Optimal Footwear Improves Comfort, Reduces Pain, and Enhances Lower Limb kinematics in Knee Osteoarthritis

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Summary

This study evaluated the immediate effects of two footwear designs—conventional sandals with lateral wedge insoles (SAN), and researcher-developed slipper socks with lateral wedge insoles (SOC)—on pain perception, comfort, and lower limb kinematics in women with bilateral medial knee osteoarthritis (OA). Twenty-three women (mean age: 55.2 ± 4.5 years) walked under each condition. Results indicate that SOC provides greater comfort and lower pain compared to SAN. Joint angles and coordination variability showed favorable outcomes for SOC compared to SAN. These findings highlight the critical role of optimal footwear design in managing knee OA.

Introduction

Knee osteoarthritis (OA) is a common musculoskeletal disorder that causes chronic pain and functional limitations, especially in middle-aged and older women [1]. Characterized by progressive degeneration of articular cartilage and altered joint mechanics, knee OA significantly impairs mobility and quality of life [2]. Conservative management strategies, such as the use of lateral wedge insoles (LWIs), aim to reduce medial knee joint loading by altering lower limb biomechanics. However, LWI effectiveness depends on footwear type and stiffness [3]. This study aimed to compare the immediate effects of conventional sandals with LWIs (SAN, high stiffness) and researcher-developed slipper socks with LWIs (SOC, low stiffness) on pain, comfort, and lower limb kinematics in women with bilateral medial knee OA. We hypothesized that SOC condition would result in improved comfort, reduced pain, and reduced inter-joint coordination variability compared to SAN.

Methods

Participants (n = 23, all women; mean age: 55.2 ± 4.5 years) with bilateral medial knee OA (OA grade II: n = 13; grade III: n = 10) walked three times along a 10-meter pathway under two conditions: SAN, and SOC. Three-dimensional marker trajectories were recorded during the walking trials. Perceived pain and comfort were evaluated with the Visual Analog Scale [4], and a 10-point Likert scale [5], respectively. Participant-specific musculoskeletal models and motion capture data across individual gait cycles were used to calculate joint kinematics in OpenSim [6]. Hip-knee and knee-ankle inter-joint coordination variability was quantified using vector coding [7]. Statistical Parametric Mapping was employed for time-series analysis of joint kinematics across walking conditions. Mann-Whitney U tests were used for analysis of coordination variability, while repeated measures ANOVA were conducted to evaluate differences in pain, and comfort ($p<0.05$). All discrete data is presented as mean± standard deviation.

Results and Discussion

SOC showed superior outcomes in comfort, pain reduction, joint kinematics, and coordination variability compared to SAN. SOC improved comfort (7.6 ± 0.6 vs. 5.5 ± 0.1, $p<0.001$) and reduced pain (5.2 ± 0.5 vs. 6.1 ± 0.7, $p<0.001$) compared to SAN.

Joint kinematics and coordination variability were significantly different between conditions. Ankle plantarflexion angles were significantly reduced in the SAN compared to SOC condition during both mid-stance (-10.7º ± 4.3 vs. -5.6º ± 4.2, $p < 0.001$) and the swing phase (-19.4º ± 4.8 vs. -13.9º ± 4.8, $p < 0.001$). SOC demonstrated lower hip-knee coordination variability (7.7º ± 4.7) compared to SAN (9.9º ± 4.9, $U = 6663$, $p < 0.001$). Similarly, knee-ankle variability was lower in SOC (9.8º ± 5.2) compared to SAN (11.3º ± 5.2, $U = 5829$, $p = 0.04$) throughout the gait cycle.

Conclusions

Walking with SOC significantly improved comfort, reduced pain, and enhanced lower limb kinematics compared to SAN and Bare conditions. The reduction in inter-joint coordination variability with SOC indicates a more stable and consistent gait pattern, reflecting improved neuromuscular control. While increased variability is often associated with instability and compensatory strategies, decreased variability suggests more efficient and stable movement [8]. These findings highlight the critical role of optimal footwear design in managing knee OA and reinforce the importance of selecting appropriate footwear for pain relief and lower limb kinematic improvement.

References

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