

Original Article

Correlation between Weight Distribution on the 5th Metatarsal of Right and Left Foot in Youngsters using Podata Postural Stabilometric Foot Plate

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ABSTRACT

Background: The human foot's complex structure plays a vital role in stability and support during various activities. Understanding the weight distribution across the metatarsal bones, particularly the 5th metatarsal, is crucial for maintaining optimal foot health and functionality. Previous studies have indicated variability in weight distribution between the left and right feet, influencing gait patterns and overall foot health.

Objective: This study aimed to investigate the correlation between weight distribution on the 5th metatarsal of the right and left foot in young adults, providing insights into foot biomechanics and informing clinical practices and footwear design.

Methods: Employing a cross-sectional observational design, the study included 140 individuals aged between 18 and 29 years. Participants with severe musculoskeletal or neurological conditions, pregnancy, or inability to maintain a standing posture were excluded. Weight distribution was assessed using the Podata Postural Stabilometric Foot Plate. Data analysis involved descriptive statistics, t-tests, and calculation of confidence intervals, performed using SPSS Version 25.

Results: The mean weight on the 5th metatarsal was 0.467 kg for the left foot (standard deviation: 0.331) and 0.995 kg for the right foot (standard deviation: 0.774). A moderate positive correlation ($r = 0.45$) was found between the weight distributions on the left and right 5th metatarsals, with a statistically significant p-value of 0.01.

Conclusion: The study revealed a significant discrepancy in weight distribution on the 5th metatarsal between the left and right feet among young adults. These findings have critical implications for personalized podiatric care and the design of orthotic devices and footwear, emphasizing the need for further research in foot biomechanics and health.

Keywords: Foot biomechanics, Weight distribution, 5th Metatarsal, Podata Postural Stabilometric Foot Plate, Orthotic devices, Footwear design.

INTRODUCTION

The human foot, a marvel of biomechanical complexity, comprises 26 bones, numerous joints, ligaments, and muscles, all intricately collaborating to ensure stability and support during various activities. Central to its functionality is the distribution of weight across the foot, particularly the metatarsal bones, which is crucial for maintaining balance and preventing musculoskeletal issues (1). The foot's role in gait production involves all its components, ensuring a coordinated movement pattern (2). This study primarily focuses on the weight distribution on the fifth metatarsal of both feet, utilizing the Podata Postural Stabilometric Foot Plate, a specialized tool in the analysis of foot biomechanics.

The fifth metatarsal, an integral bone in the forefoot extending from the midfoot to the base of the small toe, plays a significant role in foot biomechanics and weight-bearing. Its unique positioning and function facilitate the maintenance of the foot's longitudinal and transverse arches, essential for weight distribution and shock absorption. However, weight distribution across the metatarsals is not uniform, with the fifth metatarsal bearing a lesser proportion of body mass compared to the first metatarsal (great toe). This

distribution varies between individuals due to differences in foot morphology and locomotion patterns. Imbalances in this distribution can lead to conditions such as fractures of the fifth metatarsal, a common injury (4). The stabilometric footplate, by measuring the Center of Pressure from foot forces, helps in assessing postural stability, gait abnormalities, and weight-bearing asymmetries (6).

The application of the Podata Postural Stabilometric Foot Plate in this study is pivotal in understanding foot biomechanics, identifying asymmetries, and providing insights into gait analysis and potential interventions for foot-related issues. This technology is instrumental in the detection and assessment of various medical conditions and the refinement of orthotic configurations and rehabilitation protocols, thereby advancing foot health and performance. It has significant implications in the rehabilitation of major musculoskeletal disorders such as Parkinson's, cerebral palsy, spinal muscular atrophy, ACL injuries, and hallux valgus (7, 8).

The stabilometric footplate, a diagnostic tool in biomechanics and podiatry, evaluates weight bearing and pressure distribution on the lower limbs. Its platform, equipped with sensors, detects the pressure and force exerted during walking and other activities. The data gathered is vital for understanding balance, gait, and foot biomechanics, aiding in diagnosing foot health conditions, identifying variations in weight distribution, and creating personalized treatment plans. Such evaluations are crucial in clinical practice and research, offering insights into conditions like pes planus, plantar fasciitis, and balance disorders, and aiding in the development of specialized footwear and orthotic devices (9-11).

Focusing on adolescents, this study leverages their continuous physical development to gain insights into early foot mechanics. The use of stabilometric foot plates in this age group is beneficial for assessing weight distribution, detecting anomalies, and reducing the risk of musculoskeletal issues, particularly important in sports-specific assessments and injury prevention (12). This methodology is promising for advancing customized footwear and orthotic apparatus (14).

The correlation analysis of weight distribution on the 5th metatarsal using the stabilometric foot plates in youngsters has significant implications for monitoring biomechanical development, identifying future challenges, and implementing preventive interventions. This study impacts the overall welfare of individuals and advances pediatric orthopedics and podiatry by providing essential data for therapeutic interventions (12-14).

The study aims to explore the correlation between weight distribution on the 5th metatarsal of the right and left foot in young persons using the Podata Postural Stabilometric Foot Plate. Collecting precise data on weight distribution on the metatarsals will offer insights into foot biomechanics, walking patterns, and detection of asymmetries, contributing significantly to clinical assessments, orthotic therapies, and rehabilitation programs. Early detection of imbalances allows for preventive interventions, potentially alleviating more severe complications in adulthood. The hypothesis proposes a statistically significant correlation between the loads on the 5th metatarsal of both feet among this age group.

The implications of this study extend to sports medicine, orthopedics, and preventive healthcare. Tailored therapeutic interventions and treatments can be developed to address anomalies in foot weight distribution, enhancing the holistic health and well-being of various age groups, including young children. Factors such as age, gender, and body mass index (BMI) will be considered to investigate their potential effects on weight distribution. This study aims to contribute significantly to podiatry and orthopedics by utilizing data from this innovative technology.

This research elucidates the correlation between weight distribution on the 5th metatarsal in youngsters, offering valuable insights into foot mechanics and their clinical applications. Understanding these relationships can lead to improved preventive and therapeutic measures for individuals of all ages, enhancing their overall well-being.

MATERIAL AND METHODS

The methodology employed in this research adhered to a cross-sectional observational design, focusing on the correlation between weight distribution on the 5th metatarsal of both left and right feet using the Podata Postural Stabilometric Foot Plate. The study encompassed 140 individuals, selectively chosen based on specific criteria. Participants were aged between 18 and 29 years and were required to have the ability to maintain a standing posture for the duration of data collection. Informed consent was a prerequisite for participation. Exclusion criteria were stringent, disqualifying individuals below 18 or above 29 years, those with severe musculoskeletal or neurological conditions potentially affecting weight distribution, pregnant individuals, and those unable to stand for data collection.

Data collection was meticulously executed, with participants who met the inclusion criteria undergoing assessments on the Podata Postural Stabilometric Foot Plate. This device was instrumental in recording the weight distribution data specifically for the 5th metatarsal of both the left and right feet. The statistical analysis was conducted using SPSS Version 25, which facilitated a comprehensive examination of the collected data. Descriptive statistics, including means, standard deviations, and ranges, were utilized to depict an overview of the sample characteristics. T-tests were applied to evaluate the statistical significance of the mean

differences between weight distributions on the left and right feet. Additionally, confidence intervals were calculated to ascertain the precision of these differences.

Ethical considerations were paramount in this study. Informed consent was obtained from all participants, ensuring their voluntary participation and understanding of the study's purpose and procedures. Participant anonymity was maintained throughout, with data confidentiality being strictly observed. The research protocol received approval from the relevant institutional review board, adhering to established ethical guidelines.

Several limitations were acknowledged in the study. The Podata Postural Stabilometric Foot Plate, while effective in assessing pressure distribution, did not directly measure metatarsal pressure. External factors such as variations in footwear, posture, and participant fatigue were recognized as potential influences on data accuracy. The variability in foot morphology and size among individuals posed a challenge to data comparability. The sample size, while substantial, could potentially limit the generalizability of the findings to broader populations, especially considering the focus on a specific age group. Furthermore, the static nature of the measurements did not encapsulate dynamic movements and real-life weight distribution patterns during various activities, which might differ from static measurements.

The data analysis aimed to elucidate the significance of differences in weight distribution between the left and right feet on the 5th metatarsal. The findings were anticipated to have implications for footwear design and medical assessments, particularly in the realms of foot health and balance. This comprehensive methodology ensured a detailed and accurate investigation into the weight distribution on the 5th metatarsal of the left and right feet, utilizing the capabilities of the Podata Postural Stabilometric Foot Plate and the analytical power of SPSS Version 25.

RESULTS

In this study, the demographic and anthropometric data of the participants were meticulously analyzed and presented in Table 1. The average age of the 140 participants was 22.61 years, with a standard deviation of 2.181 years, encompassing a range from 18 to 29 years. The mean height recorded was 64.41 cm, showing a variation with a standard deviation of 2.921 cm, and the values ranged from 59 to 73 cm. The weight of the participants varied considerably, with a mean of 58.61 kg and a standard deviation of 12.442 kg, the values ranged significantly from 37 kg to 100 kg. The Body Mass Index (BMI) of the participants, a critical measure of body fat based on height and weight, averaged at 3.84 kg/m² with a standard deviation of 0.870 kg/m², spanning from 1.00 to 6.00 kg/m².

Further analysis focused on the weight distribution on the 5th metatarsal of both the left and right feet, as detailed in Table 2. The average weight on the 5th metatarsal of the left foot was 0.467 kg, with a standard deviation of 0.331 kg, and the values ranged from 0.00 kg to 1.49 kg. In contrast, the weight on the 5th metatarsal of the right foot was notably higher, with a mean of 0.995 kg and a standard deviation of 0.774 kg, the range being broader from 0.00 kg to 4.30 kg.

A significant aspect of the study was the correlation between the weight distributions on the 5th metatarsal of the left and right feet. The correlation coefficient (*r*) was calculated to be 0.45, indicating a moderate positive correlation between the two variables. This correlation was statistically significant, with a *p*-value of 0.01, suggesting that the relationship between the weight distributions on the left and right 5th metatarsals is not due to random chance.

Table 1 Demographic and Anthropometric Data of Participants

Parameter	Mean	Standard Deviation	Minimum	Maximum	N
Age (years)	22.61	2.181	18	29	140
Height (cm)	64.41	2.921	59	73	140
Weight (kg)	58.61	12.442	37	100	140
BMI (kg/m ²)	3.84	0.870	1.00	6.00	140

Table 2 Weight Distribution on the 5th Metatarsal and Correlation Statistics

Parameter	Mean (kg)	Standard Deviation	Minimum (kg)	Maximum (kg)	N	Correlation between Left and Right Foot	
						Correlation Coefficient (r)	P-value
Weight of the Left Foot on the 5th Metatarsal	0.467	0.331	0.00	1.49	140	0.45	0.01
Weight of the Right Foot on the 5th Metatarsal	0.995	0.774	0.00	4.30	140		

These results provide valuable insights into the biomechanical aspects of foot weight distribution among young adults. The considerable variability in the weight distribution on the 5th metatarsal, especially between the left and right feet, underscores the importance of individualized assessment in clinical settings. Moreover, the significant correlation between the left and right feet's weight distribution highlights the interconnected nature of foot biomechanics. The findings of this study have potential implications for the design of footwear and orthotic devices, aiming to achieve optimal weight distribution and thereby improve foot health and functionality.

DISCUSSION

The study's comprehensive analysis of weight distribution on the 5th metatarsal of both the left and right feet in a cohort of 140 individuals has yielded findings that are both illuminating and consistent with existing literature in podiatric research. A notable discrepancy in weight between the left and right feet was observed, with an average weight of 0.4673 kg for the left foot and 0.9950 kg for the right foot. This aligns with prior studies that have documented a similar tendency for the right foot to bear a higher load compared to the left (15, 19), a factor that can significantly influence gait patterns and overall foot health (12, 13).

The variation in weight distribution, particularly the greater variability on the right foot as indicated by the standard deviations, echoes findings from previous research such as the study by Davis and Walker (17). These variations are critical as they can affect an individual's balance and stability. The statistical significance of these differences, as demonstrated by t-test results, corroborates with similar observations in Roberts and White's study (18), further underscoring the potential impact on footwear design and clinical approaches.

The study's strength lies in its robust methodology and the significant sample size, which enhances the reliability of the findings. However, it also faces limitations. The use of a static measurement system, while effective for this study, does not capture the dynamic movements and real-life weight distribution patterns during various activities. Furthermore, the sample size, although substantial, limits the generalizability of the findings to a broader population.

In terms of clinical implications, the significant differences in weight distribution between the left and right feet, as highlighted by the mean differences and confidence intervals, support the necessity for custom-tailored treatment interventions and orthotic devices. This is in line with the work of Jones et al. (16), which emphasized the importance of considering these variations in the design of orthotic devices and footwear for optimal support and comfort.

Recommendations for future research include a deeper exploration of the underlying mechanisms driving these weight distribution variations and their long-term impact on foot health. This could significantly contribute to both clinical and footwear design fields. The findings of this study, in conjunction with other research, underscore the importance of understanding and addressing foot weight distribution in clinical practice and design applications.

In conclusion, this study contributes significantly to the existing body of knowledge on foot biomechanics by providing insights into the weight distribution of the fifth metatarsal of the human foot. Its findings have substantial implications for podiatric care, highlighting the need for individualized treatment approaches and the design of footwear and orthotic devices that accommodate the natural patterns of foot weight distribution, potentially enhancing comfort and reducing the risk of foot-related issues (14, 20). The research offers a foundational understanding that is invaluable for future investigations in the realm of foot health and biomechanics.

CONCLUSION

In conclusion, this study significantly advances our understanding of the weight distribution on the 5th metatarsal in young adults, revealing notable discrepancies between the left and right feet. These findings have profound implications for clinical podiatry and footwear design, emphasizing the need for personalized treatment approaches and the development of orthotic devices and shoes

that cater to these biomechanical variances. The insights gained underscore the importance of individualized care in enhancing foot health and function, highlighting the necessity for further research into the biomechanical nuances of foot structure and their long-term health implications.

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