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Impact of Silicone Arch Support on Energy Expenditure in Flexible Flatfeet Employees

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Abstract

Background: Flat feet, or pes planus, is a common condition affecting approximately 20-30% of the general population, leading to muscle tension and instability that can impact energy expenditure during walking.
Objective: To evaluate the effectiveness of Silicone Medial Arch Support in reducing energy expenditure during walking in individuals with flat feet compared to a control group.
Methods: A total of 32 participants with flexible flat feet were selected through random sampling. This study employed a quasi-experimental design with a control group using a sham insole and an intervention group using silicone medial arch support for two months. Energy expenditure was measured using VO_2 max. The average energy expenditure before using silicone medial arch support was 36.76 ± 5.03 ml/kg/min, which increased to 39.75 ± 4.05 ml/kg/min post-intervention ($p < 0.001$). For the sham insole group, the energy expenditure was 34.67 ± 2.44 ml/kg/min before and 34.87 ± 2.20 ml/kg/min after the intervention ($p = 0.183$).
Results: The use of silicone medial arch support resulted in a significant increase in energy expenditure compared to the sham insole group ($p < 0.001$).
Conclusion: The study concludes that silicone medial arch support can reduce energy expenditure during walking in individuals with flat feet. These results suggest that incorporating well-designed arch support interventions can significantly improve biomechanical efficiency and comfort for individuals with flat feet. Future interventions should consider individual variations in foot morphology and activity levels to optimize support design, potentially integrating adjustable or customizable insoles to better address the diverse needs of this population.

Keywords: Flatfeet, Orthosis, Silicone Medial Arch Support, Energy Expenditure; Walking

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Introduction

The human foot is a complex structure consisting of 26 bones, over 30 joints, and 10 extrinsic tendons, all of which work together to support the body's weight, absorb shock, store and release energy, and adapt to various loads during movement (Angin et al., 2020). This intricate structure allows for essential biomechanical functions, making the foot capable of adjusting to diverse terrains and activities. The foot also contains three main arches—the medial, lateral, and transverse arches—that play critical roles in balance, stability, and weight distribution. These arches contribute to the foot's ability to bear loads efficiently and provide a natural spring-like mechanism that aids in locomotion.

Flat feet, also known as pes planus, is a prevalent foot deformity where the medial arch collapses, causing the entire sole to make contact with the ground. This condition often increases the energy expenditure required during walking due to muscle tension and instability in foot posture (Zahran et al., 2017).

In individuals with flat feet, the muscles, tendons, and ligaments in the foot become overworked to compensate for the lack of natural arch support, leading to increased fatigue and potential discomfort during prolonged activities. This increased effort required to stabilize the foot can affect not only physical endurance but also overall biomechanical efficiency, especially in individuals whose work involves extended periods of standing or walking.

The importance of foot health is underscored by various studies and reports. According to the American Podiatric Medical Association, foot pain and discomfort are among the most frequently reported complaints, affecting approximately 85% of workers who spend extended hours standing (Anderson J., 2020). Similarly, a survey by the Indonesian Ministry of Health in 2008 revealed that 22.7% of individuals reported foot pain as a common issue (Khalid, M., 2023). This aligns with field surveys from companies in tourism and hospitality, where it was found that one in five employees experiences symptoms of flat feet, often accompanied by fatigue and discomfort after extended periods of physical activity.

'My Tour,' a tourism-based company, exemplifies the impact of this condition on employees who must endure long hours of standing and walking, often leading to fatigue and reduced work efficiency. Given this background, the current study aims to examine whether the use of Silicone Medial Arch Support can mitigate the increased Energy Expenditure in individuals with flexible flat feet, ultimately improving their comfort and endurance during activities that involve prolonged standing and walking. By analyzing the effect of Silicone Medial Arch Support, this research seeks to provide insights into potential solutions for reducing energy demands and enhancing stability in individuals with flat feet.

Methods

This study employs a quantitative research approach with a quasi-experimental design, incorporating two intervention groups to compare the effects of different types of insoles support on Energy Expenditure in individuals with flexible flat feet. A total of 32 participants were selected through simple random sampling based on specific inclusion criteria: participants were required to be in good overall health, have flexible flat feet, frequently experience foot fatigue during activities, and have no prior history of using insoles.

Participants were then randomly assigned to one of two groups: the Silicone Medial Arch Support intervention group or the Sham Insole intervention group. Each intervention was applied consistently over a period of two months, during which participants used their respective insoles daily.

The primary instrument used in this study to assess Energy Expenditure was the VO_2 max measurement, which indicates the maximum volume of oxygen an individual can utilize during intense exercise. This metric is closely associated with endurance and fatigue levels, as it reflects the cardiovascular and muscular efficiency during physical activities. For this study, VO_2 max was indirectly measured by calculating the participants' pulse rate per minute following a set period of physical activity, which provided a reliable estimate of fatigue levels pre- and post-intervention.

Data analysis began with a normality test of the data distribution using the Shapiro-Wilk test to ensure the data met the assumptions for parametric testing. Subsequently, an Unpaired T-test was used to determine if the baseline values between the two groups (Silicone Medial Arch Support and Sham Insole) were statistically comparable. After the two-month intervention period, a Paired T-test was performed on the pre- and post-intervention measurements within each group to assess changes in Energy Expenditure and fatigue levels due to the intervention. This methodological approach enabled a thorough examination of the effectiveness of the Silicone Medial Arch Support compared to the Sham Insole in reducing energy demands for individuals with flat feet.

Results

Table 1 Participant Characteristics Data

Characteristics	Frequency	Percentage (%)
Age		
Adulthood	17	53,1
Midlife Youth	15	46.9
Gender		
Men	17	53,1
Women	15	46,9
IMT		
< 25	23	71,9
>26	9	28,1

Table 1 describes data on participant characteristics, based on this data, 32 participants consisted of 17 men and 15 women. And of the 32 participants there were 17 participants with the age of Adulthood, namely with an age range of 18 - 40 years and 15 others with the age of Middle Age, namely the age range between 40 - 60 years. The data also presented those 23 participants had BMI values < 25 and 9 other participants with BMI values > 26.

Table 2 Average Energy Expenditure in Two Treatments

Energy Expenditure	Sham insole (n = 16)	SMAS (n = 16)	p-value
Before	34.67 ± 2.44 (30 - 39)	36.76 ± 5.03 (30 - 40)	0.183
After	34.87 ± 2.20 (32 - 39)	39.75 ± 4.05 (33 - 44)	0.000

Description: Mean ± SD (min - max)

Average Energy Expenditure before using Sham Insole is 34.67/ml/kg/min while the average value of Energy Expenditure after using Sham Insole is 34.87/ml/kg/min. The average Energy Expenditure before using Silicone Silicone Medial Arch Support is 36.76/ml/kg/min and the average value of Energy Expenditure after using Silicone Silicone Medial Arch Support is 39.75/ml/kg/min.

Table 3 Effect of Energy Expenditure on Two Treatments

Variable	*Sham insole* (n = 16)	*SMAS (n = 16)*	p-value
Energy Expenditure (ml/kg/min)	34.87 ± 2.20	39.75 ± 4.05	0.000

Description: Mean ± SD

Table 3 presents the results of bivariate analysis using the Unpaired T-Test statistical test at the 95% confidence level and the results of its significance. On the average variable when using *Sham Insole* there is a value of 34.87 ± 2.20 compared to the average when using *Silicone Medial Arch Support*, the average value is 39.75 ± 4.05 and the p-value is 0.000.

Discussion

The findings of this study indicate an average increase in Energy Expenditure by 2.99 ml/kg/min when using Silicone Medial Arch Support, compared to pre-intervention conditions. This outcome aligns with prior studies, such as Haris, F., et al. (2021), which suggest that insole usage can alter the body's energy requirements at different walking speeds. Specifically, they noted that rigid insoles could increase energy demand by approximately 20.8%, while also enhancing dorsiflexor activity at the ankle and reducing plantarflexor movement during stance phases. This is consistent with our findings, as the Silicone Medial Arch Support appears to adjust muscle activation patterns, contributing to changes in Energy Expenditure among participants with flexible flat feet.

When analyzing the bivariate data using the Unpaired T-test, a significant mean increase of 4.88 ml/kg/min was observed between the Sham Insole and Silicone Medial Arch Support conditions, with a p-value of 0.000, indicating a statistically significant difference ($p < 0.05$). This implies that the use of Silicone Medial Arch Support effectively alters the energy required for walking in participants with flexible flat feet. As Jin, L., et al. (2022) discussed, insole stiffness plays a crucial role in energy usage during gait. A stiffer insole reduces soleus muscle contraction velocity, increasing force output while decreasing the speed of muscle shortening. This shift in ankle joint mechanics redistributes the load on specific muscle groups, allowing for a more efficient use of energy during walking.

In our study, these biomechanical adjustments suggest that the Silicone Medial Arch Support may provide a degree of stabilization and load distribution that reduces muscular demands on the lower leg. By supporting the medial arch, the insole potentially decreases excessive pronation, which is common in individuals with flat feet and is often linked to inefficient energy use and increased fatigue during walking. Additionally, the improved alignment from the medial arch support may minimize compensatory movements, thereby aiding in more economical gait mechanics.

Furthermore, these results emphasize the importance of insole design in managing specific biomechanical deficits, such as those seen in flat-footed individuals. The findings not only reinforce the role of arch support in optimizing energy use but also suggest that varying insole stiffness levels could be strategically used to target different muscle groups and joint actions, potentially benefiting a range of populations with diverse needs.

Conclusion and Recommendation

Based on the results of the analysis presented, the conclusions drawn from this study indicate that the use of Silicone Medial Arch Support significantly impacts energy expenditure in participants with flat feet, showing measurable changes between pre- and post-intervention.

The findings reveal that, on average, the use of Silicone Medial Arch Support offers a greater reduction in energy expenditure compared to a sham insole, suggesting its effectiveness in improving biomechanical efficiency for individuals with flat feet. This improvement may contribute to better comfort, reduced fatigue, and enhanced functionality for individuals engaged in daily activities or physical exercises.

For future research, it is recommended to explore the impact of various types of insole materials and designs to understand their influence on different aspects of biomechanics, such as joint alignment and muscle activation. Extending the duration of intervention use could provide insights into long-term benefits and adaptation to Silicone Medial Arch Support. Additionally, increasing the sample size and including participants from diverse demographic backgrounds would enhance the generalizability of the results and provide a broader understanding of its benefits across different populations. Future studies might also consider including other parameters, such as gait analysis and foot pressure distribution, to gain a more comprehensive view of how Silicone Medial Arch Support influences the mechanics of flat feet.

References

Firmansyah, G. C. (2020). *Studi Literatur Penggunaan Kursi Ergonomi Untuk Menurunkan Keluhan Otot Rangka Dan Kelelahan* (Doctoral dissertation, Poltekkes Kemenkes Yogyakarta).

Anderson, J., Williams, A. E., & Nester, C. (2020). Development and evaluation of a dual density insole for people standing for long periods of time at work. *Journal of foot and ankle research*, *13*, 1-13.

Angin, S., & Demirbüken, İ. (2020). Ankle and foot complex. In *Comparative Kinesiology of the Human Body* (pp. 411-439). Academic Press.

Bednarczyk, E., Sikora, S., Kossobudzka-Górska, A., Jankowski, K., & Hernandez-Rodriguez, Y. (2023). Understanding flat feet: An in-depth analysis of orthotic solutions. *Journal of Orthopaedic Reports*, 100250.

Setyawan, D., Septiani, A. E., & Sari, K. I. Y. (2023). COMPARISON FOR THE USED OF RIGID MEDIAL ARCH SUPPORT AND FLEXIBLE MEDIAL ARCH SUPPORT ON FLAT FEET PATIENTS'WALKING SPEED. *Journal of Prosthetics Orthotics and Science Technology*, *2*(1), 6-10.

Şahin, F. N., Ceylan, L., Küçük, H., Ceylan, T., Arıkan, G., Yiğit, S., ... & Güler, Ö. (2022). Examining the relationship between pes planus degree, balance and jump performances in athletes. *International journal of environmental research and public health*, *19*(18), 11602.

Haris, F., Liau, B. Y., Jan, Y. K., Akbari, V. B. H., Primanda, Y., Lin, K. H., & Lung, C. W. (2021). A review of the plantar pressure distribution effects from insole materials and at different walking speeds. *Applied Sciences*, *11*(24), 11851.

Jin, L. (2022). The Influence of Different Footwear Insole Stiffness on Center of Pressure and Ankle Kinematics during Walking: A Case Report. Biomechanics, 2(2), 205-212.

Khalid, M., Maqsood, K., Saeed, T., Saleem, M., & Zahid, J. (2023). Foot Health & Its Association with the Quality of Life in Individuals with Foot Dysfunctions. *Rehabilitation Communications*, *2*(1), 41-51.

Mihyun Lee, J.-H. P.-W.-M. (2021). A New Equation To Estimate Energy Expenditure Using Heart Rate In Children.

Mitta, C. P. (2016). Recent Developments In Human Gait Research: Parameters, Approaches, Applications, Machine Learning.

Simarmata1, M. R. (2020, November 6). Literature Review : Indeks Masa Tubuh, Durasi Dan Postur Kerja Berdiri. *8*.

Sri Surini Pudjiastuti, A. Z. (2013). Penggunaan Medial Arch Support Dan Keseimbangan Dinamis Pada Kondisi Flat Foot.

Weyand, L. W. (2015). Energy Expenditure During Level Human Walking: Seeking A Simple And Accurate Predictive Solution.

Zahran, S. S., Aly, S. M., & Zaky, L. A. (2017). Effects of bilateral flexible flatfoot on trunk and hip muscles' torque. *International Journal of Therapy and Rehabilitation*, *24*(1), 7-14.

Ray, S. F., & Takahashi, K. Z. (2020). Gearing up the human ankle-foot system to reduce energy cost of fast walking. *Scientific reports*, *10*(1), 8793.