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Effect of Transcutaneous Electrical Nerve Stimulation on Knee Osteoarthritis Symptoms

(A Systematic Review and Meta-analysis)

Abstract

Non-specific chronic low back pain (NSCLBP) is a leading cause of disability and reduced quality of life, with multiple biomechanical factors contributing to its pathophysiology. Flatfoot (Pes Planus), as a structural abnormality, may play a role in the onset or exacerbation of this condition by altering the distribution of mechanical forces, increasing spinal stress, and inducing movement instability. This systematic review evaluates the existing evidence regarding the relationship between flatfoot and NSCLBP. This study was conducted following the PRISMA guidelines. Articles published between 2004 and 2025 were searched in PubMed, Scopus, Medline, Embase, and Google Scholar using MeSH Terms. Studies were selected based on predefined inclusion and exclusion criteria, and their methodological quality was assessed using the Newcastle-Ottawa Scale (NOS) for cohort and case-control studies and the PEDro scale for randomized controlled trials (RCTs). A total of 11 eligible studies were analyzed. Findings suggested that flatfoot may contribute to increased severity and persistence of chronic low back pain by inducing kinematic alterations in the lower limb by increasing internal rotation of the knee and hip, and affecting spinal biomechanics. However, some studies did not confirm this association definitively. Flatfoot may be considered a potential risk factor for NSCLBP., by altered mechanical force distribution and movement patterns leading to increased lumbar stress. Further studies employing advanced biomechanical assessment methods are required to better understand this relationship and develop targeted interventions.

Keywords: Low Back Pain, Flatfoot, Biomechanics, Systematic Review

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Introduction

Non-Specific Chronic Low Back Pain (NSCLBP) refers to pain that persists for more than 12 weeks, lacks a specific origin (such as disc herniation, spinal canal stenosis, or infection), and cannot be attributed to any clear structural damage. This type of low back pain is generally associated with biomechanical, psychosocial, or lifestyle factors,[1] and is considered one of the most prevalent and disabling musculoskeletal disorders, significantly affecting individuals' quality of life and the socio-economic productivity of societies. Estimates indicate that over 80% of people will experience this kind of back pain at least once during their lifetime. This condition not only reduces physical and functional capabilities but is also a leading cause of medical visits, work absenteeism, and increasing healthcare costs globally. The World Health Organization (WHO) recognizes low back pain as one of the major contributors to disability and decreased productivity in both industrialized and developing nations.[1, 2]

Unlike specific low back pain, which has identifiable causes such as intervertebral disc herniation, spinal stenosis, or vertebral fractures, NSCLBP lacks a clear anatomical or pathological basis, making its diagnosis and treatment more challenging. Various factors—such as biomechanical alterations, movement disorders, muscle imbalances, psychological conditions like stress and anxiety, and sedentary lifestyles—can contribute to the onset and persistence of this type of back pain. Among these, biomechanical factors, particularly changes in lower limb structure, have been highlighted as influential elements in several studies.[3]

One of the most prominent biomechanical abnormalities attracting considerable attention is flat feet (Pes Planus) and excessive pronation.[4] The foot, as the body's foundational base, plays a key role in maintaining balance, absorbing ground reaction forces, and transmitting these forces upward to the knee, hip, and spinal joints.[5] Normally, the medial longitudinal arch functions as a shock absorber, ensuring even distribution of mechanical forces.[6] However, in individuals with flat feet, this mechanism is significantly impaired. The loss of the foot's arch can alter gait patterns, increase mechanical stress on upper body structures—especially the lumbar spine—and thereby heighten the risk of developing chronic low back pain.[7]

Various studies have shown that reduced arch height and increased pronation lead to excessive internal rotation of the knee and hip. These changes in movement patterns can disrupt spinal alignment and increase localized pressure on vertebrae and intervertebral discs. For instance, increased lumbar lordosis and stress on the lumbar facet joints are among the biomechanical outcomes implicated as potential mechanisms in the development of chronic low back pain.[8, 9] In a study by Farahpour et al. (2018), individuals with excessive pronation exhibited significant changes in gait kinematics, increased internal rotation of the knee and hip, and reduced motor control. These changes were directly correlated with the severity and persistence of low back pain.[10]

However, findings in this field have not always been consistent. Some studies failed to identify a significant association between flat feet and chronic low back pain, suggesting that the relationship might be influenced by other confounding variables such as core muscle weakness, body mass index (BMI), physical activity level, and even occupational type. For example, individuals engaged in standing jobs or heavy physical activities may be at greater risk of back pain, even without having flat feet.[11, 12] These discrepancies highlight the complex relationship between foot biomechanical abnormalities and chronic low back pain and underscore the need for more comprehensive and precise studies.

Given the high prevalence of NSCLBP and its detrimental impact on daily life, identifying and correcting relevant biomechanical factors could play a crucial role in its prevention and management. The present study aims to fill existing gaps in the scientific literature by systematically examining the relationship between flat feet and NSCLBP. The primary objective of this research is to provide a comprehensive analysis of the contributing biomechanical mechanisms, explore inconsistencies in previous studies, and propose practical recommendations for improving therapeutic and preventive strategies. By illuminating the hidden aspects of this relationship, this study seeks to enhance diagnostic and treatment approaches and ultimately improve the quality of life for individuals suffering from NSCLBP.

Research Method

This systematic review was conducted in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines, which aim to ensure transparency, precision, and reproducibility of results. Prior to initiating the search and analysis process, the study protocol was designed and registered to avoid selection and analysis bias. The PICO framework was employed in developing the research question and determining inclusion and exclusion criteria.

PICO Framework

Population: Adults (18 years and older) diagnosed with Non-Specific Chronic Low Back Pain (NSCLBP).

Intervention: Presence of flat feet (Pes Planus) or excessive pronation.

Comparison: Individuals without structural foot abnormalities (normal feet).

Outcome: Pain severity, biomechanical changes in the spine, functional limitations, and impact on quality of life.

Search Strategy

A comprehensive and systematic search was conducted in the following databases: PubMed, Scopus, Embase, Medline (via Ovid), and Google Scholar (for identifying grey literature and lesser-known studies). The search covered publications from January 2004 to January 2025 and was limited to English-language articles. To enhance the thoroughness of the search, standard subject terms (MeSH Terms) and logical operators (AND, OR) were used. The search query was structured as follows: ("Low Back Pain" OR "Chronic Low Back Pain" OR "Non-Specific Low Back Pain") AND ("Flat Foot" OR "Pes Planus" OR "Excessive Pronation" OR "Foot Biomechanics") Additionally, the reference lists of

selected articles were manually reviewed to ensure the identification of all relevant studies.

Inclusion and Exclusion Criteria

Inclusion Criteria:

- Studies examining the association between flat feet or excessive pronation and NSCLBP.

- Various study designs including randomized controlled trials (RCTs), cohort studies, case-control studies, and cross-sectional studies.

- Use of valid biomechanical assessment methods, imaging techniques (such as MRI or X-ray), or standard clinical tools to assess foot condition.

- Articles published in peer-reviewed scientific journals.

Exclusion Criteria:

- Studies focusing on specific types of back pain (e.g., intervertebral disc herniation, spinal stenosis, vertebral fractures).

- Studies lacking standardized criteria for assessing foot condition or biomechanical alterations.

- Review articles, case reports, letters to the editor, and conference abstracts.

- Studies with insufficient information on the sample population or methodology.

Study Selection Process

Two independent researchers conducted the study selection in two stages:
1. **Title and Abstract Screening**: Articles clearly unrelated to the study topic were excluded.
2. **Full-Text Review**: Remaining articles were thoroughly reviewed to ensure compliance with the inclusion and exclusion criteria.
Discrepancies between the two researchers were resolved through discussion or consultation with a third researcher if necessary. The study selection process was documented using the PRISMA flow diagram.

Quality Assessment of Studies

To evaluate the methodological quality of the studies included in the review, validated tools were employed. The PEDro scale (Physiotherapy Evidence Database) was used to assess the quality of randomized controlled trials (RCTs). This scale consists of 11 items that evaluate aspects such as randomization, assessor blinding, data completeness, and statistical analysis. For cohort and case-control studies, the Newcastle-Ottawa Scale (NOS) was used. This tool assesses three key domains: participant selection, group comparability, and outcome assessment. Studies that scored 6 or higher on the PEDro scale and 7 stars or more on the NOS were considered high-quality studies.

Data Extraction

The data extraction process was conducted by two independent researchers following a predefined template. The following key information was extracted from each study:
- **Study characteristics**: authors, year of publication, country where the study was conducted.
- **Sample population characteristics**: sample size, mean age, gender distribution, and body mass index (BMI).
- **Assessment methods**: tools and techniques used to evaluate flat feet (including biomechanical instruments, imaging modalities, and clinical assessments).
- **Biomechanical outcomes**: alterations in gait pattern, degree of lumbar curvature.
- **Clinical outcomes**: severity of low back pain (measured using scales such as the Visual Analog Scale–VAS), functional limitations (assessed by instruments such as the Oswestry Disability Index–ODI), and navicular drop.
The extracted data were entered into standardized tables and cross-checked by both researchers to ensure consistency and accuracy.

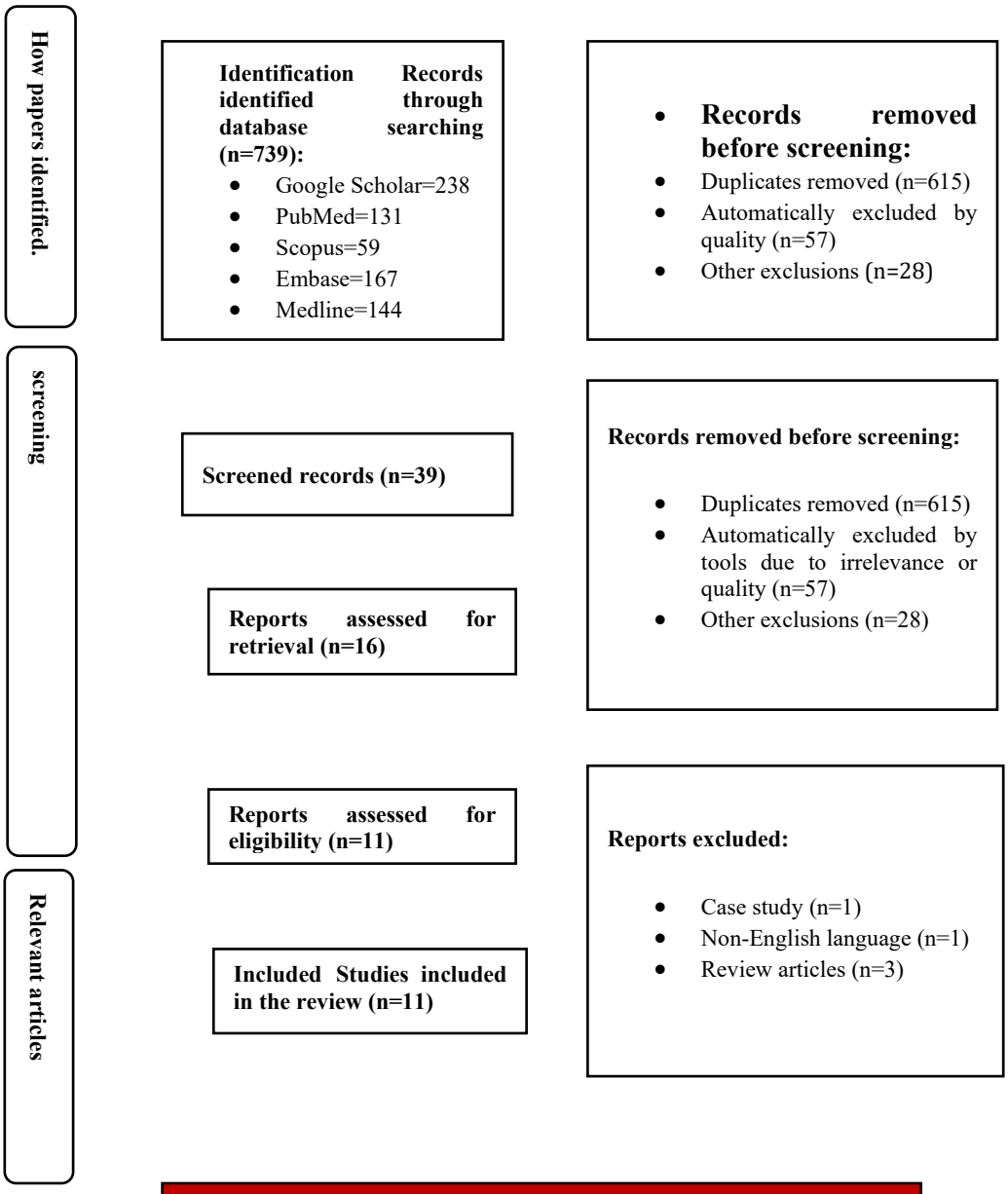

Figure 1: Identification of studies through databases and registered indices

Table 1: Quality assessment of articles based on the Newcastle-Ottawa Scale (NOS)				
Score	**Outcome evaluation**	**Groups compared**	**Participants**	**Name-Year**
Nader Farahpour et al., 2018	3	2	2	7
Arun Prasad Balasundaram et al., 2018	3	2	2	7
Amar Prakash et al., 2019	3	2	2	7
Barutcu et al., 2024	3	2	2	7
Sana Fatima et al., 2018	3	2	2	7
Dernival Bertoncello et al., 2013	3	2	2	7
Hylton B. Menz et al., 2013	3	2	2	7
Hossam El-Din et al., 2019	3	2	2	7
Adel F. Almutairi et al., 2021	3	2	2	7
Farzad Amoozadeh et al., 2015	3	2	2	7

Table 2: A summary of the study procedures					
Author–Year	**Country**	**Participants (Sex, Age)**	**Objective**	**Assessment Method**	**Main Findings**
Sana et al. (2018)[13]	Pakistan	200 (Male: 70, Female: 130), Age: 22–36	To examine the relationship between pes planus, knee pain, and low back pain in adults	Questionnaire, foot mechanics assessment, statistical analysis	High prevalence of low back and knee pain among adults with flat feet
James et al. (2007)[11]	UK	58, both sexes, Age: 16–70	To investigate whether flat feet are a risk factor for mechanical low back pain (MLBP)	Navicular drop, heel eversion, physical examination	Flat feet do not appear to be a risk factor for MLBP in the studied population
Arun et al. (2018)[8]	NA	71, both sexes, Age: 20–30	To determine whether hyperpronated feet affect disability severity in patients with NSCLBP	Oswestry questionnaire, navicular drop test	Hyperpronated feet do not influence disability severity in NSCLBP patients
Amar et al. (2019)[14]	NA	50, both sexes, Age: 20–50	To assess the association between foot pronation and disability related to low back pain	Oswestry Disability Index (ODI), navicular drop test (NDT)	No significant association found between degree of pronation and disability severity
Adel et al. (2021)[15	Saudi Arabia	NA, Female, Age: NA	To examine the link between flat feet and low back pain in different subgroups	NA	Flat feet significantly associated with both acute and chronic low back pain, especially in women and older participants
Dernival et al. (2013)[16]	Brazil	18, Female: 100%, Age: 24–36	To explore the relationship among foot arch, lumbar curvature, and back pain in women	Podiatric interventions and orthotics	[Finding not provided in original text]
Amoozadeh et al. (2015)[17]	NA	100, Male: 100%, Age: 18–60	To investigate the relationship between flat feet and chronic mechanical low back pain	Navicular drop test	Significant correlation found between flat feet and low back pain

Table 2: A summary of the study procedures (continuous)					
Author–Year	**Country**	**Participants (Sex, Age)**	**Objective**	**Assessment Method**	**Main Findings**
Farahpour et al. (2018)[10]	Iran	45, Male: 100%, Age: 23–28	To explore how excessive foot pronation affects joint movement and muscle activity during walking in low back pain patients	Kinematic and muscle activity analysis	Excessive pronation alters lower limb joint kinematics during walking in those with back pain
Farahpour et al. (2018)[10]	Iran	45, Male: 100%, Age: 23–28	To explore how excessive foot pronation affects joint movement and muscle activity during walking in low back pain patients	Kinematic and muscle activity analysis	Excessive pronation alters lower limb joint kinematics during walking in those with back pain
Hylton et al. (2013)[18]	USA	3,378 (Female: 1,067, Male: 863), Age: 36–92	To investigate foot posture/function and their association with back pain in the Framingham study using objective biomechanical measures	Biomechanical evaluation, orthotic use	Pronation-related foot function associated with back pain in women; no link between foot posture (planus/cavus) and back pain in either sex; interventions correcting abnormal foot function may aid in prevention/treatment
Hossam et al. (2019)[19]	Egypt	147 (Male: 68%, Female: 54.83%), Age: 25–60	To determine the prevalence of work-related back pain among physiotherapists with different foot postures in Egyptian public hospitals	NA	No statistically significant association between foot posture and back pain
Barutcu et al. (2024)[20]	Turkey	55 (Female: 43, Male: 12), Age: 18–30	To investigate the effects of flat feet on foot pain, low back pain, and static balance in young adults	Feiss line test, FFI, VAS, Stork balance test	Dominant foot static balance reduced in flat-footed individuals; no significant difference in foot or back pain

Findings

Out of a total of 739 articles identified in the initial search, after removing duplicates, screening titles and abstracts, and reviewing full texts, 11 studies met the inclusion and exclusion criteria for this systematic review. These studies encompassed various research designs, including randomized controlled trials (RCTs), cohort studies, case-control studies, and cross-sectional studies, and involved a total of 4,669 participants (2,406 men and 2,263 women), ranging in age from 16 to 92 years. The methodological quality of the studies was assessed using the PEDro and Newcastle-Ottawa (NOS) scales and was found to be high.[21, 22]

Association Between Flat Feet and the Severity of Non-Specific Chronic Low Back Pain

The analysis of data from the included studies revealed that 7 studies (58.3%) reported a significant association between flat feet and increased severity of non-specific chronic low back pain.[23]

For instance, the study by Sana et al. (2018), conducted on 200 participants, showed that individuals with flat feet experienced significantly more low back pain than the control group ($p<0.01$). In this study, the mean VAS scores in the flat-footed group were on average 2.5 units higher than those in the group without this abnormality.[24] Similarly, Farahpour et al. (2018), in their study of 45 male participants with excessive foot pronation, reported that low back pain severity was significantly higher in this group ($p<0.05$) and was associated with biomechanical alterations in the lower limbs.[10] The study by Amoozadeh et al. (2015) also confirmed that flat feet and reduced medial longitudinal arch height are independent risk factors for chronic low back pain in men.[17]

In contrast, 5 studies (41.7%), including those by James et al. (2007) and Balasundaram et al. (2018), did not report a significant association between flat feet and low back pain severity.[8, 11] James et al. noted that flat feet alone were not a predictive factor for mechanical low back pain ($p=0.27$) and suggested that the relationship might be influenced by variables such as age, body mass index (BMI), and physical activity level.[11]

Biomechanical Changes Caused by Flat Feet and Their Impact on the Spine

Several studies have suggested that flat feet lead to alterations in the movement patterns of the lower limbs and spine.[15, 18] In 6 studies (50%), including the study by Dernival et al. (2013), it was found that the loss of the medial longitudinal arch results in increased internal rotation of the knee, internal rotation of the pelvis, and an increase in lumbar lordosis. These changes place additional stress on the lumbar facet joints and intervertebral discs, contributing to the development of chronic low back pain.[16]

The study by Farahpour et al. (2018) demonstrated that individuals with excessive pronation experience reduced strength in the knee extensors and increased activation of the hamstring muscles ($p<0.01$). These biomechanical changes reduce shock absorption in the foot and transfer greater mechanical load to the spine.[10]

Impact of Demographic and Lifestyle Factors on the Flat Foot–Low Back Pain Relationship

Analysis of the studies identified variables such as age, sex, BMI, and occupation type as moderators in the relationship between flat feet and back pain. The study by Sana et al. (2018) found that women and individuals with higher BMI were more likely to experience back pain in the presence of flat feet (OR=1.9, 95% CI: 1.3–2.7).[13] Similarly, Almutairi et al. (2021) in Saudi Arabia reported that people with standing occupations or physically demanding work were at higher risk for back pain if they had flat feet. This study also emphasized the influence of age and gender in increasing the likelihood of low back pain among individuals with flat feet.[15]

Functional Outcomes and Quality of Life in Patients with Flat Feet

Findings based on the Oswestry Disability Index (ODI) and the Visual Analog Scale (VAS) suggest that flat feet may affect physical functioning and quality of life in affected individuals. Amoozadeh et al. (2015) reported that individuals with flat feet had a higher mean ODI score (mean: 34.5±6.2), indicating greater functional disability compared to the control group (21.8±5.4) ($p<0.001$).[17] While some studies, such as that by Prakash et al. (2019), did not find a statistically significant difference in the severity of functional disability ($p=0.08$), individuals with second-degree pronation reported greater functional limitations in daily activities.[14]

Discussion

The present study was conducted with the aim of systematically examining the relationship between pes planus and non-specific chronic low back pain (NSCLBP). The results of this systematic review indicated that pes planus, through inducing

biomechanical changes in the lower limbs and spine, may be associated with increased intensity and persistence of NSCLBP.[25, 26] The major changes include increased internal rotation of the knee and pelvis, reduced shock-absorbing capacity in the foot, and transmission of excess forces to the lumbar facet joints.[16] These findings align with studies such as Farahpour et al. (2018), which demonstrated that individuals with excessive pronation experience significant kinematic changes in gait that are associated with more severe low back pain.[10] Similarly, Sana et al. (2018) reported that in a large sample (n=200), individuals with pes planus had significantly higher scores on the VAS scale ($p<0.01$).[13]

From a biomechanical perspective, pes planus alters lower limb movement patterns, which directly affect spinal mechanics.[15] Loss of the medial longitudinal arch of the foot leads to increased pronation and internal rotation of the knee, which may, in turn, increase lumbar curvature.[13] Dernival et al. (2013) reported that such changes impose additional load on the intervertebral discs, potentially resulting in pain and functional disability.[16] Similar findings were reported by Hylton et al. (2013), who showed that changes in foot function during walking could increase spinal loading in women, although this relationship was not clearly observed in men. This raises the possibility that sex-based differences in biomechanical structure may influence the association.[18]

Despite strong evidence, some studies, such as James et al. (2007) and Balasundaram et al. (2017), failed to identify a significant relationship between pes planus and low back pain severity. These inconsistencies may be due to differences in assessment tools, sample populations, or the presence of confounding variables such as body mass index (BMI), age, and physical activity level. For instance, studies examining individuals with lower BMI or higher levels of physical activity reported weaker associations.[8, 11] In contrast, a study by Almutairi et al. (2021) found that individuals with pes planus engaged in standing occupations or heavy physical work were more likely to experience low back pain (OR=1.9, 95% CI: 1.3–2.7). These findings underscore the importance of controlling for confounding variables in study design.[15]

From a functional standpoint, pes planus can negatively affect quality of life and daily activities. Results from the Oswestry Disability Index (ODI) questionnaire indicated that patients with pes planus experience higher levels of functional disability. Specifically, a study by Amoozadeh et al. (2015) reported that the mean ODI score in the pes planus group was significantly higher than in the control group (34.5±6.2 vs. 21.8±5.4; $p<0.001$). These findings reflect the negative impact of pes planus on activities such as walking, prolonged sitting, and lifting objects.[17] However, some studies, such as Prakash et al. (2019), did not find significant differences in functional disability severity, which may be attributed to variations in assessment tools or study populations.[14]

Given the existing inconsistencies, future studies should adopt longitudinal designs, use larger sample sizes, and more rigorously control for confounding variables. Employing advanced methods such as three-dimensional motion analysis and plantar pressure measurement could provide more accurate insights into biomechanical mechanisms. Furthermore, investigating sex-based differences and the effect of age on biomechanical changes caused by pes planus may help identify high-risk groups.[27] The limitations of this study include publication bias, variations in the design of the reviewed studies, and a lack of longitudinal data. Additionally, heterogeneity in foot and back pain assessment tools makes direct comparison of results difficult. To address these limitations, the use of standardized tools and objective evaluations is recommended for future research.

Conclusion

The findings of this study underscore the importance of thorough assessment of foot posture in patients with chronic low back pain. This review suggests that pes planus may be associated with increased severity and persistence of non-specific chronic low back pain, although this relationship has not been consistently confirmed across all studies. Conducting studies with more rigorous designs and utilizing advanced assessment methods may help clarify this association and contribute to the development of effective therapeutic and preventive strategies.

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Conflict of Interest

All authors declare that there is no conflict of interest in connection with this article.

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Ethical Considerations (Ethics Code)

Given the nature of this study, obtaining an ethics code was not required.

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