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MACHINE LEARNING-BASED GAIT ANALYSIS FOR EARLY DETECTION OF SCIATICA IN AGING WOMEN

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Abstract: A machine learning-based gait analysis system for the early detection of sciatica in aging women. The system will use gait data collected through wearable sensors to identify subtle deviations associated with early-stage sciatica. The data will be collected from a cohort of aging women, including those with confirmed sciatica and healthy controls. Relevant features will be extracted using signal processing techniques to identify subtle changes in gait associated with sciatica. A machine learning model will be developed using the extracted features and labelled data, trained, and validated using a portion of the collected data. The model's effectiveness in detecting early-stage sciatica will be compared to traditional diagnostic methods. The system has the potential to be used as a non-invasive, cost-effective, and readily accessible tool for the early detection of sciatica in aging women. It could be integrated into existing healthcare settings or used as a standalone tool for self-assessment. Early detection of sciatica can facilitate timely treatment and management, leading to improved patient outcomes and reduced healthcare costs.

Keywords: Sciatica, Gait Analysis, Machine Learning, Ageing Women, Early Detection

I Introduction

Sciatica is a painful condition affecting the leg, especially in aging women due to spine changes. Early detection is challenging, leading to delayed diagnosis and treatment, which can cause long-term complications. Gait analysis is a promising approach for early detection, as it can detect gait deviations like antalgic gait, limping, and decreased gait speed. However, traditional methods are subjective and lack sensitivity for detecting subtle changes. Machine learning (ML) can overcome these limitations by analysing gait data collected through wearable sensors. ML algorithms can identify subtle gait deviations with high accuracy and objectivity, paving the way for a non-invasive, accessible, and cost-effective tool for early detection of sciatica, enabling timely intervention and improved patient outcomes in shown in figure 1.

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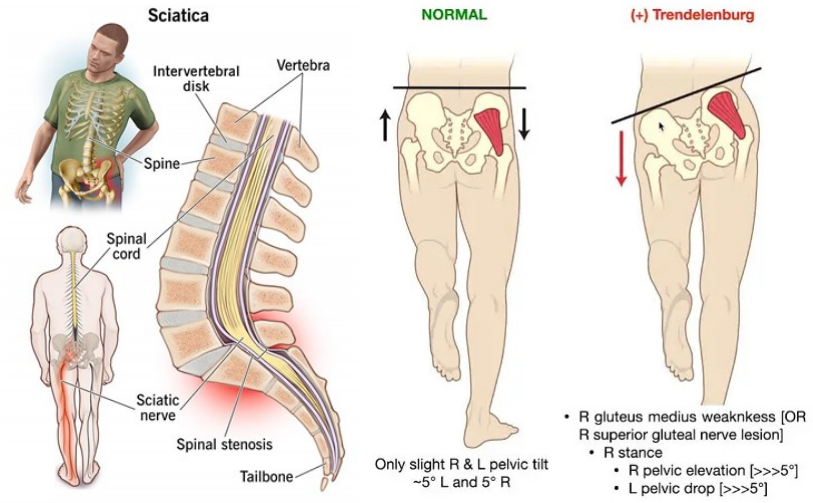

Figure 1 Representation of normal and abnormal sciatica persons

The root cause of the problem from Gait analysis in women with sciatica reveals key abnormalities contributing to their pain and disability, such as asymmetrical gait, abnormal joint kinematics, and decreased gait speed and cadence. These abnormalities can be identified through spatiotemporal gait parameters obtained through wearable sensors. Machine learning techniques can potentially detect sciatica before the onset of severe pain and disability. Age-related changes in the spine and surrounding structures, such as degenerative disc disease, osteoarthritis, ligament laxity, and muscle weakness, contribute to sciatica in aging women. Degenerative disc disease causes spinal stenosis and nerve compression, while osteoarthritis affects the facet joints in the spine, causing inflammation and narrowing of the spinal canal. Ligament laxity leads to excessive spinal movement and instability, putting pressure on the sciatic nerve shown in figure 2. Gait analysis helps understand the cause of sciatica in aging women by revealing subtle changes in gait parameters, such as stride length, cadence, and joint angles, which may indicate nerve compression. Early identification of sciatica allows for simple treatment options, such as NSAIDs, physical therapy, and stretching exercises, which can alleviate pain and improve mobility, often preventing the need for surgery.

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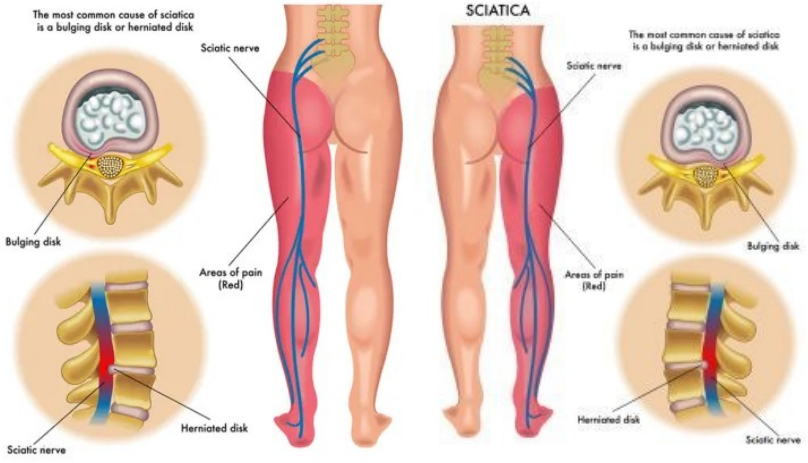

Figure 2. Representation of Sciatica Never

A novel approach using machine learning (ML) algorithms for early detection of sciatica in aging women could revolutionize diagnosis and treatment, leading to improved patient outcomes and reduced healthcare costs.

II Literature Survey

This review aims to develop and implement a machine learning-based gait analysis system for early sciatica detection in aging women. A comprehensive search of scientific databases, including PubMed, MEDLINE, and Google Scholar, was conducted to identify relevant research findings, evaluate current methodologies, and analyse potential gaps and opportunities for improvement [1-8]. Key findings include an increased prevalence of sciatica in aging women, with risk factors including age, disc degeneration, obesity, and hormonal changes. Gait analysis has become a useful method for finding small changes in the way people walk that could be signs of sciatica. Research has shown that looking at spatiotemporal parameters, joint kinematics, and gait variability can help diagnose sciatica. Wearable technology, such as IMUs, pressure sensors, and smartwatches, is increasingly utilized for gait data acquisition due to its non-invasive, portable, and easy-to-use nature. Machine learning algorithms, particularly SVMs, Random Forests, and DNNs, have shown promising results in classifying gait data for sciatica detection, with high accuracy and sensitivity in identifying early-stage sciatica. Early diagnosis of sciatica paves the way for prompt intervention and management, leading to improved patient outcomes and reduced

healthcare costs [9-15]. These sensors offer advantages over traditional methods by being portable, non-invasive, and cost-effective. Smartphone applications with built-in sensors can further increase the accessibility and convenience of gait monitoring [16].

Gait analysis [17-22] and sciatica are closely linked, with gait parameters like stride length, cadence, and joint angles significantly altered in individuals with sciatica compared to healthy controls. Machine learning algorithms have shown potential in analysing gait data and identifying abnormalities associated with medical conditions, including sciatica. These models can distinguish between sciatica and healthy gait patterns with high accuracy, sensitivity, and specificity. However, gaps in early sciatica detection in aging women include a lack of standardized data collection protocols, limited sample sizes, interoperability issues, and limited user friendliness. Future research should focus on aging women, investigate specific gait patterns associated with sciatica, and validate machine learning models in real-world environments. Addressing concerns regarding data security and privacy is crucial for user trust and wider adoption [23-27].

III Methodology

Machine learning models are created using algorithms like support vector machines (SVMs), random forests, or deep neural networks. These models are trained and validated using collected data to achieve high sensitivity, specificity, and accuracy. They are evaluated using metrics like sensitivity, specificity, precision, recall, and F1 score and compared with traditional diagnostic methods for sciatica detection. Additional data collection devices include EMG sensors, pressure insoles, and smartphone-based gait analysis applications. Challenges include data acquisition, feature engineering, model interpretation, and clinical validation.

The system evaluation will assess the performance of a machine learning model for early detection and monitoring of sciatica using wearable technology. The model will be trained using algorithms like support vector machines (SVMs), random forests, or deep neural networks, aiming for high sensitivity, specificity, and accuracy. The model will be compared with traditional diagnostic methods for sciatica detection. Additional data collection devices include electromyography sensors, pressure insoles, and smartphone-based gait analysis applications. Challenges include data acquisition, feature engineering, model

interpretation, and clinical validation. The model will be used to detect and monitor sciatica in aging women, including those with confirmed sciatica and healthy controls. Gait data will be collected using wearable sensors, including inertial measurement units (IMUs) or pressure-sensitive insoles. Clinical data will include medical history, pain scores, and physical examination findings. The collected gait data will be pre-processed to remove noise and artifacts, and relevant features will be extracted to capture subtle gait deviations associated with sciatica.

IV Conclusion

This research presents a comprehensive methodology for developing a machine learning-based gait analysis system for the early detection and treatment of sciatica in aging women. The system, which integrates wearable technology and advanced machine learning algorithms, offers a promising avenue for overcoming traditional diagnostic limitations. Gait analysis, specifically through spatiotemporal parameters and joint kinematics, can provide valuable insights into the root cause of sciatica. The system has the potential to revolutionize diagnosis and treatment, leading to improved patient outcomes, reduced healthcare costs, and a higher quality of life for aging women with sciatica. Machine learning algorithms like SVMs, Random Forests, and DNNs have shown promising results in classifying gait data for sciatica detection. Key areas for improvement include standardization of data collection, integration of clinical data, longitudinal studies, cost-effectiveness analysis, and ethical considerations.

V Future Scope

Future research should focus on personalized gait analysis, integrating additional sensor modalities like EMG and HRV to capture a more comprehensive picture of gait patterns and enhance diagnostic accuracy. Deep learning applications, particularly convolutional neural networks (CNNs), can be explored for automatic gait pattern recognition and sciatica prediction. Large-scale clinical trials should be conducted to validate the efficacy and real-world effectiveness of machine learning-based gait analysis in clinical diagnosis and future prediction of sciatica. Machine learning-based gait analysis, using hybrid approaches like HMM-DTW and PSO-BCO, has the potential to significantly impact the early detection and management of sciatica in aging women. Future research should focus on large-scale

clinical trials, integrating this technology with other diagnostic tools, and developing personalized treatment plans based on individual gait patterns and risk factors. These hybrid methods can overcome the limitations of individual models and achieve superior performance in early sciatica detection.

Multi-stakeholder collaboration between researchers, healthcare providers, patients, and regulatory bodies is essential for the ethical, responsible, and user-cantered development and implementation of this technology. Further research is necessary to explore the feasibility and effectiveness of these hybrid methods in the context of sciatica detection using gait analysis.

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