The Effectiveness of Valgus Knee Braces and Lateral Wedge Insoles on Gait Parameters in Patients with Medial Knee Osteoarthritis: A Literature Review

Ali Asghar Jamebozorgi [a], Mehdi Rezaei [b*]

a Department of Occupational Therapy, Faculty of Rehabilitation, Shahid Beheshti University of Medical Sciences, Tehran, Iran; **b** Department of Orthotics and Prosthetics, School of Rehabilitation, Shahid Beheshti University of Medical Sciences, Tehran, Iran

* ***Corresponding author***: Mehdi Rezaei, Department of Orthotics and Prosthetics, School of Rehabilitation, Shahid Beheshti University of Medical Sciences, Tehran, Iran, ***E-mail***: me.rezaei@sbmu.ac.ir

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Abstract

Introduction: Knee osteoarthritis (OA) is a prevalent degenerative joint disease among the elderly. Medial knee OA, characterized by uneven pressure distribution in the knee joint, leads to alterations in gait parameters such as reduced gaite speed, increased knee adduction moment (KAM), and decreased stride length. Valgus knee braces (VKB) and lateral wedge insoles (LWI) are common non-surgical interventions for management of this problem. This literature review aims to compare the effectiveness of VKB and LWI on gait parameters in elders with medial knee OA. **Materials and Methods:** A literature search was conducted in PubMed, Web of Science, Embase, and Scopus in November 2024. Studies investigating the effects of VKB and LWI on gait parameters such as KAM, walking speed, stride length, and Range of Motion (ROM) were included. Data were synthesized narratively, focusing on the key findings and outcomes of each study. **Results:** The review included 8 studies with a total of 211 participants. The findings indicated that VKB significantly reduced KAM, whereas the results for LWI were inconsistent. The combination of VKB and LWI resulted in a greater reduction in KAM than either intervention alone. However, neither VKB nor LWI significantly improved walking speed or stride length. **Conclusion:** VKB are more effective than LWI in reducing KAM, but the combination of both interventions may have synergistic effects. Further studies are needed to explore the long-term effects of these two orthoses on medial knee OA.

Keywords: Gait Parameters; Knee Adduction Moment Knee Osteoarthritis; Lateral Wedge Insole; Valgus Knee Brace

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Introduction

Knee osteoarthritis (OA) is a degenerative joint disease that significantly impacts the quality of life, particularly among the elders. Due to the uneven distribution of load on medial compartment of the knee which is approximately 2.5 times greater than the lateral compartment, the medial compartment of the knee joint is more susceptible to OA (1). This disproportionate loading leads to alterations in gait parameters, including reduced walking speed, increased KAM, and decreased stride length, contributing to pain, stiffness, and limited ROM (2).

The management of knee OA typically begins with non-surgical interventions aimed at slowing disease progression, improving physical function, and alleviating pain. The Osteoarthritis Research Society International (OARSI) recommends several non-invasive interventions, including weight loss, exercise, physical therapy, and the use of orthotic devices such as valgus VKB and LWI (3). These interventions aim to reduce the load on the medial compartment of the knee, thereby improving gait mechanics and reducing symptoms such as pain.

Valgus knee braces are designed to unload the medial compartment of the knee by applying a valgus force, which redistributes the load to the lateral compartment. These braces come in various designs, including pneumatic, hinged, and custom-fit models, each offering tailored support and stability (4). On the other hand, LWI are cost-effective interventions that promote foot pronation, thereby shifting the weight-bearing pressure away from the medial knee compartment. LWIs are available in different designs, such as heel wedges and full-length insoles, with or without arch support (5).

Despite the widespread use of VKB and LWI, there is ongoing debate regarding their effectiveness in improving gait parameters in individuals with medial knee OA. While some studies suggested that VKB and LWI can reduce KAM and improve gait

mechanics, others report no significant benefits on gait mechanics (6, 7). This review aimed to provide a comprehensive synthesis of the existing litratures on the effects of VKB and LWI on gait parameters in patients with medial knee OA, with a focus on KAM, walking speed, stride length, and ROM.

The present review study is important because it examines gait parameters as one of the most important indicators of quality of life and physical function in elders with knee OA. The present review study compared the effectiveness of VKB and LWI on gait parameters, including KAM, walking speed, stride length, and ROM.

Materials and Methods

Study Selection and Eligibility Criteria

This literature review followed a narrative approach to synthesize existing literatures. Studies were included if they investigated the effects of VKB and LWI on gait parameters in elders with medial knee OA, as defined by the Kellgren-Lawrence grading system (8). Both randomized controlled trials (RCTs) and quasi- experimental studies were included. Studies that measured specific gait parameters such as KAM, walking speed, stride length, and ROM were considered. Studies involving surgical interventions, lateral compartment knee OA, or foot or other disorders were excluded.

Search Strategy

A comprehensive search was conducted in PubMed, Web of Science, Embase, and Scopus in November 2024. The search strategy used keywords related to knee OA, Valgus Knee Braces, Lateral Wedge Insoles, and Gait Parameters. The search terms included: ("Knee Osteoarthritis" OR "Medial Knee OA") AND ("Valgus Knee Brace" OR "Unloader Brace") AND ("Lateral Wedge Insole" OR "Foot Orthosis") AND ("Gait Parameters" OR "Knee Adduction Moment" OR "Walking Speed" OR "Stride Length" OR "Range of Motion"). The search was limited to English-language articles published between 2000 and 2024.

Data Extraction

Two independent reviewers screened the titles and abstracts for relevancy. Full-text articles were reviewed for eligibility, and data were extracted using a standardized form. The extracted data included study design, sample size, intervention details (type of VKB or LWI, duration of use), outcome measures (KAM, walking speed, stride length, ROM), follow-up duration, and main results. Any disagreement between reviewers were resolved through discussion and consensus.

Data Synthesis

Given the heterogeneity in study designs, interventions, and outcome measures, a narrative synthesis was conducted. The findings were organized by intervention type (VKB, LWI, and combined interventions) and outcome measures (KAM, walking speed, stride length, and ROM).

Results

The review included 8 studies with a total of 211 participants, examining the effects of VKB and LWI on gait parameters in elders with medial knee osteoarthritis (OA). The findings are summarized in Table 1.

The findings of all included studies revealed that VKB significantly reduced KAM, with reductions ranging from 7% to 12% across studies. This reduction in KAM is clinically significant, as elevated KAM is strongly correlated with disease progression and pain in medial knee OA. Pagani *et al.* (4) demonstrated that VKB was more effective than LWI in reducing KAM, highlighting its potential as a biomechanical intervention to unload the medial compartment of the knee. Similarly, Jones *et al.* (6) reported significant reductions in KAM with both VKB and LWI, though the effect was more pronounced with VKB. These results suggested that VKB compared to LWI may be more suitable intervention for reducing medial knee load in elders with knee OA.

In contrast, the effectiveness of LWI in reducing KAM was less consistent. While Fu *et al.* (9) found that LWI significantly reduced KAM when used in combination with VKB, Duivenvoorden *et al.* (7) reported no significant reduction in KAM with LWI lonely. This variability may be attributed to differences in study design, insole characteristics (*e.g.*, wedge angle, material, and design), and elders individual chrachteristics such as foot alignment and severity of OA. For example, studies that incorporated subtalar strapping or customized insoles reported more favorable outcomes, suggesting that the design and fit of LWI play a crucial role in their effectiveness. Additionally, the biomechanical effects of LWI, which rely on promoting foot pronation to shift load away from the medial knee compartment, may be less predictable and more dependent on individual gait patterns and foot mechanics (10).

The combination of VKB and LWI resulted in a greater reduction in KAM compared to either intervention alone, suggesting a synergistic effect. The results of two studies demonstrated that the combined use of VKB and LWI led to a

Table 1. Summary of Studies Included in the Review

author/year	study design	Sample Size	Intervention	Findings
Fantini Pagani et al. (2011)	RCT	30	VKB *vs.* LWI	VKB significantly reduced KAM (12%) compared to LWI (5%). No improvement in walking speed or stride length were seen.
Jones et al. (2013)	RCT	40	VKB *vs.* LWI	KAM reduced 10% by VKB and 6% by LWI. No significant improvement in walking speed or stride length were achieve.
Duivenvoorden et al. (2015)	Quasi-experimental	25	LWI	There was no significant reduction in KAM or enhancement in walking speed.
Fu et al. (2015)	RCT	35	VKB + LWI	KAM reduced 15 % by using the combination of VKB LWI rather using alone.
Arazpour et al. (2012)	RCT	22	VKB *vs.* LWI	VKB reduced KAM by 7%, LWI by 3%. VKB reduced ROM compared to LWI.
Khosravi et al. (2019)	RCT	21	VKB+LWI	Combined intervention reduced KAM by 30%. Improved speed and cadence too.
Khan et al. (2019)	Quasi-experimental	20	VKB+LWI	No improvement in walking parameters was reported.
Mirzaei et al. (2018)	RCT	18	VKB+LWI	Combined intervention reduced KAM but did not improve SOW, stride length, or ROM.

***VKB**: Valgus Knee Brace, **LWI**: Lateral Wedge Insole, **KAM**: Knee Adduction Moment, **RCT**: Randomized Controlled Trial, **ROM**: Range of Motion, **SOW**: Step Width (or Step-Over Width, depending on context).*

more significant reduction in KAM than either intervention used independently (9, 11). These findings highlight the benefits of a multimodal approach to the management of medial knee osteoarthritis, where combining interventions with complementary mechanisms of action may yield better outcomes. However, further research is needed to optimize the combination of VKB and LWI, including the ideal duration, sequencing, and patient selection criteria for this approach .Despite the positive effects on KAM, neither VKB nor LWI significantly improved walking speed or stride length. Two studies reported no significant improvement in walking speed with VKB (6, 12), while Duivenvoorden *et al.* (7) found no significant effect of LWI on walking speed. This may reflect the primary focus of these interventions on altering knee alignment and load distribution rather than enhancing overall gait mechanics. Walking speed and stride length are influenced by a complex interplay of factors especially individual factors, including muscle strength, joint stability, and pain, which may not be sufficiently addressed by VKB or LWI alone. Future studies should explore the integration of these interventions with other non-surgical strategies, such as physical therapy and weight management, to achieve more comprehensive improvements in gait parameters.

In terms of ROM, one study reported that VKB significantly reduced ROM compared to LWI (9). This suggests that VKB may have a more pronounced impact on joint mechanics, potentially reducing ROM in some elders. However, the clinical implications of this finding remain unclear, as ROM is just one of many factors influencing functional ability in elders with knee OA. Further research is needed to explore the long-term effects of VKB and LWI on ROM and other functional outcomes.

Discussion

The findings of this review highlight the differential effectiveness of VKB and LWI in managing gait abnormalities in elders with medial knee OA. The sustained reduction in KAM induced by VKB use is consistent with its biomechanical mechanism of action, which involves applying valgus force to unload the medial knee compartment. This redistribution of load is critical in reducing excessive stress on the medial compartment, which is a hallmark of medial knee OA. The reduction in KAM with VKB is clinically significant, as elevated KAM is strongly associated with disease progression, pain, and functional limitations in knee OA patients. The magnitude of KAM reduction (7% to 12%) observed in this review is consistent with previous studies, reinforcing the potential of VKB as a non-surgical intervention for managing the medial knee OA.

In contrast, the effectiveness of LWI in reducing KAM was less consistent. While some studies reported significant reductions in KAM by using LWI (13, 14), others found no significant effectiveness (9). This variability may be attributed to differences in study design, insole characteristics (*e.g.*, wedge angle, material, and design), and patient individuals characteristics such as foot alignment and severity of OA. For instance, studies that incorporated subtalar strapping or customized insoles reported more favorable outcomes, suggesting that the design and fit of LWI play a crucial role in their effectiveness. Additionally, the biomechanical effects of LWI, which rely on promoting foot pronation to shift load away from the medial knee compartment, may be less predictable and more dependent on individual gait patterns and foot mechanics.

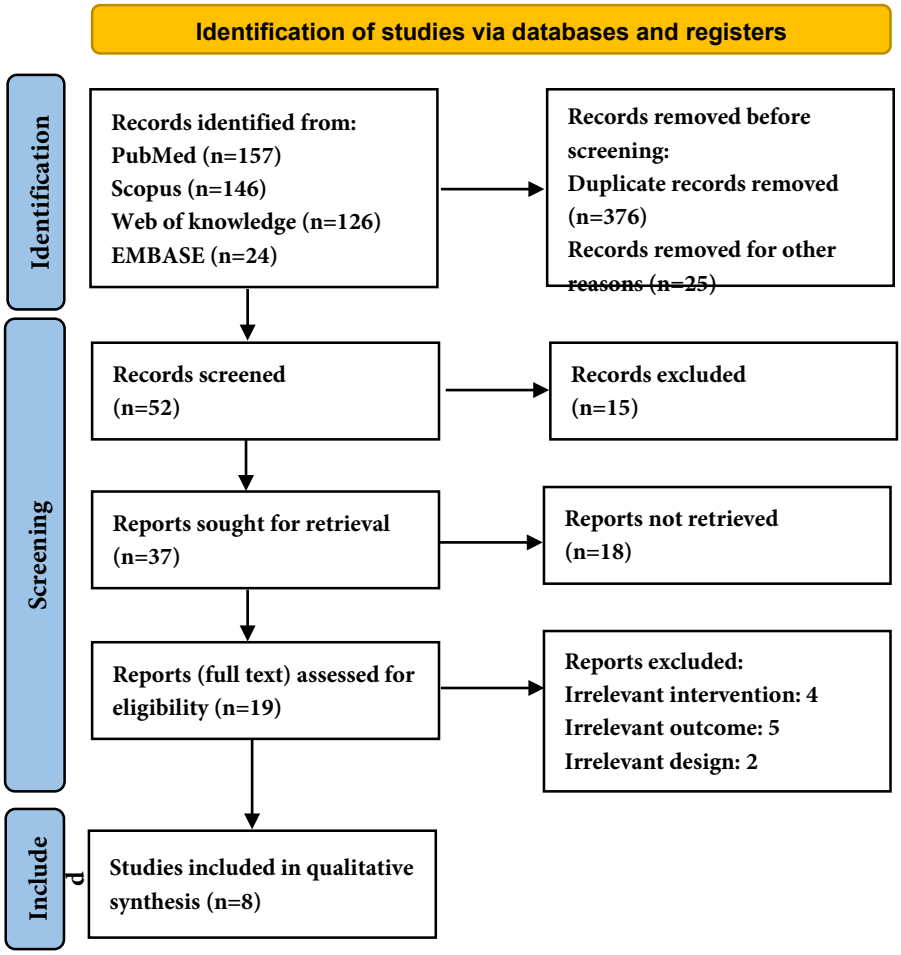

Figure 1. Flowchart of the articles selection using the PRISMA

The synergistic effect observed with the combination of VKB and LWI is particularly noteworthy (13, 14). The simultaneous use of these interventions may address multiple biomechanical factors contributing to medial knee OA, such as knee alignment and foot mechanics, leading to a greater reduction in KAM (15). This finding showed the potential benefits of a multidisciplinary approach to managing knee OA, where combining interventions with complementary mechanisms of action may yield superior outcomes compared to single interventions alone. However, further research is needed to optimize the combination of VKB and LWI, including the ideal duration, sequence, and patient selection criteria for this approach.

Despite the positive effects on KAM, neither VKB nor LWI significantly improved walking speed or stride length (12). This may reflect the primary focus of these interventions on altering knee alignment and load distribution rather than enhancing overall gait mechanics. Walking speed and stride length are influenced by a complex interplay of factors, including muscle strength, joint stability, and pain, which may not be sufficiently addressed by VKB or LWI alone. Future studies should explore the combination of these interventions with other non-surgical strategies, such as physical therapy and weight management, to achieve more comprehensive improvements in gait parameters.

The heterogeneity among the included studies, particularly in terms of study design, intervention duration, and outcome measures, limits the generalizability of the findings. For example, the follow-up duration varied widely across studies, ranging from immediate assessments to 24 weeks, which may have influenced the observed outcomes. Longer-term studies are needed to evaluate the sustained effects of VKB and LWI on gait parameters and disease progression. Additionally, the lack of standardized protocols for measuring gait parameters, such as KAM, walking speed, and stride length, may have contributed to the variability in results. Future research should adopt standardized methodologies to facilitate comparisons across studies and enhance of findings for generalizability.

Another limitation of this review is the lack of consideration for patient individual characteristics, such as age, Body Mass Index (BMI), and activity level, which may influence the effectiveness of VKB and LWI. For instance, older adults or individuals with higher BMI may experience different biomechanical responses to these interventions compared to younger patients. Similarly, the severity of knee OA, as assessed by the Kellgren-Lawrence grading system, may impact the outcomes, with more advanced disease potentially limiting the effectiveness of non-surgical interventions. Future studies should incorporate these variables into their analyses to identify subgroups of patients who are most likely to benefit from VKB, LWI, or their combination usage.

Conclusion

In conclusion, this review demonstrates that VKB are more effective than LWI in reducing KAM in elders with medial knee OA. However, the combination of VKB and LWI may offer synergistic benefits, highlighting the potential of a multimodal approach to managing gait abnormalities in this population. While these findings provide valuable insights for clinicians, further high-quality studies are needed to address the limitations of the existing evidence and optimize the use of VKB and LWI in clinical practice. Future research should focus on long-term effects, patient individual charachteristics, and the integration of these interventions with other non-surgical strategies to achieve comprehensive improvements in gait parameters and overall quality of life for elders with medial knee OA.

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Authors' contributions
MR: supervision, data curation, formal analysis, investigation, and methodology, writing, original draft. AJ: supervision, resources, and writing, original draft.

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