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Enhancing Footwear Comfort: Preliminary Study On Material, Design, And GAIT Analysis

Akshaya Raman M[1*], Loganathan T[1], K.Elayaraja[2] , Anila Sasi[3], M.Vishva Kumar[4]

[1*]CSIR – Central Leather Research Institute, Chennai, TamilNadu, India
[1,2,3,4] FDDI- Footwear Design and Development Institute,Hyderabad, India

ABSTRACT
The emphasis on fashion over comfort in women's footwear has frequently diminished the significance of designing comfortable footwear, highlighting the need for deliberate material choices. This research aims to recognize appropriate materials, detailed design aspects, and confirm gait analysis to attain enduring comfort. There is still limited exploration into the interaction between material, sandal design, and gait patterns despite the dominance of comfort in sportswear. Consumers looking for formal footwear and women's sandals emphasize refined comfort by focusing on footbeds that provide arch support and cushioning. To ensure longevity, proper cushioning footbeds are necessary along with designs that mimic natural foot contours. Additionally, leather lining significantly improves comfort as seen in specialized sandals designed to address foot distress while providing essential arch support.
Comfortable footwear has advanced in materials to align with foot movements and minimize discomfort. However, there is a lack of research on the intricate connection between materials, design, and walking patterns. Walking analysis corresponds with individual foot shapes through treadmill analysis that captures specific parameters and plantar pressure. This study has the potential to completely change how the industry approaches women's sandals, focusing on comfort while still maintaining elegance. The aim is to transform women's sandals by combining comfort with elegance, emphasizing material intricacies, careful design, and gait validation. It aims to redefine footwear by offering a mix of comfort and style that revolutionizes the industry across different preferences and occasions.

KEYWORDS :- Comfortable footwear, Gait analysis,Sandal design

INTRODUCTION

In the quest for women's footwear, comfort has often taken a backseat to style. However, it is crucial to prioritize comfort in the pursuit of comfortable footwear. This preliminary study focuses on material identification, design intricacies, ananalysis validation to enhance footwear comfort.
The study aims to explore the interplay between materials, sandal design, and gait patterns, which has been underexplored in the field.
Introducing comfortable footwear is not only important for aesthetic and fashion purposes but it also plays a crucial role in maintaining foot health and preventing injury. Moreover, there is an increasing amount of evidence underscoring the influence of footwear on functional capabilities, especially about athletic performance and walking tendencies [1]. It is essential to delve deeper into the various aspects of footwear design and material selection to understand their implications on comfort, gait patterns, and overall foot health. This study aims to bridge the gap between material science, footwear design, and the biomechanics of gait to pave the way for the development of more comfortable and functionally beneficial footwear.

ROLE OF MATERIAL SELECTION IN ENHANCING FOOTWEAR COMFORT

The choice of materials used in footwear plays a significant role in enhancing overall comfort. Materials that provide adequate cushioning, support, and breathability are crucial in creating comfortable footwear [2]. By carefully selecting materials with superior shock attenuation and functional stability, designers can ensure that the footwear meets the demands of high-impact activities while still providing the necessary comfort and support [3]. Also, materials that allow for moisture management and temperature regulation can further enhance comfort by keeping the foot dry and cool [4].
Comfort is a crucial element in designing footwear, particularly for those who spend long hours on their feet [5]. Developing materials that prioritize comfort and functionality is essential for creating functional shoes that meet the daily needs of consumers [6]. Material selection plays a critical role in addressing changes in foot volume, perspiration, and overall comfort within the footwear [7]. The use of innovative materials holds great promise for enhancing the ease and satisfaction of wearers, marking an important advancement in achieving enhanced footwear comfort.
As designers delve deeper into the role of material selection in enhancing footwear comfort, it becomes evident that the intricate interplay between materials, design considerations, and GAIT patterns is essential. This holistic approach ensures that footwear not only looks aesthetically pleasing but also fulfils its intended purpose while providing lasting comfort and support.

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ROLE OF DESIGN PARAMETER IN FOOTWEAR COMFORT

The design parameters of footwear play a significant role in determining overall comfort. Factors such as the shape and structure of the shoe, the positioning of straps and closures, and the overall fit of the footwear can greatly affect comfort levels [8]. Comfort is vital for footwear performance and injury prevention. The assessment of comfort is a crucial part of the design process to ensure usability and functionality, impacting foot health and preventing injuries. By considering the natural contours of the foot and incorporating features such as contoured footbeds, arch support, and cushioning, designers can create footwear that conforms to the natural shape of the foot and provides optimal comfort. The design of the footwear should also consider factors such as breathability, flexibility, and lightweight materials to enhance comfort during movement [9].

Comfort and human factors should be foremost when designing prescribed footwear to accommodate individual variations in gait patterns. Accurate comfort assessment methods and user feedback during the design process are crucial for optimal usability. Footwear comfort has extensive implications for injury prevention and overall foot health, making it imperative to understand how design parameters and material selections impact comfort for advancing footwear technology [10]. It is important to note that comfort is not solely determined by material and design choices. Other factors, such as the fit of the footwear and its ability to accommodate individual variations in foot size and shape, also contribute significantly to overall comfort [11]. The development of new materials is an essential aspect of manufacturing functional shoes that prioritize comfort.

By utilizing materials that offer cushioning, shock absorption, and breathability, footwear designers can enhance comfort levels [12]. The focus on comfort in footwear design may compromise support and stability. Overly cushioned shoes can lead to instability and increased injury risk during high-impact movements, despite the emphasis on customized fit for comfort [13]. Designers must balance comfort with support to ensure optimal foot health and biomechanical efficiency. Therefore, designers must consider multiple factors such as material selection, design intricacies, and individual variations in gait patterns to create footwear that prioritizes comfort, functionality, and overall foot health [14].

Design parameters are an essential factor in footwear comfort and functionality. They influence the fit, support, and stability of the footwear. Designers can use gait analysis data to create customized footwear that addresses individual needs and promotes foot health. By integrating gait analysis with material selection and design parameters, they can develop footwear that prioritizes comfort and enhances biomechanical performance, reducing the risk of injuries [15]. The association between gait patterns and footwear comfort provides valuable information about the specific requirements of different activities. By understanding these patterns, designers can create footwear that optimally supports natural foot movements, reduces muscle strain, and promotes overall comfort during physical activities [16].

By integrating gait analysis with material selection and design parameters is pivotal in enhancing footwear comfort. This comprehensive approach ensures that both comfort and functional capabilities are addressed in the pursuit of creating footwear conducive to foot health.

THE VITALITY OF GAIT ANALYSIS IN ENHANCING FOOTWEAR COMFORT

The vitality of gait analysis in enhancing footwear comfort cannot be overstated. By analyzing the intricate details of an individual's gait patterns, designers gain crucial insights into the specific requirements of different activities [17]. This knowledge is instrumental in creating footwear that not only supports natural foot movements but also reduces muscle strain and promotes overall comfort during physical activities [18].

By integrating gait analysis with material selection and design parameters is pivotal in enhancing footwear comfort. This comprehensive approach ensures that both comfort and functional capabilities are addressed in the pursuit of creating footwear conducive to foot health. With the complexity of what makes a shoe comfortable still not fully understood, the use of gait analysis becomes even more important. By accurately identifying and analyzing an individual's gait patterns, designers can tailor footwear to meet their specific needs and preferences [19].

In addition to material and design considerations, a deeper comprehension of gait patterns is crucial in improving footwear comfort. Gait analysis entails the methodical examination of human motion, particularly how people walk or run. This includes evaluating stride length, foot strike patterns, and overall biomechanical motions during movement [20]. By incorporating gait analysis into the design process, footwear engineers can customize the characteristics of the shoes to suit individual gait patterns, thus boosting both comfort and performance.

The relationship between footwear comfort and walking patterns is crucial, particularly in sports shoes. Uncomfortable footwear can notably change a person's walking pattern, affecting lower body muscle activity during running and potentially raising the risk of injury [21]. Thus, incorporating gait analysis data into the design process can result in specialized footwear customized to individual biomechanics, enhancing comfort and reducing the likelihood of injury.

In the design of comfortable footwear, various factors such as material selection, thoughtful design elements, and integration of gait analysis data need to be considered. It is crucial to understand how these components interact to produce footwear that meets aesthetic and functional needs while also maximizing comfort and performance. By considering the diversity in foot characteristics across race, gender, environment, and lifestyle, it becomes evident that a one-size-fits-all approach to footwear is insufficient [22]. Footwear should be personalized to fit each individual's unique gait patterns and biomechanics, providing the necessary support and cushioning to enhance comfort and prevent injury [23]. Therefore,

designers must utilize gait analysis as a valuable tool in the research and development of footwear that promotes foot health, ensures optimal performance, and maintains lasting comfort.

RESEARCH AND METHODOLOGY

Our research is rooted in the ongoing pursuit of comfortable footwear, particularly in women's sandals, where the intersection of style and comfort remains a challenge. This area is crucial, given the limited options that seamlessly integrate both elements. Recognizing this, our study aims to unravel complexities surrounding footwear comfort for women's sandals.

There is a noticeable gap in understanding the interplay between material composition, design intricacies and gait analysis specific to women's sandals. This gap prompts our comprehensive investigation to unify these elements and enhance comfort.

Our research's significance extends beyond fashion, impacting the footwear industry and consumer health. By addressing knowledge gaps, our findings could redefine industry standards, empowering manufacturers to craft not just stylish but supremely comfortable women's sandals. Moreover, improved comfort directly influences foot health, potentially alleviating discomfort, pain, and long-term musculoskeletal issues.

In a broader context, our work aligns with industry trends, emphasizing sustainability and consumer-centric practices. By promoting comfortable and well-designed women's sandals, we contribute to a shift toward more thoughtful and health-conscious choices in the fashion landscape.

In essence, our research strives to fill existing knowledge voids, offering a holistic understanding of women's sandal comfort. Its potential impact spans from industry innovation to individual well-being, echoing the evolving trends towards sustainability and health-centric decisions in footwear design.

LITERATURE SUMMARY

The research study delves into the intricate realm of enhancing footwear comfort through a comprehensive exploration of materials, design principles, and the pivotal role of gait analysis in validating footwear efficacy. It traverses through a rich landscape of studies, elucidating the evolution of materials and their impact on comfort, highlighting the synergy between material composition and foot movement [24].

Emphasizing the significance of design intricacies, the summary navigates various design concepts aimed at maximizing comfort without compromising style, particularly in the context of women's sandals and formal footwear. It scrutinizes footbeds, insoles, and innovative designs tailored to mimic natural foot contours, crucial for sustaining enduring comfort [25].

Central to this narrative is the integration of gait analysis as a cornerstone in validating the effectiveness of footwear products. The literature discerns the role of gait patterns in tailoring footwear to individual foot forms, underscoring the necessity of empirical validation through instrumented treadmill analysis. It underscores how gait analysis captures spatial-temporal parameters and plantar pressure in static and dynamic modes, offering an empirical lens to assess the comfort and functionality of footwear designs [26].

This study weaves together the essential threads of material science, design ingenuity, and the indispensable validation via gait analysis, illuminating the path toward revolutionizing footwear comfort, emphasizing its paramount importance in the environment.

SUMMARY OF QUESTIONNAIRE SURVEY

The survey aimed to gather insights on comfort parameters and the requirement for gait analysis technique in developing footwear with enhanced comfort through proper material selection and design parameters.

The survey was conducted using Google Forms and targeted individuals with diverse footwear preferences and experiences. The sample size included a range of demographic profiles to ensure comprehensive data collection.

This preliminary study delves into the pressing issue of footwear comfort by examining the preferences and attitudes of women towards materials, design and gait analysis. Through the "Stepping into Comfort: A Footwear Preference and Gait Analysis Survey," a substantial number of participants contributed valuable insights, revealing a prevalent experience of discomfort or pain while wearing footwear. These findings underscore the urgent need for improved comfort in footwear design, highlighting the critical importance of prioritizing comfort as a primary consideration in the industry. Moreover, the majority of respondents emphasized the high importance of comfort when selecting footwear, indicating a strong demand for comfortable options that seamlessly blend style and functionality.

This survey revealed a growing awareness among respondents of the impact of materials and design on footwear comfort, with specific preferences for certain materials noted. Interestingly, there was considerable interest in footwear marketed as having gait analysis-verified comfort, suggesting consumer receptiveness to technologically-validated comfort claims. The preference for customized footwear tailored to individual foot shapes and gait patterns further emphasizes the need for personalized comfort solutions to meet diverse consumer demands. These findings not only shed light on the current challenges faced by consumers in finding comfortable footwear but also point towards potential avenues for innovation

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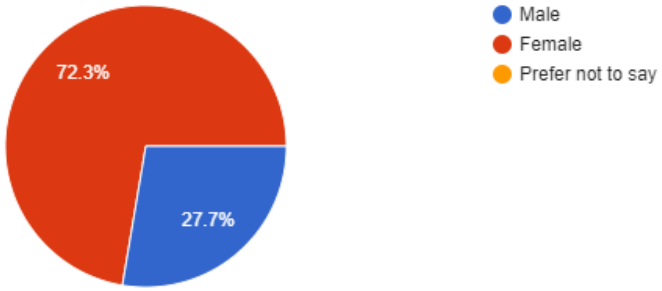
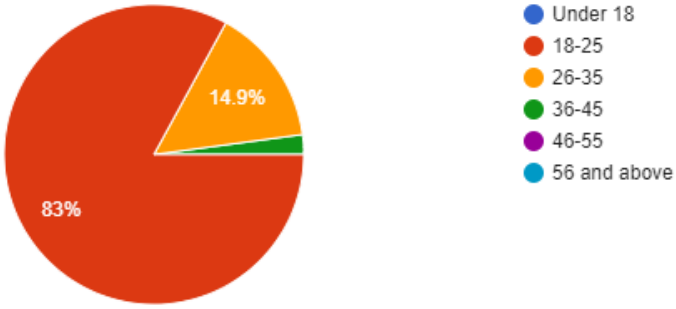
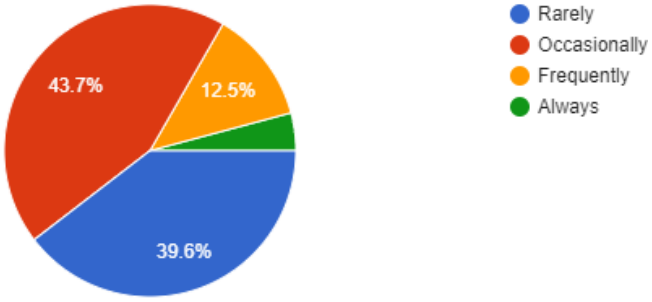
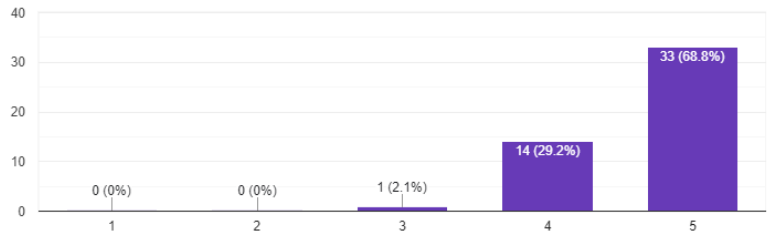
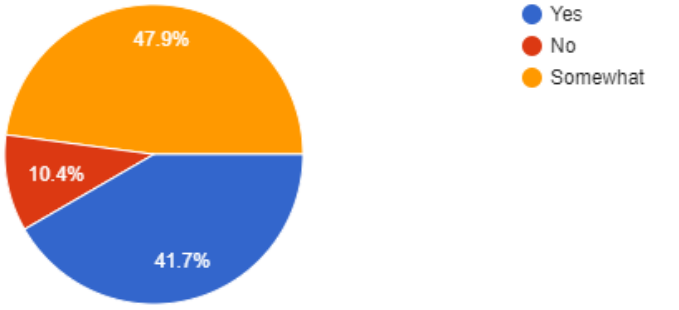
and improvement in the footwear industry, with the integration of advanced validation methods such as gait analysis offering promising prospects for enhancing comfort and meeting consumer expectations.

S No.	Survey Questions	Survey Responses
1	Gender	
2	Age Group	
3	How often do you experience discomfort or pain while wearing footwear?	
4	How important is comfort when choosing footwear?	
5	Are you aware of the impact of materials and design on footwear comfort?	

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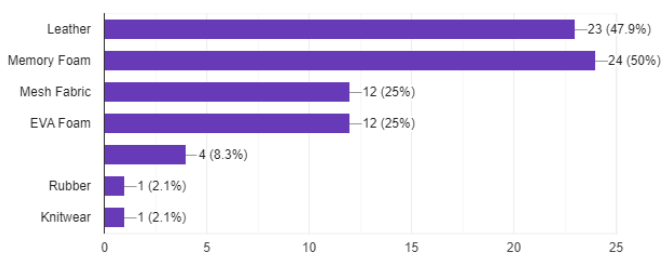
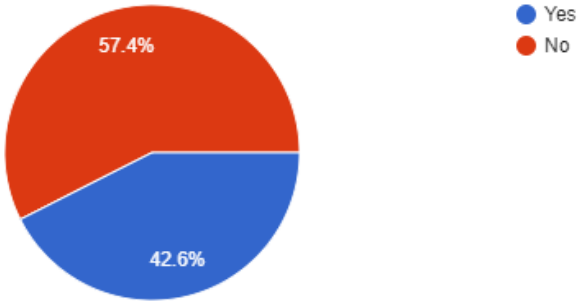
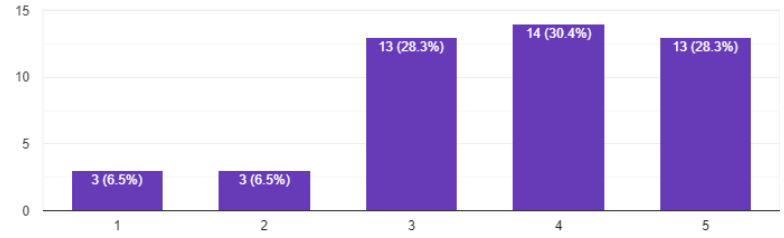
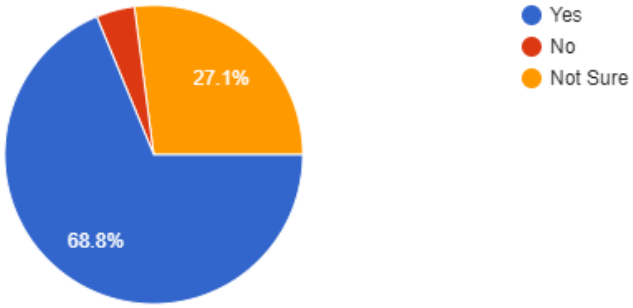
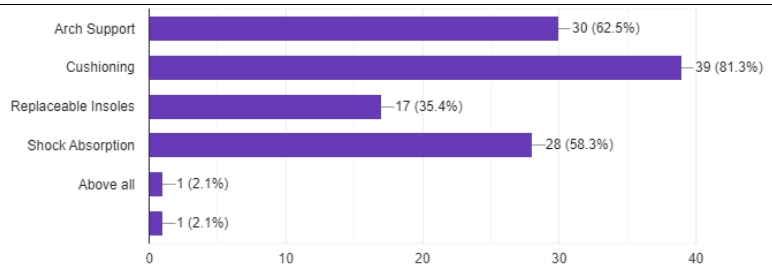
6	What materials do you find most comfortable in footwear?	
7	Have you ever heard of Gait Analysis in the context of footwear comfort?	
8	How likely are you to consider purchasing footwear if it is marketed as having gait analysis-verified comfort?	
9	Would you prefer footwear specifically designed for different foot shapes and gait patterns?	
10	What features do you believe are crucial for comfortable footwear?	

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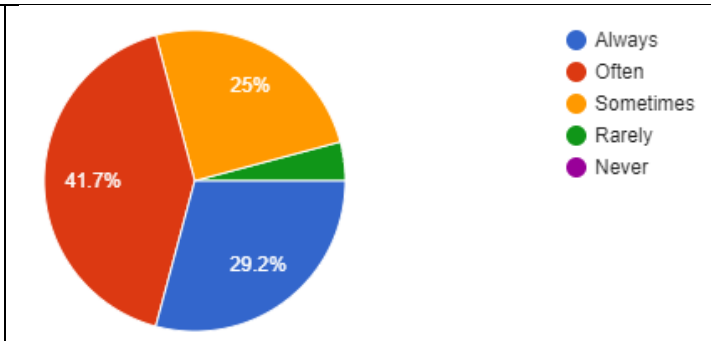
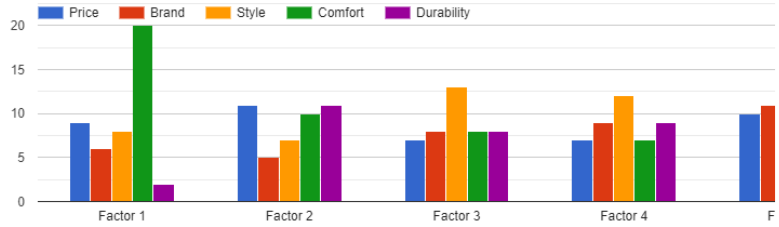
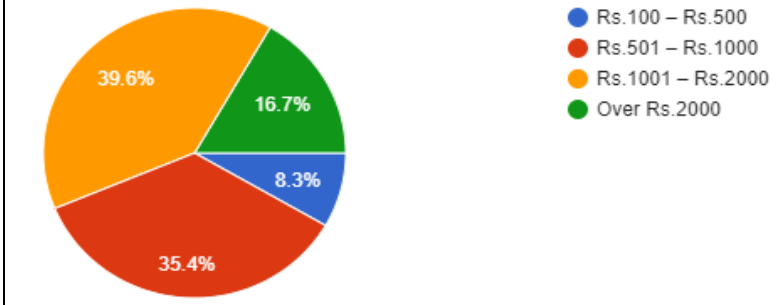
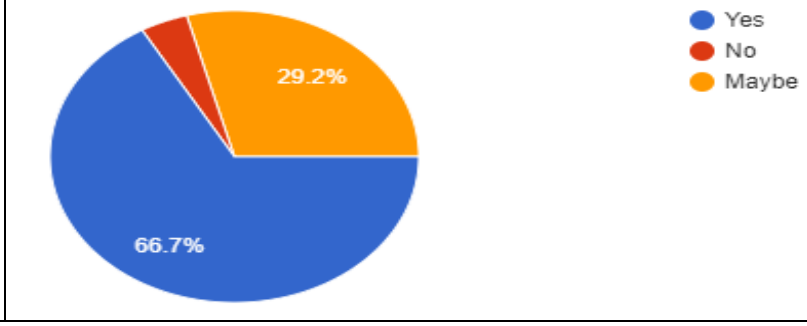
11	How likely are you to prioritize comfort over style when purchasing footwear?	
12	What factors influence your footwear purchase decisions the most?	
13	How much would you be willing to pay for footwear marketed as offering superior comfort through advanced materials and design?	
14	Would you be interested in participating in a study involving testing footwear comfort through gait analysis?	

Table 1: Questionnaire Survey to the People of India

REAL-TIME GAIT ANALYSIS: OBSERVATION AND OUTCOMES

Subject Information for the GAIT Study

In conducting gait analysis, it is essential to carefully select subjects who meet specific criteria to ensure accurate and reliable results. For this study, the selection process focused on identifying four female subjects who met the following criteria:

- No abnormal foot conditions
- No current use of medications that could affect gait
- No recent wounds or injuries

that could impact their walking patterns. These criteria were crucial to ensure that the gait analysis results were not confounded by any underlying foot issues, medication effects, or acute injuries. By selecting only female subjects, the study aimed to provide a more focused understanding of gait patterns in this demographic, taking into account potential gender-specific differences in walking biomechanics. The decision to limit the sample size to four subjects was made to allow for a detailed and in-depth analysis of each individual's gait, both barefoot and while wearing their own footwear.

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The rationale behind selecting only four subjects for gait analysis was driven by the need for a more nuanced understanding of how gait patterns may differ between individuals, particularly in relation to their choice of footwear. By focusing on a small sample size, the study aimed to thoroughly examine the gait characteristics of each subject, taking into account their unique biomechanical factors and potential variations in walking patterns. This approach allowed for a detailed analysis of the impact of both barefoot walking and the use of personal footwear on gait, providing valuable insights into how different individuals may adapt their walking patterns based on their choice of shoes. Furthermore, by specifically selecting female subjects, the study sought to address potential gender-specific considerations in gait analysis, acknowledging the importance of understanding how factors such as body composition and biomechanics may influence walking patterns in women. The careful selection of four female subjects for gait analysis aimed to provide a comprehensive exploration of gait dynamics, taking into account individual variations and potential gender-specific differences in walking biomechanics.

Subject Information for the GAIT Study				
Subject ID	DOB	Body weight	Height	BMI
SID1	23.11.1975	80kg	170cm	27.68
SID2	07.10.1990	83kg	180cm	25.62
SID3	11.12.1986	73kg	155cm	30.39
SID4	30.06.1995	70kg	168cm	24.80

Table No 2:The GAIT analysis's subject details

Gait Analysis with G sensor

	Barefoot		**Own Footwear**	
	Left	Right	Left	Right
Stride length (m)	1.29±0.07	1.29±0.02	1.40±0.01	1.42±0.11
Stance phase (%)	63.33±1.52	60.32±1.76	59.91±1.31	62.62±3.06
Swing phase (%)	36.67±1.52	39.68±1.76	40.09±1.31	37.38±3.06
First double support phase (%)	12.01±2.06	12.51±0.97	8.66±0.43	13.56±4.58
Single support phase (%)	38.71±1.40	36.53±2.95	38.34±4.25	40.13±4.53
Cadence	118.25±8.55		119.76±13.82	
Speed (m/s)	1.27±0.01		13.9±0.02	
Gait Cycle	Symmetry Index:97.6		Symmetry Index: 91.7	

Spatial -Temporal Parameters

	Barefoot		**Own Footwear**	
	Left	Right	Left	Right
Stride length	1.77±0.07	1.72±0.06	2.03±0.21	2.00±0.55
Step length	48.75±3.76	51.25±1.67	54.0±5.21	46.0±2.99
Stance phase	60.02±2.46	58.76±1.24	62.40±1.24	65.27±0.18
Swing phase	39.98±2.46	41.24±1.24	37.60±1.24	34.73±0.18
First double support phase	10.72±1.07	9.15±0.58	11.89±3.81	15.75±0.29
Single support phase (%)	40.95±2.09	38.55±0.50	34.89±3.49	38.34±4.38
Cadence	108.72±6.81		112.65±12.98	
Speed (m/s)	1.58±0.02		1.85±0.01	
Gait Cycle	Symmetry Index: 93.9		Symmetry Index: 87.4	

KEY FINDINGS ON THE RESEARCH WORK

Discomfort and Pain: A significant percentage of respondents reported experiencing discomfort or pain while wearing footwear, highlighting the need for improved comfort in footwear design.

Importance of Comfort: The majority of respondents emphasized the high importance of comfort when choosing footwear, indicating a strong demand for comfortable footwear options.

Awareness of Material Impact: A notable proportion of respondents expressed awareness of the impact of materials and design on footwear comfort, demonstrating a growing understanding of footwear technology.

Preferred Materials: Responses revealed specific materials that are favored for their comfort properties, providing valuable insights for material selection in footwear design.

Gait Analysis Marketing: A considerable number of respondents expressed willingness to consider purchasing footwear if marketed as having gaot analysis-verified comfort, indicating consumer interest in technologically-validated comfort claims.
Customized Footwear: A significant portion of respondents indicated a preference for footwear specifically designed for different foot shapes and gait patterns, emphasizing the need for personalized comfort solutions.
Comfort over Style: A majority of respondents expressed willingness to prioritize comfort over style when purchasing footwear, highlighting the significance of comfort as a primary consideration.
Validation through Gait Analysis: The survey findings underscore the critical role of gait analysis in validating and optimizing the footwear design process. By leveraging gait analysis techniques, footwear designers can tailor designs to individual gait patterns and foot shapes, thereby enhancing overall comfort and performance.
The survey results provide compelling evidence for the integration of gait analysis into the footwear development process, aligning with the growing demand for scientifically-validated comfort solutions.

CONCLUSION

This research lays on enhancing footwear comfort for women's sandals has laid the groundwork for further research and development in this critical area. The integration of material science, design ingenuity, and gait analysis has been identified as pivotal in revolutionizing footwear comfort, emphasizing its paramount importance in the industry. The potential impact of this research spans from industry innovation to individual well-being, echoing the evolving trends towards sustainability and health-centric decisions in footwear design. This study paves the way for future work to develop comfortable footwear for women, validated by gait analysis, thereby addressing the longstanding challenge of balancing style and comfort in women's footwear.

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Conflicts of Interest
No conflict of interest was reported.
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