International Clinical and Medical Case Reports Journal
Case Report (ISSN: 2832-5788)

Analysis of The Platar Arch Index and Postural Stability Control in Patients Undergoing Unilateral Total Knee Arthroplasty

Robson Emiliano José de Freitas1, Carolina Pereira Vieira1, Pedro Henryque Perna Batista1, Luana Cardoso Garcia2, Ulbiramar Correia da Silva Filho1, Helder Rocha da Silva Araújo3, Edmundo Medeiros Teixeira1, Jaqueline Gleice Aparecida de Freitas4, Fernanda Grazielle da Silva Azevedo Nora5

1Department of Orthopedics and Traumatology, IOG – Instituto Ortopédico de Goiânia, Goiânia, Brazil

2Department of Orthopedics and Traumatology, HUGO – Hospital de Urgências de Goiânia, Goiás, Brazil

3Department of Orthopedics and Traumatology, HC/UFG – Hospital das Clínicas, Universidade Federal de Goiás, Goiânia, Goiás, Brazil

4Higher School of Physical Education and Physiotherapy of Goiás, UEG – State University of Goiás, Goiânia, Goiás, Brazil

5Faculty of Physical Education and Dance, UFG – Federal University of Goiás, Avenida Esperança s/n, Campus Samambaia, Goiânia, Goiás, Brazil

Citation: *Robson Emiliano José de Freitas, Carolina Pereira Vieira, Pedro Henryque Perna Batista, Luana Cardoso Garcia, Ulbiramar Correia da Silva Filho, Helder Rocha da Silva Araújo, Edmundo Medeiros Teixeira, Jaqueline Gleice Aparecida de Freitas, Fernanda Grazielle da Silva Azevedo Nora. Analysis of The Platar Arch Index and Postural Stability Control in Patients Undergoing Unilateral Total Knee Arthroplasty. Int Clinc Med Case Rep Jour. 2023;2(16):1-8.*

Received Date: 28 October, 2023; **Accepted Date:** 06 November, 2023; **Published Date:** 21 December, 2023

***Corresponding author:** Fernanda Grazielle da Silva Azevedo Nora, Faculty of Physical Education and Dance, UFG – Federal University of Goiás, Avenida Esperança s/n, Campus Samambaia, Goiânia, Goiás, Brazil

ABSTRACT

Introduction: Human balance is maintained through a complex system that involves several components, including the center of pressure. Objective: to evaluate the behavior of the center of pressure in patients undergoing primary total knee arthroplasty. Methodology: 17 patients of both sexes who underwent the primary TKA surgical procedure participated in the study. The amplitude of displacement of the center of pressure in the anteroposterior (COPAP) and mediolateral (COPML) directions and the type of plantar arch were evaluated. To compare foot types (normal, flat and cavus) and COP displacement amplitude, statistical analysis was performed using Minitab 21 software, and the t test was performed. The study was approved by the UFG Research Ethics Committee: 3.845.175. Results: When analyzing the amplitude of COP displacement in the anteroposterior direction (COPAP), the group classified with flat foot (8.54 cm) showed greater oscillation when compared to the group with normal foot (1.77cm) and cavus foot (2 .83cm) with this showing a statistically significant difference (p = 0.02). Therefore, analyzingthe amplitude of displacement of the COPin the mediolateral direction (COPML), the

group classified with flat foot (8.54 cm) showed greater oscillation when compared to the group with normal foot (1.32cm) and cavus foot (2.25cm), therefore showed a statistically significant difference (p = 0.03). Conclusion: In patients with osteoarthritis, balance can be affected due to pain, joint stiffness, and impaired function. Changes in the center of pressure can be observed, indicating an additional challenge to maintain postural stability.

Keywords: Osteoarthrosis; Knee; Total Knee Replacement; Center of Pressure; Plantar Arch Index; Postural Stability

INTRODUCTION

In elderly diagnosed with unilateral knee osteoarthritis, their balance can be substantially compromised due to several factors, including pain, joint stiffness, and impaired functionality. Osteoarthritis, a degenerative joint condition, can induce pain, inflammation, and reduced mobility, all of which can disrupt a patient's capacity to maintain proper balance and postural stability. Moreover, a decline in muscle strength surrounding the affected knee can further contribute to a diminished sense of stability [1].

Indeed, balance is a fundamental concern for patients with osteoarthritis, as compromised joint function can have a substantial impact on stability, consequentlyincreasing therisk of falls [1].

The Center of Pressure (COP) is indeed a crucial measurement in the evaluation of balance and postural stability. It serves as the midpoint for all the pressure forces exerted by the feet on the ground during balance maintenance. Variations in the COP can signify issues related to postural control and the body's capacity to sustain equilibrium. COP analysis is frequently employed in clinical settings to gain insights into how osteoarthritis affects both static and dynamic balance. Understanding the behavior of the COP can aid orthopedic physicians in developing tailored treatment and rehabilitation strategies aimed at enhancing stability and minimizing the risk of falls, both before and after undergoing the total knee arthroplastysurgical procedure [1-4].

The assessment of the center of pressure is a useful tool in identifying balance deficiencies. The center of pressure refers to the point where the force of the ground acts on the foot during balance, and its trajectory can be recorded using force platforms or pressure sensors. Changes in the center of pressure may indicate problems in postural control and stability [1-4].

The analysis of the Center of Pressure (COP) can offer valuable insights to healthcare professionals, including physiotherapists and physicians, when assessing the postural stability of patients dealing with unilateral knee osteoarthritis. Understanding how the disease impacts postural stability is crucial for comprehending its progression and for evaluating the efficacy of therapeutic interventions over time. Hence, the assessment of COP is a pivotal component in the management of unilateral knee osteoarthritis, contributing to the enhancement of patients' quality of life and functional abilities [1-5].

Center of pressure analysis indeed serves as a valuable tool for healthcare professionals, including physiotherapists and physicians, in their assessment of postural stability among patients with unilateral knee osteoarthritis. It is instrumental in discerning how the disease impacts postural equilibrium, which, in turn, is pivotal for comprehending the trajectory of osteoarthritis and gauging the efficacy of therapeutic interventions over time. Asa result, evaluating the center of pressure plays a critical role in the overall management of unilateral knee osteoarthritis, contributing significantly to the enhancement of affected patients' quality of life and functional capabilities [1-5].

The Plantar Arch Index (IAP) indeed serves as a measurement for assessing the height and structure of the plantar arch in the foot. This plantar arch represents the longitudinal curve along the underside of the foot, primarily comprised of the tarsal bone and ligaments [6-9].

The Plantar Arch Index (IAP) is indeed valuable in the assessment of orthopedic disorders and foot-related conditions, including flat foot (reduced plantar arch) and cavus foot (elevated plantar arch). In elderly individuals with these conditions, the IAP can offer objective insights into the extent and severity of these anatomical variations. Furthermore, the IAP may prove to be a useful tool in monitoring the progression of certain foot-related disorders over time and in evaluating the outcomes of orthopedic treatments, including total knee arthroplasty (TKA) surgeries.

Hence, research investigations into the behavior of the Center of Pressure (COP) and the Plantar Arch Index in elderly individuals with knee osteoarthritis can yield valuable insights into the impact of this condition on both postural stability and foot biomechanics. Among elderly individuals with knee osteoarthritis, it's commonly observed that the COP undergoes alterations during balance, often shifting away from the affected knee as a strategy to alleviate the load on the painful joint [1-5]. Simultaneously, the Plantar Arch Index may provide indications of adaptive alterations in the foot's structure due to changes in gait and posture patterns. These studies assume particular importance, given that knee osteoarthritis can significantly hinder the performance of daily activities and elevate the risk of falls in elderly individuals. A comprehensive understanding of the interplay between COP and the Plantar Arch Index concerning balance is paramount for the development of therapeutic and fall prevention strategies aimed at this susceptible demographic. Such strategies may include the incorporation of interventions such as strength-building exercises, physical therapy, or orthotic devices [6-9].

The aim of this study was to assess the Plantar Arch Index and the Center of Pressure behavior in elderly individuals who have undergone unilateral total knee arthroplasty. Total knee arthroplasty is a frequently performed surgical procedure aimed at addressing severe osteoarthritis, which can substantially affect the biomechanics and stability of the operated limb. Consequently, this study strives to elucidate the impact of osteoarthritis on the Plantar Arch Index and Center of Pressure dynamics, thereby offering valuable insights into alterations in foot structure and postural stability among elderly individuals prior to undergoing total knee replacement surgery.

MATERIALS AND METHODS

Participants

The study enrolled 17 elderly participants, encompassing both males and females, with an average age of 71.35 years. Each of these individuals had previously received a diagnosis of unilateral knee osteoarthritis and had subsequently undergone unilateral knee arthroplasty surgery. Table 1 furnishes comprehensive information pertaining to the sample's characteristics, offering keyinsights into the study participants, encompassing their age, gender, and the knee subjected to the arthroplasty procedure. This preliminary dataset is instrumental for comprehending the sample's composition and the demographic of elderly individuals undergoing knee arthroplasty as part of the study.

Table 1: Sample characterization.

Group	Age (Years)	Height (cm)	Body Mass (KG)	Operated Knee	Gender
ATJ_Group	71.5 (±13.4)	162.2(±31.4)	80.69 (±9.24)	Left: 9 Right: 8	Man: 4 Woman: 13

Data are expressed as mean ± standard deviation.

Ethical Aspects

The ethical integrity of this study was meticulously upheld at every phase of the research. Prior to their participation, all individuals were provided with a comprehensive explanation of the research's objectives, significance, and the procedures involved in data collection. This rigorous process guaranteed that each participant was fullyapprised of the nature of their involvement.

Each participant was extended a voluntary invitation to contribute to the study and was given the opportunity to address any inquiries or concerns that might arise. Following the receipt of thorough information, all participants manifested their consent, which was both informed and voluntary, by affixing their signatures to the Free and Informed Consent Form (TCL). This document formalized the participants' consent, bearing witness to their willingness to partake in theresearch.

It is of paramount importance to underscore that the study was conducted in strict accordance with the highest ethical standards and garnered approval from the Ethics Committee of the Federal University of Goiás, with registration number 3.845.175. This endorsement procedure ensured that the research adhered to established ethical principles, therebysafeguarding therights and well-being of all participants throughout the study.

Experimental Protocol

The data collection procedure was executed as follows: before initiating data collection, participants were instructed to stand without shoes, assuming a bipedal support position, with their feet positioned comfortably while adhering to their base of support, on a plantar pressure platform. To commence data collection, participants were guided to maintain a stationary and immobile stance, with their gaze fixed upon a predetermined reference point, for a duration of 60 seconds, awaiting a sound cue, as depicted in Figure 1. This activity was repeated three times, with a 2-minuterest interval between each iteration.

Figure 1: Experimental protocol and plantar pressure platform used in the study.

Plantar pressure data was captured using a 50x50 cm Barosccan plantar pressure platform, specifically the Podotech model, which is equipped with 4,096 capacitive sensors and has a sampling frequency of 50Hz. The experimental protocol was implemented precisely 1 hour prior to the surgical procedure, within the same hospital where the surgery was scheduled to take place and with the identical team of orthopedic surgeons. This method was employed to ensure that data collection transpired within a consistent environment and context, thereby minimizing the influence of external variables that could potentially impact the results. This rigorous approach is indispensable for upholding the qualityand validity of the data gathered in the study.

Variable Analyzed

The evaluation of the Plantar Arch Index (AI) was employed to analyze various parameters of foot structure. This method entails the division of the foot into distinct regions, enabling a more precise assessment of the plantar arch's anatomy during both static and dynamic activities [10]. AI serves as a commonly utilized metric for quantifying the relative height of the plantar arch, allowing for the classification of different types of plantar arch. This categorization aids in determining whether an individual has a low plantar arch (flat foot), a normal plantar arch (anatomically neutral), or a high plantar arch (cavus foot) [11].

The variables related to the behavior of the Center of Pressure (COP) included the following: Amplitude of COP Displacement in the anteroposterior direction (COPAP) and in the mediolateral direction (COPML), measured in centimeters [12].

Statistical Analysis

The statistical analysis for this study was carried out using Minitab 21 software. Initially, assessments were conducted to evaluate the normality and homogeneity of data distributions, employing the Kolmogorov-Smirnov test. Subsequently, to assess differences within the group concerning the variables under scrutiny, the non-parametric Tukey's test was applied.

The established level of statistical significance was 5% ($p \leq 0.05$), which indicates that statistically significant disparities were considered present when the obtained p-value equaled or fell below 0.05. The outcomes pertaining to the analyzed variables are presented, along with their respective means and standard deviations, offering a lucid depiction of the patterns and variations discernible in the data.

RESULTS

In our analysis of the Center of Pressure (COP) displacement amplitudes, we observed that the group classified with flat feet (8.54 cm) showed significantly greater oscillations in the anteroposterior direction (COPAP) compared to the group with normal feet (1.77 cm) and those with cavus foot (2.83 cm). This difference was statistically significant (p=0.02). Similarly, when assessing the amplitude of COP displacement in the mediolateral direction (COPML), the group with flat feet (7.24 cm) displayed notably larger oscillations in comparison to the group with normal feet (1.32 cm), with a statistically significant difference (p=0.03). For a more detailed presentation of the findings, please refer to Table 2 in this study.

Table 2: Analyzed variables of the behavior of plantar pressures on the base of support

	Grupo Flat Foot	Group Normal Foot	P value
COAP (cm)	8.54 (±6,67)	1.77(±1,23)	0.02*
COPML (cm)	7.24 (±5,21)	2.32 (±0,94)	0.03*

The flat foot group was made up of elderly people who presented IAP: 0.36 (10 elderly people) and the normal foot group was made up of elderly people who presented the IAP: 0.24 (7 elderly people). Data are expressed as mean ± standard deviation. *Significant Tukey test ($p \leq 0.05$).

DISCUSSION

The group of elderly individuals characterized by a flat Plantar Arch Index experiences instability during both static and dynamic balance. Their challenge in maintaining balance arises from the absence of arch support, which amplifies the risk of falling [13,14]. Additionally, they may exhibit misalignment in their lower limbs, impacting the waythese individuals walk and move, therebyincreasing the likelihood of stumbling or falling.

Elderly classified as having flat feet may possess a less stable base of support, rendering them more susceptible to balance disturbances. Conversely, those with pes cavus may encounter comparable challenges due to the foot's reduced contact area with the ground. Consequently, the connection between the plantar arch index and falls in the elderly can be attributed to the impact of foot shape on posture and balance, establishing it as a pivotal factor to be considered in the prevention of falls and the enhancement of safetyamong the elderly [13,14].

Elderly with flat feet who have been diagnosed with unilateral knee osteoarthritis are those who have a condition characterized by a flattened plantar arch of the foot and who have received a diagnosis of osteoarthritis in only one of their knees. This combination of conditions can have a significant impact on their stability, gait, and overall quality of life. Osteoarthritis can lead to pain and limitations in the affected knee, while flat feet can influence foot alignment and the distribution of body weight. Consequently, these elderly individuals may encounter additional challenges when performing everyday activities like walking and maintaining their balance, primarily due to the complications stemming from both conditions [13,14].

Flat feet can indeed affect how the foot contacts the ground and the distribution of pressure during walking or standing. This can result in a more pronounced displacement of the Center of Pressure (COP), rendering elderly individuals with flat feet more vulnerable to swaying and challenges in maintaining balance. Therefore, it is crucial to take these characteristics into account when assessing stability and formulating intervention strategies for elderly individuals with flat feet. The goal is to enhance their quality of life and reduce the risk of falls [5-12].

Center of Pressure (COP) displacement in elderly with osteoarthritis pertains to the shifting of the central point where all pressure forces are applied by the feet when engaging in balance-related activities. This displacement of the COP in elderly individuals with osteoarthritis may undergo changes influenced by factors such as pain, joint stiffness, muscle weakness, and alterations in the body's biomechanics [1-5].

Elderly with flat feet typically exhibit increased displacement of the Center of Pressure (COP) in both the anteroposterior (AP) and mediolateral (ML) directions during balance-related activities when compared to individuals with feet considered to have a normal arch. This disparity can be attributed to the structure of flat feet, which tends to provide a less stable base of support and a less effective distribution of body weight [1,15].

Osteoarthritis, a condition affecting the joints, disrupts joint stability and muscle strength, leading to increased displacement of the Center of Pressure (COP) in both the anteroposterior (COPAP) and mediolateral (COPML) directions. These changes can result in heightened instability during static balance in elderly individuals with flat feet compared to those with normal arches. Osteoarthritis can compromise joint integrity and the capacity to support body weight, thereby impacting balance maintenance. This makes elderly individuals with flat feet and

osteoarthritis more susceptible to swaying and falls during static balance. Consequently, the combination of flat feet and osteoarthritis can exacerbate postural stability in theelderly [1,15].

Elderly with flat feet who have received a diagnosis of unilateral knee osteoarthritis are those who exhibit a condition characterized by a flattened plantar arch in the foot and have also been diagnosed with osteoarthritis affecting only one knee. This combination of conditions can have a significant impact on their stability, gait, and overall quality of life. Osteoarthritis may lead to pain and limitations in the affected knee, while flat feet can influence foot alignment and the distribution of body weight. Consequently, these elderly individuals may encounter additional challenges when performing daily activities, such as walking and maintaining balance, primarilydue to complications arising from both conditions [13,14].

CONCLUSION

Patients with unilateral knee osteoarthritis often experience compromised balance attributed to factors such as pain, joint stiffness, and reduced joint function. Observing alterations in the center of pressure (COP) provides valuable insights, indicating an additional challenge in maintaining postural stability. Consequently, the assessment of the center of pressure serves as a beneficial tool for identifying balance deficits and guiding both conservative and surgical therapeutic interventions. This data is instrumental in the evaluation of postural stability and in understanding how this condition alters one's ability to maintain stability.

REFERENCES

1. de Freitas REJ, de Freitas JGA, Vieira CP, Endres DC, Inacio FM, da Silva Azevedo Nora FG. Analysis of Postural Control in Patients Diagnosed with Unilateral Knee Osteoarthrosis and Its Relationship with the Risk of Falls. Adv Orthop. 2023;2023:5536304.
2. Shengxing Fu, Tingjin Duan, Meijin Hou, Fengjiao Yang, Yatai Chai, Yongkang Chen, et al. Postural balance in individuals with knee osteoarthritis during stand-to-sit task. Frontiers in Human Neuroscience. 2021;15.
3. Ahmad H Alghadir, Shahnawaz Anwer, Bibhuti Sarkar, Ashis K Paul, Dilshad Anwar. Effect of 6-week retro or forward walking program on pain, functional disability, quadriceps muscle strength, and performance in individuals with knee osteoarthritis: a randomized controlled trial (retro-walking trial) BMC Musculoskeletal Disorders. 2019;20(1):159.
4. Kento Sabashi, Satoshi Kasahara, Harukazu Tohyama, Takeshi Chiba, Yuta Koshino, Tomoya Ishida, et al. Changes in postural control strategy during quiet standing in individuals with knee osteoarthritis. J Back Musculoskelet Rehabil. 2022;35(3):565-572.
5. Menz HB, Fotoohabadi MR, Wee E, Spink MJ. Visual categorisation of the arch index: a simplified measure of foot posture in older people. J Foot Ankle Res. 2012;5(1):10.
6. Nawoczenski DA, Saltzman CL, Cook TM. The effect of foot structure on the three-dimensional kinematic coupling behavior of the leg and rearfoot. Phys Ther. 1998;78(4):404-416.
7. Kaufman KR, Brodine SK, Shaffer RA, Johnson CW, Cullison TR. The effect of foot structure andrange of motion on musculoskeletal overuse injuries. Am J SportsMed. 1999;27(5):585-593.

8. Murley GS, Menz HB, Landorf KB. A protocol for classifying normal- and flat-arched foot posture for research studies using clinical and radiographic measurements. J Foot Ankle Res. 2009;2:22.
9. Spink MJ, Menz HB, Fotoohabadi MR, Wee E, Landorf KB, Hill KD, et al. Effectiveness of a multifaceted podiatry intervention to prevent falls in community dwelling older people with disabling foot pain: randomised controlled trial. BMJ. 2011;342:d3411.
10. W C Chu, S H Lee, W Chu, T J Wang, M C Lee. The use of arch index to characterize arch height: a digital image processing approach. IEEE Trans Biomed Eng. 1995;42(11):1088-1093.
11. Cavanagh PR, Rodgers MM. The arch index: a useful measure from footprints. J Biomech. 1987;20(5):547-51.
12. Da Silva Azevedo Nora Fernanda GRAZIELLE; Milan Michelle BAZILIO; Paiva FRANCIELE; De Souza Nilva PESSOA; De Oliveira Assis ALFREDO et al. 2019. Gait initiation process: comparing force and pressure platforms data. In: Ifmbe proceedings. Brasil.
13. Aenumulapalli A, Kulkarni MM, Gandotra AR. Prevalence of Flexible Flat Foot in Adults: A Cross-sectional Study. J Clin Diagn Res. 2017;11(6):AC17-AC20.
14. Mehta J, Czanner G, Harding S, Newsham D, Robinson J. Visual risk factors for falls in older adults: a case-control study. BMC Geriatr. 2022;22(1):134.
15. Lee PA, Wu KH, Lu HY, Su KW, Wang TM, Liu HC, et al. Compromised balance control in older people with bilateral medial knee osteoarthritis during level walking. Sci Rep. 2021;11(1):3742.