movement. A postural evaluation can bring about a dependable safety and health culture which is very important for industries that have a heavy physical strain across their time horizons (Norman and Wells, 1998). Since railway maintenance is quite labour-intensive, postural evaluation techniques can assist in minimizing the physical impact on workers to promote healthy and sustainable workforce development.

Some of the common posture assessment tools used in the assessment include:

i. **Rapid Upper Limb Assessment (RULA**) – RULA is one of the observational evaluation tools to assist in the assessment of upper limb and neck and trunk musculoskeletal strain through qualitative observational assessments of posture. This is particularly relevant for tasks where frequent or awkward upper body movements are involved, as is often the case in railway maintenance, especially those that require the use of tools or forces Corlett and Discomfort, 1998 and Christopher, 2019). It scores the positioning of upper limbs, where the forces act 'activity type' and the forces involved, which helps inform practitioners as to whether the task warrants ergonomic attention or not. RULA helps in recognizing the factor that prompts neck or shoulder pain, a common complaint to most railway workers engaged in performing repetitive tasks, by concentrating on the source of musculoskeletal strain on the upper limbs. RULA also helps in postural risk assessment of the upper torso which reduces the chances of sustaining upper extremity tendonitis or shoulder impingement injuries in the course of railway maintenance activities (Check, 2010). Using RULA, organizations can outline training modules that promote safe upper body movements, promote upright posture and the use of ergonomic devices. Such interventions enhance workers' safety and minimize repetitive strains on the muscles, thus sustaining physical health and job efficiency.

ii. **Rapid Entire Body Assessment (REBA):** Unlike RULA, REBA has the advantage of employing aspects of the whole posture and therefore is ideal for giving holistic assessments in fields with physically straining work (Li, et. al. 2019). It looks into body parts that have been established as vital in railway maintenance work such as the trunk, neck, and legs in tasks like track repairing and ballast handling which engage the whole body. Risk scores are assigned by REBA based on the angle and duration of body positioning, the amount of force applied and the different types of activities (Micheletti et. al. 2019). REBA tool may assist in the diagnosis and prevention of musculoskeletal disorders in Nigerian railway workers since many activities in railway maintenance can be physically demanding, while REBA provides advice on how long a particular body posture may be used in conducting a particular task. In such spaces as railway maintenance, where moving to different postures is quite frequent, REBA's capability to evaluate posture in its entirety is a great help in addressing complicated physical stress. OSHA recommends that bearing accuracy with high prevalence in muscle disorders and uneconomic endurance be especially blamed for high risk and belief REBA encourages moderation of tasks procedures, task requests on equipment, and taking longer rest to achieve desired work efficacy.

iii. **Workplace Ergonomic Risk Assessment (WERA**): In its construct, WERA may be an ergonomic assessment including several body regions such as the neck, shoulders, back and arms and legs regarding multiple ergonomic risk factors (Abd Rahman, et. al. 2011 and Pratiwi, et.al. 2019). In instances such as postural and force-related risks, the WERA tool is relevant for the maintenance of the railway since workers have to routinely lift, carry and do so in infrequent postures. In Nigeria's railway maintenance system, WERA is specifically useful when manual labour is the principal method used in making repairs and it can enable assistance in identifying different ergonomic risks and suggest task modification, such as reducing the weight lifted or modifying task frequency. It can emphasize what body parts are the most burdened during certain processes, like lifting up heavy fittings or tilting the upper body in the process of track repair, thus allowing for the provision of a global evaluation that facilitates ergonomic considerations.

iv. OWAS (Ovako Working Posture Analysis System): The OWAS method was designed to record and classify postures of the body according to their level of

*Corresponding Author: AJAYEOBA A. O

ergonomic risk, specifically to occupations involving manual work (Garcia, et. al. 2013). The OWAS system classifies different postures of the back, arms and legs and places them in a sequence of low to very high risk. In Nigeria within the activities of railway maintenance, OWAS is useful in the evaluation of postures where the operator has to lift heavy equipment or where the operator has to squat for long. Its dynamic as well as static posture evaluation capacity explains the effect of the impact of sustained or repetitive position on the workers over some time. Such results of OWAS can suggest changes in procedure or time in high-risk postures for a particular task and incorporating lifting aids, or redesigning equipment to improve accessibility and comfort. By systematically implementing these changes, railway companies can lower the physical demands on workers, reduce injury rates, and enhance productivity. Additionally, using OWAS for regular assessments enables organizations to track the effectiveness of ergonomic interventions over time and ensure continuous improvements in workplace safety (Gajšek, et. al. 2022).

4.0 Implementation and Benefits of Postural Assessments in Nigeria

There are likely to be numerous positive gains for both workers and employers if postural assessments, along with appropriate relevant safety awareness and International Standard Organization (ISO) standards compliance, are incorporated into Nigeria's railway maintenance sub-sector. Risk-based approaches help companies in railways understand activities that are most prone to risk enabling them to allocate tasks, design work ergonomics, and develop organizational policies that are informed by data (Guidi, 2022). For instance, the results of the assessments have many other practical applications such as educating the employees on safe lifting strategies, recommending breaks, and encouraging the purchase of lifting devices with minimal strain on the employees (Kirkhorn, et. al. 2010). Their use in practice would also enhance the overall objective of sustainable preventive occupational health measures by minimizing the incidence of injuries and ergonomic exposure. Furthermore, given the development of Nigeria's railway sector, and with the placing of ergonomic interventions at the early stage, successful practices in railway maintenance would create an opportunity for the transfer of work-related injury prevention practices to other industries, creating a safety and health culture in the country. In this context, the importance of sticking to the correct posture cannot be overemphasized, because it minimizes the chances of disorders and injuries occurring in the muscles or musculoskeletal system-particularly during maintenance of the railway which puts the workers in a strategically sustained physical strain. Repetitive/forceful motions, holding awkward postures for prolonged periods and improper lifting is a source of fatigue that leads to MSDs (Ali and Roslan, 2024), and all these factors are basics in railway maintenance tasks. Good posture during these activities helps minimize the biomechanical load on muscles, joints and connective tissues and this reduces the risk for strain-related injuries and chronic pain.

5.0 Physical strain during maintenance of Railway

Physical strain refers to the physiological and biomechanical stress imposed on the body during physical activities above the threshold levels. Physical strain leads ultimately to the results of discomfort, exhaustion, damage and dysfunction (Eriksen et. al 2003), because, in industries such as railway maintenance, the long and often strenuous character of labour processes means the strain is especially significant. Strain is a work-related health problem. It affects labour welfare, effectiveness, Occupational health and safety issues, and Ailing lifestyle. The interplay of these various forces of static and dynamic, environmental strains leads to a holistic approach to health and safety that emphasizes ergonomic modifications along with health surveillance measures equally. Maintaining railways is a laborious job that typically puts the workforce through heavy exertion and less-than-desirable environmental conditions. Weather can also be an issue as it tends to lead to more strain and fatigue (Lundgren, et. al., 2013). Most of the maintenance procedures and processes are very vocal, which are to put a lot of strain on certain muscles and joints for hours at a time. The demands are classified into three categories namely, static strain, walking posture and dynamic strain with environmental strain. These kinds of strains are important to understand because they dictate what types of interventions can be introduced to decrease injuries and improve the work environment's ergonomics.

Physical strain suggests major health-related risk factors for workers which involve, musculoskeletal, cardiovascular and overall well-being Warren, 2001). Research evidence suggests that high levels of physical work over long periods can cause Musculoskeletal Disorders (MSD), a problem seen in some jobs with repetitive and high-contact actions Work-related musculoskeletal disorders (MSDs) are prevalent, with lumbago, shoulder tendinitis and knee injuries being common complaints among maintenance workers in the railway industry that have been associated with overuse and repetitive strain on particular joints and muscle groups. The cardiovascular system is also in jeopardy, with extremely high heart rates, hypertension, and in the extreme conclusion; cardiovascular diseases can occur due to a merge of strenuous physical activities and heat exposure (Kivimäki and Steptoe, (2018). Among their findings are indications that railway work does elevate blood pressure while heavy tasks enhance this risk; such as irregular working and resting times. Although there is a physical activity part to the cardiovascular complications that those workers experience when they exert themselves, other factors such as working in extreme heat and dehydration also play a role, the researchers noted; situations that are commonplace when railway maintenance work necessarily takes them out into the field.

In addition to this, the stress and strain related to physical work in railway maintenance have adverse effects on the

*Corresponding Author: AJAYEOBA A. O

mental health of a person. Now throw in all that physically taxing work, fatigue, and injury risk, and you almost always have an environment rife with stress. As such, these workers are more prone to all sorts of mental disorders, especially stress and depression due to physical and other occupational stressors. These observations are also evidence of the connection between people and as such the relationship that must exist between physical stress and mental health. This is especially important taking into account the information that by improving employee physical fitness, health protection of employees involved in railway maintenance may be more effective.

6.0 Some of the relevant measuring tools and metrics for physical strain analysis are:

i. **Heart Rate Monitoring:** Heart rate (HR) is one of the most frequent markers in defining physical load and stress applied to the heart during exercise(Tonello et. al., 2014). By continuously tracking HR, one can see how much effort and at what levels of stress a worker runs the risk of overexertion. When wrist-based HR monitors, chest straps or any other real-time feedback-producing monitoring devices are being utilized, it is possible to measure how much physical work these workers expended and more importantly when to intervene as they exceed safe limits of physical reaching out exertions (Miyashita et al., 2021). Which is this metric that outputs Relative Cardiovascular Load(%CVL), Cardiovascular Strain (%CVS), and Relative Heart Rate (RHR).

ii. **Borg Rating of Perceived Exertion (RPE):** strains are differentiated via self-reporting of subjects using the Borg RPE scale (7-point scale). For the upkeep of railways, the Borg RPE scale is useful for workers to communicate their work strain despite different levels of physical fitness (Morillo and Demichela, 2023). This is a practical on-the-spot feedback system that allows supervisors to immediately modify assigned loads and/or provide breaks where necessary in an attempt to reduce the risk of overexertion.

iii. **Electromyography (EMG)**: Used to assess muscular load on the body in terms of how activated certain muscles are while performing certain tasks (electromyography EMG); In railway maintenance, EMG data would be useful due to certain muscle groups being predominant in heavy lifting, hammering and other activities. Medical authorities use EMG to identify stressed muscles and suggest treatments like job transfer abilities or muscle strengthening to minimize injury (Garg and Kapellusch, 2009).

7.0 Basic Factors that Influence Postural and Physical Strain in Nigerian Railway Maintenance Workers

Due to Nigeria's particular environment, inadequate infrastructure and the tangible nature associated with railway maintenance work itself, there are different challenges facing railway maintenance in Nigeria. Workers are commonly exposed to the following factors:

- **Environmental Factor:** One of the main contributing factors to physical strain in railroad work is Nigeria's hot climate, where temperatures may reach over 35°C in large parts of the country (Beitelmal et al., 2024). In such conditions, the temperature compromise increases the load of cardiovascular for dissipating heat and can lead to dehydration and fatigue. Research indicates that manual workers carrying out hot jobs are at an increased risk of (MSDs), since passive flexor muscles and connective tissues used in repetitive or forceful exertions when the body is hot may exceed their thermal tolerance limits. In such conditions, railway workers are especially vulnerable and need to lift heavy materials, operate tools and perform physically demanding work.
- **Limited Equipment and Infrastructure Factors:** Railway maintenance is a manpower-intensive operation and access to ergonomic tools and machinery that reduce physical strain in other contexts is often not available, as is the case in Nigeria. For instance, lack of lifting aids leads to more manual handling of materials by workers causing higher chances of musculoskeletal injuries. The lack of infrastructure, low quality of tracks and maintenance facilities make rail replacement, ballast adjustments and other inspections physically harder to do. Wearing no PPE and insufficient ergonomic training leads to these challenges because workers become prone to using uncomfortable postures and techniques while doing the tasks at hand.
- **Old and obsolete Equipment Factors:** Research carried out in workplaces with old and obsolete equipment, particularly in physically demanding fields like railway maintenance has shown considerable ergonomic risks to these workers. Old school equipment tends to be bulkier, less customizable in ways that matter, and devoid of proper ergonomics compared to modern designs, so workers bear increased physical burdens. For example, without an ergonomic grip or shock absorption, workers have to put in more effort It increases the likelihood of developing MSD/Is, especially in the shoulders, wrists, and hands, when using manual tools. Workers are exposed to regular bending, lifting, and carrying of heavy goods when operating outdated gear that lacks lifting or support mechanisms, which might strain their knees and back. Inefficient work practices brought on by outdated equipment can also result in repetitive or lengthy movements, which put additional strain on the body over time. Workers are also more likely to experience noise, vibrations, and uncomfortable

*Corresponding Author: AJAYEOBA A. O

postures in the absence of more recent, labor-saving technologies. These factors can eventually lead to increased fatigue, discomfort, and the risk of chronic pain or injury. Thus, modernizing equipment and implementing ergonomic upgrades can be crucial in lowering physical strain and fostering a more secure and comfortable work environment.

- **Lackadaisical Approach to Ergonomic Procedures:** A lackadaisical approach to ergonomic procedures is defined as a careless, inattentive, or unmotivated way of following or implementing ergonomic procedures in the workplace. Workers are frivolous and lethargic in adhering to elementary systems. They are relying upon their old methods of operating instead of the actual ergonomic ways of performing such. Typically, this involves some reflected lack of focus on addressing or avoiding unnecessary workplace health risks such as not adhering to guidelines for safe lifting, posture, or workstation design. Failure to successfully implement ergonomic procedures in this manner only makes it more likely for an employee to experience discomfort and injury related to musculoskeletal disorders, not to mention that he will improve productivity less and work in general will become less safe.

Figure 1, however, demonstrates the processes that railways can undertake to embrace technologies, change policies, and build capabilities for workers to overcome the issues of postural and physical discomfort in the Nigerian railway sector.

8.0 Common Postures and Ergonomic Risks in Nigeria: An Analysis

However, most research into physical strain tends to center on those industries where manual labour is vigorous, like construction, agriculture and mining in Nigeria. These studies find high rates of MSDs, respiratory illnesses, and cardiovascular strain among Nigerian workers, particularly in jobs with limited ergonomic access. For example, 'several construction workers in Nigeria were noted to have severe back and shoulder pain stemming from the repetitive and vigorous exertions required by their work (Njaka et. al., 2021). Similar results therefore have implications for railway maintenance, given that both construction and railway work involve frequent lifting, bending and sustained postures over a long period. Research on physical strain

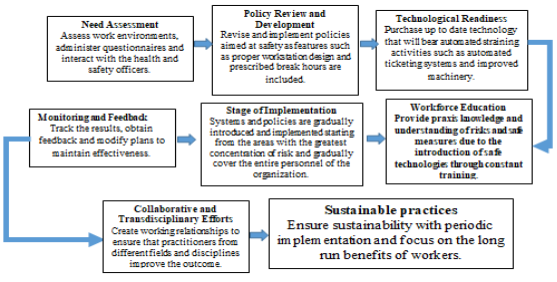

Figure 1: Steps to Achieve Sustainable Practices for postural and physical strain free in Nigerian Railway Industry Workers similarly emphasizes the role of external factors in cumulatively compromising worker health. Nigerian workers in mining and construction encounter a higher incidence of injury, as well as fatigue due to heat stress and equipment deficiencies. With no mechanized tools, workers are physically dependent and easily overexerted. Despite the similar demands and environmental considerations of the railway maintenance workforce in Nigeria, evidence-based knowledge on physical exposure encountered by railway professionals is still scarce, which limits the establishment of appropriate interventions.

Railway maintenance operations require a variety of postures or motions that can be associated with a considerable ergonomic risk when performed continuously or improperly (Das, 2020). The simple actions of lifting material, bending down to go check or do some repairs on the tracks and standing quite a long time while operating equipment, or doing inspections are tasks that are performed quite often. These actions also mostly involve awkward postures like squatting, twisting, or bending forward which load structures in the spine, shoulder and knees. In cases of heavy lifting without a lifting aid, it places excessive strain onto the lumbar spine which contributes to a considerably high prevalence of low back pain. This is further compounded by the fact that railway workers have to frequently operate in cramped work environments like tight spaces that exist just above the tracks in the middle of two rails. In situations where repairs have to be carried out in these cramped spaces, it might involve the worker having to stretch or twist which adds on cumulative stress onto the back and shoulders. There is therefore a picture whereby these postures in conjunction with motion that is repetitive come in handy in increasing the risk of Musculoskeletal disorders and more so in the absence of ergonomic training or appropriate equipment.

There is a considerable amount of ergonomic risks that can be said to exist in a railway maintenance task like the neck, back shoulder and even lower limbs (Charles et. al., 2018). Track maintenance and ballast preparation involve a lot of squatting as well as forward hip bending, which leads to the compression of the various disc structures of the spine (Jäger, 2023). Sufficient bending and lifting of the spine can also result in damage to the spine structures over some time because it is repetitive. Special twisting movements when doing these detailing jobs of track alignment or a minor adjustment also add stress onto the intervertebral discs, and as a result, if these movements are continued or are prolonged, the person is likely to develop disc herniation or chronic back pain. Even repetition in using tools and equipment without adequate ergonomic changes can also increase the frequency of upper limb problems (Stock, 1991). Sustained gripping or excessive arm force, such as those associated with hand tools and large metal pieces, causes stress in shoulders, wrists and forearms. When this stress is repeated and becomes chronic, people may acquire tendonitis, carpal tunnel syndrome, and

*Corresponding Author: AJAYEOBA A. O

rotator cuff injuries that are frequent for workers in the industrial areas in Nigeria.

They are on record that railway maintenance workers often complain of lower back pain, swelling in the shoulders and knee pains which are all indications or signs of excessive physical labour (Khan and Singh, 2018). Such workers would always be in extreme conditions whereby because of lack of water or perhaps a refusal to take breaks in their routine to take a rest, would end up overexerting themselves, leading to either short-term injuries or long-term complications to their health.

Table 1 serves as a conjunctive table categorized to include postural and physical strain stressors within the Nigerian rail sector and identifies hints of key coping mechanisms, long-term viability solutions and multidisciplinary frameworks towards safety. This Table draws attention on the necessity for disciplines to converge including ergonomics, safety engineering, health science and environmental professionals towards achieving safer and better sustainable working conditions for the employees in the railway industry of Nigeria.

9.0 International Standards for Postural and Physical Strain Assessment

There have been attempts to ease these difficulties such as job rotation and short pauses to reduce the cumulative stresses due to repetitive tasks. These processes, however, tend to be haphazard and implemented in a non-uniform manner, making them ineffective. Ergonomic aids were hardly provided by Nigeria railway repairs, mainly due to limited finances and this compels the employees to depend on the traditional method of work. Proposals for ergonomics improvement in this area indicate mechanized tools, specific PPE, ergonomic practices training and heat acclimatization as effective in reducing physical and cardiovascular overload. In addition, minimal costs on PPE can also alleviate the negative impact of physiological overload. General criteria regarding physical overload and postural overload have a practical use for the development of workplaces intended to reduce ergonomic overload. But as for Nigeria and similar areas, the restriction applies as there are some factors like structure, type of climate, and available resources that complicate the use of such standards.

Table 1 Postural and Physical Strain Challenges in The Nigerian Railway Industry

S/N	Challenges	Key Adaptive Strategies	Sustainable Solutions	Transdisciplinary Approaches to Safety
1	Prolonged Sitting for Train Operators	Promote the importance of taking rest breaks to perform stretching exercises. Make use of chairs that conform to ergonomic standards.	Work with colleagues who study sleep patterns in people about their job activities. Work with those who are experienced in the field of health, safety and environment.	Create ergonomic workstations with the help of ergonomic consultants. Place physiotherapies as part of the health check-ups at regular intervals.
2	Repetitive Movements (e.g., Ticketing Staff)	Instruct staff on the use of proper techniques while performing repetitive actions. Use mechanized tools to avoid putting in high levels of exertion.	Set up a reliable ticketing system to reduce manual processes. Assistive tools for performing monotonous tasks should be integrated.	Provide occupational therapy for staff training. Implement automatic processes in consultation with engineers.
3	Heavy Lifting (e.g., Maintenance Workers)	Employ mechanical resources for transporting loads. Educate the staff on proper lifting methods.	Buy light and simple equipment. Set up lifting maximums and maintain policies about it.	Integrate lifting aids with the assistance of safety engineers. Employ standing trainers for manual handling training regularly.
4	Standing for Long Hours (e.g., Security)	Use anti-fatigue carpets at workstations. Permit	Change the design of the stations to allow people to	Employ industrial design personnel to develop aesthetically pleasing

*Corresponding Author: AJAYEOBA A. O

		regular standing-up periods.	stand and sit. Enhance shift planning to decrease people's standing time.	places. Include occupational health personnel to oversee compliance procedures.
5	Exposure to Vibrations (e.g., Locomotive Crew)	Where necessary, use vibration-absorbing materials in work areas. Provide the staff with protective gear against vibration.	Modify existing machinery to include vibration /noise isolators. Vibration-generating machines should be subject to regular maintenance.	Engage in redesigning of equipment with mechanical engineers. Health specialists are required to assess vibrations at certain intervals.
6	Poor Posture from Inadequate Workspaces	Use the right tools and equipment for the right jobs Develop an understanding of correct movements and right posture to avoid damaging the body.	Ergonomically shaped workstations are to be adopted at all places of work. Be prepared to reassess and change workplaces when necessary.	Employ ergonomic researchers to determine the ergonomics of the workstation. Practice redesign procedures with the help of architects and industrial designers.
7	Heat Stress and Dehydration (Outdoor Workers)	Naturally, shaded regions, as well as devices for cooling and vaporizing, should be provided to workers. Make water available so workers don't forget to drink enough of it.	Develop uniforms that can self-cool. Where feasible, plan work for times that will be when it's least hot.	Provide solutions for adaptation to changing climate in cooperation with environmental scientists. Engage in monitoring hydration levels with health specialists.
8	Noise Induced Strain (e.g., Maintenance and Train Crews)	Provide soundproof earmuffs. Use noise-suppressing materials.	Consistently check the loudness of the sounds and instill laws allowing for sound scattering. Change machinery to less noisy equipment.	Work with specialized professionals in hearing loss prevention programs. Work with other professionals who facilitate sound management.
9	Mental Strain from Job Demands	Put measures in place to prevent any mental health issues. Allow time off	Provide mental health assistance specific to railway employees.	Join a professional where several people can visit for multi-part therapy. Work with human

*Corresponding Author: AJAYEOBA A. O

		and promote outdoor fun.	Avoid excessive work by properly staffing.	resource professionals to address job hazards.
10	Accident Risk from Fatigue	Stress on relaxing time at work. Implement fatigue risk monitoring systems.	Eliminate human error by using automated systems. Rearrange work schedules for the best periods of rest and work.	Work with colleagues who study sleep patterns in people about their job activities. Work with those who are experienced in the field of health, safety and environment.

a) **ISO 11226:2000, Ergonomics – Evaluation of static working postures**: The ISO 11226, an International Standardization Organization standard, focuses on static working postures and is applicable worldwide Gattamelata and Fargnoli, 2022). It provides recommendations concerning assessment protocols for body postures that may elicit body strain, especially among workers whose activity habits are characterized by the same biomechanical components over prolonged durations. The standard specifies the acceptable angles of posture, duration of postures and frequencies of movements to dampen MSDs and body discomfort (ISO, 2020). This standard has a broad applicability across different industries providing a standard for measuring the intensity of stress in static postures which is commonly required in railroad maintenance activities.

b) **ISO 5349:2020, Mechanical vibration**: Measurement and evaluation of human exposure to hand-transmitted vibration- ISO 5349 presents issues related to the potential hazards of hand-transmitted vibrations which are particularly important for those workers who use machinery or hand tools (Sampso and Van Niekerk, 2003). This standard establishes the recommended practices and limits for the measurement of vibration levels to assist in minimizing the risk of disorders such as Hand-Arm Vibration Syndrome (HAVS), which is common among maintenance workers using heavy-duty tools. The standard effectively provides measures to protect them from the risk of chronic effects from continuous exposure to osteopathogenic frequencies through recommended thresholds (ISO, 2020).

c) ISO 10075-2:2024, Ergonomic principle related to mental workload Part 2: Design principles This ISO standard is informative because it concerns the design principles for work systems including tasks, equipment, workplace environment, working conditions, and social and organizational factors (Cuello-Cuello, et. a., 2024).. Emphasis is placed upon the structuring of technical, organizational, and socio-psychological aspects as opposed to employee selection or training. It covers all kinds of human work related to cognitive, mental and physical activities and it is empirical in nature and addresses designers of systems, employers, workers and their agents who are involved in the design or major redesign of work systems. Measurement of cognitive workload and its impact remains outside of the document.

11.0 The Merits of Integrating Global Standards for Nigeria's Railway Maintenance Personnel

Nigerian railway maintenance practitioners will be able to derive six key benefits from observing these international standards.

i. **Reduced Risk of Injury and Disorders:** Ergonomics as guidelines aids in minimizing the adverse impact of awkward body position and too much tool vibration and vibration-induced disorders.

ii. **Reduced stress and improved comfort and reduced fatigue**: It reduces excessive fatigue through enhancing work postures and tools when carrying out tasks, and therefore enhances worker comfort and reduces physical strain.

iii. **Improved Occupational Performance:** These standards help in the management of mental workload which, in turn, supports cognitive performance, job satisfaction, and individual well-being.

iv. **Higher Productivity and Enhanced Reliability:** The combination of maintenance work peace of mind, increased health, and comfort assist in the more accurate performance of maintenance activities thus raising the quality of the railway system.

v. **Long-Term Cost Savings:** Lowering costs related to injury and absenteeism enhances the sustainability of the workforce thus resulting in cost benefits in the long term and increased labour retention.

By putting these standards in the Nigerian context, it will be possible to enhance safety and improve ergonomically friendly working conditions for the railway maintenance people

*Corresponding Author: AJAYEOBA A. O

12.0 Conclusion

In Nigerian railway maintenance, physical overuse or postural stress injuries can be caused by extrinsic factors like environment, structural deficiencies, worker laziness, lack of ergonomics, and because of the characteristics of the task which are strenuous. Employees within this industry tend to adopt unsafe postures such as bending, squatting and lifting as a part of their work processes which lead to increased occurrence of musculoskeletal disorders and long-term negative health consequences. Even though available literature on physical strain in Nigeria compares similar experiences in other industries in Nigeria there is no specific focus on the maintenance of railways inviting the need for such related studies for ergonomic adjustments.

Case studies show that even by employing basic ergonomic principles, such as the simple inclusion of personal protective equipment (PPE) or scheduling structured rest breaks, the health outcomes of the workers can be positively affected but such comprehensive solutions are chronically underfunded. In improving safety and minimizing the physical strain of Nigerian railway maintenance, a multi-layered approach would be required. This approach should be supported by mechanized equipment, and ergonomic education of the workers alongside standard measures such as the rotation of tasks and hydration measures. Provided these ergonomic risks are addressed, the Nigerian railway sector would guarantee a safer and more sustainable workplace for the maintenance personnel which in turn would lead to enhanced productivity and improved health of the workers.

References

1. Naweed, A., and Golightly, D. (2022). Advancement in rail transportation and safety: Key themes for human factors and systems thinking. *HIGH SPEED RAIL IN ASIA*.
2. Ryan, B., Golightly, D., Pickup, L., Reinartz, S., Atkinson, S., and Dadashi, N. (2021). Human functions in safety-developing a framework of goals, human functions and safety-relevant activities for railway socio-technical systems. *Safety Science*, *140*, 105279.
3. Georgiev, N. (2013). Knowledge management system for improvement of quality of railway transport service. *Machenes, technologies, materials. ISSN*, 1313-0226.
4. Guidi, G. (2022). The importance of human factor and maintenance activities in risk assessment for railway applications.
5. Abiramalakshmi, A., and Shree, K. C. (2018). R. Systematic measurement of occupational hazards among healthcare workers. *International Journal of Physiology, Nutrition and Physical Education*, *Nova Délhi-Índia [internet]*, *3*(2), 560-563.
6. Sabri, N. A., Sara, A. R., Eslam, M. S., and Amr, S. M. (2022). A Review of Occupational Hazards in Health Sector: Risks and Awareness. *Medp Public Health Epide-miol*, *1*(1).
7. Khan, M., Nnaji, C., Khan, M. S., Ibrahim, A., Lee, D., and Park, C. (2023). Risk factors and emerging technologies for preventing falls from heights at construction sites. *Automation in Construction*, *153*, 104955.
8. Fasinu, J. O. (2023). Improving the Health and Safety of Manufacturing Workers by Detecting and Addressing Personal Protective Equipment (PPE) Violations in Real-Time with the Use of Automated PPE Detection Technology.
9. Landsbergis, P., Johanning, E., Stillo, M., Jain, R., and Davis, M. (2020). Occupational risk factors for musculoskeletal disorders among railroad maintenance-of-way workers. *American Journal of Industrial Medicine*, *63*(5), 402-416.
10. Landsbergis, P., Johanning, E., Stillo, M., Jain, R., and Davis, M. (2021). Upper extremity musculoskeletal disorders and work exposures among railroad maintenance-of-way workers. *American Journal of Industrial Medicine*, *64*(9), 744-757.
11. Sundstrup, E., Seeberg, K. G. V., Dyreborg, J., Clausen, T., and Andersen, L. L. (2024). Systematic Review of Workplace Interventions to Support Young Workers' Safety, Work Environment and Health. *Journal of Occupational Rehabilitation*, 1-19.
12. Sparks, K., Faragher, B., and Cooper, C. L. (2001). Well-being and occupational health in the 21st-century workplace. *Journal of occupational and organizational psychology*, *74*(4), 489-509.
13. Eyayo, F. (2014). Evaluation of occupational health hazards among oil industry workers: A case study of refinery workers. *IOSR J Environ Sci*, *8*, 2319-99.
14. Das, B. (2020). Work-related injuries, postural stress, and musculoskeletal disorders among the railway track maintainers in India. *Toxicology and industrial health*, *36*(5), 371-385.
15. Gillespie, R., and Center, T. L. (2005). The Health Impact of Urban Mass Transportation Work in New York City.
16. Fray, M., and Davis, K. G. (2024). Effectiveness of safe patient handling equipment and techniques: a review of biomechanical studies. *Human Factors*, *66*(10), 2283-2322.
17. Ranavolo, A., Draicchio, F., Varrecchia, T., Silvetti, A., and Iavicoli, S. (2018). Wearable monitoring devices for biomechanical risk assessment at work: Current status and future challenges—A systematic review. *International journal of environmental research and public health*, *15*(9), 2001.
18. Seo, J., and Lee, S. (2021). Automated postural ergonomic risk assessment using vision-based posture classification. *Automation in Construction*, *128*, 103725.
19. Yu, Y., Umer, W., Yang, X., and Antwi-Afari, M. F. (2021). Posture-related data collection methods

*Corresponding Author: AJAYEOBA A. O

for construction workers: A review. *Automation in construction*, *124*, 103538.
20. Lowe, B. D., Weir, P., and Andrews, D. (2014). Observation-based posture assessment: review of current practice and recommendations for improvement.
21. Ray, S. J., and Teizer, J. (2012). Real-time construction worker posture analysis for ergonomics training. *Advanced Engineering Informatics*, *26*(2), 439-455.
22. Al Salaheen, M., Alaloul, W. S., Musarat, M. A., Johari, M. A. B., Alzubi, K. M., and Alawag, A. M. Journal of Open Innovation: Technology, Market, and Complexity.
23. Khan, M. R., and Singh, N. K. (2018). Prevalence of musculoskeletal disorders among Indian railway sahayaks. *International journal of occupational and environmental health*, *24*(1-2), 27-37.
24. Corlett, E., and Discomfort, H. W. (1998). Rapid upper limb assessment (RULA). *The Occupational Ergonomics Handbook*, 437.
25. Christopher, V. S. (2019). Analysis of Repetitive Motion in Manual Material Handling Systems Using a Digital Twin Framework.
26. Check, J. (2010). *An Ergonomic Analysis of the Seat-Sewing Line at Company XYZ. Graduate Degree/Major: MS Risk Control Research Adviser: Dr. Brian Finder, CIH MonthrYear: May, 2010 Number of Pages: 87* (Doctoral dissertation, University of Wisconsin-Stout).
27. Abd Rahman, M. N., RANI, M. R. A., and Rohani, J. M. (2011). WERA: an observational tool developed to investigate the physical risk factor associated with WMSDs. *Journal of human ergology*, *40*(1_2), 19-36.
28. Pratiwi, I., Setyowati, R., Alghofari, A. K., and Fitriadi, R. (2019). Work posture analysis using WERA and NERPA methods in batik workers. *Test Engineering and Management*, *81*, 6625-6633.
29. Garcia, P. P. N. S., Polli, G. S., and Campos, J. A. D. B. (2013). Working postures of dental students: ergonomic analysis using the Ovako Working Analysis System and rapid upper limb assessment. *Med Lav*, *104*(6), 440-447.
30. Gajšek, B., Draghici, A., Boatca, M. E., Gaureanu, A., and Robescu, D. (2022). Linking the use of ergonomics methods to workplace social sustainability: The Ovako working posture assessment system and rapid entire body assessment method. *Sustainability*, *14*(7), 4301.
31. Kirkhorn, S. R., Earle-Richardson, G., & Banks, R. J. (2010). Ergonomic risks and musculoskeletal disorders in production agriculture: recommendations for effective research to practice. *Journal of agromedicine*, *15*(3), 281-299.
32. Ali, N. F., & Najihah Roslan, A. N. (2024). Ergonomic Risk Factors (ERFs) and Prevalence of Work-related Musculoskeletal Disorders (WMSDs) Among Solvent Manufacturing Workers in Shah Alam, Selangor. *Malaysian Journal of Medicine & Health Sciences*, *20*(5).
33. Eriksen, J., Jensen, M. K., Sjøgren, P., Ekholm, O., & Rasmussen, N. K. (2003). Epidemiology of chronic non-malignant pain in Denmark. *Pain*, *106*(3), 221-228.
34. Lundgren, K., Kuklane, K., Gao, C., & Holmer, I. (2013). Effects of heat stress on working populations when facing climate change. *Industrial health*, *51*(1), 3-15.
35. Warren, N. (2001). Work stress and musculoskeletal disorder etiology: The relative roles of psychosocial and physical risk factors. *Work*, *17*(3), 221-234.
36. Kivimäki, M., & Steptoe, A. (2018). Effects of stress on the development and progression of cardiovascular disease. *Nature Reviews Cardiology*, *15*(4), 215-229.
37. Tonello, L., Rodrigues, F. B., Souza, J. W., Campbell, C. S., Leicht, A. S., & Boullosa, D. A. (2014). The role of physical activity and heart rate variability for the control of work-related stress. *Frontiers in physiology*, *5*, 67.
38. Morillo, C. A., & Demichela, M. (2023). Exploring the Impact of Repetitive Exercise on Physical Fatigue: A Study of Industrial Task Simulation in a Controlled Fitness Setting. *Chemical Engineering Transactions*, *99*, 163-168.
39. Garg, A., & Kapellusch, J. M. (2009). Applications of biomechanics for prevention of work-related musculoskeletal disorders. *Ergonomics*, *52*(1), 36-59.
40. Beitelmal, W. H., Nwokolo, S. C., Meyer, E. L., & Ahia, C. C. (2024). Exploring Adaptation Strategies to Mitigate Climate Threats to Transportation Infrastructure in Nigeria: Lagos City, as a Case Study. *Climate*, *12*(8), 117.
41. Njaka, S., Yusoff, D. M., Anua, S. M., Kueh, Y. C., & Edeogu, C. O. (2021). Musculoskeletal disorders (MSDs) and their associated factors among quarry workers in Nigeria: A cross-sectional study. *Heliyon*, *7*(2).
42. Charles, L. E., Ma, C. C., Burchfiel, C. M., & Dong, R. G. (2018). Vibration and ergonomic exposures associated with musculoskeletal disorders of the shoulder and neck. *Safety and health at work*, *9*(2), 125-132.
43. Jäger, M. (2023). Lumbar-Load Register for Previous Branch-Specific Examinations. In *The Dortmund Lumbar Load Atlas: A Contribution to Objectifying Lumbar Load and Load-Bearing Capacity for an Ergonomic Work Design of Manual Materials Handling* (pp. 343-440). Cham: Springer International Publishing.
44. Stock, S. R. (1991). Workplace ergonomic factors and the development of musculoskeletal disorders of the neck and upper limbs: A meta-

*Corresponding Author: AJAYEOBA A. O

analysis. *American journal of industrial medicine*, *19*(1), 87-107.

45. Gattamelata, D., & Fargnoli, M. (2022). Development of a new procedure for evaluating working postures: an application in a manufacturing company. *International Journal of Environmental Research and Public Health*, *19*(22), 15423.
46. Sampson, E., & Van Niekerk, J. L. (2003). Literature survey on anti-vibration gloves. Safety in Mines Research Advisory Committee. Prepared for SIMRAC Health 806.
47. Cuello-Cuello, Y., Acosta-Prieto, J. L., Dueñas-Reyes, E., García-Dihigo, J., & Domínguez-Gómez, Z. (2024). Study of mental workload in public administration managers. *DYNA*, *91*(232), 112-120.

*Corresponding Author: AJAYEOBA A. O